

A Comparison of Traditional and Non-Traditional Strength Training on Selected Health-Related Fitness Measures and Physical Activity Enjoyment in Adolescents

by

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Bachelor of Kinesiology with Nutrition, Acadia University, 2006

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Abstract

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This study compared the effects of a non-traditional and a traditional strength training program for adolescents on measures of health-related fitness and physical activity enjoyment (PACES). Male ($n = 7$) and female ($n = 12$) adolescents between the ages of 15 and 18 years registered for a community based program and volunteered to participate in the study component. Participants were assigned to a non-traditional training group ($n = 10$) utilizing kettlebells or a traditional training group ($n = 9$) utilizing dumbbells. Health-related fitness and PACES were measured at baseline and post-training, with an additional PACES measure at mid-training. Both training groups significantly improved several health-related fitness measures, with the only significant difference between groups being seen in KB swing squats. PACES significantly decreased from baseline to mid-training, and stayed constant from mid- to post-training, for both training groups. There was no significant difference between training groups on physical activity enjoyment.

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Dedication

To my mom and dad, your support and encouragement has truly been the guiding force behind my accomplishments thus far. Because I am sure that I don't say it enough, I am truly appreciative of all that you do and I love you. This one's for you....

Chapter 1 - Introduction

Children and adolescents are our most precious asset and the face of the future. In recognition of the importance in ensuring that the next generation is a healthy one, parents, physical education advocates, professionals, and academics are focusing their efforts on the youth population and variables related to their current and prospective health. With regards to adolescents, one in every five people worldwide has been identified as being between 10 and 19 years of age (World Health Organization [WHO], n.d.).

Unfortunately, preventable risk factors, such as obesity, physical inactivity and inadequate physical fitness are compromising the current and future health of the youth population. As a result, children and adolescents are developing chronic diseases at a young age (de Ferranti et al., 2004; Kaufman, 2002; Weiss et al., 2004) or setting the stage for the onset of disease in adulthood (Twisk, Kemper, & van Mechelen, 2002). It has been argued, that physical activity patterns during childhood serve as a foundation for a lifetime of regular physical activity (Goran, Reynolds, & Lindquist, 1999). In addition, health habits and behaviors that develop during the adolescents years are thought to track into adulthood (WHO, n.d.; Williams, 1993); thus, there is a substantiated need to intervene at a young age.

Excess body weight and childhood obesity have recently been identified as pandemics (“BBC News”, 2007; Miller, Rosenbloom, & Silverstein, 2004), an indication that these conditions affect an exceptionally high proportion of the population worldwide (“Pandemic”, 2008). In the face of these critical health concerns, it is of increasing

importance that research is focused on better understanding this pandemic and identifying strategies to stall, or reverse, this harmful trend.

Reductions in physical activity and exercise amongst youth have commonly been identified as important contributing factors to the increased prevalence of childhood obesity. For this reason, physical activity and exercise are often recommended in the prevention or treatment of obesity amongst children.

In addition to contributing to obesity prevention, participation of children and adolescents in regular exercise has been associated with a number of additional health benefits (Lou, Ganley, & Flynn, 2002; Warburton, Whitney Nicol, & Bredin, 2006). While previous exercise recommendations for youth have focused on aerobic activities, research in the past decade has identified strength training as a safe and effective method of conditioning for young girls and boys (Faigenbaum et al., 1996; Faigenbaum, 2001). The increased popularity of strength training for youth has even lead to the development of health objectives aiming to increase the number of children six years old and older who regularly participate in physical activities that enhance muscular strength, endurance, and flexibility (U.S. Department of Health and Human Services, 1996).

When evaluating the effectiveness of strength training programs for youth, the focus should be on more than its effects on physical fitness and health of the individual. It is important that enjoyment of the program is also taken into consideration, as this factor is likely to influence adherence and subsequent health benefits derived from long-term training (Wankel, 1993; Weiss, 2000). In addition, the enjoyment of an activity and the distraction that participation provides from any unfavourable stimuli, may act to enhance the mood of participants during and after participation (Peluso & de Andrade,

2005) with the potential to positively influence long term psychological wellness (Bahrke & Morgan, 1978).

While there has been a great deal of research done in the field of physical activity and exercise for youth, there is a continuing need to identify new, alternate modes of being active. By doing so, it is possible to appeal to a broader portion of the population, and in turn, encourage more people to be active.

It is well known that traditional strength training programs for youth can produce desirable results such as improved muscular strength and local muscular endurance. However, it is unlikely that one traditional form of resistance training appeals to the entire population of youth and therefore, there is a need to determine alternate methods of resistance training. Where traditional strength training methods have been the focus of previous research, little research exists looking at non-traditional forms of strength training, such as kettlebell (KB) strength training.

Originating in Russia over a century ago, KB's have the physical appearance of a cast iron cannonball with a handle. This form of training consists of fluid movements opposing gravity, incorporating several muscle groups which work in harmony to complete an exercise. To date, only two descriptive abstracts have been published to date focusing on the energy cost and cardiorespiratory responses of adults to a single KB exercise session (Bishop, Collins, & Lanier, 2005; Lanier, Bishop, & Collins, 2005). No research has been conducted using KB strength training as a method of conditioning for adolescents.

1.1 Statement of the Problem

The obesity pandemic alone provides clear indication that today's population is facing significant health challenges. While physical activity and exercise are consistently being recognized for their positive effects on body composition and overall health (Warburton et al., 2006), the majority of today's youth population is failing to meet the physical activity recommendations for health and prevention of disease ("Active Healthy Kids Canada", 2008). The identification of new, alternative means to being active, such as non-traditional strength training, may work to encourage adherence and maintenance to this health enhancing behaviour.

1.2 Significance of the Problem

Health care professionals, policy experts, children's advocates, and parents share a common concern for today's youth generation (Anderson & Butcher, 2006). The current era of physical inactivity, overweight and obesity amongst youth gives rise to concerns regarding their current and future health. This inadequate state of health amongst youth emphasizes the importance of intervention strategies focused on improving the physical activity profile of the youth population.

In support of these concerns, British Columbia has taken an important step in recognizing the importance of physical activity and healthy nutrition in the prevention and treatment of childhood obesity. On September 4, 2007, British Columbia established itself with the highest school health standards in the country by announcing Canada's most aggressive initiative to date. This initiative, commencing in September 2008, will

remove junk food from all schools and mandate physical activity for all kindergarten to grade twelve students. Acknowledging physical activity and exercise as being critical components of health and wellness, physical activity is becoming a prominent component of these students' educational requirements. Kindergarten students will take part in 15 minutes of daily physical activity as a part of their education. Students in grade one to grade nine will be required to take part in a minimum of 30 minutes of physical activity per day as a part of their educational program, whereas grade 10 to grade 12 students will be required to document and report a cumulative minimum of at least 150 minutes of physical activity per week as a component of their Graduation Transitions Program (Ministry of Education, 2007).

1.3 Purpose

The purpose of this study was to investigate the effect of strength training on a variety of health-related fitness parameters, as well as the effect of strength training on physical activity enjoyment, in adolescents. This study also served to compare the effect of KB training (a non-traditional form of strength training) to dumbbell training (DB; a traditional form of strength training) on health-related fitness and physical activity enjoyment.

1.4 Research Questions

Reflecting the purpose, this study will answer the following questions:

- 1) Does strength training effect any of the following health-related fitness components in 15 to 18 year old adolescents: muscular strength, muscular endurance,

muscular power and flexibility as measured by: grip strength, KB and DB specific squat tests, maximal push-ups, partial curl-ups, back extension, vertical jump and the sit and reach flexibility test?

- 2) Is a non-traditional (KB) training a more effective mode of strength training when compared to traditional (DB) training methods?
- 3) Does non-traditional (KB) training enhance physical activity enjoyment more than traditional (DB) training methods?

1.5 Hypotheses

Complimenting the research questions, the hypotheses of this study are:

- 1) Both modes of strength training will significantly improve all measures of health-related fitness: muscular strength (grip strength, KB and DB specific squat strength), muscular endurance (push-ups, partial curl-ups, back extension), muscular power (vertical jump), and flexibility (sit and reach) ($\alpha = .05$).
- 2) Non-traditional (KB) strength training will improve muscular strength (grip strength, KB and DB specific squat strength), muscular endurance (push-ups, partial curl-ups, back extension), muscular power (vertical jump) and flexibility (sit and reach) significantly more than traditional (DB) strength training ($\alpha = .05$).
- 3) Participants in the non-traditional (KB) training group will have greater increases in physical activity enjoyment from baseline, compared to traditional (DB) training ($\alpha = .05$).

For statistical purposes, the research hypotheses are stated in their null form.

- 1) Neither mode of strength training will have any significant affect on any measures of health-related fitness: muscular strength (grip strength, KB and DB specific squat strength), muscular endurance (push-ups, partial curl-ups, back extension), muscular power (vertical jump) and flexibility (sit and reach) ($\alpha = .05$).
- 2) Non-traditional (KB) strength training will not significantly improve muscular strength (grip strength, KB and DB specific squat strength), muscular endurance (push-ups, partial curl-ups, back extension), muscular power (vertical jump), or flexibility (sit and reach) ($\alpha = .05$).
- 3) There will be no significant difference in physical activity enjoyment between the non-traditional (KB) and traditional (DB) strength training groups ($\alpha = .05$).

1.6 Assumptions

The following assumptions were identified in this study:

- 1) Participants gave consistent and prescribed levels of effort during all training and testing sessions.
- 2) Participants complied with the recommendation to avoid additional strength training, or other forms of conditioning that would have affected the results of this study, throughout the duration of the strength training program.
- 3) There was no major difference in the levels of free living physical activity (i.e. team sports, etc.) between each group.
- 4) There was no major difference between the contributing health and fitness factors of participants in each group (i.e. hours of sleep per night, smoking).

5) The physical activity enjoyment scale (PACES) (Motl et al., 2001) is a valid measurement tool for enjoyment in male adolescents.

1.7 Limitations

This study will face limitations which cannot be controlled by the researcher:

- 1) The researcher was only in control of the participants exercise regime when they were exposed to the intervention.
- 2) The nature of this study being experimental/intervention limited the number of participants in this study. Participant numbers were limited to that which could be recruited to volunteer for the study, and commit to the strength training program for the entire eight week duration.
- 3) The participants' caloric intake and quality of food consumed was not controlled for although it could have influenced the participants' performance (energy for each training session, responses to exercise) and fitness enhancements (strength training adaptations).

1.8 Delimitations

With specific reference to the scope of the study, the following delimitations were applied to enhance the strength of the study:

- 1) The researcher designed the *training* programs for each group, ensuring that the exercise selection and packaging distinctly represented that promoted by each modality. Other training variables were held constant throughout the intervention between groups (frequency and duration).

- 2) The researcher selected valid and reliable *tests* to comprise the test battery.
- 3) The researcher oversaw all *training* sessions, adhering to protocol, to ensure reliability.
- 4) The researcher conducted all *testing* sessions, collecting data and adhering to protocol, to ensure reliability.
- 5) The traditional strength training intervention was designed according to the National Strength and Conditioning Association guidelines (Baechle & Earle, 2000) in order to ensure that the traditional program was representative of that performed by the general population.
- 6) The non-traditional intervention was designed with reference to the guidelines and exercises put forth by KettleBell Concepts (“KettleBell Concepts”, n.d.; Vatel & Gray, 2005) in order to ensure that the KB program was an accurate representation of that being promoted to the public.

1.9 Significance of the Study

Research supports youth participation in strength training programs as a means to enhancing overall health and well-being. Unlike the adult population, youth are rarely motivated to exercise for the sole purpose of enhancing their health. Exercise must be associated with enjoyment and immediate gratification in order to encourage youth to adhere to this type of activity (Bar-Or, 2003). The understanding of motivations for physical activity participation in youth, and the support and gaining popularity of strength training for this population, is supportive of this study. It seems reasonable to declare

that research is needed to determine the most enjoyable, response-oriented method of strength training for youth.

This study served as the first community program for the Pacific Institute of Sport Excellence (PISE) of Victoria, BC. This centre emphasizes academic and athletic excellence, and community programming serves as one of its four pillars for generating economic impact and social well-being. By serving as a pilot program for the PISE, this program generated an initial interest in the local PISE and emphasized its connection with the community.

This study has the potential to positively influence the physical activity and health practices of youth. On a small scale, the sample of adolescent participants in this study benefited from the opportunity to participate in a supervised, low cost, strength training program. For many participants, this experience acted as an introduction to strength training. Participants had the opportunity to learn the fundamentals of strength training (specific guidelines, techniques, definitions, breathing, etc), providing them with the tools needed to continue this type of activity upon completion of participation in this study.

On a larger scale, this study addresses the potential importance and need for non-traditional forms of physical activity as a means to encouraging physical activity adherence amongst youth. Specifically, if results indicate KB training is an effective and equally enjoyable form of physical activity for the participants, a more widespread adoption of this revived form of exercise may be encouraged. This study may work to encourage physical education classes, gyms, and recreation centers to make these training tools more available, thereby providing adolescents with more opportunities to enhance their physical activity levels.

This study was the first to, the researcher's knowledge, focusing on KB strength training as a method of conditioning for youth. Scientific literature investigating the effects of KB training is essentially non-existent; this study provides the opportunity to contribute to the limited, general literature focusing on non-traditional forms of strength training for youth. This study may also provide the basis for future studies looking into the effectiveness of KB training as a form of training for sport or occupational performance.

Increasing the appeal of strength training as a form of physical activity could positively enhance the health status of the youth population. The benefits associated with an increase in physical activity (Hass, Feigenbaum, & Franklin, 2001), in combination with those specifically associated with strength training (Faigenbaum, 2001; Hass et al., 2001; Myer & Wall, 2006), support strength training interventions as a means to addressing the eroding health status of today's youth population. In addition, by providing youth with the opportunity to learn lifetime activities at a young age, as opposed to solely activities focused on play, the future exercise practices of these children may potentially be influenced. With strength training being a relatively common form of exercise for adults, having developed the skills and knowledge needed to perform this form of exercise at a young age may transfer to a greater adoption of this form of activity in adulthood.

Finally, the findings of this study will be useful in developing a framework for practical, strength training interventions for youth and other populations.

1.10 Operational Definitions

Adolescents: Youth aged 15 to 18 years old.

Enjoyment: A simple positive emotion, affective state, or response (Scanlan & Simons, 1992; Wankel, 1993) reflecting feelings of pleasure, liking, and fun (Scanlan & Simons, 1992). The term enjoyment is considered synonymous with fun (Scanlan, Carpenter, Lobel, & Simons, 1993).

Health-related fitness: A form of physical fitness focusing on the essential components of good health and/or the prevention of disease. The components of health-related fitness include: cardiorespiratory endurance, muscular endurance, muscular strength, body composition, and flexibility (Caspersen, Powell, & Christenson, 1985). This study specifically focused on measures of muscular strength, muscular endurance, muscular power and flexibility as the studied components of health-related fitness.

Non-traditional strength training: Any type of strength training that does not classify as traditional (ie. medicine ball training, theraband training, etc). This study specifically focuses on training with KBs as its form of non-traditional strength training.

Strength training: A specialized method of conditioning involving the use of a variety of resistive loads and training modalities (i.e. barbells, DBs, weight machines, elastic tubing, medicine balls, and body weight; Faigenbaum, 2003). For the purpose of this study, strength training will specifically refer to DB training and KB training.

Traditional strength training: A form of strength training that uses weight machines, body weight, barbells, or DBs as resistance. For this study, specific reference is to training with DBs.

Chapter 2 – Literature Review

A lack of sufficient physical activity, in combination with an overweight or obese status, relates to an increased risk of all-cause mortality (Koezuka et al., 2006). The serious implications that are associated with a sedentary lifestyle emphasize the need to improve the poor physical activity profile of today's youth population.

This chapter will introduce the issues surrounding physical inactivity, poor physical fitness, and overweight and obesity amongst youth. Specifically, this chapter will address: the adolescent population; physical activity and fitness levels of youth; consequences of the current trends in activity, fitness, and weight status; strength training as a form of activity for youth; and the enjoyment construct.

2.1 The Adolescent Population

The World Health Organization (WHO) defines adolescence as occurring between the 10th and 19th year of life. Currently, adolescents comprise a considerable one fifth of the world population (World Health Organization [WHO], 2008). With such a significant portion of the population being adolescents, there is importance in ensuring that this next generation of leaders is a healthy one.

Research has indicated that many of the health habits and behaviours developed during adolescence track into adulthood (Caspersen, Pereira, & Curran, 2000; Centers for Disease Control [CDC], 2006; Hardy, Bass, & Booth, 2007; Koezuka et al., 2006; Michaud, Suris, & Viner, 2007; Molnar, 2003). Unfortunately, the adolescent population seems to be developing poor habits and behaviours with many being overweight or obese (section 2.4.1.), physically inactive (section 2.2), of poor physical fitness (section 2.3),

and/or enroute to several chronic diseases (section 2.4.2.). In accordance with the suggested tracking affect, an estimated 70% of premature deaths amongst adults have been associated with behaviours initiated during adolescence, according to the WHO (Family and Community Health, Pan American Health Organization, 2003).

The promotion of increased physical activity and fitness amongst adolescents has the potential to significantly impact their overall health. In addition, these components have the ability to influence the social, psychological, and academic aspects of an adolescent's life. By establishing optimal health patterns during the adolescent years, it is anticipated that there will be a carry over affect into adulthood (DiNubile, 1993).

2.2 Physical Activity

2.2.1. Current State of Physical Activity in Youth

The remarkable increase in the rate of obesity, diabetes, and other health conditions worldwide seems to coincide with a decrease in physical activity participation (Bassett Jr. et al., 2007). Low levels of physical activity affect overall energy balance (energy consumed versus expended) and are thought to play an important role in the current pandemic of childhood obesity ("BBC News", 2007; Biddle et al., 2003; Miller, Rosenbloom, & Silverstein, 2004).

The general perception amongst the major health organizations is that most individuals of all ages are not attaining a level of physical activity or fitness associated with the prevention of chronic disease (Hass, Feigenbaum, & Franklin, 2001). Recognizing this concern, the Healthy People 2010 initiative identified physical activity and physical fitness as two focus areas for disease prevention and health promotion in the United States. Based on the recommendation of at least 20 minutes of vigorous activity

on three or more days of the week, it was found that only 65% of adolescents were sufficiently active in 1999. In response to this finding, Healthy People 2010 established a goal of increasing this percentage to 85% of all adolescents (Healthy People 2010, 2000).

In accordance with the United States, Canada is also encouraging an increase in exercise and physical activity. Backed by the support of some of Canada's most influential health organizations (Public Health Agency of Canada, as well as The College of Family Physicians of Canada, the Canadian Paediatric Society, and the Canadian Society for Exercise Physiology), Canada's Physical Activity Guide for Youth was designed to help Canadian youth improve their health and prevent disease (Public Health Agency of Canada, 2002). This guide identifies a number of guidelines and recommendations geared towards improving physical activity and exercise levels.

The specifics of Canada's Physical Activity Guide for Youth support an increase in physically active time by 30 minutes per day. It is recommended that one third of Canadian youth's active time be vigorous and two thirds be moderate in intensity. Maintaining the one-third to two-third ratio, youth are encouraged to continually increase their daily physical activity levels until they reach 90 minutes per day more than their personal starting level. This increase in physical activity and exercise will consequently result in a concurrent reduction in time spent inactive (Public Health Agency of Canada, 2002).

The need for increased physical activity amongst Canadian youth is solidified by the results of Canada's Report Card on Physical Activity for Children and Youth. The 2008 report presented a failing grade for the fourth consecutive year, representing the stall in progress to improve the physical activity profile of our children and youth. The

2008 overall grade of “D” also indicates a lack of definitive and measurable progress, and emphasizes the need for continued efforts addressing this problem area. With specific reference to the physical activity levels of Canadian youth, an individual grade of “F” was given, consistent with the grade received in 2007 (“Active Healthy Kids Canada”, 2008).

2.2.2. Youth Physical Activity Literature

Several studies have indicated that more often than not, children and youth are failing to attain the daily recommended levels of physical activity for optimal health and development. The purpose of this section is to introduce these findings and current trends.

While numerous recommendations for physical activity amongst youth have been set forth by various organizations nation- and worldwide (Janssen, 2007), the current Canadian recommendation for children and youth are those presented in Canada’s Physical Activity Guide for Youth (Public Health Agency of Canada, 2002). These recommendations encourage increasing physically active time by 30 minutes per day until daily activity is greater than or equal to 90 minutes per day. Unfortunately, classification of physical activity and inactivity generally differs by study, making comparisons between studies less clear.

Canadian Physical Activity Levels Among Youth (CAN PLAY), a major national study examining the physical activity levels of children and youth, was developed with the intent to be conducted annually until 2010. CAN PLAY randomly sampled thousands of children and youth each year with the intent to act as effective and objective means to studying young Canadian children and adolescents’ physical activity and fitness patterns.

The CAN PLAY study found that 90% of Canadian children and youth did not meet the recommended 90 minutes of moderate to vigorous activity per day (or equivalent 16,500 steps per day) (Canadian Fitness and Lifestyle Research Institute [CFLRI], 2007).

Koezuka and colleagues (2006) analyzed 7982 male and female adolescents (12-19 yrs old) from the 2000-2001 Canadian Community Health Survey. The results of the analysis of self-report questionnaire responses indicated that 50.3% of males and 67.8% of females were inactive as defined by expending less than 3 kilocalories per kilogram of bodyweight per day (equal to approximately 60 minutes of brisk walking).

Physical activity patterns and correlates amongst American youth have illustrated similar findings to that noted in its neighbouring country. In a study of 878 adolescent females and males from the San Diego County, many of these 11 to 15 year olds were not attaining sufficient physical activity. Using accelerometers, it was found that 66.4% of females and 41.0% of males did not attain 60 minutes or more of physical activity per day (Sanchez et al., 2007).

2.2.3. Explaining the Trends

Many speculations have been made in an attempt to explain the decrease in youth physical activity levels. Biddle and colleagues (2003) suggested several potential contributors to this growing concern, including: the development of new technologies, additional televisions and television programs; a greater reliance on automotive transportation; safety concerns for children in unsupervised settings; decreased appeal for cycling and walking; reduced physical education emphasis in the school curricula; and additional demands which compete for young people's time.

The somewhat recent development of reliable physical activity measures has presented a difficulty in assessing physical activity trends over time via reliable, experimental methods. As a result, some researchers have relied on alternate methods to represent the physical activity trends over time. For example, studies of Amish populations have been utilized as a representative look at physical activity patterns when individuals are free from the influences of modern society and technology. Overall, these studies have provided support for the influence of current, modern society on population wide physical activity levels (Bassett Jr., Schneider, & Huntington, 2004; Bassett Jr. et al., 2007).

With technology and transportation continuing to replace physical activity in our day to day lives, studies of Amish communities provide an opportunity to examine the significance of this influence. Research in this area is supportive of a mismatch between activity levels long ago, and those current in modern society. Amish communities, which refrain from modern technologies and rely on manual labour and active transportation, have greater levels of physical activity than that of people in modern society. Children from these communities walk to school, work on the farms, and perform daily household chores without spending time on the daily activities that children in modern societies have come to rely on so heavily – television, computers, and video games (Bassett Jr. et al., 2007).

In 2004, Bassett Jr. and colleagues assessed the physical activity levels of an Old Order Amish community in southern Ontario using pedometers. Participants in this study included 98 adults between the ages of 18 and 75 years old. The results of this study

indicated that the average number of steps taken per day was 18,425 for men and 14,196 for women.

Similarly, Bassett Jr. and colleagues (2007) proceeded to study the physical activity levels of children in an Old Order Amish community. Using pedometers, teenage Amish boys averaged 20,292 steps per day for four weekdays. This proved to be considerably higher than that of grades 7-9 and 10-12 American boys with 11,082 and 10,828 steps per day, respectively (Le Masurier et al., 2005). Similar trends were noted for teenage girls. Where the Amish girls averaged 13,558 steps per day for four weekdays (Bassett Jr. et al, 2007), American girls in grades 7-9 and 10-12 accumulated only 10,080 and 9,706 steps per day, respectively (Le Masurier et al., 2005).

Though physical activity levels amongst youth are evidently declining, Biddle (2003) argued that youth remain the most active population in society, having many opportunities to be active through school and community programming. It seems that, although physical activity levels amongst youth are inadequate, the rest of the population may be facing even greater obstacles in attaining sufficient physical activity. Given that children will one day become adults, the adolescent years provide an opportune time to establish positive health habits that will transition into adulthood, a time where responsibilities and commitments make healthy, active living even more of a challenge.

2.3 Physical Fitness

2.3.1. Current State of Physical Fitness in Youth

Children of the United States are apparently fatter, slower, and weaker than those of other developed nations (DiNubile, 1993). Given the numerous shared traits between

the United States and Canada, it is likely that Canadian youth are facing a similar trend; however, this literature is unclear.

During the first 10 to 15 years of a child's life, they develop the health behaviours that will influence and carry over into the rest of their lives (DiNubile, 1993). The health behaviours and attitudes practiced in childhood and adolescence largely influence current and prospective health, thus raising concern over the steady decrease in physical fitness and physical activity levels amongst youth today.

Though the consequences of poor fitness and inactivity aren't always present during childhood, the "far-reaching consequences" that arise later in life are readily accepted, and recognized amongst the adult population. The recognition of this association between previously established health habits and adult based chronic diseases provides support for the importance of developing optimal fitness and activity profiles in youth. DiNubile (1993) acknowledged fitness as a needed component at the foundation of all widespread preventive efforts targeting health promotion and disease prevention.

2.3.2. Youth Physical Fitness Literature

Literature in the field of physical activity and exercise suggests that the majority of individuals of all ages are not expending an adequate amount of energy on a daily basis (U.S. Department of Health and Human Services, 1996). However, controversy surrounding this consensus exists, with some experts strongly supporting an evident erosion of youth fitness over the past few decades, and others contending that this is an exaggeration. With national data being collected for several decades now, a recent switch in the fitness assessment emphasis from performance and motor skills, to health-related fitness, makes it difficult to formulate conclusive comparisons of data and trends

over the years (Kuntzelman, 1993). That being said, there are statistics specifically pertaining to the youth physical fitness trends which are noteworthy.

DiNubile (1993) described 30 to 50% of American youth as being below an acceptable standard for cardiovascular and health protection, unable to run one mile in ten minutes. In specific reference to musculoskeletal fitness, 50% of girls and 25% of boys were unable to perform a single pull-up, and 66% of all youth were below acceptable standards for jogging, sit-ups and toe-touch tests (DiNubile, 1993). Similarly, another study of 104 male and female elementary aged children found that 61% of participants could not perform a single pull-up (Folsom-Meek, Herauf, & Adams, 1992).

Tremblay and Chiasson (2002) compared the physical fitness characteristics of current male and female college students to those who participated in the 1981 Canada Fitness Survey. Push-up scores were used as the representation of muscular fitness for this study. Participants of this study included 423 male and 427 female participants between the ages of 17 and 20 years old. The authors of this study found that muscular fitness was lower in participants of their study compared to those from 1981. Similarly, body weight, waist circumference, and sum of five skinfolds were inferior in 2002, with greater values compared to participants in 1981. Finally, this study indicated that only 5% of the sample population from 2002 ($n = 850$) participated in vigorous physical activities at least five times per week (Tremblay & Chiasson, 2002).

Tremblay and Chiasson's (2002) study indicated a decline in fitness and healthy body compositions amongst adolescents transitioning to adulthood. In consideration of the fact that adolescence is often free from all the responsibilities and commitments of

adulthood, it seems that the physical activity and fitness of these individuals will only decline further as their responsibilities and commitments increase.

The poor musculoskeletal fitness scores of children, adolescents, and young adults are likely stemming from poor adoption or adherence to the activities that develop this system. Research has found that one half of males and two-thirds of females aged 12 to 21 years were not regularly participating in strengthening and toning activities (U.S. Department of Health and Human Services, 1996).

2.4 Consequences of Current Trends

The current trends in overall health of the youth population are a serious concern. If something is not changed, the cost of health care, incidence of disease, and functionality of citizens will continue to be negatively influenced (Kuntzleman, 1993). The major themes when examining the consequences of the current trends in physical activity, fitness, and body composition are: obesity, chronic diseases, tracking, and economic burden.

2.4.1. Overweight/Obesity

Most reports suggest that a sedentary lifestyle corresponds with the prevalence of overweight and obesity (Bar-Or, 2003; Janssen, Katzmarzyk, Boyce, King, & Pickett, 2004). Over the past several years, the prevalence of obesity consistently rose, with research indicating that the rate of juvenile obesity was considerably greater than that observed in Canadian adults (Bar-Or, 2003).

The prevalence of overweight and obesity amongst youth has dramatically increased over the past 25 years. In 2004, the combined overweight/obesity rate for each sex was approximately 70 percent higher than that recorded in 1978/79 (Shields, 2006).

When the prevalence of juvenile obesity was assessed using the body mass index (BMI) recordings from 1965 National Health and Nutrition Examination Survey (NHANES) data and the 1995 NHANES III data, a significant increase in obesity rates were observed for youth of all ages. In youth aged 6 to 11 years old, significant increases in the prevalence of obesity were noted amongst both boys (108% increase) and girls (106% increase). Similar trends were also noted for older youth; however, there was a more distinct difference between the genders. Amongst the 12 to 17 year old population, boys had a significantly greater increase in the prevalence of obesity (146% increase) when compared to the girls (69% increase) whose increase was still discouraging from a health standpoint (Bar-Or, 2003).

The proportion of adolescents, aged 12 to 17 years old, that were overweight or obese in 2004 was approximately 26 percent (compared to the 15 percent in 1978/79). Thus, over a quarter of the adolescent population was either overweight or obese in 2004 (Shields, 2006).

The adolescent years are an important area of focus for research in the field of health due to the critical role these years play in the transition from childhood to adulthood. Adolescence has been consistently identified as a critical period in ones life for the development of health-related attitudes, behaviours, and in turn, the potential for adult obesity. Though childhood obesity is a major concern across all age groups, it appears that adolescents are most significantly impacted by this pandemic. Statistics

indicate that the proportion of overweight/obese boys in Canada were higher amongst adolescents (32 percent) compared to children aged two to five (19 percent) (Shields, 2006). The high prevalence of overweight/obesity amongst the adolescent population, in addition to the documented tracking that occurs during this transitional period of life, identifies this population as one that is in need of interventions targeting their health profile.

Comparatively, non-modernized Amish communities which adhere to greater levels of physical activity reflect lower levels of overweight and obesity amongst their youth population. In a 2007, 139 Amish children between the ages of 6 and 18 years were evaluated on their BMI. This study found that 1.4% of these children were obese, and 7.2% were overweight (Bassett Jr. et al., 2007).

2.4.2. Chronic Diseases

The pandemic levels of childhood obesity (“BBC News”, 2007; Miller et al., 2004), resulting in part due to low levels of physical activity and physical fitness, have been associated with a number of chronic diseases and disease risk factors in youth and long term, as adults. Literature in this area has identified a number of health concerns for youth, including: coronary heart disease risk (Katzmarzyk, Malina, & Bouchard, 1999; Schofield, Schofield, Hinckson, & Mummer, 2007); type 2 diabetes mellitus (Kaufman, 2002; Pinhas-Hamel & Zeitler, 2005); the metabolic syndrome (de Ferranti et al., 2004; Weiss et al., 2004); and even psychosocial affects (CDC, 2006; Dietz, 1998; Whetstone, Morrissey, & Cummings, 2007).

2.4.2.1. Coronary Heart Disease Risk

With obesity being the most prevalent nutritional disease for children and adolescents of the United States, it is now being recognized for its significant, long-term effects on a number of adult-onset diseases. Commonly recognized obesity-related morbidities in adults are now being linked to precursors thought to exist in obese children and adolescents (Dietz, 1998).

In 2007, Schofield and colleagues studied the step counts of 415 adolescent girls from Australia, as they related to coronary risk factors. The risk factors assessed in this study included: low daily physical activity levels (<10,000 steps per day), high blood pressure (greater than the 95th percentile), overweight (greater than the 85th percentile) and/or obese (greater than the 95th percentile), a family history of heart disease, poor cardiorespiratory fitness (low estimated VO₂max), and regular smoking.

It was determined that 41.2% of the girls in the cross-sectional sample had at least two risk factors for coronary disease. When physically inactive participants were compared to active participants, it was shown that the inactive participants were significantly more likely to be obese (with an odds ratio of 4.7), less likely to be underweight (odd ratio of 0.29) and more likely to be of poor cardiovascular fitness (odds ratio of 3.27; Schofield et al., 2007).

When participants with at least three risk factors for coronary heart disease were assessed, it was determined that all of these participants were physically inactive (< 7409 steps per day). The authors of this study indicated that lifestyle choices may be implicated in the pathogenesis of coronary heart disease. These authors also concluded, that while adolescents are rarely diagnosed with coronary heart disease, the noted

accumulation of risk factors is likely significantly disadvantageous in terms of future health status (Schofield et al., 2007).

Katzmarzyk et al.'s (1999) study of the Quebec Family Study also investigated coronary heart disease risk factors in youth. Specifically, this study examined the relationship between physical activity, fitness, and these risk factors in 342 male and 268 female participants between the ages of 9 and 18 years old. The risk factors assessed in this study were mean arterial blood pressure and fasting blood levels of triglycerides, glucose, LDL-cholesterol, and HDL-cholesterol. Physical activity was assessed by daily energy expenditure, involvement in physical activities of moderate to vigorous intensity, physical inactivity, and time spent watching television. Physical fitness was assessed by sum of six skinfolds, submaximal work capacity, strength of the quadriceps, and sit-ups (Katzmarzyk et al., 1999)

The results of this study indicated that 5 to 20% and 11 to 30% of the risk profile variance was explained by activity and fitness levels, respectively. The results of this study suggested that physical fitness had a stronger relationship on coronary heart disease risk factors in youth than level of activity or inactivity (Katzmarzyk et al., 1999).

2.4.2.2. Type 2 Diabetes Mellitus

Type 2 diabetes mellitus (T2DM) was first diagnosed in Canadian children in 1984 (Harris, Perkins, & Whalen-Brough, 1996) and in the United States during the 1990s (Pinhas-Hamel & Zeitler, 2005). What was once considered an adult onset disease is now commonly diagnosed in children and adolescents and has even been labelled an epidemic among youth (Kaufman, 2002). Research seems to suggest, that the increased

prevalence of T2DM amongst youth is paralleling the increase in childhood obesity (Kaufman, 2002; Pinhas-Hamel & Zeitler, 2005).

Reported levels of T2DM amongst youth seem to vary depending on the population and geographic location studied. Harris, Perkins, and Whalen-Brough (1996) identified the First Nation's people as being Canada's most studied population with regards to the occurrence of child-onset T2DM. In 1998, Dean reported that only two cases of T2DM were reported amongst 5-17 year old Manitoba based First Nation's children in 1986. These two cases comprised 5% of all new-onset diabetes cases. By 1995, this number had grown to 11 cases comprising 17% of all new-onset diabetes cases (Dean, 1998).

Data reported by Kaufman (2002), indicated that T2DM diagnoses amongst youth ranged from 8% to 24% in 1999, depending on the location of study. Other reports indicate that less than 3% of all new diabetes cases in youth were T2DM 15 years ago; whereas now, up to 45% of all new diabetes cases amongst adolescents are T2DM (Pinhas-Hamel & Zeitler, 2005).

Though a discrepancy exists between the values assigned to child-onset T2DM rates, it is clear that its occurrence is on the rise. Children and adolescents diagnosed with T2DM will subsequently face long disease durations and it is expected, that the life-long occurrence of diabetes-associated complications will be higher in this group (Pinhas-Hamel & Zeitler, 2005).

2.4.2.3. Metabolic Syndrome

The metabolic syndrome is a condition that is comprised of a cluster of health conditions including glucose intolerance (type 2 diabetes, impaired glucose tolerance, or

impaired fasting glycemia), insulin resistance, central obesity, dyslipidemia, and hypertension (Eckel, Grundy, & Zimmet, 2005). Though several different definitions have been developed for the adult populations, consensus has yet to be reached, establishing a standard pediatric definition.

In de Ferranti et al.'s study (2004), the components involved in diagnosing pediatric metabolic syndrome were fasting triglycerides, HDL, fasting glucose, waist circumference, and systolic blood pressure. Each component was assigned a reference value in which children were matched against when diagnosing the metabolic syndrome. Having three or more of the above mentioned conditions of a certain level (described in greater detail in the study) diagnosed that child with the metabolic syndrome. This study determined that two-thirds of the 1960 children 12 years old and younger had at least one metabolic abnormality and almost one in ten was diagnosed with the metabolic syndrome. The data utilized for this study was derived from the findings of the Third National Health and Nutritional Survey between 1988 and 1994. Nearly one third of overweight/obese adolescents had the metabolic syndrome (de Ferranti et al., 2004).

Other studies have further demonstrated the relationship between obesity and the metabolic syndrome. As the severity of obesity increases, the likelihood of metabolic syndrome is also thought to increase. In fact, one study found that the prevalence of metabolic syndrome reached 50% amongst severely obese children and adolescents (Weiss et al., 2004).

2.4.2.4. Psychosocial

In addition to these physical health risks, overweight and obesity is associated with psychosocial health concerns. Dietz (1998) described psychosocial consequences as

the most widespread of childhood obesity. Overweight and obese youth are often targets of early, regular teasing and taunting. The psychological stress this teasing and taunting causes can lead to low self-esteem and negative self-images that appear to persist into adulthood (CDC, 2006; Dietz, 1998). These psychosocial affects have also been described as having an affect on academic and social performance (CDC, 2006). Whetstone et al. (2007) found that male and female adolescents with poor perceptions of body image (often a result of being overweight and obese) were significantly more likely to report suicidal thoughts and actions.

2.4.3. Tracking

The chronic diseases and associated health care costs that are prevalent in overweight and obese adults have been suggested to initiate in childhood and track into adulthood. This tracking affect emphasizes the importance of addressing physical inactivity, low levels of physical fitness, and overweight/obesity at a young age. Research has focused on three main areas of tracking from childhood to adulthood: physical activity, overweight and obesity, and chronic diseases (Caspersen, Pereira, & Curran, 2000; CDC, 2006; Hardy, Bass, & Booth, 2007; Koezuka et al., 2006; Molnar, 2003).

Physical activity levels decline during adolescence and carry over into adulthood (Koezuka et al., 2006). The decline in physical activity is seen specifically in the transition from early to mid-adolescence. Girls with a mean age of 12.8 years have been reported to spend approximately 45% of their free time in sedentary behaviors, increasing to 63% at 14.9 years old (Hardy, Bass, & Booth, 2007). Similarly, it has been noted that the most significant decrease in physical activity was between the ages of 15 and 18

years, indicating that Hardy and colleagues (2007) may have noted an even further increase in sedentary behaviours had the girls been studied at an older age (Caspersen, Pereira, & Curran, 2000). Although the most significant decrease in physical activity patterns is believed to occur between the ages of 15 and 18 years old, young adulthood (18 to 19 yrs old) also shows a continued erosion of activity patterns, with middle adulthood (30 to 64 yrs old) revealing a stabilization of these patterns. These findings support the need for interventions early in life as a means to offsetting the consistent decline in physical activity adherence that is noted throughout adolescence and adulthood (Caspersen, Pereira, & Curran, 2000).

With regards to the tracking of overweight and obesity, it is generally accepted with good certainty that overweight and obese youth are more likely to become overweight and obese adults. Previous research has shown that 80 percent of children that were overweight at the age of 10 to 15 years old, were obese as adults at the age of 25 years old (CDC, 2006). Research has also shown that 40 to 85 percent of obese children will stay obese as adults. These findings indicate the strong influence of childhood obesity on adult morbidity and mortality (Molnar, 2003).

Tracking of obesity from childhood to adulthood is further influenced by the weight status of these children's parents. Several studies have identified a strong, influential role of parental weight status on the current and future weight status of their children. Lake, Power, and Cole (1997) found that children with two obese parents were fatter in their childhood and faced a stronger tracking pattern of overweight or obesity from childhood to adulthood compared to children of parents with lower BMIs. These authors stated that the extent of BMI tracking from childhood to adulthood was likely to

strengthen with an increased prevalence of parent obesity. Similarly, Whitaker et al. (1997) stated that amongst obese and non-obese children under the age of ten years old, the risk of adult obesity more than doubled when these children's parents were obese. Other studies of pre-pubertal children have found similar results, indicating that parental obesity was the main risk factor for obesity amongst their children (Maffesi, Talamini, & Tato, 1998).

In addition to the tracking of physical activity patterns and overweight/obesity, chronic diseases are being recognized as originating and tracking from childhood to adulthood. Childhood obesity has been associated with cardiovascular risk factors, type 2 diabetes mellitus, and the origins of atherosclerosis and metabolic dysfunctions leading to serious diseases later in adult life (Molnar, 2003).

2.4.4. Economic Burden

Several chronic diseases, and/or alternate poor health conditions, are the result of physical inactivity and obesity. Problems that arise from preventable risk factors result in a waste of health care dollars. Both Canada and the United States are seeing billions of dollars being wasted due to conditions that arise from physically inactive or obese lifestyles.

In 2004, Katzmarzyk and Janssen published a widely cited analytical review estimating the direct and indirect costs of Canadian physical inactivity and obesity in 2001. This review indicated that the economic burden of physical inactivity comprised \$1.6 and \$3.7 billion on direct and indirect costs, respectively, totalling \$5.3 billion on physical inactivity alone. The costs associated with obesity included \$1.6 and \$2.7 billion on direct and indirect costs, respectively, totalling \$4.3 billion on obesity alone.

Using American data from the 1998 Medical Expenditure Panel Survey (MEPS) and the 1996/1997 National Health Accounts (NHA) data, findings indicate that approximately \$51.5 billion (MEPS) to \$78.5 billion (NHA) was spent per year on adult medical expenses attributed to overweight and obesity. The majority of the variance between these two estimates is accounted for by the inclusion of nursing home expenditures in the NHA estimates (CDC, 2007).

2.5 Youth Strength Training

Strength training for youth is gaining popularity as boys and girls of all ages and capabilities are turning to sports camps, recreation centers, and schools to enhance their muscular fitness (Faigenbaum, 2003). Though strength training is currently recognized for its beneficial role in performance and health-related fitness amongst both adult and youth populations, these benefits have not always been recognized.

Previously, strength training for children was viewed as a controversial activity (Faigenbaum, 2003; Myer & Wall, 2006) and physical activity recommendations for this population remained primarily focused on aerobic activities (Faigenbaum, 2003). However, evidence in the last decade has provided clarification, and support, for the safety and efficacy of this activity for youth (Faigenbaum, 2003; Myer & Wall, 2006).

Today, a number of medical and fitness organizations are recognizing the role for strength training in the overall health and wellness of youth and are encouraging participation. Provided appropriate guidelines are followed and supervision is provided, supporting medical communities include: the American Academy of Family Physicians (AAFP, 2008), American Academy of Orthopaedic Surgeons (AAOS, 2008), American

College of Sports Medicine (ACSM, 2007), American Medical Society for Sports Medicine (AMSSM, n.d.), American Orthopaedic Society for Sports Medicine (AOSSM, 2008), American Osteopathic Academy of Sports Medicine (AOASM, 2008), National Strength and Conditioning Association (NSCA, 2005), American Academy of Pediatrics (AAP, n.d.), and The President's Council on Physical Fitness and Sports (2008). In support of the participation of youth in this form of training, public health objectives have been set to increase the number of children aged six years and up that regularly participate in activities to develop and maintain musculoskeletal fitness (US Department of Health and Human Services, 1996).

2.5.1. Benefits of Physical Activity and Exercise

Participation of children and adolescents in regular physical activity and exercise has been associated with a number of health benefits. Many of these benefits are described in Warburton et al.'s (2006) review of the health benefits of physical activity, including improvements in: body composition, lipid lipoprotein profiles, glucose homeostasis and insulin sensitivity, autonomic tone, coronary blood flow, endothelial function, and psychological well-being. In addition, regular physical activity and exercise have been associated with reductions in: blood pressure, systemic inflammation, and blood coagulation (Warburton et al., 2006).

Complimenting these benefits, regular physical activity participation has been supported for its contribution to the primary and secondary prevention of several chronic diseases (Lou, Ganley, & Flynn, 2002; Warburton, Whitney Nicol, & Bredin, 2006). In Warburton et al.'s (2006) review, the primary and secondary prevention of cardiovascular disease, diabetes mellitus, cancer, and osteoporosis were summarized.

With regards to cardiovascular disease, it seems that a dose-response relationship exists in which those with the lowest risk of premature death are those with the highest levels of physical activity and fitness (Warburton et al., 2006).

Secondly, regular physical activity is also supported in the primary prevention of type 2 diabetes mellitus, though the most effective form of training (resistance versus aerobic) and exercise intensity for the prevention of diabetes remains unclear. As a method of secondary prevention, exercise has been shown to be beneficial in its improvement of glucose homeostasis (Warburton et al., 2006).

Thirdly, routine physical activity has been suggested to play a role in decreasing the incidence of breast and colon cancer, as well as providing health benefits to those diagnosed with cancer. Finally, there seems to be a preventive role in the loss of bone mineral density and the onset of osteoporosis, particularly amongst postmenopausal women. As a form of secondary prevention, regular physical activity may play a role in the maintenance of bone health and fight against osteoporosis (Warburton et al., 2006).

2.5.2. Benefits of Strength Training

Strength training as a specific form of exercise for youth has a number of unique benefits. Assuming appropriate prescription and supervision is provided, the benefits that youth can attain from this form of activity are now being considered greater than that attributable to their normal growth and development (Myer & Wall, 2006). Though much of the existing information pertaining to strength training protocols, adaptations, and its efficacy has come from studies of adult-based populations, recent years have been host to a number of studies examining the effects of strength training for youth. These studies indicate that untrained children and adolescents are capable of enhancing their

strength by roughly 30-50% following appropriately designed, short term (8-12 weeks) strength training programs (Faigenbaum, 2003). Much of this information surrounding strength training for youth can be found in the literature amongst meta-analyses (Falk & Tenenbaum, 1996; Payne, Morrow, Johnson, & Dalton, 1997), scientific reviews (Blimkie, 1992; Faigenbaum, 1993; Faigenbaum, 1996; Faigenbaum, 2000; Malina, 2006), and clinical observations (Bar-Or, 1983; Micheli, 1988).

Regular adherence by youth to a strength training program can offer a preparatory effect for all other forms of physical activities, including sporting and recreational activities. As Faigenbaum et al. (1996) stated, “children cannot “play” themselves into shape” and thus there is an important role for these types of strengthening activities in physical preparation, regardless of athletic ability.

Other general benefits associated with youth strength training include an improvement in: muscular strength, local muscular endurance, muscular power, cardiorespiratory fitness, body composition (Faigenbaum, 2003), motor performance skills and sports performance (Faigenbaum, 2003; Rupnow, 1985), performance of activities of daily living (Hunt, 2003), blood lipid profiles, and cardiovascular risk profiles (Faigenbaum, 2003; Fripp & Hodgson, 1987; Weltman, Janney, Rians, Strand, & Katch, 1987). Hypertensive adolescents have even been shown to benefit from submaximal resistance training through reduced blood pressure (Faigenbaum et al., 1996).

One of the most widely cited benefits of strength training for youth is that of its influence on bone mineral density. Childhood has been referred to as a “window of opportunity” during which the bone-modeling process best responds to the mechanical

loading of strength training type activities (Conroy et al., 1993; Davies, Evans, & Gregory, 2005; Faigenbaum, 2003; Hind & Burrows, 2007; Janz, 2002; Nichols, Sanborn, & Love, 2001).

In addition to the more readily recognized physical benefits of youth strength training, this activity may also play a role in achieving a number of psychological benefits, however, the literature has yet to unequivocally establish this (Faigenbaum et al., 1996). Mental health and well-being have been suggested to improve through strength training for youth, in turn, fostering a more positive outlook towards lifetime physical activity (Faigenbaum, 2003). The socialization and mental discipline that are a part of adherence to a strength training program have been compared to participating in team sports and activities, and seem to be primarily responsible for this enhanced mental health and well-being (Faigenbaum, 1995).

Additional psychological benefits of strength training for youth include the opportunity it provides for children and adolescents of any weight, shape, or size to challenge themselves and experience success - reflecting positively on their self-esteem (Faigenbaum et al., 1996; Faigenbaum, 2003). Having the ability to individualize and vary strength training programs provides an opportunity for youth to participate in a form of exercise that is structured for success. Overweight and obese youth may take a particular liking to this form of activity due to its minimal aerobic demands. By providing an opportunity for all youth to experience success and confidence, an interest in maintaining physically active lifestyles may then be increased (Faigenbaum, 2003).

2.5.3. Mechanisms of Strength Gains in Youth

The two predominant mechanisms of strength gains have been identified as neural and muscular adaptations (McDonagh & Davies, 1984; Phillips, 2000; Sale, 1988; Staron et al., 1994). In adults, neural adaptations are thought to be primarily influential during the initial phases of prolonged strength training, while hypertrophy of the muscle is thought to play a more predominant influence during the later phases, allowing for even greater increases in muscular strength (Sale, 1988). Conversely, pre-pubescent children, seem to attain the majority of their strength gains, regardless of the phase of training, through neural adaptations. The neural adaptations during the initial phases of training for adults, and the neural adaptations primarily responsible for all strength gains in pre-pubescent children, are thought to be similar. Since pre-pubescent children lack the hormones required for significant muscle hypertrophy, this factor is often considered insignificant in the strength gains noted amongst strength training youth (Ozmun, Mikesky, & Surburg, 1994; Ramsay et al, 1990).

The role of neural adaptations as the predominant mechanism of strength gains early in a training program have been nearly conclusively supported (Akima et al., 1999; Chilibeck, Calder, Sale, & Webber, 1998; Enoka, 1997; McDonagh & Davies, 1984; Phillips, 2000; Sale, 1988). Much of the rationale for this support seems to be derived from noted increases in strength, prior to increases in muscle size, during the early stages of training (Sale, 1988). Studies of prepubescent strength gains have provided further support for the significant role of neural adaptations in strength gains in general (Ozmun, Mikesky, & Surburg, 1994; Ramsay et al., 1990)

Neural adaptations which are suspected to contribute to increased strength over short duration strength training, or the initial phases of prolonged training, are: increased

neural drive to the active muscle fibers (Sale, 1988); altered recruitment, activation, number, rate of firing, synchronization, and coordination of motor units (Gabriel, Kamen, & Frost, 2006; Hickson, Hidaka, Foster, Falduto, & Chatterton, 1994; Ramsay et al., 1990; Sale, 1988; Semmler, 2002; Staron et al., 1994), lowered neural inhibitory reflexes (Hickson, Hidaka, Foster, Falduto, & Chatterton, 1994); improved coordination or motor skill learning (Benjamin & Glow, 2003; Ramsay et al., 1990); and a better ability to maximally activate muscles voluntarily (Sale, 1988).

Though general theories regarding strength training adaptations during the initial phases of a training program do support this predominant influence of neurological factors, an existing body of literature has proposed that the influence of muscular adaptations during this phase may be more significant than once suspected.

Several studies have indicated periods of six to eight weeks before notable increases in muscle hypertrophy were observed (Akima et al., 1999; Hickson et al., 1994; Narici et al., 1989; Staron et al., 1994). However, differences between studies in measurement methodology have resulted in inconsistent findings. In fact, some studies have even suggested that a small, but significant, increase in muscle and muscle fiber cross-sectional area during the initial phases of strength training may be contributing to overall strength gains (Akima et al., 1999; Chilibeck et al., 1998; Enoka, 1997; Phillips, 2000; Staron et al., 1994).

An increase in myofibrillar protein volume density, rather than increased fiber diameter, may be responsible for the commonly reported non-apparent increase in muscle fiber cross-sectional area during the initial training phases. However, this increased myofibrillar protein synthesis would act as a mechanism, in addition to neural factors,

influencing the initial gains in strength. This muscular adaptation has been suggested to initiate after just one training session (Phillips, 2000) indicating that significant changes within the muscle are taking place early, contributing to strength gains (Staron et al., 1994). With a number of studies suggesting an early production of force producing myofibrillar proteins (Akima et al., 1999; Chilibeck et al., 1998; Enoka, 1997), it seems that the exclusive role for neural mechanisms in initial strength gains is inconclusive.

Though neural and learning factors are commonly cited as having a predominant role in strength gains during the initial phase of strength training, the ultimate strength capacity of an individual is dependent upon the physiological factors within the muscle (McArdle, Katch, & Katch, 2001). Muscular adaptations shift to become the primary factor influencing strength development in adherence to prolonged training (McDonagh & Davies, 1984).

Muscular adaptations which may start to play a predominant role towards the end of short duration training programs include alterations to fiber type, contractile protein composition, amount of muscle mass, and tendon attachments (Hickson et al., 1994).

Overall, it seems that enhanced strength amongst pre-pubescents can be attributed to neural adaptations, as they lack the circulating androgens necessary for muscle hypertrophy. These neural adaptations are also thought to be primarily responsible for the strength gains noted in short duration training programs, or during the early phases of longer duration programs, for post-pubescents (adolescents) and adults.

2.6 Safety Concerns for Youth Strength Training

Much of the controversy surrounding strength training for youth has focused on the likelihood and susceptibility of injury. Though strength training is now promoted as having a role in injury prevention for youth, it was previously discouraged for younger populations due to a presumed high risk of injury (Faigenbaum et al., 1996).

During the 1970s and 1980s, a common misperception was that youth strength training would damage the epiphyseal plates (as they are not yet ossified in children), in turn, stunting statural growth or leading to limb deformity (Faigenbaum, 2000; Faigenbaum, 2003; Faigenbaum et al., 1996). The fear of injury seems to have mostly come from data gathered by the National Electronic Injury Surveillance System (NEISS) of the US Consumer Product Safety Commission. This data came from hospital emergency room visits and made projections regarding the national sum of injuries as a result of exercises and equipment (U.S. Consumer Product Safety Commission, 1979; 1987).

Although the majority of injuries reported were only strains and sprains, data indicated that over half of the 35,512 strength training related injuries in 1979 affected 10- to 19-year olds (U.S. Consumer Product Safety Commission, 1979). In addition, data from 1987 indicated that, 8,590 children under the age of 14 years were taken to the emergency room for strength training related injuries (U.S. Consumer Product Safety Commission, 1987). Reported injuries did not differentiate between those associated with strength training and those associated with powerlifting or the sport of weightlifting (which require more complex exercises with heavier loads) (Faigenbaum et al., 1996).

The literature which has reported epiphyseal plate fractures (Gumbs, Segal, Halligan, & Lower, 1982; Ryan & Salciccioli, 1976) has often been poor in quality. These studies were often case studies, involving poor lifting technique, excessive loads, poorly designed equipment, and poor supervision (Faigenbaum, 2003; Faigenbaum et al., 1996).

Claims pertaining to a potential stunting of statural growth when children lift heavy loads seem to come from very different literature (Kato & Ishiko, 1964). Kato and Ishiko (1964) studied children from the mountainous village of Iwate Prefecture, Japan with respect to the affect of constant engagement in heavy labour on growth. Of the 4000 children studied, a reported 116 were affected by obstructed growth – as measured by x-rays of the knee and foot joints, with some participants having their blood examined for the volume of protein, calcium, and phosphor (Kato & Ishiko, 1964). The results of this study seem to have formed the basis for the claims that strength training for children may result in a stunting of growth. However, closer examination of the study and its protocol reveal poor control over participants, with severe malnutrition affecting many. Thus, the results of this study cannot be conclusively based on the heavy loads alone.

Currently, strength training for youth is being promoted for its role in injury resistance during sporting and recreational activities (Faigenbaum, 2003; Myer & Wall, 2006). The ACSM has stated that an estimated 50 percent of youth sports injuries could have been prevented if more emphasis was focused on the development of fundamental fitness abilities prior to sport participation (Faigenbaum, 2003). Hunt (2003) described strength training as having an influence over the prevalence and prevention of

musculoskeletal disorders such as muscle sprains, shoulder instability, knee stability and pain, low back pain, osteoporosis, and osteoarthritis.

The mechanisms behind strength training's role in injury resistance can be attributed to beneficial adaptations in the strength and balance of the supporting structures around a joint (muscle balance, bones, ligaments, and tendons) (Faigenbaum, 2003; Myer & Wall, 2006). Stronger muscles are also better able to absorb shock, and therefore resist injury when compared to weaker muscles (Rupnow, 1985).

With no current prospective, well designed, and supervised youth strength training studies indicating significant injury or decrease in stature, it is misleading to assume that strength training in a controlled environment will cause injury. To claim that adequately designed and supervised strength training programs for youth will cause injury based on a handful of poorly designed studies and vague reports, would be misleading (Faigenbaum, 2000; Faigenbaum, 2003; Faigenbaum et al., 1996). Keeping in mind that strength training differs from powerlifting and the sport of weight lifting, competently supervised strength training programs for youth will continue to be supported as a safe and effective form of physical activity (Benjamin & Glow, 2003).

2.7 Strength Training Prescription for Youth

Appropriately and competently designed strength training programs are critical components of training safely and preventing injury. These programs can vary in numerous ways, including mode of training, delivery of program, and training volume assignment.

Studies of strength training for youth have implemented various modes of training. These studies have utilized adult and child size weight machines, hydraulic machines, pneumatic machines, isometric contractions, wrestling drills, modified pull-ups, calisthenics, and free weights (as described in Faigenbaum et al., 1996).

Free weight training, the mode of strength training utilized for the traditional and non-traditional training groups of this study, utilizes handheld weights as the form of resistance. The benefits of this mode of training lie in the fact that range of motion is free from the limitations of a machine, stabilizing muscles are utilized to a greater extent, and the execution of an exercise can be modified to produce specific results for motor development or sport performance. This form of training is limited in that participants can more readily use improper form, lose control of the weights, and/or potentially injure themselves. Also, free weight training for youth requires competent supervision and spotters, whereas other forms of training may allow for more independent training (Myer & Wall, 2006).

Several guidelines have been presented to date with regards to strength training program delivery for youth, and the critical focus areas for each phase of training. Safety needs to be the initial focus in strength training with children and adolescents. It is important that participants are given the time and guidance needed to comfortably familiarize themselves with safe strength training practices. This familiarization and safety focused phase of a strength training program generally benefits from a higher instructor to participant ratio than that required during the later stages of a program (Faigenbaum, 2000).

Once young strength trainers are familiar with safe training practice, exercise technique becomes the next area of focus. Finally, upon perfecting technique, the participants are then able to focus on training intensity: ensuring appropriate exercise technique is maintained as load is increased (Myer & Wall, 2006). At this point, an instructor-to-participant ratio of one to ten has been recommended (Faigenbaum et al., 1996).

General guidelines have been put forth for establishing the weights which youth strength trainers use in their training. Faigenbaum (2000) suggested that these participants start with a light weight while working within the training repetition range (for example, a training repetition range may be 8 to 12 repetitions). From here, they can increase this weight through trial and error to determine the optimal training load that can be handled with proper form.

With regards to the prescription of training volume – specifically the prescribed sets and reps, the literature has shown that a number of modalities and combinations of repetitions and sets are able to enhance the strength of child and adolescent strength trainers (Faigenbaum, 2003). Literature indicates that progressive strength training utilizing one set of ten repetitions (Westcott, 1992) to 5 sets of 15 repetitions (Isaacs, Pohlman, & Craig, 1994) can enhance the strength of children and adolescents (Faigenbaum et al., 1996).

2.8 Traditional and Non-traditional Youth Strength Training in the Literature

2.8.1. Adolescent Strength Enhancements

Literature focused on strength training for youth, via traditional and non-traditional modalities, seems to conclusively support the ability of children and adolescents to enhance their strength (Blimkie, 1992; Falk & Tenenbaum, 1996; Malina, 2006; Payne, Morrow, Johnson, & Dalton, 1997). Much of the literature in this area is focused on pre- and early-pubescent children in an effort to clarify previous misconceptions that this population was unable to enhance their strength. However, literature focused on normal adolescent populations and strength training is somewhat sparser, as the ability of this population to enhance their strength has been conclusively established for quite some time (Gallagher & Delorme, 1949).

A closer look at meta-analyses (Falk & Tenenbaum, 1996; Payne et al., 1997) and reviews (Blimkie, 1992; Faigenbaum et al., 1996; Malina, 2006) of youth strength training provides further indication that the focus in recent years has been on the ability of pre-pubescent children to enhance their strength through various modalities and programs. However, with specific respect to the trainability of adolescents, one meta-analysis did present an effect size based on the existing literature studying boys between the ages of 16 and 18 and girls between the ages of 14 and 18. This meta-analysis suggested a moderate to large mean effect size of 0.69 ± 0.39 for strength training in these “older” children (Payne et al., 1997). This indicates that the magnitude of the strength training effect is considerable and provides further support and rationale for the

well established role of strength training in enhancing strength amongst the adolescent population.

Reviews discussing the efficacy of strength training in children and youth have centered on the child dominated strength training literature, with few studies of older children included. The conclusions of these reviews have overall supported the role of traditional forms of strength training in enhancing the fitness of these children (Blimkie, 1992; Faigenbaum et al., 1996; Malina, 2006).

It appears, based on the published effect size for adolescent strength training and the generally well established consensus that adolescents are able to increase their strength, that the ability of adolescents to positively respond to a strength training program is conclusively supported.

2.8.2. Training Modalities in the Youth Strength Training Literature

While the support for strength training by youth as an effective means to enhancing strength is seemingly conclusive, there remains a need to identify the efficacy of various forms of strength training in order to provide youth with alternative options for being active. Keeping in mind that all adolescents will differ in their activity preferences, it is obvious that no single form of training would appeal to the entire population. For this reason, the focus of this section is on the various modalities of training (with a focus on strength training) which have been presented in the literature to date.

In an evidence-based review of weight training for youth, Malina (2006) described the recent trends in youth strength training literature. Analyzing 22 reports focused on experimental resistance training protocols, Malina's (2006) review identified a dominance of traditional styles of strength training in the literature, such as isotonic

weight machines or free weights. However, within the use of isotonic machines and free weights, the specific exercises performed have varied (Malina, 2006). Similar trends in modality prescription can also be noted in Blimkie's (1992) review of strength training in children, and Falk and Tenebaum's (1996) meta-analysis of strength training for boys and girls under the age of 12 and 13 years old, respectively.

The results of these reviews and meta-analyses, and the current body of literature, provide a rationale and support for the identification of free weight, or dumbbell, training as the traditional modality in this study.

2.8.3. Non-Traditional Strength Training for Youth

Previous literature has investigated the effect of several different modalities of training for youth, in recognition of the need to constantly identify new and effective means to enhancing physical activity and overall health. Non-traditional modalities which have been found effective in enhancing the musculoskeletal fitness of youth include: medicine ball training (Faigenbaum & Mediate, 2005; Faigenbaum & Mediate, 2006; Szymanski, Szymanski, Bradford, Schade, & Pascoe, 2007), plyometric training (Faigenbaum et al., 2007), and mixed modalities (Cowan, Bolen, Weatherby, & Foster, 2007; Myer, Ford, Palumbo, & Hewett, 2005).

Interactive video games have also been shown to improve motivation to be active and measures of health-related fitness (Epstein, Beecher, Graf, & Roemmich, 2007; Warburton et al., 2007). Finally, some studies of non-traditional strength training have investigated very unique forms of training such as "junk yard training" (Berning, Adams, Climstein, & Stamford, 2007).

2.8.3.1. Medicine Ball Training

In 2006, Faigenbaum and Mediate studied the efficacy of a medicine ball training intervention on the physical fitness of 118 grade ten students (15-16 years old). This training program was implemented during the first 10 to 15 minutes of each physical education class for the duration of six weeks. The program frequency was two times per week, equivalent to the number of physical education sessions per week, on non-consecutive days.

Participants were split into a training ($n = 69$) and control ($n = 49$) group. The training group took part in the medicine ball training program prior to participating in the physical education classes. The control group only participated in the physical education classes (Faigenbaum & Mediate, 2006).

The progressive training program consisted of a 3-5 minute warm-up period, followed by 7-10 minutes of conditioning. The complexity of the exercises was increased as the participants' confidence and competence improved. During the first two weeks, participants completed one set of 5-7 repetitions. During weeks three and four, two sets of 7-10 repetitions were completed, and during the final two weeks, two to three sets of 10-15 repetitions were completed (Faigenbaum & Mediate, 2006).

Participants were assessed at baseline and post-training on a variety of physical fitness measures, including: a shuttle run, long jump, sit and reach flexibility, abdominal curl, medicine ball push-up, and medicine ball seated toss. Upon analysis, the results of this study indicated that training group was able to elicit significantly greater gains ($p < .05$) on all tests when compared to the control group (Faigenbaum & Mediate, 2006).

In 2007, Szymanski et al. studied the effect of 12 weeks of medicine ball training on high school baseball players. The 49 participants had a mean age of 15.4 ± 1.2 years.

These participants were divided into two groups with both groups adhering to a regular schedule of exercises and drills, and the experimental group adhering to additional medicine ball training three days per week for the full 12 week duration.

Participants were assessed on their three repetition maximum (3RM) dominant and non-dominant side torso rotational strength, their hip-torso-arm rotational strength, their 3RM parallel squat, and their 3RM bench press. The results of this study found that both groups improved significantly on their two torso rotational strength tests and their hip-torso-arm rotational strength, though the experimental group made significantly greater gains than the control group. In addition, there was no difference between groups on the parallel squat and bench press tests, though both groups did significantly improve from baseline (Syzmanski, Syzmanski, Bradford, Schade, & Pascoe, 2007).

2.8.3.2. Plyometrics

In 2007, Faigenbaum et al. investigated the effects of six weeks of plyometric and strength training on the physical fitness of 12 to 15 year old boys. The 27 male participants of this study were split into two training groups. The experimental group performed strength training and plyometric training, while the control group performed strength training only. Training frequency and duration for both groups consisted of two, 90 minute training sessions on non-consecutive days. While the experimental group performed the plyometric training, the control group performed stretching.

The plyometric training group was found to have significantly greater improvements in long jump (10.8 cm vs. 2.2 cm), medicine ball toss (39.1 cm vs. 17.7 cm), and pro agility shuttle run time (-0.23 sec vs. -0.02 sec) compared to the control group after six weeks of training (Faigenbaum et al., 2007).

2.8.3.3. Mixed Modalities

In 2007, Cowan et al. presented their research on non-traditional strength training programs as a part of a physical education curriculum. Utilizing 185 male and female (grades five to eight) students as participants, an eight week mixed modality training program was implemented three times per week. This non-traditional strength training program incorporated body weight, medicine ball, towel, stability ball, training bar, dumbbell, and resistance band exercises. Also, one additional session per week was dedicated to cardiovascular and agility exercises.

Health-related fitness was assessed in this study using the President's Challenge Fitness Test. Results indicated that participation in the non-traditional strength training was able to significantly decrease mean scores on a one-mile run (11.68 vs. 11.00), shuttle run (11.40 vs. 11.17), push-ups (14.92 vs. 18.32), curl ups (37.76 vs. 41.24), and overall percentile scores (18.84 vs. 30.03) from baseline (Cowan, Bolen, Weatherby, & Foster, 2007).

2.8.3.4. Interactive Video Games

In recognition of the potential for non-traditional forms of exercise to enhance the health and fitness of our youth population, some researchers have focused their studies on interactive video games. The following section describes two studies, one by Warburton et al. (2007) and one by Epstein, Beecher, Graf, & Roemmich (2007).

Warburton and colleagues (2007) examined the effect of interactive video game cycling, in comparison to traditional stationary cycling, on adherence, health-related physical fitness, and resting blood pressure. Participants included 14 low-active college

aged males (18 to 25 years) stratified and randomly assigned to an experimental ($n = 7$) and control ($n = 7$) group.

The experimental group was assigned to the interactive video game cycling while the control group participated in stationary cycling. In both cases, intensity of cycling was self-determined by the participants. A training frequency and duration for both groups was set at three days per week, 30 minutes per session, for a duration of six weeks (Warburton et al., 2007).

The results of this study indicated a significant difference between groups in attendance rates ($78\% \pm 18\%$ for the interactive video game vs. $48\% \pm 29\%$ for the stationary cycle). This difference in attendance was deemed responsible for mediating the between group differences on health-related fitness and resting blood pressure. Where the experimental group saw a significant increase in $VO_2\text{max}$ ($11\% \pm 5\%$), the changes in the control group were insignificant ($3\% \pm 6\%$). Similarly, the experimental group noted a significantly greater reduction in resting systolic blood pressure (132 ± 6 vs. 123 ± 6 mmHg) compared to the control group (131 ± 7 vs. 128 ± 8 mmHg; Warburton et al., 2007). Warburton's (2007) study provides support for the role of non-traditional forms of exercise in encouraging adherence and subsequent improvements in health-related physical fitness.

In 2007, Epstein et al. examined the influence of interactive dance and cycling games on physical activity promotion in overweight and non-overweight youth. Participants of this study consisted of 18 overweight and 17 non-overweight 8 to 12 year old children. Participants were offered several different options with regards to being active in order to differentiate between the choice to engage in sedentary versus active

activities. Children were given the option to a) play the interactive game using a handheld controller (sedentary), b) do the activity alone, c) do the activity while watching a video, or d) do the interactive version of the activity (Epstein et al., 2007).

The results of this study indicated that participants were motivated to play the interactive dance video game (Dance Dance Revolution, a Sony Playstation 2 game) but not as motivated to play the interactive cycling game (using a Cateye stationary bike connected to a Sony Playstation – game was titled “Freekstyle”). Also, with regards to the dance game, it was found that the interactive version was more reinforcing than dancing alone, or while watching a video. There was no significant difference in the various cycling conditions (Epstein et al., 2007). Overall, it seems that children may be motivated to participate in physical activity if they are provided the opportunity to play an interactive dance video game (Epstein et al., 2007).

2.8.3.5. Junkyard Training

Finally, in a simple introduction to the truly unique modalities of training that are being used today, junkyard training will be briefly introduced. Junkyard training involves the use of heavy implements and movement patterns that are not common in traditional training programs. This form of training allows for a unique application to certain athletes through its requirement for unpredictable and unrehearsed movements and reactions, common to sport performance. Implements often used in this form of training include chains, tires, cement blocks, anchors, and motor vehicles (Berning et al., 2007).

2.8.4. Kettlebells

The final mode of non-traditional strength training which is of particular interest for this study is KB strength training. Though minimal research exists examining the efficacy of this form of training in enhancing fitness, the regaining popularity of this training modality warrants a more critical look into the components and what is known to date.

KBs, known as giryas in Russia, are more than a century old. Originating in Eastern Europe, KB training was once so popular amongst Russian strongmen, athletes, and the Soviet Special Forces that this form of training became Russia's national sport. In more recent years, KB training has been acknowledged as a "new" form of strength training for fitness enthusiasts, professional athletes, martial artists, the United States military, and the law enforcement officers of North America (Vatel & Gray, 2005).

Though a relatively ancient tool, KBs are not yet widely recognized in today's society. Their physical appearance resembles that of a cast iron cannonball with a handle (Figure 1). The original KBs were differentiated by their weight in poods (1 pood = 35 pounds or 16 kilograms), whereas manufacturers today offer a variety of weights and styles. Straying from the original, limited selection of three weights for the KBs (1, 1.5, and 2 poods), manufacturers are now producing KBs ranging from 0.25 to 2.5 poods. The styles available include the original cast iron, vinyl iron, coloured, and even adjustable KBs with stackable plates (Vatel & Gray, 2005).



Figure 1. A picture of cast-iron kettlebells.

Training with this non-traditional form of strength training consists of *fluid movements opposing gravity* with several muscle groups working in harmony to complete an exercise. KB training has been praised as an excellent full body workout, having benefits for strength, endurance, cardiovascular fitness, flexibility, and body composition (Vatel & Gray, 2005).

Similar to other forms of strength training, KB training can be modified to target muscular endurance or muscular strength, depending on the goals of the individual. However, KB training also offers the unique aspect of training the body to be able to effectively absorb forces due to the requirement to both accelerate and decelerate from the fluid motions (Vatel & Gray, 2005).

KB training has also been suggested to improve cardiovascular fitness through the production and maintenance of high heart rates over the course of the training session. It is the continuous, fluid nature of KB training that allows heart rates to stay high throughout, and in turn, condition cardiovascular fitness (Vatel & Gray, 2005). Contrary to the promotion of this activity for its cardiovascular benefits, the findings from the only

English study identified to date are not supportive of the role of KB training in enhancing cardiorespiratory fitness. This study looked at the cardiorespiratory responses to a single KB training session and was not able to prove its efficacy in training the cardiorespiratory system (Bishop, Collins, & Lanier, 2005).

A gain in flexibility is another suggested benefit of KB training. The momentum of this type of training encourages participants to use their full range of motion, in turn influencing flexibility. It has been suggested that prolonged adherence to a KB training program (comprised of exercises requiring fluid movements) can increase joint flexibility, reduce arthritis effects, and enhance one's overall grace of motion (Vatel & Gray, 2005).

KB training is thought to influence body composition in a similar manner to other forms of strength training. However, it is suggested that the cardiovascular component of KB training makes it a more effective method of modifying body composition compared to other forms of strength training. These suggestions are due to the suspected increased caloric expenditure (Vatel & Gray, 2005).

Finally, KB training has been identified as an effective form of conditioning for those who find it difficult to set aside time for physical activity. The full body focus of this training, in addition to its continuous, fluid motions, allow for both strength components and cardiovascular components to be addressed in one training session (Vatel & Gray, 2005).

2.8.4.1. Kettlebell Training in the Literature

With KB training being suggested to positively affect a wide variety of fitness components, it is no surprise that this form of training appeals to such a diverse

population. Though it is known that fitness enthusiasts, professional athletes, martial artists, the United States military, and law enforcement officers in North America have taken interest in this unique form of training (Vatel & Gray, 2005), no research to our knowledge has studied the affect of short-term adherence to a KB training program in youth. To date, an absence of KB training literature in refereed journals of the English language has resulted in the reliance upon the only two published poster abstracts available for research based information pertaining to KB training. These abstracts describe studies in which the responses to a single KB training session in adults have been the focus.

The first study looked at the energy cost and intensity of a basic KB training protocol with adult participants (30.2 ± 10.6 years). After participating in a treadmill VO_2 max test, participants subsequently performed the KB training session. This training session consisted of five sets of ten repetitions of two-arm swings, snatches, and clean and presses using 4, 8, 12 or 16 kilogram KBs. Using a metabolic measurement system, the authors of this study concluded that the intensity, as assessed by heart rate, of a KB strength training session appeared to be sufficient (122.08 ± 21.13 bpm; $M \pm SD$) to improve cardiovascular fitness. However, the training stimulus of just 32% of VO_2 max did not appear to be high enough when referenced to ACSM's recommendations. The authors of this study concluded that KB strength training may provide an appropriate alternative to more common forms of physical activity in terms of achieving the recommended amount and intensity of physical activity needed to improve health (Lanier, Bishop, & Collins, 2005).

The second KB strength training study appeared to be comprised of a similar group of participants (aged 24 to 58 yrs old). The focus of this study was to assess the cardiorespiratory responses to a single KB training session. Participants performed five sets of ten repetitions for two-arm swings, one-arm snatches, and one-arm clean and presses, with one minute of rest between each exercise. The females in this study trained with a four or eight kilogram KB and the males trained with an 8, 12, or 16 kilogram KB. Using a metabolic system, descriptive statistics indicated that the cardiorespiratory responses were relatively low. The authors of this study attributed low responses to the incorporation of momentum in KB training and the size of KBs used by participants. Overall, the results of this study did not conclusively support KB training as an effective form of cardiorespiratory training (Bishop, Collins, & Lanier, 2005).

2.9 Strength Training for Youth – Final Thoughts

Depending on previous exercise experiences, program design, training and testing specificity, equipment selection, instruction quality, and the control of a learning affect, children as young as six year old (Falk & Mor, 1996) have been found to enhance their strength to varying degrees (Faigenbaum et al., 1996). It seems clear that strength training for youth is effective, however, the promotion of this activity for youth is not simply based on its efficacy in enhancing strength; youth strength training has also been associated with a number of other health benefits. It seems appropriate to promote this form of activity as a component of a well rounded physically active lifestyle.

2.10 Enjoyment

2.10.1. Defining “Enjoyment”

Enjoyment has been defined in a number of ways, varying depending on the source. Some define enjoyment as a simple positive emotion, affective state, or response (Scanlan & Simons, 1992; Wankel, 1993) reflecting feelings of pleasure, liking, and fun (Scanlan & Simons, 1992). The term enjoyment is considered synonymous with fun (Scanlan, Carpenter, Lobel, & Simons, 1993).

Enjoyment is considered to have a clear link to intrinsic motivation as it is one, central dimension of the multi-dimensional construct of intrinsic motivation (Wankel, 1993). However, the interchangeable use of the constructs enjoyment and intrinsic motivation is inappropriate and misleading. Some authors describe enjoyment as a broader and more inclusive construct, when compared to intrinsic motivation. Enjoyment is thought to have many different possible sources (Scanlan et al., 1993), such as the enjoyment of being extrinsically satisfied (Goudas & Biddle, 1993).

2.10.2. Enjoyment’s Application to Physical Activity and Exercise

Several research papers have provided support for a relationship between enjoyment and physical activity/education participation for adults (Leslie et al., 1999; Lewis, Marcus, Pate, & Dunn, 2002; Salmon, Owen, Crawford, Bauman, & Sallis, 2003) and youth (Carroll & Loumidis, 2001; Dishman et al., 2005; Fairclough, 2003; Lewis, Marcus, Pate, & Dunn, 2002; Sallis et al., 1999; Scanlan, Carpenter, Lobel, & Simons, 1993; Weiss, 2000).

Wankel (1993) emphasizes that the bottom line regarding selection and adherence to physical activities is that people will choose to participate in the activities that they

enjoy. Enjoyment has the potential to influence current and future levels of physical activity and exercise participation. When adherence to physical activity is sustained, individuals are able to reap the associated psychological and physiological benefits of a physically active lifestyle (Wankel, 1993).

Correlational and descriptive studies are supportive of an association between enjoyment of an activity or sport and adherence levels (Motl et al., 2001). It is thought, that enjoyment influences adherence by increasing the appeal of current activities and decreasing the appeal of alternate, sedentary pursuits (e.g. screen time) or negative behaviors (e.g. gangs, at-risk behaviors) (Weiss, 2000).

As an illustration of the relationship between physical activity participation and enjoyment, Susan Harter's (1987) model of self-esteem was adapted by Weiss and Ebbeck (1996; see Weiss, 2000 for visual). In this model (represented in Weiss, 2000), social support was shown to influence perceived competence/adequacy and the central construct self-esteem. Perceived competence/adequacy (as influenced by social support) was shown to also impact the central construct self-esteem. As outcomes of self-esteem, enjoyment and physical activity behaviour are shown also to be effected. Finally, enjoyment was represented as having a direct influence on physical activity behaviour. This model indicates that interventions which increase perceived competence, social support, and enjoyment will result in a maintenance or increase of physical activity levels amongst children and youth (Weiss, 2000).

Enjoyment also affects the long-term physical activity levels of youth. When children establish a pattern of regular physical activity in their lives, they optimize the potential for long-term health benefits. By developing interventions in which the

cognitive, emotional, physical, and social maturity of the youth are targeted, physical activity is more likely to be enjoyable. By increasing the enjoyment, children are more likely to continue participation in physical activity due to an intrinsic desire to adopt a physically active life. The emphasis on the importance of enjoyable physical activity experiences and programs for children is undeniable. When positive attitudes are formulated regarding the importance of exercise, the stage is set for the maintenance of a physically active lifestyle throughout adolescence and adulthood, in turn influencing long-term health (Weiss, 2000).

Overall the distinct influence of enjoyment on adherence to current and future physical activity participation seems to be well established. Of most importance, this maintenance and continued participation of physical activity amongst youth, and future adults, encourages the eventual accumulation of physical and psychological benefits (Wankel, 1993; Weiss, 2000).

2.10.3. Enjoyment and Physical Activity Literature

To date, there is no previous literature available comparing the affect of two different strength training modalities on physical activity enjoyment amongst adolescents. Though enjoyment has been studied in several determinant and correlational studies, only a few intervention studies have utilized an enjoyment measure as one of their dependent variables (Baranowski, Anderson, & Carmack, 1998). These studies have mainly focused on modifying physical activity behaviours. The results of these studies have been inconsistent (Calfas et al., 2000; Castro et al., 1999; Dishman et al., 2005; Nichols et al., 2000).

In 2005, Dishman and colleagues utilized the most recent 16 question version of the PACES (Motl et al., 2001) in their study of the Lifestyle Education for Activity Program's (LEAP) affect on physical activity participation amongst 2087 adolescent females. LEAP was designed to increase physical activity amongst black and white high school aged girls through its comprehensive school-based approach, with a specific emphasis on changing instruction and school environment. This program emphasized the promotion of physical activity enjoyment, physical education enjoyment, and self-efficacy as its core objectives of the physical education component.

This study found that increased physical activity enjoyment resulted in increased physical activity amongst adolescent girls. Physical activity enjoyment was found to have an indirect effect on physical activity through its influence on self-efficacy (Dishman et al., 2005).

In 2000, Project Graduate Ready for Activity Daily (Project GRAD) was implemented and evaluated in 185 male and 153 female senior university students (24.23 ± 1.95 yrs; $M \pm SD$). Participants were randomly assigned to a control group or an intervention group. The control group took part in a course which covered general health topics and the intervention group took part in a course specifically designed to promote adoption and maintenance of physical activity (for more information, refer to Calfas et al., 2000).

Utilizing the 18 question version of the PACES questionnaire (Kendzierski & DeCarlo, 1991), Calfas and colleagues (2000) assessed enjoyment (in addition to several other dependent variables) at baseline, one year and two years for each group. The results of this study indicated that neither group significantly changed their average rating

of enjoyment, at any enjoyment measure. An overall effect size of .038 and .042 was reported for the females and males, respectively (Calfas et al., 2000).

Utilizing a similar approach, Nichols and colleagues (2000) modeled their worksite behavioural skills intervention after Project GRAD's intervention course which was designed to promote the adoption and maintenance of physical activity (for more information, refer to Nichols et al., 2000). In addition, the intervention group in Nichols' (2000) study was encouraged to participate in a 12-week semi supervised exercise program at the YMCA with the free gym membership they received. The control subjects received a free membership to the same facility, but were not provided with the opportunity to take part in the semi supervised exercise program or behavioural skills classes (Nichols et al., 2000).

A final sample size of 58 participants, between the ages of 24 and 61 years (42.0 ± 9.7 yrs; $M \pm SD$), was involved in this study. Enjoyment was measured at baseline, after the 3 month intervention, and at six months follow-up as a maintenance measure using the 18 question version of the PACES questionnaire (Kendzierski & DeCarlo, 1991). It was found that the intervention had no significant effect on enjoyment; though a moderate effect size of 0.50 was noted providing indication that the intervention was quite strong in improving enjoyment (Nichols et al., 2000).

2.11 Conclusions

DiNubile (1993, pp. 592) stated that "there is nothing inherently wrong with the children of this country; they are simply products of an environment that we have created for them". One factor which is influential in the development of environments conducive

to healthy lifestyles and behaviours, is the availability and convenience of opportunities to be active. With a constant emphasis on enjoyment, youth can be encouraged to adhere to current and long-term physical activity. The currently available opportunities for youth to be active seem to be inadequate at enhancing fitness, as the majority of youth have been reported to have concerning, poor levels of fitness (Shephard, 2007).

The poor levels of physical activity, physical fitness, and the associated obesity pandemic, provide support for a need to continually search for effective strategies to combat these concerns. Though it is unlikely that KB strength training will drastically alter the physical activity composition of our population, it may act as an alternate, enjoyable option to being active for youth, appealing to a broader portion of the population. The limited research on this topic and the need for new activities to encourage the adolescent population to adopt physically active lifestyles provide strong support for the current study.

Chapter 3 – Methods

3.1 Research Design

As illustrated in Figure 2, this study followed a quasi-experimental design, specifically a pre-test-post-test two group design (Thomas, Nelson, & Silverman, 2005, p. 333) utilizing the matched-pair technique with random assignment to either the control or experimental group (Thomas et al., 2005, p. 327).

<u>Pre-test</u>	<u>Control Intervention</u> (DB training)	<u>Post-test</u>
<i>Week 1: Feb. 5, 2008</i>	<i>Week 1-7: Feb. 7-Mar. 20, 2008</i>	<i>Week 8: Mar. 25, 2008</i>
<u>Pre-test</u>	<u>Experimental Intervention</u> (KB training)	<u>Post-test</u>
<i>Week 1: Feb. 5, 2008</i>	<i>Week 1-7: Feb. 7-Mar. 20, 2008</i>	<i>Week 8: Mar. 25, 2008</i>

Figure 2. The research design schematic: a pre-test/post-test two group design. Both groups completed the same pre- and post-training health-related fitness assessments with differing training interventions.

Due to the community based, applied nature of this study, the research design called for a matched-pair technique with random assignment to training groups in order to allow friends that registered together, to train together. Participants were matched based on their pre-training health-related fitness scores and physical activity enjoyment scores to ensure that both groups were equivalent at baseline ($p > .05$).

The dependent variables were the components of the health-related fitness assessment: grip strength (upper body strength), maximal push-ups (upper body endurance), sit and reach flexibility (hamstring and low back flexibility), maximal partial

curl-ups (abdominal endurance), vertical jump height (lower body power), maximal back extension hold (back endurance), maximal KB and DB specific squat repetitions (lower body strength), and physical activity enjoyment scores (PACES). The independent variables were the control (DB specific) and experimental (KB specific) training programs.

3.2 Statistical Analysis

All data was analyzed using SPSS 16.0 Graduate Student Version for Windows and is presented in chapter four as mean \pm standard deviation, unless stated otherwise. Changes in health-related fitness within groups were assessed using dependent t-tests and between group differences were assessed with a multivariate analysis of variance (ANOVA). Physical activity enjoyment was assessed using a two group by three factor repeated measures ANOVA.

3.3 Participants

Nineteen participants from Victoria, BC volunteered to take part in this study. There were six female and three male participants in the control group ($n = 9$). The experimental group ($n = 10$) consisted of six female and four male participants.

For the most part, participants lived within a 6 to 20 minute drive from the training facility and travelled to and from training sessions either by carpooling with friends or getting dropped off by their parents. Prior to commencing this training program, all participants reported having little to no strength training experience and were not adhering to a regular strength training program.

3.3.1. Participant Recruitment

Potential participants were notified of this study by informational handouts distributed to three local high schools and a local newspaper article that described the strength training program. Participants registered for this community based “Strength Training for Adolescents” program, paying \$55.00 for the program. They were given the option of having their data utilized for the study component and all participants (and parents/guardians) agreed to this by signing an informed consent.

In an effort to mimic the real life variability of community based training programs, participants were not delimited based on their strength training abilities or experiences. However, participants were informed that while training load could be adjusted to suit the individual, the training programs were designed under the assumption that most participants would be novice strength trainers.

3.4 Procedures

The “Strength Training for Adolescents” program consisted of 16 sessions (two times per week for eight weeks). Program day one was the pre-training assessment day. Prior to commencing the assessment, participants were required to submit their consent forms (signed by the parent and participant) and physical activity readiness questionnaire (PAR-Q). In addition, all participants were asked to fill in a strength training history questionnaire designed by the researcher and the physical activity enjoyment scale (PACES) (Motl et al., 2001). Participants were asked to complete the following assessment components in this order: 1) resting heart rate and blood pressure; 2) anthropometrics (weight, height, and waist circumference); 3) *warm-up*; 4) grip strength; 5) push-ups, 6) sit and reach; 7) partial curl-ups; 8) vertical jump; and 9) back extension.

Program day two involved completing the remaining components of the health-related fitness battery. After a brief warm-up, participants completed the KB double arm swing squat test and the DB squat test, with approximately ten minutes of rest following the first, KB squat test. Following the completion of these final tests, participants were divided into their training groups and introduced to their training programs.

Program day three involved reviewing the exercises learned on day two, and introducing the remaining exercises. Once the groups had learned how to perform all of the exercises in their programs, they were encouraged to select their training loads, and record them in their training logs. For the control group, this was a load with which they could perform at least eight repetitions, but no more than twelve. Participants were asked to train so that the effort was “hard”. For the experimental group, the emphasis was on performing maximal repetitions within 25 seconds of work. Similarly, the participants were asked to train so that their effort was “hard”.

Program day 4 through 14 required participants to split into their respective training groups and complete their training prescriptions following a brief, instructor-led group warm-up. On most days, 10 to 15 minutes at the end of each training session were used to bring both groups together to complete, additional “bonus exercises”. On program day 8, participants completed a PACES mid-test prior to initiating their warm-up.

Program day 15 was day one of the post-training fitness assessment. This day was identical to program day 1.

Program day 16 was day two of the post-training fitness assessment. This day consisted of completing a brief warm-up, followed by the KB double arm swing squat

test, approximately ten minutes of rest, and the DB squat test. The load used for both squat tests was the same as that utilized in the pre-testing.

3.5 Assessment Components

3.5.1. Physical Activity Enjoyment Scale

Physical activity enjoyment was measured using the Physical Activity Enjoyment Scale (PACES) as modified by Motl and his colleagues (2001). Development of the original PACES is credited to Kendzierski and DeCarlo (1991). This scale was developed for college-aged males and females, consisting of 18 bipolar statements rated on a seven point scale.

In 2001, Motl and colleagues made modifications to Kendzierski and DeCarlo's (1991) version of the PACES in order to suit it to adolescent females. Based upon a series of focus groups with eighth grade girls, several modifications were made to the original PACES. The statement "I am very absorbed in the activity" was removed for being irrelevant to eighth grade girls, as was the statement "It's very invigorating" because it was deemed redundant to other items. Final changes to the scale included rewriting the statements to be comprehensive to eighth grade girls and simplifying the rating scale from a seven point scale to a five point Likert-type scale ranging from "Disagree a lot" (1) to "Agree a lot" (5). This modified version of the PACES was deemed valid for measuring physical activity enjoyment amongst African-American and Caucasian adolescent girls by Motl and colleagues (2001), thus it was selected as the measure of physical activity enjoyment for this study. A limitation of this study is that, to our knowledge, this measure has not yet been validated for use in adolescent boys. It was

assumed (section 1.6), that comprehension and applicability would be similar between boys and girls of the same age.

3.5.2. Resting Cardiovascular Measures

Blood pressure and heart rate were measured with an automated blood pressure cuff. These readings were used as clearance measures, ensuring the participants were below the cut-offs established by the Canadian Society for Exercise Physiology [CSEP] (1996) prior to commencing the physical portion of the assessment. CSEP (1996) established cut-offs consist of a resting heart rate below 100 bpm, systolic blood pressure less than or equal to 144 mmHg and a diastolic blood pressure less than or equal to 94 mmHg.

3.5.3. Anthropometry

Anthropometric measures were taken for descriptive purposes. Measures included weight (measured to the nearest 0.1kg), height (measured to the nearest 0.1cm), and waist circumference (measured to the nearest 0.1cm).

3.5.4. Musculoskeletal Fitness

Grip strength, push-ups, sit and reach, partial curl-ups, vertical jump, and back extension measures were all components of the health-related fitness assessment at pre- and post-test. All measures followed the CSEP (1996) protocol, with the exception of partial curl-ups (modified to perform maximal partial curl-ups in one minute) and back extensions (modified to hold extension for maximal time).

In addition, participants completed a KB double arm swing squat test and DB squat test as measures of lower body strength. At the pre-test, participants were asked to select a load that they thought would fatigue them in less than ten repetitions. However, due to availability of heavier weights for the KBs, and the participants' inexperience with selecting training loads, there was a higher than desired number of repetitions performed. Both tests were performed for repetitions to fatigue. The exact same protocol was followed for post-test, with the load held constant from pre-test.

3.6 Intervention Protocol

3.6.1. The Training Groups

The design of the training programs for the DB and KB groups differed based on: 1) the program design and 2) the type of weight lifted (DBs or KBs). Both programs were designed in line with the guidelines and prescriptions promoted for their specific modality (Baechle & Earle, 2000; "KettleBell Concepts", n.d.; Vatel & Gray, 2005). Differences between programs included: momentum exercises to the experimental training program and the number of repetitions performed (the control group performed 8-12 repetitions, whereas the experimental group performed maximal repetitions in 25 seconds). Similarities between programs included: the number of exercises performed (each group was prescribed nine exercises), the number of sets performed (2 sets per training session), the frequency of training (2x/wk), and the duration of training (~30 min per session, excluding warm-up and additional group exercise time).

3.6.2. Training Programs

Figure 3 represents the exercise prescription for the control and experimental groups. With regards to the intensity for each training group, the training loads were increased as needed in order to ensure both groups were progressively challenged and within their intensity prescription. Program instructors monitored the participants training loads and exercise technique, suggesting modifications as needed.

3.7 Training Modalities

The control group trained with DBs ranging in weight from 2.5 lbs to approximately 75 lbs, whereas the experimental group trained with vinyl coated cast iron KB's ranging in weight from 10 lbs to 30 lbs (Power Systems, Inc, 2004).

<p><u>Control</u> – Dumbbell training</p> <p>F – 2x/wk I – 8-12RM, TWO SETS T – ~30 min; ~30sec rest btwn exercises T – traditional style, traditional modality (DBs), 9 exercises total, circuit style</p>	<ol style="list-style-type: none"> 1) DB Bench press 2) DB Squat 3) DB Bent-over row 4) DB Lunges 5) DB Military press 6) DB Stiff-legged deadlifts 7) DB Bicep curls 8) DB Tricep extension 9) Medicine ball Russian twist
<p><u>Experimental</u> – Kettlebell training</p> <p>F – 2x/wk I – 25sec work, max reps, TWO SETS T – ~30 min; ~30sec rest btwn exercises T – non-traditional style, non-traditional modality (KBs), 9 exercises total, superset/circuit style</p>	<ol style="list-style-type: none"> A. 1) KB Squat 2) KB double arm swing squat B. 3) KB Bent-over row 4) KB alternating arm swing squat C. 5) KB Chest press 6) KB double arm swing squat D. 7) KB Standing shoulder press 8) KB push press E. 9) KB Russian twist

Figure 3. The training program prescription for the control and experimental groups, matched on frequency (F) and time (T) and differing in terms of their modality specific intensity (I) prescriptions and type (T) of exercises.

Chapter 4 – Results

4.1 Participant Characteristics

The physical characteristics of the participants in the control (six females, three males) and experimental (six female, four male) groups are listed in Table 1. All adolescent participants had little to no strength training experience.

Table 1

Physical Characteristics of Control and Experimental Group Participants at Pre-test

Group	N	Age (yrs)	Height (cm)	Weight (kg)	WC* (cm)
Control	9	16.8 ± 0.7	171.6 ± 10.1	68.7 ± 11.7	77.7 ± 6.6
		<i>Range:</i> 15.4 – 17.4	<i>Range:</i> 159.0 – 190.0	<i>Range:</i> 54.5 – 86.8	<i>Range:</i> 68.5 – 88.0
Experimental	10	17.7 ± 1.0	170.5 ± 7.2	69.0 ± 9.2	80.5 ± 7.9
		<i>Range:</i> 15.2 – 18.9	<i>Range:</i> 157.5 – 180.0	<i>Range:</i> 59.5 – 88.2	<i>Range:</i> 71.0 – 98.0

Note. All statistics are noted as mean ± standard deviation; *WC = waist circumference.

4.2 Baseline Measures

4.2.1. Health-Related Fitness

Table 2

Tests of Between-Subjects Effects by Group at Pre-Test

Variable	Sum of Squares	df	Mean Square	F	Sig.
Grip strength (kg)	.87	1,13	.87	.00	.96
Push-ups (#)	.69	1,13	.69	.01	.93
Sit & reach (cm)	20.31	1,13	20.31	.55	.47
Curl-ups (#/min)	269.73	1,13	269.73	1.37	.26
Vertical jump (cm)	5.34	1,13	5.34	.06	.81
Back extension	2764.97	1,13	2764.97	1.62	.23
KB load (lbs)	.74	1,13	.74	.05	.82
KB reps (#)	848.02	1,13	848.02	3.62	.08
DB load (lbs)	14.41	1,13	14.41	.23	.64
DB reps (#)	.10	1,13	.10	.00	.95

As shown in Table 2, there was no significant difference between the control and experimental groups at pre-test based on any of the health-related fitness variables assessed ($p > .05$).

4.2.2. Physical Activity Enjoyment

Utilizing the sum score from the PACES questionnaire (with negatively phrased questions flipped and numbering adjusted to represent positive connotations) it was found that the groups did not significantly differ on pre-test physical activity enjoyment ($p > .05$). When combined with the non-significant differences between groups at baseline for health-related fitness variables (section 4.2.1), these results provide indication that groups were equivalent on all test measures at baseline.

4.3 Post-Training Measures

4.3.1. Health-Related Fitness within Groups

Figure 4 illustrates the group means and mean standard errors (SE), at pre-test and post-test, for each of the training groups on all measured variables. Raw numbers pertaining to group means, standard deviations, group sizes, and difference scores can be found in Appendices H and I.

For the control group, dependent t-tests of all measured fitness variables showed significant differences ($p < .05$) on the following measures: grip strength (11.85% improvement; $p = .02$; $ES = .55$), push-ups (51.98% improvement; $p = .00$; $ES = .77$), sit and reach (18.04% improvement; $p = .00$; $ES = .95$), curl-ups (26.13% improvement; $p = .00$; $ES = .67$), vertical jump (11.31% improvement; $p = .03$; $ES = .38$), KB swing squat repetitions (125.78% improvement; $p = .00$; $ES = 1.56$), and DB squat repetitions (72.41% improvement; $p = .00$; $ES = 1.48$). The back extension measure was the only variable which did not show significant change from pre-test (12.22% improvement; $p = .24$; $ES = .12$).

For the experimental group, dependent t-tests of all measured fitness variables showed significant differences ($p < .05$) on the following measures: push-ups (33.90% improvement; $p = .00$; $ES = .96$), sit and reach (8.43% improvement; $p = .04$; $ES = .56$), curl-ups (22.38% improvement; $p = .02$; $ES = .56$), KB swing squat repetitions (157.32% improvement; $p = .01$; $ES = 1.33$), and DB squat repetitions (102.76% improvement; $p = .01$; $ES = 1.68$). Measures showing no change from pre-test included back extension (9.92% improvement; $p = .09$; $ES = .31$), grip strength (5.79% improvement; $p = .09$; $ES = .16$), and vertical jump (1.53% improvement; $p = .11$; $ES = .31$).

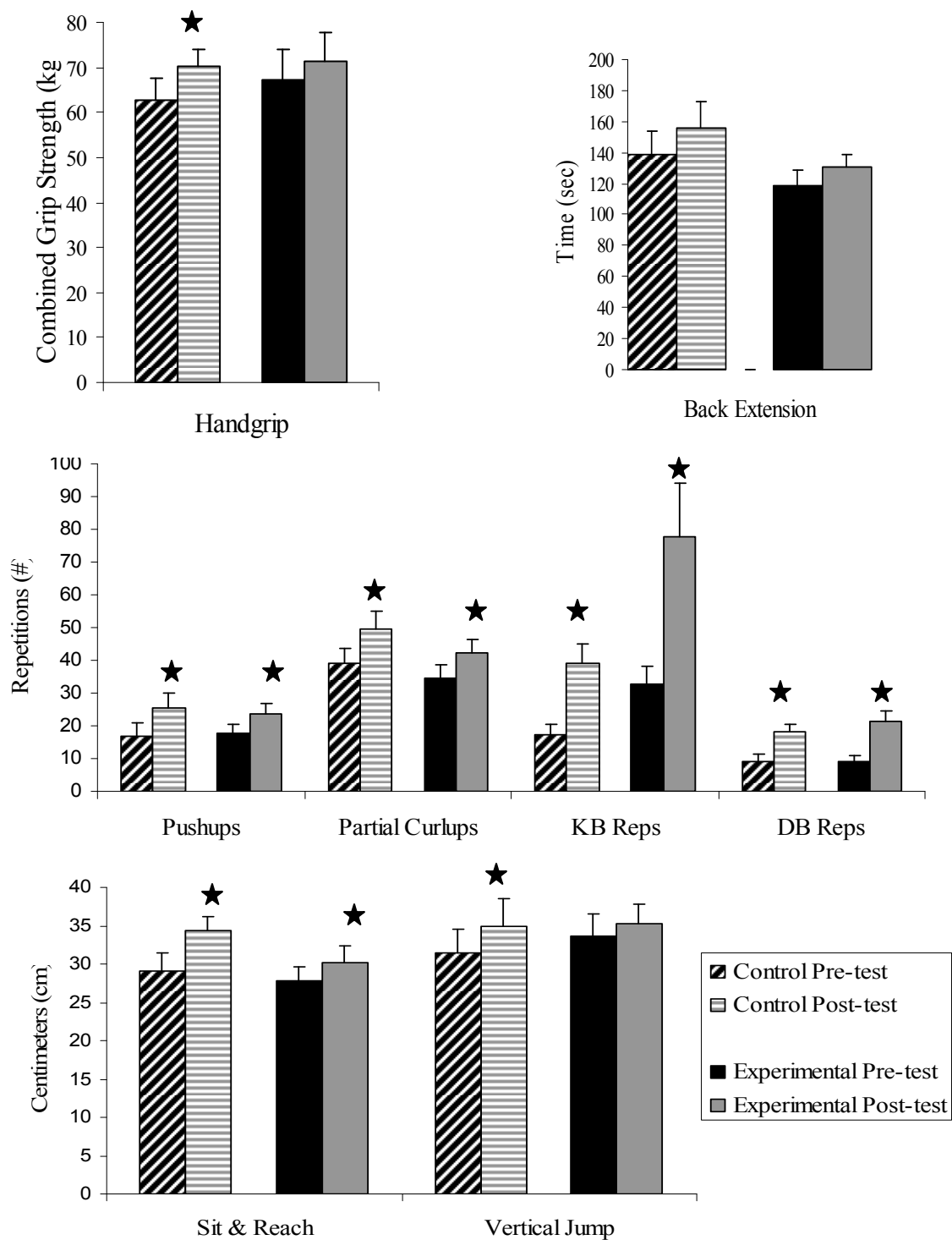


Figure 4. Control and experimental group mean (+ SE) scores for all health-related fitness variables a pre- and post-test (pre-test and post-test sig. diff. within groups = ★, $p = .05$).

4.3.2. Health-Related Fitness between Groups

Table 3

Tests of Between-Subjects Effects by Group at Post-test

Variable	Sum of Squares	df	Mean Square	F	Sig	Effect size
Grip strength (kg)	102.90	1,13	102.90	.52	.49	-.37
Push-ups (#)	34.81	1,13	34.81	.27	.61	-.27
Sit & reach (cm)	76.20	1,13	76.20	2.19	.16	-.77
Curl-ups (#/min)	440.08	1,13	440.08	1.68	.22	-.67
Vertical jump (cm)	.05	1,13	.05	.00	.98	.01
Back extension	2153.60	1,13	2153.60	1.78	.21	-.69
KB load (lbs)	.74	1,13	.74	.05	.82	/
KB reps (#)	5631.70	1,13	5631.70	5.43	.04*	1.21
DB load (lbs)	14.41	1,13	14.41	2.31	.64	/
DB reps (#)	40.31	1,13	40.31	.69	.42	.43

Note. Scores were calculated as experimental minus control group data; therefore, negative scores represent a greater score for the control group. * = significant at $p < .05$.

Based on the reported results, it was concluded that there was no significant difference between groups ($p > .05$) on the measured fitness variables, with the exception of KB swing squat repetitions ($p = .04$). The reported effect sizes did vary however. A small effect size was found for grip strength, push-ups, and DB squat repetitions. Moderate to large effect sizes were noted for sit and reach, curl-ups, and back extension. Finally, a large effect size was noted for KB reps.

4.3.3. Physical Activity Enjoyment

Mauchly's test indicated that there was a violation of the assumption of sphericity ($\chi^2(2) = 24.99, p < .00$), therefore the Greenhouse-Geisser estimates of sphericity ($\epsilon = .56$) were used to correct the degrees of freedom. The results of this analysis indicated a significant main effect of within group time of measure on enjoyment, $F(1.12, 18.99) = 55.79, p = .00$. These results indicate that time of measure significantly influenced ratings of physical activity enjoyment. In addition, there was no significant interaction between type of training program adhered to and time of measures, $F(1.12, 18.99) = .08, p = .81$. Finally, no significant main effect was found for between training group differences on physical activity enjoyment, $F(1, 17) = 1.23, p = .28$. This indicates that one modality of training was not superior to another in influencing physical activity enjoyment amongst adolescents.

Figure 5 represents physical activity enjoyment over the duration of the experiment. The above mentioned significant main effect of time of measure on enjoyment can be seen to occur from pre-test to mid-test for both groups.

Both the control group and the experimental group saw a significant decline within groups from pre- to mid-training PACES scores (control group - $F(1, 8) = 26.16, p = .00$; experimental group - $F(1, 9) = 37.74, p = .00$) and pre- to post-training PACES scores (control group - $F(1, 8) = 22.25, p = .00$; experimental group - $F(1, 9) = 31.90, p = .00$). There was no significant difference from mid- to post-training PACES scores for either group (control group - $F(1, 8) = .33, p = .58$; experimental group - $F(1, 9) = .79, p = .40$).

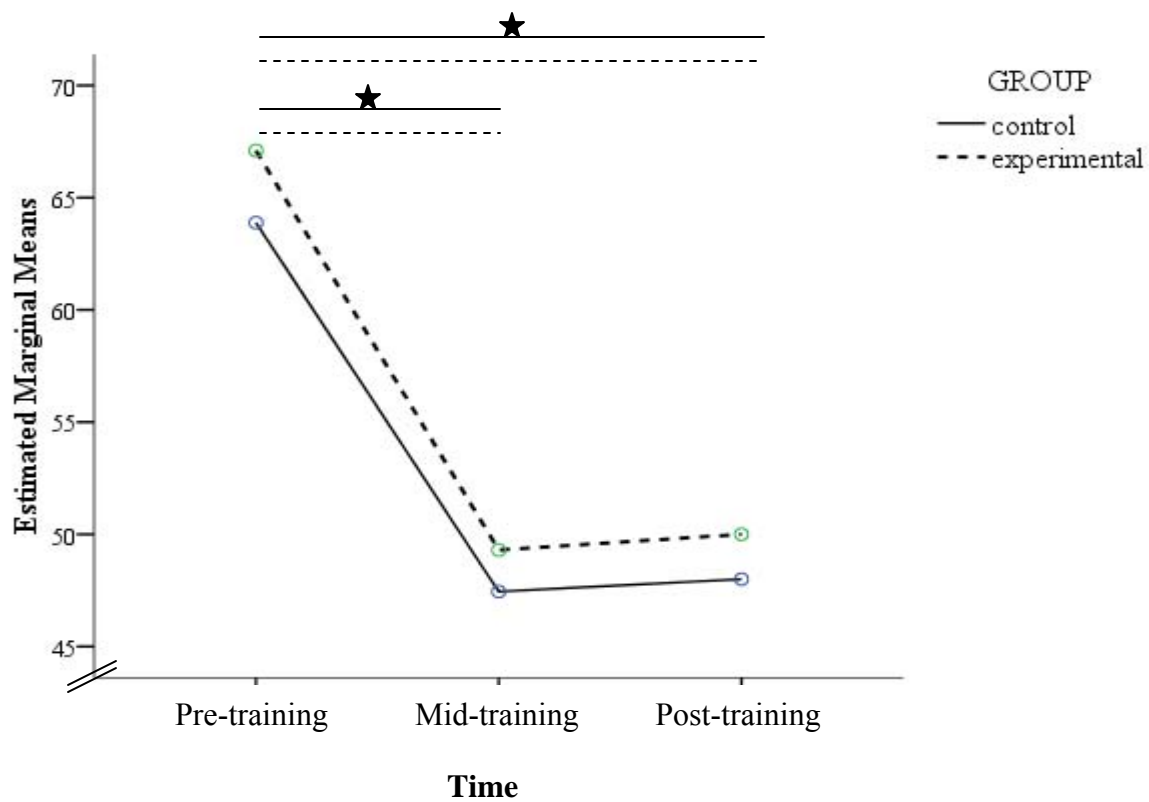


Figure 5. Visual representation of mean physical activity enjoyment scores, at each different measure (pre-, mid- and post-training) by group

Chapter 5 – Discussion

The first hypothesis, that both modes of strength training (KB and DB) would significantly improve measures of health-related fitness was supported ($p < .05$) for the majority of dependent variables through a rejection of the statistically analyzed null hypothesis. Both the control and the experimental group saw significant changes from baseline on a number of health-related fitness measures (seven out of eight measures and five out eight measures, respectively). The second hypothesis, that KB training would improve measures of health-related fitness more than DB training, was rejected ($p > .05$) for all fitness variables but one. The KB group made significantly greater improvements in the performance of KB swing squat repetitions compared to the DB group ($p = .04$). Finally, the third hypothesis, that participants in the KB group would have greater increases in physical activity enjoyment from baseline, compared to the DB training group, was also rejected ($p > .05$).

5.1 Strength Training and Health-Related Fitness

The results of the current study showed significant improvements in the majority of health-related fitness measures ($p < .05$) for both groups. The control and experimental groups significantly improved from pre-test to post-test on push-ups, sit and reach, curl-ups, KB swing squat repetitions, and DB squat repetitions. In addition, the control group significantly improved their grip strength and vertical jump.

5.1.1. Expectations

Adherence to eight weeks of traditional (DB) and non-traditional (KB) strength training was expected to significantly improve the selected measures of health-related fitness. With “free weight training” being one of the most common forms of strength training for youth (Malina, 2006), and a frequency of two times per week for a duration of eight weeks falling within the norm (Baechle & Earle, 2000; Malina, 2006), it was expected that the traditional training group would enhance the measured components of health-related fitness.

In addition to those expectations for traditional training adaptations, the KB training group was also expected to enhance fitness. With no literature to suggest otherwise, this expectation was based on the overload principle and standard strength training prescription guidelines (Baechle & Earle, 2000). Though it seems logical that KB training should enhance the components of health-related fitness assessed, no previous literature was available describing KB training adaptations or KB training for youth. In fact, only two descriptive abstracts have been published with a focus on cardiorespiratory and energy cost responses in adults after one KB training session (Bishop et al., 2005; Lanier et al., 2005).

The expectation that both groups would significantly enhance their fitness after adhering to eight weeks of training was further influenced by the existing body of literature focused on strength training for the youth population. This literature, focused on strength training for youth via traditional and non-traditional modalities, seems to conclusively support the ability of children and adolescents to enhance their strength (Blimkie, 1992; Cowan et al., 2007; Epstein et al., 2007; Faigenbaum et al., 2007;

Faigenbaum & Mediate, 2005; Faigenbaum & Mediate, 2006; Falk & Tenenbaum, 1996; Malina, 2006; Payne et al., 1997; Szymanski et al., 2007; Warburton et al., 2007).

5.1.2. Discussion of Findings

Literature focused on strength training adaptations emphasizes two predominant mechanisms responsible for improving overall strength: neural adaptations and hypertrophic adaptations within the muscle (McDonagh & Davies, 1984; Phillips, 2000; Staron et al., 1994).

It has been well established, that strength gains early in a training program are the result of predominantly neural adaptations (Akima et al., 1999; Chilibeck et al., 1998; Enoka, 1998; McDonagh & Davies, 1984; Phillips, 2000; Sale, 1988). The short duration of this training program (and the participants' inexperience with strength training) lends itself to neural adaptations as being primarily responsible for the strength gains seen in this study, though hypertrophic factors may have had a more dominant influence towards the end of the training program. Unfortunately, no measures of neural or hypertrophic responses were taken in this study and therefore any discussion on the topic is speculative based upon the existing body of research.

5.1.3. Additional Findings

The majority of dependent variables changed significantly from baseline in both the control and the experimental groups, though neither group significantly improved upon back extension. There was a smaller change in the experimental group on this measure, though all of the momentum exercises required back extension for performance. Although non-significant, noted differences from pre-test to post-test were identified for

the control group (17.00 ± 39.99 sec; $M \pm SD$) and the experimental group (11.80 ± 19.76 sec; $M \pm SD$) on this measure.

The control group's significant improvement in grip strength may have been a result of the constant need for a firm grip on the DBs, holding their weight against gravity, for each exercise of the program. In contrast, the experimental group did not note a significant improvement in grip strength. This may have been due to the use of momentum exercises (which require a looser grip for effective execution) and the overhead exercises which required the handle of the KB to simply rest on the base of the palm, rather than be held with a firm grip. The experimental group demonstrated a slight change from pre- to post-test in this measure (3.90 ± 6.47 kg).

The control group experienced significant increases in vertical jump height compared to the experimental group, which experienced no change (increase of 1.72 ± 2.90 cm from baseline). This could have been due to more varied stimulus to the lower body musculature through several different exercises (squats, lunges, deadlifts) compared to the experimental groups training program which performed only squats as their lower body exercise (squats were required for all momentum exercises, in addition to the standard squat exercise). The power required for performing the KB exercises did not transfer to this measure of lower body power.

It is possible that the previously mentioned small differences in fitness measures were deemed non-statistically significant due to limitations of the study.

5.1.4. Conclusions

Analysis of the first hypothesis and supporting literature provides indication that adolescents have the ability to enhance several parameters of health-related fitness via

traditional and non-traditional strength training modalities. Although some components of the health-related fitness assessment did not significantly improve after eight weeks of training, noted differences from pre- to post-test were observed, suggesting the need to re-examine these components. It is likely that many of the observed differences from pre- to post-test on non-significantly changed components would transfer to a significant improvement in performance of a task, in spite of their statistical non-significance.

5.2 Modality Specific Affects on Health-Related Fitness

The second hypothesis, that KB training would enhance health-related fitness more than DB training, was rejected for all variables except one ($p > .05$). KB training was proven more effective than DB training at enhancing the performance of KB swing squat repetitions. While traditional strength training has been shown to enhance fitness in youth (Blimkie, 1992; Falk & Tenenbaum, 1996; Malina, 2006; Payne et al., 1997), and non-traditional strength training has shown favourable results (Cowan et al., 2007; Epstein et al., 2007; Faigenbaum et al., 2007; Faigenbaum & Mediate, 2005; Faigenbaum & Mediate, 2006; Szymanski et al., 2007; Warburton et al., 2007), no research to date had compared the two modalities in terms of their efficacy in enhancing parameters of health-related fitness.

5.2.1. Expectations

With no literature available to the contrary, this study's second hypothesis speculated that KB training would have a greater affect on health-related fitness when

compared to DB training. Overall, the results of this study did not support this hypothesis ($p > .05$).

5.2.2. Discussion of Findings

The results of this study indicated no significant difference between groups for seven out of eight measures of health-related fitness. The program design and fitness test components likely influenced these findings.

Both the KB and DB training programs had a number of similarities in terms of the exercises that comprised them. Given the novice level of all participants in the program, it was necessary to implement beginner level programs for each modality. However, by doing so, there was cross-over between the two programs (both programs performed squats, bent-over row, chest press, shoulder press, and Russian twists as five of their eight exercises). While both programs were still representative of that marketed to beginner level participants for each respective modality, it is likely that the similarity in program prescription contributed to the similar findings between groups. Had more advanced participants been used, the traditional program could have remained unchanged (with the incorporation of heavier loads) and the KB program could have incorporated those exercises that are relatively unique to this form of training (i.e. almost entirely momentum exercises, including cleans, clean and jerks, and snatches with the KB). By implementing a program prescription for more advanced participants, changes between groups may have been observed.

In addition, the prescription design was very similar. Both programs were matched for frequency (two times per week), training session duration (60 minutes), and training program duration (eight weeks). Similarly packaged training programs likely

played an integral role in the lack of difference between groups on measured components of health-related fitness.

The fitness test components were selected as a standardized, commonly utilized measure of health-related fitness (CSEP, 1996). Given the beginner level of the participants and the overall emphasis on simply encouraging active living, the test battery was deemed appropriate. However, true measures of differences between training modalities would have been better represented by selecting measures that were more specific to each form of training. More appropriate tests may have included repetition maximum testing of several exercises that comprised the training programs.

Although it was hypothesized that KB training would have a greater influence on measures of health-related fitness compared to DB training, careful consideration into the similarities between the two modes of training support the trend for an overall non-significant difference between groups. Both KB and DB training provide participants with the opportunity to train unilaterally and functionally. This method of training has the potential to significantly enhance performance through its transfer to sporting actions or activities of daily living. In addition, the handheld nature of both training tools corresponds to several similarities in training stimuli (Chiu, n.d.).

The most apparent difference between groups in this study was that the KB strength training group improved their KB swing squat performance significantly more than the DB group. It seems likely, that familiarity with the exercise and regular performance of the exercise throughout the training program duration, contributed to the significant difference between groups.

5.2.3. Additional Findings

Although there was no significant difference between groups on seven out of eight measures of health-related fitness, effect size calculations indicated that several of these statistically non-significant changes were meaningful. Specifically, grip strength (7.44 ± 7.78 vs. 3.90 ± 6.47 kg; *control vs. experimental; M ± SD*), push-ups (8.78 ± 5.52 vs. 6.00 ± 3.89 reps), sit and reach (5.26 ± 3.93 vs. 2.34 ± 2.99 cm), curl-ups (10.22 ± 7.41 vs. 7.70 ± 8.19 reps), vertical jump (3.56 ± 4.16 vs. 1.72 ± 2.90 cm), back extension (17.00 ± 39.99 vs. 11.80 ± 19.76 sec), and DB squat repetitions (8.88 ± 5.30 vs. 12.00 ± 7.30 reps) all saw some improvements.

The between group effect sizes for measures of health-related fitness varied from negligible (vertical jump) to large (KB reps) at post-test. A small effect size was noted for push-ups (- .27), grip strength (- .37), and DB reps (.43) indicating the strength of relationship between training modality and each fitness measure was small. Moderate effect sizes were found for curl-ups (- .67), back extension (- .69), and sit and reach (- .77). Finally, a large effect size was noted for KB reps (1.21).

The traditional training group seemed to have a greater influence on measures of push-ups, grip strength, curl-ups, back extension, and sit and reach, with negative numbers representing greater scores for the DB group. The non-traditional training group had a greater influence on measures of DB reps and KB reps. The traditional training group saw greater improvements on the standard CPAFLA measures of health-related fitness (CSEP, 1996), whereas the non-traditional training group saw greater improvements on modality focused measures of DB and KB squat repetitions.

5.2.4. Conclusions

The results of this study indicate that beginner level DB and KB training programs did not differ significantly in their affect on health-related fitness, with the exception of KB swing squat repetitions. The KB training group improved on this measure significantly more than the DB training group. These findings suggest that both modalities are equivalently effective in enhancing health-related fitness, with KB training having the added benefit of enhancing the performance of KB squats. Also, though non-significant, there were a number of additional noted differences between the two training modalities on measures of health-related fitness. Future studies may benefit from the utilization of advanced participants, advanced program prescriptions, and a more specific testing protocol – as opposed to a generalized health-related test battery.

5.3 Physical Activity Enjoyment

There was no significant difference between groups on physical activity enjoyment pre-training, mid-training, post-training, or for the sum of all scores. However, both groups showed a significant decrease in mid-training, although scores did not differ from mid- to post-training for either group.

5.3.1. Expectations

It was expected that the non-traditional form of strength training would encourage a greater level of physical activity enjoyment than the traditional modality. However, the results of the current study rejected this hypothesis, finding no significant difference between groups on any measure of physical activity enjoyment. Currently, there is no

previous literature comparing the affect of two different strength training modalities on physical activity enjoyment amongst adolescents.

In 2005, Dishman and colleagues utilized the most recent 16 question version of the PACES (Motl et al., 2001) in their study of the Lifestyle Education for Activity Program's (LEAP) affect on physical activity participation amongst 2087 adolescent females. This study found that increased physical activity enjoyment resulted in increased physical activity participation amongst adolescent girls (Dishman et al., 2005).

Dishman and colleagues (2005) reported the mean PACES scores for those participants who completed the questionnaire at baseline and those who completed both the baseline and one year follow-up questionnaire. The reported mean sum scores were 67.32 ± 10.18 and 67.78 ± 10.02 for those that completed the baseline only and baseline plus follow-up questionnaires, respectively. These scores correspond to those reported in the current study at baseline, with 63.89 ± 10.75 and 67.10 ± 10.20 as the mean sum scores for the control and experimental groups, respectively.

In contrast, the mean sum scores attained in the current study for mid-training and post-training were noticeably lower than those reported by Dishman and his colleagues (2005). The current study reported mean sum scores of 47.44 ± 4.30 and 49.30 ± 2.45 for the control and experimental groups respectively at mid-training, and 48.00 ± 3.35 and 50.00 ± 1.56 for the control and experimental groups at post-training. When compared to the reported mean values from the LEAP program, these values are evidently lower.

In 2000, Project Graduate Ready for Activity Daily (Project GRAD) was implemented and evaluated in 185 male and 153 female senior university students (24.23 ± 1.95 yrs; $M \pm SD$). Utilizing the 18 question version of the PACES questionnaire

(Kendzierski & DeCarlo, 1991), Calfas and colleagues (2000) assessed enjoyment (in addition to several other dependent variables) at baseline, one year and two years. The results of this study indicated that enjoyment stayed consistent for all measures, regardless of the interventions (Calfas et al., 2000).

Utilizing a similar approach, Nichols and colleagues (2000) modeled their worksite behavioural skills intervention after Project GRAD's intervention course which was designed to promote the adoption and maintenance of physical activity (for more information, refer to Nichols et al., 2000). A final sample size of 58 participants, between the ages of 24 and 61 years (42.0 ± 9.7 yrs; $M \pm SD$), was involved in this study. Enjoyment was measured at baseline, after the three month intervention, and at six months follow-up as a maintenance measure using the 18 question version of the PACES questionnaire (Kendzierski & DeCarlo, 1991). It was found that the intervention had no significant effect on enjoyment; though a moderate effect size of .5 was noted providing indication that the intervention was quite strong in improving enjoyment (Nichols et al., 2000).

In the current study, the significant decrease in enjoyment from baseline to mid-training was not hypothesized. Upon further investigation into the literature, one study with similar findings was identified (Castro et al., 1999). This randomized controlled trial of a walking program involved 125 ethnic minority women (aged 24 to 55 years old). Enjoyment measures were taken at baseline, eight week post-test, and five months follow-up utilizing five questions from the original 18 question PACES (Kendzierski & DeCarlo, 1991). Results of this study indicated a significant decrease in enjoyment from baseline to eight weeks post-test, as well as from baseline to five months follow-up for

both the control and intervention groups (Castro et al., 1999). These results are in support of those found in the current study, with a decrease from baseline to mid-training, and baseline to post-training PACES scores.

5.3.2. Discussion of Findings

Contrary to our hypothesis, the current study did not find a significant difference between training groups on measures of physical activity enjoyment. In an effort to explain these findings, a few potential influencing factors have been identified. These factors include the strength training experience of the participants, program design, and study limitations.

The participants in the current strength training study had minimal to no strength training experience prior to commencing this study. It is possible that there was no difference between training groups on physical activity enjoyment because both groups were essentially experiencing the same stimulus: an introduction to strength training in general. If the participants had had a background in strength training, it is possible that this would have acted as a reference for their PACES responses and thus allowed for true differences between groups to be identified. With experienced participants, it is possible that there would have been a shift in stimulus from an “introduction to strength training in general” to “modality specific training”, thus allowing for a more clear distinction of modality specific enjoyment. With no previous strength training experience, participants in the current study had nothing to compare their experiences to, and thus, no reason to differ in their rating of enjoyment between modalities.

Secondly, the similarity between training program designs may have contributed to the similarity in ratings of physical activity enjoyment between groups. Due to the

beginner level of the participants and the attempt to control as many variables of the program design as possible, there were a limited number of differences between training programs. The similarity between training groups may have resulted in too much overlap and not enough distinction between the two modalities to allow for differences in enjoyment. The main differences between training programs were: a) the utilization of DBs or KBs, b) the specific exercises that comprised the programs (though several exercises were similar), and c) the repetition prescription (DB program – 8-12RM; KB program – maximum repetitions in 25 seconds). The few differences between programs may not have been enough to correspond to differing PACES scores. With more advanced participants, the programs could have skipped the novice exercises and focused more on the advanced exercises for each modality, potentially allowing for differing PACES based on more significantly different training programs.

An additional speculation for why there was no difference between groups on physical activity enjoyment is simply due to the limitations of this study (discussed in section 1.7 and 5.5). More participants and a longer duration program may have allowed for a more clear identification of physical activity enjoyment differences and/or patterns.

With regards to the time course for levels of enjoyment over the duration of a training program, it was not hypothesized that physical activity enjoyment would significantly decline in both groups from baseline to mid-training, and remain constant from mid-training to post-training. Several suggested rationale have been identified for these findings, including a desire to please the instructor, expectancy and fatigue, repetitive programming or boredom, and physiological state.

It is possible, that participants at baseline may have reported higher physical activity enjoyment scores in an effort to provide the instructor with the information that they suspected was wanted. Participants may have felt the need to please their instructor on the first day, but felt more comfortable providing honest answers at mid- and post-training after getting to know their instructors better.

Secondly, it is possible that expectancy may have influenced the PACES scores at baseline. Participants may have expected strength training to be more enjoyable than they truly felt it was once they were a part of the program. After commencing the program, it is possible that unexpected fatigue and muscle soreness were affecting the participants, and thus, enjoyment may not have been rated as high as it was in the rested state.

Thirdly, in Fairclough's (2003) article, a book by Csikszentmihalyi entitled: "Flow: The Psychology of Optimal Experience" was referred to in discussing the importance of matching task difficulty with participant ability. It was stated, that a task that is not challenging will often lead to boredom and a task that is too challenging may lead to drop out. In both cases, lowered levels of motivation and enjoyment are responsible. The repetitive program design of this study may have lead to boredom, and thus lowered enjoyment from baseline to mid-training and baseline to post-training PACES assessment.

Finally, the constant physical activity enjoyment rating throughout the duration of the program may be explained by the physiological states of the participants. During this eight week period, these states would have remained relatively constant (with slight fatigue and muscle soreness throughout). The fatigue and muscle soreness experienced at

mid- and post- training would have been constant, though much different than that experienced in the rested, pre-training state. Thus these differences may have contributed to the significant decrease in enjoyment from baseline and consistency of enjoyment throughout the program.

5.3.3. Additional Findings

Though physical activity enjoyment reportedly decreased significantly from baseline to mid- and post-training, qualitative responses to open ended questions implied that enjoyment in the training programs was very high. In response to the question “did this program change the way you viewed being physically active at all?” responses included:

Experimental group:

- “Yes, it made me want to focus on weight training & being active on a regular basis”
- “Yes, because it showed me how much I can improve with such a little amount of exercise”
- “Yes, I like it more now”
- “Yes, I enjoy being more active, I feel like I accomplished something at the end of the day”
- “Yes, it gave me the knowledge I need to create a workout routine for myself, and gave me an exposure to weight training which I have done little of in the past”
- “The program seemed to mask the boredom that comes with strength training by its challenging circuit”
- “I already enjoyed being active but learning new exercises made it exciting to use at my gym”

- “I have always loved physical activity”
- “No, because I was physically active beforehand. It did however, open my eyes to new training methods”
- “No, I still don't enjoy it. Just the feeling after that I've done something good for myself, not during.”

Control group:

- “Yes, I think it did, it gives me a better/bigger drive to be more active. I think I'm going to get a gym membership when this is done and continue on from what I learned”
- “It made me get more motivated to do physical activity”
- “Yes, as I have now seen viable results from the program it is something I look forward to pursuing”
- “Yes, more active than before”
- “I'm always active but for sure the way I see weights now for I like it”
- “Not really, except it gave me a view into strength training, I am a triathlete and horse rider so that is usually how I spend my time”
- “This program didn't make any large difference on how I view physical activity”

In addition, the majority of participants were eager to initiate another program immediately after completing the described program, indicating a certain level of enjoyment and desire to continue regular adherence to physical activity. Thus, it may be more likely that baseline sum scores were overrated and mid- and post-training measures were a more accurate representation of their consistent enjoyment throughout the

program. With no decrease in enjoyment throughout the course of the program, and the consistently positive feedback associated with the training, it seems that overall, both programs were highly enjoyable – regardless of the pattern of data.

5.3.4. Conclusion

The results of this study indicate that adherence to eight weeks of novice level DB and KB training programs do not significantly differ in their affect on physical activity enjoyment amongst adolescents. Based on anecdotal comments and a consistent rating of enjoyment throughout the program, this study's community based strength training program appeared to positively affect participants' views on being physically active and interest in participating in future community based strength training programs.

5.4 Impact of the Study

The results of this study indicate that adherence to eight weeks of beginner level KB strength training was as effective as adherence to eight weeks of beginner level DB training in enhancing health-related fitness parameters and influencing physical activity enjoyment. By presenting a new, effective means to being active and enhancing health-related fitness, it is possible that KB training will: a) act as an additional option for being active amongst currently active youth and/or b) appeal to a portion of the inactive youth population, who may not have taken interest in the currently popularized training modalities.

In addition, the success and interest in KB training that was noted in the current study may influence other programs and facilities to make these training tools and programs more available to the public. Specifically, recreation centers and physical

education programs in the school may take interest in incorporating this form of training and equipment into their existing programs.

The results of this study have the potential to impact future studies investigating KB strength training for various populations. The beginner level training program utilized in this study may provide the foundation for future studies investigating more advanced KB training prescriptions for youth, sport specific training for various athletes, or occupational fitness training for various professions including the military, fire department, and police department.

5.5 Limitations of the Study

This study, and its results, is not without limitations. In addition to the limitations described in section 1.7, there were additional study limitations related to the need for a pre-learning phase, the need for a control group, and the overall nature of the study.

According to Falk and Tenenbaum (1996), the inclusion of a pre-learning phase prior to baseline fitness testing is an appropriate way to better ensure tests are reflecting valid gains in strength, rather than test familiarization amongst participants. This study did not include such a phase. It is possible that failing to include this phase may have affected the results of this study. However, the eight week span between performance of the tests (pre- to post-test), in combination with the fact that the test components were not a part of the training programs, allows for the possibility that pre-learning may not have significantly affected the results. Where test components were unfamiliar to participants at baseline, it seemed that the majority of participants were equally unfamiliar with the test protocol at the eight week post-test. With this in mind, future studies should consider

including a pre-learning phase in order to satisfactorily rule out the affect of test familiarization on dependent measures.

In addition to not allowing a pre-learning phase for fitness measures, this study would have also benefited from allowing a familiarization phase for the physical activity enjoyment measure as well. By administering the enjoyment measure one or two weeks into the program, it may have allowed participants to better understand what was involved in the program and ensure their expectations were realistic upon reporting their baseline physical activity enjoyment score.

Secondly, this study did not make use of a true control group. Given the age of participants, it may have been beneficial to include a true control group to reflect standard growth and development changes over the course of eight weeks. It would have also been of interest to compare the health-related fitness and enjoyment scores of both training groups to a non-exercising true control group.

Finally, the practicality and applied nature of this study resulted less stringent control over the specificity of testing. Unfortunately, with no funding, this study had to rely on volunteers to assist with the pre- and post-testing. These volunteers were relatively inexperienced. It would have been beneficial to this study to have more, experienced help in administering the pre- and post-tests.

In addition, the nature of the program and testing sessions resulted in shuffling up to 15 adolescents through a lengthy test battery in one day with only two to four individuals administering the tests. Due to an insufficient number of individuals administering the tests, this study was limited in its specificity of testing for certain components. For example, future studies would benefit from establishing a set 90 degree

angle for each participant, ensuring that all participants squat to this angle for each repetition of the DB and KB squats.

5.6 Recommendations

Several recommendations can be made to guide future research investigating KB strength training. These include modifying the research design, adjusting the time course for dependent measures, investigating alternate physiological adaptations, and comparing alternate training modalities.

In order to accurately investigate the affect of KB strength training on physical activity enjoyment and fitness, future studies would benefit from studying each component individually. By simply focusing on physical activity enjoyment within and between groups, future studies could place participants in two groups (one per training modality) and have these participants switch to the opposite group after four weeks. This design would allow participants to experience both forms of training. By taking measures of enjoyment throughout and incorporating a feedback questionnaire post-training, it may be easier to determine the more enjoyable and preferred form of training for adolescents.

An alternate study could specifically focus on fitness adaptations within and between training groups. By utilizing experienced strength trainers as participants, more advanced training programs could be implemented as they are promoted to the public. Along with a more specific testing battery, it may be possible to more accurately determine any differences between groups on enhancing fitness.

Secondly, future studies should incorporate delayed baseline measures, to allow for pre-learning and a familiarization with program components. This may allow for more valid scores on physical fitness components, and also a more accurate rating of physical activity enjoyment.

Thirdly, future research in this field may wish to look into alternate physiological components and adaptations, such as cardiorespiratory responses. With KB training often being promoted for its cardiorespiratory responses (Vatel & Gray, 2005), it may be of interest to have future studies incorporate heart rate monitors during training or measures of cardiorespiratory fitness at pre- and post-test. These studies could compare the two modalities of training on fitness testing results and also heart rate responses during training sessions.

Finally, while the focus of this study was specifically on KB versus DB training, future studies may wish to compare more obviously different modalities such as KB versus barbell training. This may allow for a more clear representation of the differences between training modalities and the key physiological responses and adaptations associated with each.

5.7 Conclusions

Beginner level non-traditional, KB, strength training was found to be equally effective in enhancing select measures of health-related fitness when compared to beginner level traditional, DB, strength training. It was also determined that KB training was better able to enhance performance of KB swing squats, and thus, athletes who require the performance of this type of action in their sport, may benefit from this form of

training. In addition, KB training was found to have an equivalent affect on physical activity enjoyment amongst adolescents when compared to DB training.

With this in mind, KB strength training holds the potential to influence the physical activity profiles of today's youth. In a time where the majority of youth are failing to meet the physical activity recommendations ("Active Healthy Kids Canada", 2008), it seems that the identification of new, appealing means to encouraging adoption and maintenance of physical activity will continue to be of interest for quite some time. This study has identified KB strength training as an effective and appropriate form of activity for improving the physical activity profiles of adolescents.

KB strength training has the potential to influence physical activity participation amongst active and inactive adolescents. Physically active youth may choose to incorporate this form of training into their current activities, providing them with the opportunity to vary their routines. Physically inactive youth with no interest in the currently popularized physical activity opportunities, may take interest in this non-traditional form of training.

The significance of increasing the physical activity levels of youth lies in its affect on their overall health and wellness. In the face of a current childhood obesity pandemic ("BBC News", 2007; Miller, Rosenbloom, & Silverstein, 2004), increased energy expenditure via physical activity and exercise has a clear role in promoting healthy lifestyles and encouraging our next generation to be a healthy one.

Based on the potential impact of KB strength training, physical educators and community recreation centers may wish to incorporate these training tools into their

programs in order to offer a greater portion of the youth and adult population the opportunity to be active.

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Appendix A Notice of Program & Registration Form

Pacific Sport Institute's FIRST Community Program: "Strength Training for Adolescents"

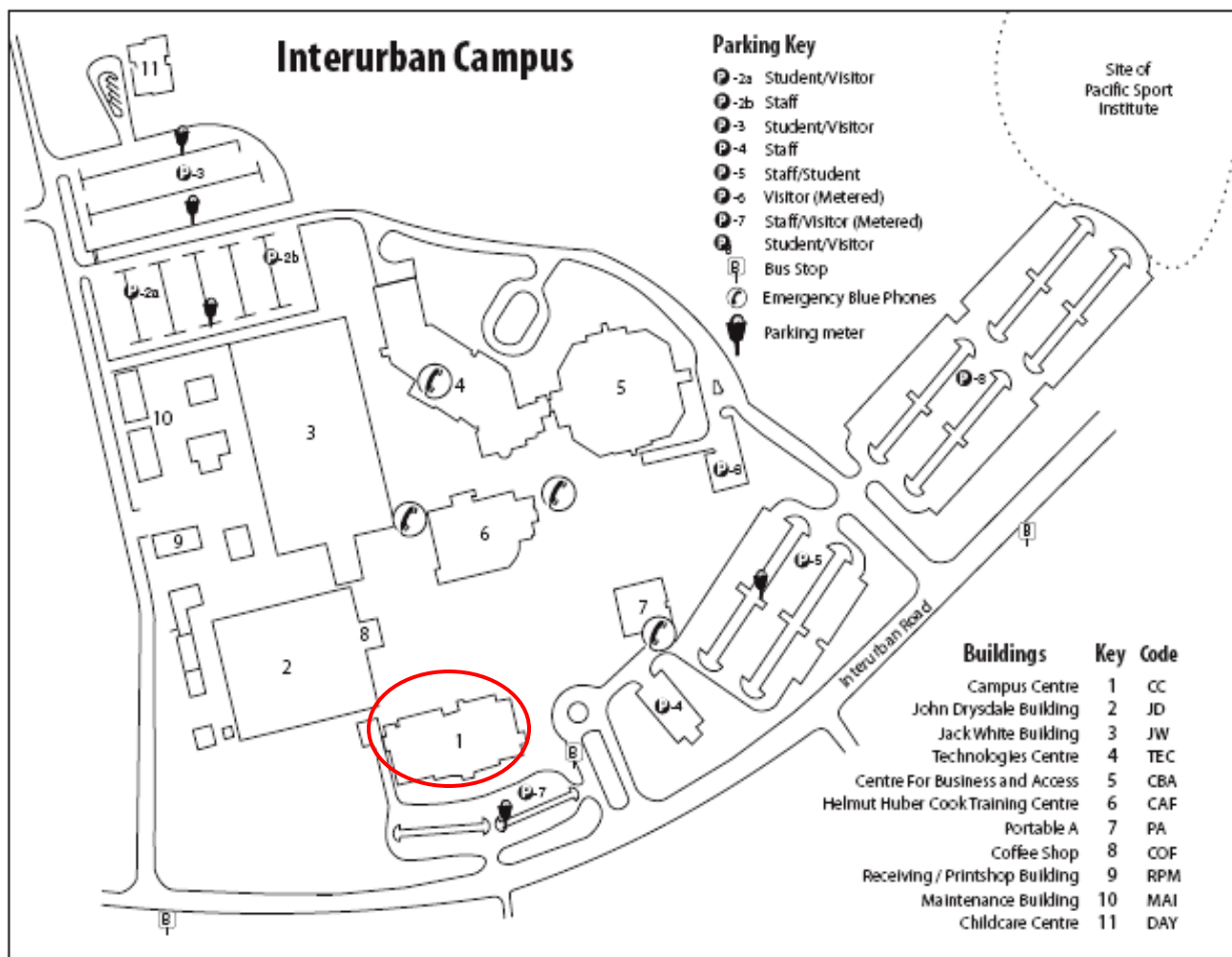
Come take part in an exciting and unique opportunity to be a part of the FIRST community program for the developing Pacific Sport Institute! This program is specifically designed to **enhance the health, fitness, and performance** of 15 to 18 year old adolescents.

Participants will have the opportunity to learn all they need to know about following a strength training program in a safe and effective manner. Upon completion of this program, participants will not only be more fit and strong, but they will be better prepared to continue this type of activity in the future, gaining all the skills and information needed to safely do so in this program.

- WHO:** 15-18 year old male and/or female adolescents of any level of fitness or experience (beginners are welcome!)
- WHAT:** An exciting opportunity for adolescents to obtain supervised, structured strength training by qualified and experienced staff at a **low cost** (\$55 for the program)!!
- WHEN:** February 5, 2008 – March 27, 2008; Tuesday & Thursdays;
6-7pm, 7-8pm, & 8-9pm
- WHERE:** Pacific Sport Institute/Camosun College's Interurban campus (map - pg 2)
4461 Interurban Rd
Victoria, BC
V9E 2C1
- Note date change*
- WHY:** Why not?! This program will not only enhance fitness, but also health, performance, and the knowledge needed to continue an active lifestyle!

Please refer to the attached registration information to sign up today!

Questions regarding the program or registration can be addressed to the program coordinator Thalia Parkinson at thalia@uvic.ca or (250) 661-4221.





REGISTRATION

To register...

Participants will be enrolled in this program in the order in which registration forms are received. Please fill in this form and submit it as soon as possible to avoid disappointment.

Participants can register ...

...by e-mail – Fill in the information below and send it to thalia@uvic.ca

...by mail – Fill in the information below and mail it to:
Thalia Parkinson
c/o Dr. Peter Rehor
Centre for Sport & Exercise
4461 Interurban Road
Victoria, BC
V9E 2C1

To pay...

Fee payment will be **due at the first class** (January 15, 2007) via cash or cheque

Parent/Guardian Name:		
Address:		Postal Code:
Home Phone:	Work Phone:	Cell Phone:
Email:		
Emergency Contact:		Relationship:
Home Phone:	Work Phone:	Cell Phone:

payments. Cheques can be made payable to: the **Centre for Sport & Exercise**

Participant	M/F	Birthdate DD/MM/YY	Program Name	Start Date	End Date	Cost
			Strength Training for Adolescents <i>Check one:</i> <input type="checkbox"/> 6-7pm class <input type="checkbox"/> 7-8pm class <input type="checkbox"/> 8-9pm class	Feb. 5, '08	Mar. 27, '08	\$55

Questions regarding the program or registration can be addressed to the program coordinator Thalia Parkinson at thalia@uvic.ca or (250) 661-4221.

Appendix B

Youth Informed Consent

As a participant of the **Strength Training for Adolescents** program offered by Camosun College's *Pacific Sport Institute* & the *University of Victoria*, I voluntarily agree to take part in the following components of this program (*please check all boxes*):

- A strength training program supervised & instructed by a qualified trainer
 - A pre- & post-training fitness assessment to identify changes in fitness, including:
 - Body composition measures,
 - Muscular fitness measures, &
 - Flexibility measures
-

The Training

Training will involve performing a set strength training routine, as explained by the instructors. The main exercises in the program will remain unchanged over the course of the eight weeks, providing you with the opportunity to get comfortable with the program, perfect technique, & increase the amount of weight you can lift. With the warm up & cool down included, each session will be approximately 60 minutes in duration.

Participation is completely voluntary & you are free to stop the training or testing at any point if you desire; however, you are encouraged to participate in as many training sessions as possible, in order to ensure you gain the most benefits.

The Fitness Assessments

Before the actual training component starts & after it finishes, there will be a health-related fitness assessment. You will not be judged on your scores (they will be kept private – between yourself & the tester), the purpose is simply to provide you with some baseline & follow-up information so that you can clearly note any changes to your fitness. These assessments will take 30-60 minutes to complete.

The fitness assessments will include: height, weight, waist circumference, grip strength, push-ups, toe reach, partial curl-ups (not quite a full sit up), vertical jump, a back extension test, & two lower body strength tests.

Possible Risks & Discomforts

As with any form of strength & fitness training or testing, there is always a possibility that certain risks & discomforts may occur. These include episodes of transient lightheadedness, loss of consciousness, nausea, abnormal blood pressure, chest discomfort, pulled muscles, sprained ligaments, leg cramps, minor bruising, & muscle soreness.

To prevent or deal with these risks, warm-up exercises will be performed prior to training, instructors will ensure proper technique & form is being followed at all times, &

appropriate protocol will be followed if muscle soreness occurs. Also, the instructors will be certified in standard first aid & basic rescuer CPR should an incident occur.

The risks involved in participating in this program will be no different, and in fact lesser, than that associated with an adolescent commencing a strength training program on their own (a common practice).

Expected Benefits

You are being provided with an opportunity to take part in a low-cost, supervised strength training program led by qualified & experienced instructors. The lead instructor holds the national gold standard certification for fitness training & testing as a Certified Exercise Physiologist through the Canadian Society for Exercise Physiology (CSEP-CEP).

This program will provide you with the opportunity to enhance your physical fitness. You will also gain a greater understanding of the fundamentals of strength training (including specific guidelines, techniques, definitions, breathing methods, etc). Upon completion of this program you will have all the tools necessary to continue safely & effectively strength training on your own.

Data Collection

In signing this consent form, you are providing your consent for Thalia Parkinson (a graduate student at the University of Victoria) to use your data in partial completion of her Masters of Science thesis. This data will in no way be linked to your name or able to be traced back to you.

Inquiries

Questions about the procedures used in testing & training are encouraged. Please contact Thalia Parkinson (thalia@uvic.ca; 250-661-4221) with any inquiries.

Freedom of Consent

I have read this form carefully & I fully understand the training & assessment procedures that are involved in this program, as well as any risks or discomforts. Knowing these risks & having had the opportunity to ask questions that have been answered to my satisfaction, I am signing this consent to participate in the training & tests & allow the use of my data.

Name of Participant

Date

Witness

Date

Appendix C

Parent Consent Form

Examining the effect of a non-traditional form of strength training on health-related fitness and perceived enjoyment in youth.

Your dependent is invited to participate in a study entitled “Examining the effect of a non-traditional form of strength training on health-related fitness and perceived enjoyment in youth” that is being conducted by Thalia Parkinson.

Thalia Parkinson is a graduate student at the University of Victoria in the department of Exercise Science, Physical and Health Education at the University of Victoria and may be contacted if you have further questions by telephone (250-661-4221) or email (thalia@uvic.ca).

As a graduate student, I am required to conduct research as part of the requirements for a degree in my Masters of Science in Kinesiology. This study is being conducted under the supervision of Dr. Lynne Wolski and Dr. Peter Rehor. You may contact my supervisors at 250-721-7884 (Dr. Lynne Wolski) or 250-370-4544 (Dr. Peter Rehor).

Purpose and Objectives

The purpose of this research project is to assess whether non-traditional forms of strength training, as exemplified by kettlebell strength training, play a role in positively influencing the physical fitness and perceived enjoyment of this activity in adolescents.

Importance of this Research

With the current pandemic of childhood obesity and associated increase in sedentary behaviors, it is important that researchers focus on improving the physical activity profile of youth. Influencing health and physical activity practices in youth will encourage a positive tracking of health-related practices and behaviors into adulthood. This is of specific importance to adolescents as they are at a critical transition point in their lives from childhood to adulthood.

Unlike the adult population, youth are rarely motivated to exercise for the sole purpose of enhancing their health. Exercise must be associated with enjoyment and immediate gratification in order to encourage adherence amongst youth. By determining the most response oriented form of strength training for youth, future strategies and interventions geared towards increasing the activity levels and health of this population can enhance their likelihood of success and adoption.

Participants Selection

Your dependent is being asked to participate in this study to act as a representative sample of the youth population. Potential participants were notified of this study by their community sports team coaches and advertisements.

What is involved

If you agree to allow your dependent to voluntarily participate in this research, their participation will include meeting two times per week for a duration of eight weeks. Each session will be approximately 60 minutes long. This program will involve a pre- and post-training fitness appraisal. The fitness appraisal will be health focused and includes the following tests:

- Measurements of standing height, weight, and circumference, and tests of grip strength, push-ups, sit and reach, curl-ups, vertical jump, back extension, and squats (approximately 30-60 minutes in duration).

Following the initial pre-training fitness appraisal, the participants will begin an eight week strength training program. This program will moderate in intensity, individualized to each participant. Qualified and experienced individuals will be present at all times to ensure proper warm up and cool down; training protocol; form; and technique.

Benefits

To the participant:

Participants in this study will have the opportunity to take part in a cost-free, supervised strength training program led by a qualified and experienced individual. The instructor is qualified to conduct the appraisals and training components through the Canadian Society for Exercise Physiology with the designation of a Certified Exercise Physiologist (CSEP – CEP). This qualification is considered the gold-standard for fitness training and testing in Canada.

This experience may act as an introduction to strength training, providing participants with the opportunity to learn the fundamentals of strength training (specific guidelines, techniques, definitions, breathing methods, etc) and the tools needed to continue this type of activity upon completion of participation in this program. Participants will also experience the benefits and enjoyment that can be associated with regular adherence to a strength training program likely leading to improvements in health and overall physical fitness.

To society:

On a larger scale, this study may emphasize the importance and need for non-traditional forms of physical activity as a means to encouraging physical activity adherence amongst youth. Specifically, if kettlebell training is proven to be an effective and enjoyable form of physical activity for the participants, it may encourage a more widespread adoption of this revived form of exercise (Kettlebell training was very popular many years ago and is starting to regain popularity now). This study may work to encourage physical education classes, gyms, and recreation centres to make these training tools more available, thereby providing adolescents with more opportunities to enhance their physical activity levels.

To state of knowledge:

This study will be the first, to the researcher's knowledge, focusing on kettlebell strength training as a method of conditioning for youth.

Risks

There are some potential risks to your dependent by participating in this research and they include: episodes of transient lightheadedness, loss of consciousness, nausea, abnormal blood pressure, chest discomfort, pulled muscles, sprained ligaments, leg cramps, minor bruising, and muscle soreness. To prevent or deal with these risks, warm-up exercises will be performed prior to training, instructors will ensure proper technique and form is being followed at all times, and appropriate protocol will be discussed with the participant if muscle soreness occurs. In addition, the instructors will be certified in standard first aid and basic rescuer CPR should an incident occur. Finally, standardized school or team protocols will be followed should any risk or harm occur during a training session.

The risks involved in participating in this program will be no different, and in fact lesser, than that associated with an adolescent commencing a strength training program on their own (a common practice).

Voluntary Participation

Your dependent's participation in this research must be completely voluntary. If he/she does decide to participate (with your consent), he/she may withdraw at any time without any consequences or explanation. If he/she does withdraw from the study, their data will not be used.

On-going Consent

To make sure that your dependent continues to consent to participate in this research, I will remind them at the beginning of each session that participation is completely voluntary and they are free to withdraw at any point without explanation. By continuing to participate in the training and testing sessions, their on-going consent will be implied.

Anonymity

Anonymity is only partial in this study since the investigators and other participants will know of your dependents participation. However, all scores will be recorded in confidence and will not be shared with the group. Individual participants will be given personal identification numbers to ensure anonymity in the analysis and documentation of the results. In addition, the data obtained in this study will only be available to the primary investigator. If the results are published, information will be presented in such a way that anonymity of the participants will be ensured.

Confidentiality

Your dependents confidentiality and the confidentiality of the data will be protected by storing all data and personal information in a locked cabinet where only the primary investigator will have access. Complete confidentiality of the results of the fitness training and testing cannot be completely ensured due to the group setting of this study.

Dissemination of Results

It is anticipated that the results of this study will be shared with others in the following ways: directly to participants, in a published article, and my thesis write up and presentation, Data will in no way be linked to any specific participant and the organization from which the participants were derived will not be identified. The analysis and documentation of the results will make use of personal identification numbers at all times.

Disposal of Data

Personal information from this study will be disposed of immediately upon completion of the project. Any raw data will be kept for five years in a secure storage unit, after which it will be destroyed. Paper data will be destroyed by shredding and electronic data will be deleted.

Contacts

Individuals that may be contacted regarding this study include Thalia Parkinson – graduate student & primary investigator, Dr. Lynneth Wolski – supervisor, and Dr. Peter Rehor – supervisor.

In addition, you may verify the ethical approval of this study, or raise any concerns you might have, by contacting the Human Research Ethics Office at the University of Victoria (250-472-4545 or ethics@uvic.ca).

Your signature below indicates that you understand the above conditions of participation in this study and that you have had the opportunity to have your questions answered by the researchers.

Name of Dependent/Participant

Signature of Parent/Guardian

Date

A copy of this consent will be left with you, and a copy will be taken by the researcher.

Appendix D Strength Training History Questionnaire

Current Training Practice

Are you **currently** strength training (with weights, body weight – push ups, lunges, medicine balls, tubing, etc)?

Yes No

If yes.....

Frequency: **Do you train on a regular basis or randomly?** Regular basis Randomly

Frequency: **On average, how many strength training sessions do you perform in a week?** _____

Frequency: **When did you start this training?** _____

Intensity: **When you strength train, on average, is your effort....**

Very light Light Moderate Hard Very hard Maximal

Type: **a) What kind of strength training do you do? (i.e. machines, free weights, body weight exercises, medicine balls, tubing, etc.)**

b) Where did you learn the exercises? (self taught, trainer, coach, friend)

Past Training History (excluding current training practice)

Have you ever strength trained before (with weights, body weight, medicine balls, tubing, etc)?

Yes No

If yes.....

Frequency: **Did you train on a regular basis or randomly?** Regular Randomly

Frequency: **On average, how many strength training sessions did you perform in a week?** _____

Frequency: **How long did you stick to this training?** _____

Frequency: **When did you last strength train?**

This month 1-2 mo ago 3-6 mo ago >6 mo ago

Intensity: **When you strength trained, on average, was your effort....**

Very light Light Moderate Hard Very hard Maximal

Type: **a) What kind of strength training did you do? (i.e. machines, free weights, body weight exercises, medicine balls, tubing, etc.)**

b) Where did you learn the exercises? (self taught, trainer, coach, friend...) _____

Do you have any experiences that you think will help or hinder you in this strength training program? (i.e. specific sporting experience, exercise knowledge...etc)

Appendix E

Physical Activity Enjoyment Scale

When I am active.....

	<i>disagree a lot</i>	<i>disagree</i>	<i>not sure</i>	<i>agree</i>	<i>agree a lot</i>
1. I enjoy it	1	2	3	4	5
2. I feel bored	1	2	3	4	5
3. I dislike it	1	2	3	4	5
4. I find it pleasurable	1	2	3	4	5
5. It's no fun at all	1	2	3	4	5
6. It gives me energy	1	2	3	4	5
7. It makes me depressed	1	2	3	4	5
8. It's very pleasant	1	2	3	4	5
9. My body feels good	1	2	3	4	5
10. I get something out of it	1	2	3	4	5
11. It's very exciting	1	2	3	4	5
12. It frustrates me	1	2	3	4	5
13. It's not at all interesting	1	2	3	4	5
14. It gives me a strong feeling of success	1	2	3	4	5
15. It feels good	1	2	3	4	5
16. I feel as though I would rather be doing something else	1	2	3	4	5

From:

Motl, R. W., Dishman, R. K., Saunders, R., Dowda, M., Felton, G., & Pate, R. R. (2001). Measuring enjoyment of physical activity in adolescent girls. *American Journal of Preventive Medicine*, 21(2): 110-117.

4. Push-ups

Max number _____

5. Sit & Reach

Trial 1 _____ cm Max reach _____ cm

Trial 2 _____ cm

6. Partial Curl-Up

Max number _____ /per minute

7. Vertical Jump

Standing reach _____ cm Max difference _____ cm

Jump trial 1 _____ cm

2 _____ cm

3 _____ cm

8. Back Extension

Max _____ sec

9. Squat Specific Strength

Kettlebell Swing Squat

Load used _____ kg _____ lbs

Repetitions _____

Dumbbell Squat

Load used _____ kg _____ lbs

Repetitions _____

Appendix G Additional Follow-up Questions

Since you are the first group of participants to take part in a Pacific Sport Institute community program, your feedback is very valuable!!

Please take the time to answer the following questions carefully and honestly. Your feedback will be very important in determining the effectiveness of this program.

1) My parents participate in regular physical activity (*check one answer*):

True Unsure Not true

2) How long of a drive is it to Camosun College's Interurban campus from your house (*check one answer*):

about 5 minutes or less
between 6 and 10 minutes
between 11 and 15 minutes
between 16 and 20 minutes
more than 20 minutes

3) What did you like most about this program (*i.e. time of day, facilities, instructors, equipment used, program layout, being able to train with friends*)?

4) What did you like least about this program (*i.e. time of day, facilities, instructors, equipment used, program layout, being able to train with friends*)?

5) What health related (*i.e. physical activity, exercise, nutrition*) programs would you like to see in the future as the Pacific Sport Institute continues to develop and offer more community programming for teens?

6) Did this program change the way you viewed being physically active at all?
*(YES, I now enjoy being active MORE or LESS than I did when I first started the program;
 or NO, this program did not change my enjoyment of physical activity → please comment)*

7) If you missed a training session, what was your reasoning?

I just didn't feel like coming

I was too sore (*from the previous training session*) to participate that day

I was busy with previously arranged commitments (*concerts, sporting events, vacations*)

I injured myself outside of this training program

I injured myself during this training program

I was sick

8) What, if anything, do you feel like you have gained from this program (*i.e. do you feel stronger, more fit, more flexible, better self-esteem, better body image, happier, more energy, etc...*)?

9) a) Did you do any additional strength training sessions (besides the Tuesday & Thursday training sessions over the course of the program – Feb 5 – Mar 27)?

YES, how many? _____

NO

10) Any additional comments?

Appendix H Group Data at Pre- and Post-test

Group Scores for all Fitness Variables at Pre- and Post-Test

	Experimental		Control	
	Pre-test	Post-test	Pre-test	Post-test
Grip strength (kg)	67.40 ± 20.57 (n = 10)	71.30 ± 20.81 (n = 10)	62.78 ± 14.02 (n = 9)	70.22 ± 11.64 (n = 9)
Push-ups (#)	17.70 ± 8.58 (n = 10)	23.70 ± 9.50 (n = 10)	16.89 ± 11.92 (n = 9)	25.67 ± 13.06 (n = 9)
Sit & reach (cm)	27.76 ± 6.01 (n = 10)	30.10 ± 7.23 (n = 10)	29.13 ± 6.71 (n = 9)	34.39 ± 5.31 (n = 9)
Curl-ups (#/min)	34.40 ± 13.46 (n = 10)	42.10 ± 13.55 (n = 10)	39.11 ± 13.33 (n = 9)	49.33 ± 17.01 (n = 9)
Vertical jump (cm)	34.80 ± 9.12 (n = 10)	35.33 ± 7.52 (n = 9)	31.44 ± 9.08 (n = 9)	35.00 ± 10.47 (n = 9)
Back extension (sec)	119.00 ± 31.88 (n = 10)	130.80 ± 24.81 (n = 10)	139.11 ± 45.15 (n = 9)	156.11 ± 49.00 (n = 9)
KB load (lbs)/reps (#)	<i>Load:</i>	<i>Load:</i>	<i>Load:</i>	<i>Load:</i>
	27.00 ± 3.50	26.43 ± 3.78	27.22 ± 3.63	26.88 ± 3.72
	<i>Reps:</i>	<i>Reps:</i>	<i>Reps:</i>	<i>Reps:</i>
	30.20 ± 17.59 (n = 10)	77.71 ± 43.65 (n = 7)	17.22 ± 8.66 (n = 9)	38.88 ± 17.10 (n = 8)
DB load (lbs) /reps (#)	<i>Load:</i>	<i>Load:</i>	<i>Load:</i>	<i>Load:</i>
	31.50 ± 9.14	29.29 ± 8.38	31.11 ± 6.97	31.25 ± 7.44
	<i>Reps:</i>	<i>Reps:</i>	<i>Reps:</i>	<i>Reps:</i>
	10.50 ± 5.40 (n = 10)	21.29 ± 8.69 (n = 7)	10.44 ± 6.35 (n = 9)	18.00 ± 6.59 (n = 8)

Note. All statistics are noted as mean ± standard deviation.

Appendix I

Within Group Differences at Pre- and Post-test

Differences Within Groups for all Fitness Variables at Pre- and Post-test

	Experimental		Control	
	Difference	Sig.	Difference	Sig.
Grip strength (kg)	3.90 ± 6.47	.09	7.44 ± 7.78	.02*
Push-ups (#)	6.00 ± 3.89	.00*	8.78 ± 5.52	.00*
Sit & reach (cm)	2.34 ± 2.99	.04*	5.26 ± 3.93	.00*
Curl-ups (#/min)	7.70 ± 8.19	.02*	10.22 ± 7.41	.00*
Vertical jump (cm)	1.72 ± 2.90	.11	3.56 ± 4.16	.03*
Back extension	11.80 ± 19.76	.09	17.00 ± 39.99	.24
KB load (lbs)	0 ± 0	/	0 ± 0	/
KB reps (#)	45.14 ± 28.13	.01*	21.38 ± 11.76	.00*
DB load (lbs)	0 ± 0	/	0 ± 0	/
DB reps (#)	12.00 ± 7.30	.01*	8.88 ± 5.30	.00*

Note. Difference score calculated by post-test minus pre-test. All statistics are noted as mean ± standard deviation. * represents significance (p<.05)

Appendix J
Individual Fitness Scores at Pre- and Post-Test

CONTROL GROUP

Partici- pant (#)	Grip (kg)		Pushups (#)		Sit&Reach (cm)		Curlups (#/min)		VertJump (cm)		BackExt (sec)		KBlod (lbs)		KBreps (#)		DBlod (lbs)		DBreps (#)	
	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post
47	64	70	32	34	24.0	26.5	28	36	36.0	36.5	120	230	30	/	15	/	30	/	21	/
157	55	79	14	20	35.2	42.0	41	61	30.0	28.0	180	190	20	20	8	20	20	20	4	15
197	65	74	20	22	29.5	38.0	44	40	34.0	46.5	150	129	30	30	9	34	35	35	3	14
207	59	63	9	20	13.5	26.0	24	33	28.0	28.0	135	180	30	30	20	52	35	35	12	13
217	41	53	10	22	33.0	33.0	27	29	24.0	27.0	140	145	25	25	6	11	25	25	5	14
148	52	63	39	52	31.0	38.5	55	70	16.0	21.0	200	180	30	30	30	61	30	30	11	30
178	79	80	7	14	31.0	34.5	54	69	45.5	50.0	82	91	25	25	19	51	45	45	16	21
188	62	60	18	37	30.5	35.0	25	39	27.5	31.0	180	180	30	30	29	35	30	30	6	12
228	88	90	3	10	34.5	36.0	54	67	42.0	47.0	65	80	25	25	19	47	30	30	16	25

EXPERIMENTAL GROUP

Partici- pant (#)	Grip (kg)		Pushups (#)		Sit&Reach (cm)		Curlups (#/min)		VertJump (cm)		BackExt (sec)		KBload (lbs)		KBreps (#)		DBload (lbs)		DBreps (#)	
	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post
126	39	46	15	21	23.7	26.0	18	20	22.0	25.5	155	134	20	20	13	53	20	20	8	31
136	63	63	17	19	24.4	27.5	20	26	24.5	31.0	120	152	30	30	18	36	30	30	15	27
18	81	99	16	15	36.0	33.0	50	60	45.5	/	102	138	30	/	35	/	40	/	11	/
28	100	104	34	41	31.5	34.0	41	42	40.0	37.5	120	130	30	/	15	/	45	/	20	/
58	96	95	26	37	29.0	31.0	51	61	40.5	44.0	97	104	30	30	75	157	40	40	12	31
88	48	54	4	11	34.5	40.5	26	45	21.5	25.0	63	104	25	25	35	64	20	20	4	12
108	77	74	16	19	20.0	20.0	52	43	45.0	47.0	120	128	30	30	31	119	40	40	16	21
98	49	58	14	23	30.5	33.5	21	33	38.0	38.5	95	98	25	25	26	51	30	30	7	10
118	63	65	10	21	30.0	37.5	36	53	33.0	33.5	150	140	25	25	30	64	25	25	3	17
168	58	55	25	30	18.0	18.0	29	38	38.0	36.0	168	180	25	/	24	/	25	/	9	/

Appendix K
Individual Physical Activity Enjoyment Scores at Pre-, Mid-, & Post-Test

CONTROL GROUP

Participant (#)	Pre-PACES	Mid-PACES	Post-PACES
47	71	45	50
157	44	49	50
197	57	43	42
207	74	49	46
217	69	47	48
148	72	56	52
178	55	43	47
188	75	51	52
228	58	44	45

EXPERIMENTAL GROUP

Participant (#)	Pre-PACES	Mid-PACES	Post-PACES
126	58	48	50
136	55	46	49
18	72	48	49
28	77	53	52
58	78	51	50
88	51	51	48
108	80	52	52
98	62	48	52
118	67	46	50
168	71	50	48