Comparison of strength gains over 13 and 26-weeks of Resistance Training in children

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ABSTRACT

The primary aim of this study was to determine if there were significant strength gains achieved by children participating in the Hamilton Wentworth District School Board Sport Academy Program. The secondary aim was to determine if the children participating in the 26-week program achieved greater gains or if a plateau in strength adaptations occurred following the 13-week session. The tertiary aim was to determine if there were varying levels of response to the training stimulus between grade 7, grade 8 and grade 9 subjects. Ninety-eight (98) subjects completed a13-week RT program. 6RM strength testing of the chest press, seated row and leg press were conducted prior to the program. Subjects were tested following the 13-week training stimulus to determine if strength gains were achieved and to assess the variation in strength adaptations between the groups. Forty seven (47) subjects completed 26 weeks of RT. Subjects' strength was tested prior to starting the program, at week 13 of the program and at week 26 of the program to determine the variation in adaptation over a 13 week program versus a 26-week RT program. There were significant ($p<0.05$) gains across strength measures in the sample following 13 weeks of RT. Strength adaptations were not significantly ($p<0.05$) different between groups. The 26-week RT program results showed a significant improvement in all strength measures from pre intervention to 13 weeks. From 13 weeks to 26 weeks grade 8 subjects showed significant gains in both the chest press and seated row exercises while grade 9 subjects showed significant gains across the 6RM seated row, chest press, and leg press measures.

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Chapter 1: Introduction and Theoretical Framework

1.1 Introduction

Observation suggests the number of children participating in sport at early ages is increasing. Although it is important for children and young adults to engage in physical activity, it is equally important to closely monitor muscular imbalances and overtraining resulting from early sport specialization. In the right environment, and with proper supervision and technique execution, strength training for children has been deemed safe and effective and has been approved in various association position papers (American Academy of Pediatrics, 2001; American College of Sports Medicine 2006; American Society of Sports Medicine, 2004; National Strength and Conditioning Association, 2004).

There appear to be increasing numbers of children who specialize in a sport at an early age, train year-round for a sport, and/or compete on an "elite" level (Australian Physiotherapy Association, 2004). The successes of young athletes can serve as a powerful motivator for others to follow. Most Olympic sports have selection processes that attempt to identify future champions and initiate specialized training, often before the prospect finishes elementary school. The lure of a college scholarship or a professional career can also motivate athletes (and their families) to commit to specialized training regimens at an early age. The low probability of reaching these lofty goals does not appear to act as a deterrent to those aspiring to elite levels of competition. To be competitive at an elite level requires training regimens for children that could be considered extreme in relation to those that are required for basic health and fitness, even for adults. The ever-increasing demands for success create a constant pressure for athletes to train longer, harder, more intelligently, and in some cases at an earlier age. The unending efforts to outdo predecessors and outperform counterparts are the nature of competitive sports. The necessary commitment and intensity of training raises concerns about the sensibility and safety of high-level athletics for any young person.

In the past, resistance training (RT) was considered ineffective and potentially harmful. In 1978 Vrijens went so far as to suggest that strength gains can only be achieved by a population that is of a post-pubertal age. The accumulated research since that time indicates that both pre-pubertal boys and girls are capable of improving strength with a period of resistance training. Recommendations suggest that school-aged youth should participate in 60 minutes or more of moderate to vigorous physical activity that is developmentally appropriate, enjoyable, and involves a variety of activities most days of the week (Sewall & Micheli, 1986). Not only is regular physical activity essential for normal growth and development but a physically active lifestyle during the pediatric years may help to reduce the risk of developing some chronic diseases later in life (Ramsay et al, 1990).

Many recent studies have reported that RT can be effective in producing strength gains in prepubescent and adolescent-aged youth beyond those that can be attributed to normal growth and maturation (Benson et al, 2007; Faigenbaum et al, 1993; Falk & Eliakim, 2003, Ramsay et al, 1990).

Research to date has shown that children do not generally incur muscle hypertrophy so it can be stated that strength gains in this population can largely be attributed to neural adaptations such as motor learning, coordination improvements and skill acquisition (Blimkie, 1993; Faigenbaum, 2000; Falk & Eliakim, 2003; Hass et al, 2001). It has been stated that RT has no effect or results in very small improvements in body composition (Faigenbaum et al, 1993; Hass eta l, 2001; Lillegard et al, 1997; Sadre et al, 2001; Siegal et al 1989; Sotherb et al, 2000).

This research is novel because the duration of the program is 26 weeks in length and because the research is looking at a "real life" training experience. Participants in the study are coming form a school-based program, the Sport Academy. They are engaging in strength and conditioning training at McMaster University under the supervision and coaching of certified fitness professionals. The program is a pilot program and the research will contribute to weather the program will become a permanent offering by the school board.

1.2 Purpose of the Study

The primary aim of this study was to determine if there were significant strength gains achieved by individuals participating in the Hamilton Wentworth District School Board Sport Academy Program. The secondary aim was to determine if the subjects participating in the 26-week program achieved greater gains or if a plateau in strength adaptations occurred following the 13-week session. The tertiary aim was to determine if there were varying levels of response to the training stimulus between grade 7, grade 8 and grade 9 subjects.

1.3 Hypothesis

The strength levels achieved in the 13-week program will be greater relative to the base line values. In the 13-week program the gains achieved by the grade 9 students will be greater in relation to grade 7, and grade 8 students. Grade 7 and grade 8 students will achieve similar gains. Lastly, in the 26-week program there will be strength adaptations across all participants from the pre intervention and 13-week results.

Chapter 2: Literature Review

The purpose of this literature review was to identify the current research findings surrounding RT in children and to determine where the gaps are in the research and where further research is warranted. This research review has allowed the study investigator to set the parameters for the study that was conducted. The research will expand on the current knowledge that has been established by leaders in this field. The literature review has evaluated current research looking at the benefits of RT for children, the risks associated with resistance training for children, current RT guidelines, and the physiological mechanisms underlying strength development in the preadolescent population.

2.1 Resistance Training

In addition to the obvious goal of getting stronger, strength-training programs may be undertaken to try to improve sports performance and prevent injuries, rehabilitate injuries, and/or enhance long-term health. Similar to other forms of physical activity, RT has been shown to have a beneficial effect on several measurable health indices, such as cardiovascular fitness, body composition, bone mineral density, blood lipid profiles, and mental health (Abernethy & Bleakley, 2007; Adams et al, 1992). Recent studies have shown some benefit to increased strength, overall function, and mental well-being in children with cerebral palsy (American Academy of Pediatrics, 2000; American Academy of Pediatrics, 2008). There are numerous beneficial effects of RT in general, and for children in particular. Most notably these include an increase in muscle strength (Blimkie et al, 1989; Falk & Tenenbaum, 1996; Pfeiffer & Francis, 1986; Sale, 1989). Other benefits include a potential increase in bone strength, an improvement in body composition, and an improvement in motor skills and performance (Behm et al, 2008). Resistance training is being incorporated into weight-control programs for overweight children as an activity to increase the metabolic rate without high impact. Similar to the geriatric population, strength training in youth may stimulate bone mineralization and have a positive effect on bone density (American Academy of Pediatrics, 2003; American College of Sports Medicine, 2007).

Multiple studies have shown that strength training with proper technique and strict supervision can increase strength in preadolescents and adolescents (American Dietetic Association, 2006; American Orthopedic Society for Sports Medicine, 1988). Frequency, mode (type of resistance), intensity, and duration all contribute to a properly structured program. Virtually all modes of strength training performed at an appropriate prescribed intensity will induce increases in strength within eight weeks and can occur with training as little as once a week, although training twice a week may be more beneficial (American College of Sports Medicine, 2007, Behm et al, 2008). Appropriately supervised programs emphasizing strengthening of the core (focusing on the trunk muscles, eg, the abdominal, low back, and gluteal muscles) are deemed safe for children and theoretically benefit sports-specific skill acquisition and postural control (Behm et al, 2008; American College of Sports Medicine, 2006).Unfortunately, gains in strength, muscle size, and power are lost six weeks after resistance training is discontinued (Abernethy & Bleakley, 2007, Baker, 2002).

In preadolescents, proper resistance training can enhance strength without simultaneous muscle hypertrophy. Such gains in strength can be attributed to a neural mechanism whereby training increases the number of motor neurons that are "recruited" or activated with each muscle contraction (Annesi et al, 2005; Bass, 2000; Behm et al, 2008). This mechanism accounts for the increase in strength in populations with low androgen concentrations, including female individuals and preadolescent boys. In contrast, strength training augments the muscle growth that normally occurs with puberty in boys and girls by actual muscle hypertrophy (Bailey et al, 1996; Bass, 2000; Behm et al, 20081; Behm et al, 2005).

Strength training is a common practice in sports in which size and strength are desirable. Unfortunately, results are inconsistent regarding the translation of increased strength to enhanced youth athletic performance (Abernethy & Bleakley, 2007; Bass, 2000; Bellow & Gehrig, 2006; Benson et al, 2006). Preventive exercise (pre-habilitation) refers to strength-training programs that address areas commonly subjected to overuse injuries, such as providing rotator cuff and scapular stabilization exercises preventively to reduce overuse injuries of the shoulder in overhead sports. There is limited evidence to suggest that prehabilitation may help decrease injuries in adolescents, but it is unclear whether it has the same benefit in preadolescent athletes (Abernethy & Bleakley, 2007; Benson, 1983; Blanksby & Gregor, 1981) and there is no evidence that strength training will reduce the incidence of sports-related injuries in youth. Evidence suggests a possible reduction in sports-related anterior cruciate ligament injuries in adolescent girls when strength training was combined with specific plyometric exercises (American Academy of Pediatrics, 2003). Plyometric exercises enable a muscle to reach maximum strength in a relatively short time span through a combination of eccentric and concentric muscle contractions, such as jumping down from an elevated box and then up onto another (Chu et al, 2006).

2.2 Risks Associated with Strength Training

Much of the concern over injuries associated with strength training come from data from the US Consumer Product Safety Commission's National Electronic Injury Surveillance System (Blanskby, 1983) which has estimated the number of injuries connected to strength-training equipment. The data from the National Electronic Injury Surveillance System neither specify the cause of injury nor separate recreational from competitive injuries that result from lifting weights. Muscle strains account for 40% to 70% of all strength-training injuries, which occur commonly in the hand, low back, and upper trunk (Blanskby, 1983; Blimkie et al, 1989). Most injuries occur on home equipment with unsafe behavior and unsupervised settings (Blanskby & Gregor, 1981). Injury rates in settings with strict supervision and proper technique are lower than those that occur in other sports or general recreational activities at school (Blimkie, 1992; Blimkie et al, 1989).

Youth RT does carry an inherent risk of musculoskeletal injury, yet the risk is no greater than many other sports and recreational activities in which children and adolescents regularly participate. In one study the incidence of sports related injuries in school-aged youth over a one-year period was evaluated (Zaricznyj et al, 1980). RT resulted in 0.7% of 1576 injuries whereas football, basketball, and soccer resulted in approximately 19%, 15% and 2% of all injuries, respectively. In general, injuries related to RT in high school athletes appear to involve the aggressive progression of training loads or improper exercise technique (Brener, 2007; Brown et al, 1983; Jeffries et al, 2007; Ryan & Salciccioloi, 1976). Although data comparing the relative safety of RT, weightlifting, and other sports are limited, one retrospective study evaluating injury rates in adolescents it was revealed that RT and weight lifting were markedly safer than many other sports and activities (Hamil, 1994). The overall injury rate per 100 participant hours was 0.8000 for rugby and 0.0120 and 0.0013 for resistance training and weight lifting (Hamil, 1994). These findings can be partially attributed to the fact that the sport of weight lifting requires a high volume of technical coaching and a gradual progression of training loads which are required to allow for effective learning of the advanced multi-joint lifts. With qualified instruction and a gradual progression through the training program, researchers have reported significant gains in muscular strength without any report of injury when weight lifting movements (snatch, clean and jerk, modified cleans, pulls and presses) were incorporated into a youth RT program (Faigenbaum & Mediate, 2006; Guy & Micheli, 2001; Sailors & Berg, 1987).

Since weightlifting movements involve more complex neural activation patterns than other RT exercises, childhood may be an ideal time to develop the movement patterns and skill technique to perform these lifts correctly (Docherty et al, 1987). Due to the potential for injury during the performance of multi-joint free weight exercises (Roberts et al, 2008), it is extremely important that adequate time is spent with youth to ensure that proper technique is executed and that those instructing are knowledgeable about the progression from basic exercises to skill transfer exercises to the competitive lifts.

Another concern related to youth resistance training is the appropriateness of plyometric training for children and adolescents. Plyometric exercise conditions the body through dynamic movements involving a rapid eccentric muscle action that is immediately followed by a rapid concentric muscle action (Clarkson, 2006; Fatouros, 2000). When the muscle is stretched and shortened quickly the force generated is greater than if the muscle is not pre-stretched before the muscle action (Flannagan, 2002). It has been established that thorough RT programs that include plyometric exercises improve functional capacity, improve movement mechanics and decrease the risk of sports related injuries in young athletes (Hejna et al, 1982; Hewett et al, 2005; Lephart et al, 2005). Research studies indicate that plyometric training can be a safe and valuable method for training children when appropriately prescribed and executed (Dimitrov, 1993; Faigenbaum et al, 2001; Faigenbaum et al, 2004; Ingle et al, 2006; Kotzmanidis, 2006; Lephart et al, 2005; Marginson et al, 2005; Matavulji et al, 2001). Moreover, observation of children and their movement patterns during recreational activities such as skipping, bounding and jumping would elucidate that this type of activity involves eccentric contractions followed quickly by a concentric contraction, which ultimately results in an increase in speed of movement and power production (Chu et al, 2006). However, there is a potential for injury when volume and/or frequency of this high impact training is beyond a participant is capable of. A twelve-year old boy developed exertional rhabdomylosis after he was instructed to perform excessive repetitive squat jumps in a physical education class (Clarkson, 2006).

The most frequently referenced area of concern related to youth RT is the risk of damage to the growth cartilage. Growth cartilage is found at three main sites: the growth plates near the ends of the long bones, the articular cartilage that lines the joint surfaces and the attachment points for major tendons (Micheli et al, 2000). Growth cartilage is more susceptible to damage as a result of repetitive micro trauma because it is weaker than connective tissue (Micheli et al, 2000). If growth cartilage is damaged it can result in an inability to train, pain with participation, and growth impairment (Caine et al, 2006). A few studies from the 1970s and 1980s reported that preadolescents (Gumbs et al, 1982) and adolescents (Benson, 1983; Brenner, 2007, Gumbs et al, 1982; Jenkins & Mintowt-Czyz, 1986; Rowe, 1979; Sailors & Berg, 1987) endured injury to the growth cartilage as a result of resistance training. A number of these injuries can be attributed to poor technique while lifting, lifting beyond the ability of the participant, or lack of appropriate supervision. The potential for injury in preadolescents may be greater than that in adolescents as their growth cartilage may be stronger and as a result better able to resist shearing forces (Micheli, 1988). There is no evidence to suggest that resistance training will be detrimental to long term growth and maturation during childhood and adolescence (Malina et al, 2006).

The risk for repetitive strain injuries is another concern surrounding RT in youth. Determining the incidence of these injuries is difficult as they usually accumulate over time and are frequently left undiagnosed or treated. Surprisingly, the number of adolescents experiencing back pain is approaching the rates in adults (Anderson & Behm, 2004; Jeffries et al, 2007). In a number of studies, high school athletes participating in RT who presented with injury cited back pain as the most prevalent injury (Brenner, 2007; Caine, 2006; Risser et al; 1990). Resistance training can be used as a preventative measure to reduce the incidence of back pain or to decrease the severity as back pain is associated with insufficient strength, muscular endurance and/or stability (Anderson et al, 2006; Sjolie & Ljungren, 2001).

2.3 Guidelines for Resistance Training

Youth RT programs need to be carefully prescribed and progression implemented due to individual differences in physical maturation, training experience, and stress tolerance. All participants should have a desire to participate and should be able to follow coaching and instruction and adhere to safety rules. A pre-participation medical exam is not required for apparently healthy children, but is recommended for youth with suspected health problems (Behm et al, 2008).

Youth participating in RT should receive instruction from health and fitness professionals that have a thorough understanding of youth resistance training guidelines and safety procedures. Professionals should have an understanding of the developmental level of the participant and be able to present information in a way that is appropriate to the individual's level of comprehension. Direct supervision of children and youth participating in RT can result in better program adherence and greater strength gains as compared with unsupervised training (Faigenbaum et al, 1997). Instructors need to be aware of the inherent risks associated with participation in resistance training and should match the abilities of the participant with a program that matches their individual needs and abilities. This notion is especially important for untrained children, as they have been reported to perceive their abilities to be greater than they are (Kraemer, 1989).

A warm-up should be completed prior to resistance training. A warm-up including dynamic movement has been shown to enhance performance in children and adolescents (Faigenbaum & Westcott, 2000; Faigenbaum et al, 2003). Pre-event static stretching has been shown to have a negative impact on lower extremity power and isokinetic peak torque in youth (McNeal & Sands, 2003; Zakas et al, 2006). Dynamic movements require greater attention by the participants and encourage them to focus on instruction (Graham, 2001).

There are a large number of exercises that can be used to enhance strength in preadolescents and adolescents. The exercise should be appropriate to the participant's body size, fitness level, and exercise experience. A variety of equipment such as medicine balls, tubing, Universal machines, free weights and body weight exercises, have been shown to be safe and effective (Annesi et al, 2007; Faigenbaum et al, 2002; Faigenbaum et al, 2008; Falk & Tenenbaum, 1996; Rians et al, 1987; Sailors & Berg, 1987; Sotherb et al, 2000).

Plyometric training has been shown to enhance muscular power in children and adolescents if appropriate training and guidelines are followed (Brown et al, 1986; Diallo et al, 2001; Kotzamanidis, 2006; Lephart et al, 2005; Mandelbaum et al, 2005; Marginson et al, 2005; Matavulj et al, 2005). Plyometric training involves body mass jumping and bounding exercises and weight transfer exercises that are performed quickly and explosively. The neuromuscular system is conditioned to react more quickly in a muscle stretch shortening cycle. As a result, this type of training can result in an increase in speed of young athletes (Christou et al, 2006).

Exercises that require balance should be incorporated into a youth RT program because balance is essential to motor control, efficient movement and injury prevention (Verhagen et al, 2005). Significant relationships between skating performance and a static wobble board balance test have been reported in youth under the age of 19 (Behm et al, 2005). It has been suggested that because balance and coordination are not fully developed in children (Ozmun et al, 1994) balance training could be effective in reducing the risk of injury in children and adolescents. The advantage of training children on an unstable surface is that you can achieve a high activation of muscle fibres without introducing a high relative load (Anderson & Behm, 2004; Behm et al, 2005).

It has been established that appropriate RT programs have no apparent adverse effect on linear growth, growth plates, or the cardiovascular system, (Abernethy et al, 2007; Annesi et al, 2007; Annesi et al, 2005; Blimkie et al, 1996; Bompa, 2000) although caution should be used for young athletes with preexisting hypertension. The potential for additional elevation of blood pressure with strength training is present if participants exhibit poorly controlled blood pressure. Youth who have received chemotherapy with anthracyclines may be at increased risk for cardiac problems because of the cardio-toxic effects of the medications, and RT in this population should be approached with caution (Brenner, 2007). Furthermore, youth with other forms of cardiomyopathy (particularly hypertrophic cardiomyopathy), who are at risk for worsening ventricular hypertrophy and restrictive cardiomyopathy or hemodynamic decompensation secondary to an acute increase in pulmonary hypertension, should be counseled against weight training. Also, individuals with moderate to severe pulmonary hypertension should refrain from strenuous weight training, due to the increase risk for acute decompensation with a sudden change in hemodynamics (British Association of Exercise and Sport Sciences, 2004).

Pre-pubertal children are involved in competitive weightlifting, but philosophies often vary between Western nations and Eastern European nations (Bulgakova et al, 1990). Limited research on weightlifting as a sport has revealed that children have participated with few injuries, (Byrd et al, 2003) and some programs have decreased rates of injury because they require stringent learning of techniques before adding any weight. As with general strength training, strict supervision and adherence to proper technique are mandatory for reducing the risk for injury.

Training intensity and training volume have a direct impact on training adaptations (Kraemer et al, 2006). Although there is not one combination of sets and repetitions that will be optimal for all participants a reasonable approach to starting out would be to work at a low resistance until proper technique is perfected. Participants should begin with 1 or 2 sets of 8-15 repetitions for 8 to 12 exercises (Faigenbaum & Westcott, 2007; Kraemer et al, 1989). Different combinations of sets and repetitions varying from single set protocols with moderate load (Westcott et al, 1995) to programs consisting of multiple sets with higher loads have proven safe and effective for youth (Rains et al, 1987). Children and adolescents can gradually progress and their programs can be systematically varied to stimulate further adaptations to allow for greater gains (Kraemer et al, 1989). Over the long term, program variation and adequate rest will allow for continued strength improvements (Bompa, 2000; Kraemer & Fleck, 2005).

The methods used to evaluate strength changes that are due to the applied training program should also be considered. In some studies the subjects were trained and evaluated using different modalities (Pfeiffer & Francis, 1986; Sewall & Micheli, 1986; Weltman et al, 1987), while in other studies the subjects were evaluated using high RM values (Faigenbaum et al, 2007; Faigenbaum et al, 1993; MacKelvie et al, 2004; Westcott, 1992). Strength changes have also been evaluated by maximal load lifting (1 RM) on the equipment used in training (Benson et al, 2007; Dimitrov, 1993; Faigenbaum et al, 2005; Faigenabum et al, 2003; Horvat et al, 2007; Rowland, 2005; Rowland, 2007; Roberts et al, 2008; Sale, 1989; Voltek et al, 2003).

A number of researchers have not used 1RM testing to evaluate strength adaptations because of the idea that high intensity loading may put subjects at risk for injury. To date, no injuries have been reported as a result of maximum strength testing when appropriate warm ups are conducted and a qualified individual supervises the strength testing.. In one study, 96 children performed a 1RM strength test on one upper body and one lower body weight machine (Faigenbaum et al, 2003). No injuries occurred during the study period and the protocol was reportedly well tolerated by the participants. In a number of other studies children and adolescents performed 1RM strength tests using free weight exercises with no reported incidences (Baker, 2002; Benson et al, 2008; Horvat et al, 2007; Kravitz et al, 2003; Mayhew et al, 2004; Payne et al, 1997). A number of the forces that youth are exposed to in various sporting and recreational activities have greater exposure times and magnitude than the maximal strength tests. As a result it is fair to say that maximal force producing capabilities can be evaluated using 1RM testing when a proper warm up is used and time is spent on the coaching of appropriate technique and detailed procedures for evaluating 1RM strength are reported in research by Faigenbaum et al and Kraemer et al (Faigenbaum et al, 1993; Kraemer et al, 2006).

Certainly, maximal strength testing is appropriate for determining training-induced changes in muscular strength; however, 1RM testing can be very labor intensive and time consuming. In some instances the use of field-based measures may be more appropriate. For example, researchers have documented significant correlations between

1RM testing and field tests such as grip strength and long jump in children (Micheli & Purcel, 2007). However, it is important to note that children or adolescents should not perform 1RM testing when they are not adequately supervised or coached on proper technique due to the risk of injury (Risser, 1990; Roberts et al, 2008).

2.4 Benefits of Resistance Training

In the past RT was not recommended for children because of the thought that it was ineffective in developing strength in children and at the same time could lead to injuries and damage to the growth plates and ultimately result in the premature closing of epiphyses. However, current research suggests that RT can be beneficial to this population (Behm et al, 2008). For instance, RT can contribute to increases in bone mineral density, develop greater muscular endurance and strength, and maintain lean body mass (Bass et al, 1998, Dencker et al, 2006).

There are many health and fitness related benefits associated with regular physical activity in children and adolescents. Participation in regular physical activity is essential for normal growth and development and can play an important role in physical and psychosocial well-being (Faigenbaum, 2007; Hass et al, 2001; Suman et al, 2001). The majority of the pediatric research has focused on activities that enhance cardiorespiratory fitness (Rowland, 2007). However, findings indicate that RT can positively influence several other indices of health and fitness such as body composition in obese youths (Sotherb et al, 2000; Treuth et al, 1998).

The extent to which research supports RT in a number of different health associated characteristics is further being established (Faigenbaum, 2007; Malina et al, 2004; Strong et al, 2005). The argument that both children's and adolescent's health is likely to improve with regular participation in RT is supported by statements from numerous professional organizations (American Orthopedic Society for Sports Medicine, 1988; Behm et al, 2008; British Association of Exercise and Sport Sciences, 2004; Roberts et al, 2008). The potential for these habits to positively influence adult lifestyle should be recognized (Malina, 2001; Mersch & Stoboy, 2003; Telema et al, 2005).

Given that the prevalence of obesity among children and adolescents continues to increase worldwide the potential influence that RT has on body composition has become an area that requires further investigation (Ogden et al, 2006; Wang & Lobstein, 2006). This notion stems from the fact that childhood obesity is a significant risk factor for the development of type 2 diabetes, earlier in life and into adulthood, which is a critical threat to public health (Institute of Medicine of the National Academies, 2005). Certainly, there are a number of other factors that play a role in the development of childhood and adolescent obesity (American Academy of Pediatrics, 2003; Ebbeling et al, 2002). It is becoming evident that obesity in this age group may be attributed to physical inactivity (Ebbeling et al, 2002; Goran et al, 1999).

To abate the occurrence of obesity, it is often prescribed that obese children participate in aerobic activities to encourage weight loss. Aerobic activities such as jogging and skipping can increase the risk of musculoskeletal injuries due to their repetitive weight bearing nature. In addition, obese children's ability to perform aerobic exercise may be hindered by their excess body weight. Furthermore, they often lack the motor skills and confidence to be physically active and they may perceive aerobic exercise to be less stimulating than other activities and may be perceived as uncomfortable. It has been reported that total body fat was inversely related to minutes of vigorous physical activity per day in youth (Dencker et al, 2006) and this highlights the importance of physical activity as an important countermeasure to obesity. It has been reported that this decline in physical activity may start earlier in obese children (Gillis et al, 2006), thus further highlighting the importance of implemented physical activity in children.

It has been suggested that RT may offer improvements in health to children and adolescents (Benson et al, 2008; Faigenbaum et al, 1999; Watss et al, 2005). Obese youth tend to enjoy RT because it is reflective of how children tend to function with short bouts of effort followed by rest and exercises that are commonly performed are more characteristic of how children move and play (Bailey et al, 1995; Graham, 2001). Moreover, numerous studies have reported improvements in body composition in children and adolescents who were obese or at risk for obesity following participation in a RT program or circuit training program (combination of RT and aerobic exercise) (Schwingshandl et al, 1999; Shabi Cruz et al, 2006; Sotherb et al, 2000; Strong et al, 2005; Telama et al, 2005; Wang & Lobstein, 2006; Yu et al, 2005). Certainly it is worth considering a child's initial body composition as one report found that the children with a higher level of adiposity showed a lesser training effect than those with lower levels of adiposity (Falk & Tenenbaum, 1996). This suggests that obese children may require a greater training stimulus to see the same results as those who have less adiposity.

Researchers found that after participating in a 16-week RT program there was a decrease in body fat and an increase in insulin sensitivity in adolescent males who were at risk for obesity (Shabi Cruz et al, 2006). These researchers also reported that ninety-six percent of participants complied with the program which highlights the notion that adherence to RT programs is high in this age group. Others have found that muscular strength is an independent and strong indicator of insulin sensitivity in youth aged 10 to 15 years (Benson et al, 2006). However, further studies are required to determine the effects of RT on metabolic health outcomes in children.

Currently, there is no clear association between regular physical activity and reducing blood pressure in normative youth. Limited data suggest that RT may be effective in reducing hypertension when submaximal loads are used and appropriate exercise techniques are utilized (Hagberg et al, 1984). Researchers have recommended low intensity, high repetition RT for hypertensive adolescents (Zahka, 1987). Acute blood pressure response in children and adults has been reported to be the same (Nau et al, 1990) but dizziness, loss of consciousness and hypertension which have been reported in adults competing in weightlifting have not been reported in children (Faigenbaum et al, 1993; Rians et al, 1987) or adolescents (Hagberg et al, 1984).

Limited data suggest that RT can have a positive impact on the blood lipid profile of children (Sung et al, 2002; Weltman et al, 1987). Because changes in body composition and nutritional factors may influence lipo protein profiles in children this suggests that a well balanced healthy lifestyle including regular activity, positive behaviours, and nutritional education may show the greatest results for improving the blood lipid profile in youth (American Dietetic Association, 2006).

Current observations suggest that childhood and early adolescence may be an opportune time for the bone modeling and remodeling process to respond to the tensile and compressive forces associated with weight bearing activities (Bass, 2000; Hind & Borrows, 2007; Turner & Robling, 2003; Vicente-Rodriguez, 2006). If age appropriate guidelines for RT are followed and nutritional requirements are met participation in a regular RT program can improve bone mineral density during childhood and adolescence (Turner & Robling, 2003; Vicente-Rodriguez, 2006; Virvidakis et al, 1990). Research has shown that there is no detrimental effect of RT on linear growth in children and the adolescent population (Falk & Mor, 1996; Malina, 2006).

Several studies have found that regular participation in sport and fitness programs that include RT can be a strong stimulus for bone formation in youth (Bass et al, 1998; Benson et al, 2006; Dencker et al, 2006; Malina, 2006; Morris et al, 1997; Nichols et al, 2001; Virvidakis et al, 1990; Ward et al, 2005). Adolescent weight lifters have shown levels of bone mineral density (Conroy et al, 1993) and bone mineral content (Virvidakis et al, 1990) well above age-matched norms. In other research it has been found that year round participation in soccer promotes greater bone development than resistance training (Bellow & Gehrig, 2006). The repetitive loading associated with sports such as gymnastics has also produced higher bone mineral density values when compared to age matched control groups (Bass et al, 1998; Ward et al, 2005).

Genetics influence peak bone mass, (Carbonell & Brandi, 2007) but regular participation in high effort activities such as RT can have positive impacts on bone health in children and adolescents. It is apparent that through the prescription of multi-joint moderate to high intensity RT the osteogenic response can be enhanced in children and adolescents. Additional research is required to better define the exercise prescription. It is also important to sustain the activity throughout the lifespan because these training induced improvements in bone health may be lost as a result of detraining (Gustavsson et al, 2003).

Data from adult studies suggest that RT has produced improvements in mental health and well-being (Tucker, 1982; Tucker, 1983). Although it seems reasonable to assume children and adolescents would see similar improvements in mental health it is important to recognize that further research needs to be conducted because of factors like psychological immaturity in children and adolescents relative to an adult population. Limited data suggest that the RT may influence the psychosocial well-being of children (Holloway et al, 1988; Yu et al, 2008). It has been noted that children who participated in a physical activity program that included aerobic activity and RT showed significant improvements in mood and self-appraisal factors (Annesi et al, 2007). In contrast, no significant changes in self-concept were found in children following RT in additional studies (Faigenbaum et al, 1997; Sadres et al, 2001).

Researchers have noted that the socialization and mental discipline of children who engaged in RT programs were similar to team sport participants (Ramsay et al, 1990). Children who engaged in RT programs had improved attitudes toward physical education, physical fitness and lifelong exercise (Wescott, 1979; Westcott, 1992). Overly enthusiastic coaching, intensive training and excessive pressures to perform at a level beyond the individual's capabilities can have a negative effect on youth who are emotionally and psychologically susceptible (American Academy of Pediatrics, 2000; Calfas & Taylor, 1994). Negative experiences around interactions with a coach can lead to unhealthy eating practices (Nattiv et al, 2007) or overtraining syndrome (Brenner, 2007).

From a motor learning perspective, after children and adolescents engaged in a RT program that utilized a variety of training modalities (weight machines, free weights, body weight and medicine balls) improvements in selected motor performance skills were observed (Faigenbaum et al, 2007; Faigenbaum et al, 1993; Falk & Tenenbaum, 1996; Hakkinen et al, 1989; Kraemer & Fleck, 2005; Sewall & Micheli, 1986; Violan et al, 1997). Improvements in motor performance have also been observed following regular participation in plyometric training programs (Brown et al, 1986; Kotzamanidis, 2006; Matavulj et al, 2001; Steben, 1981). Researchers have reported that a combination of RT and plyometrics may be of the most benefit for adolescent athletes (Faigenbaum et al, 2004; Lephart et al, 2005). As observed in adults, the effects of combined RT and plyometric training produced greater improvements than when each program was performed on its own (Adams et al, 1992; Fatouros et al, 2000).

Other studies (Faigenabum et al, 2005; Faigenbaum et al, 1993; Flanagan et al, 2002) reported significant gains in strength without improvements in selected motor performance skills following several weeks of RT training. Because the effects of RT on motor performance are dependent on the design of the training program the specificity of the program should be considered when evaluating the data. As observed in an adult population (Folland & Williams, 2007), children and adolescents show improvements in motor performance skills, such as velocity of movement and contraction type and force, that are trained within the RT program (Hakkinen et al, 1989; Nielson et al, 1980). The principle of specificity appears to apply to both children and adults irrespective of age.

The idea that RT could contribute to the improved sport performance of young athletes seems reasonable. Empirical evidence to support this idea is difficult to produce because athletic performance has so many contributing factors. Two studies (Blanksby & Gregor, 1981; Bulgakova et al, 1990) showed improvements in swim performance following participation in a progressive RT program. Additional studies in young basketball and soccer players have recognized the importance of incorporating RT into sports training sessions in order to maximize gains in both strength and power in young athletes (Christou et al, 2006; Vamvakoudis et al, 2007). Although most published reports and comments from coaches indicate that a well-designed RT program will result in improved sport performance (Faignebaum & Westcott, 2000; Kraemer & Fleck, 2005; Micheli & Purcel, 2007) further research is required. One of the greatest benefits of RT for children may be its ability to better prepare children and adolescents for successful and enjoyable participation in athletic activities (Kraemer & Fleck, 2005).

The number of children participating in structured sports programs continues to increase. Along with the increase in participation comes an increase in reported sports-related injuries to those who are not physically capable or properly trained (American Academy of Pediatrics, 2000; Christou et al, 2006; Emery et al, 2005; Micheli et al, 2000). Sports-related injuries make up a significant number of those children who are hospitalized and incur health care costs (Micheli et al, 2000). Osteoporosis is a skeletal chronic multifactorial disease, characterised by abnormal low bone mass and microarchitectural deterioration of bone tissue. It has been suggested that participation in certain youth sports may increase the risk of developing osteoarthritis later in life in susceptible children because of the wear and tear on bone tissue that is genetically predisposed (Carbonell & Brandi, 2007).

Eliminating sports related injuries is not a realistic goal but having children participate in an appropriately designed and safely progressed RT program may help reduce the likelihood of sports related injuries (Abernethy & Bleakley, 2007; Malina, 2006; Sale, 1989). It appears that a number of children are not physically prepared for the demands of sport participation (Faigenbaum & Westcott, 2000; Sale, 1989). There are many mechanisms, such as proper supervision, safe environments, proper equipment, and progressive programs, to potentially reduce the number of both acute and overuse sport-related injuries in children and it has been suggested that injuries could be reduce by 15% to 50% (Caine et al, 2006).

Appropriate conditioning programs that include RT and/or plyometrics have been shown to be effective in reducing sports related injuries in adolescent athletes (Caine et al, 2006; Faigenbaum, 2007; Lephart et al, 2005; Kraemer et al, 2006; Malina et al, 2004; Prodromos et al, 2007). It is possible that similar effects would be observed in children. Additional research is needed to test this hypothesis. Injuries and their severity were reduced in high school football players (Cahill & Griffith, 1978) and adolescent soccer players (Heidt et al, 2000) when a preseason-conditioning program including RT was undertaken. In other reports in was found that balance training (Faigenabum & Mediate, 2006; Faigenbaum et al, 2005; Verhagen et al, 2005) or a combination of balance and RT (Cahill & Griffith, 1978; Caine et al, 2006) were effective in reducing the number of sports-related injuries in adolescent athletes.

Due to the relatively high rate of young female athletes suffering from knee injuries in comparison to males (Caine et al, 2006) investigators have looked at the effects of different RT programs on injury rates in female subjects. Pre-season conditioning programs that included RT, plyometrics and education on jumping mechanics significantly decreased the number of serious knee injuries in adolescent female athletes (Mandelbaum et al, 2005; Prodromos et al, 2007). Females who engaged in plyometric training during their competitive season showed no significant difference in injury rates compared to a control group (Verhagen et al, 2005). Differences in the program designs as well as the timing of implementation could explain the conflicting results.

The majority of the evidence suggests that regular participation in a pre-season conditioning program that includes RT, plyometrics, balance and education around proper mechanics may reduce the likelihood of sports-related injuries. Only a small sample of the total adolescent sport participants participates in a comprehensive conditioning program (Brooks et al, 2007).

When deciding whether to incorporate a pre-season conditioning program it is important to consider the total exercise dose that the child or adolescent is engaging in because this type of training will contribute to the chronic, repetitive stress placed upon the developing musculoskeletal system. The variation in the rate of musculoskeletal development in adolescents makes the administration of a program difficult, as each participant may not be able to tolerate the same exercises or volume of training. Stress failure syndromes such as traction apophysitis, injuries to joint surfaces and/or injuries to the immature spine may result if daily activity is not taken into account (American Academy of Pediatrics, 2000; Ryan & Salciccioli, 1976; Jeffries et al, 2007).

In the end, it is important that each child must be treated as an individual and observed for signs of injury. Programs may require modification of the training frequency, volume, intensity and progression of training. It may be necessary for young athletes to delay sport participation to allow for preparatory strength and conditioning. A decline in performance and an increase in the risk of injury may be a result of frequent training sessions without adequate rest and recovery between training sessions (Fry & Kraemer, 1997).

There is further research required to determine the effect of RT on "energy" levels, sleep patterns, emotional maturity, immune function, nutritional status, cognitive performance, or health care utilization. It is probable that an RT program would positively affect these factors provided the program is properly designed, enjoyable and rewarding.

2.4 Effectiveness of Resistance Training

During childhood and adolescence factors related to growth and development are in a constant state of evolution. Healthy children will show significant gains in height, weight, maximal oxygen uptake (result of changes in lung volume), anaerobic capacity, and muscle strength (Rowland, 2007). Children do not follow the same rates of change but performance variables such as grip strength normally increase through childhood into the early pubertal years (Malina et al, 2004). As a result, strength changes from low volume, short duration resistance training programs can be difficult to distinguish from those that can be attributed to growth and development (Faigenbaum, 2000; Ingle et al, 2006). In order to differentiate between the adaptations that are a result of the training stimulus and those that are attributed to growth and development the training stimulus must be adequate.

A significant number of studies present evidence that indicates children and adolescents can increase their strength providing that the RT program is of sufficient intensity, volume and duration (Bompa, 2000; Diallo et al, 2001; Faigenbaum et al, 2001; Faigenbaum et al, 2004; Faigenbaum et al, 2002; Faigenbaum et al, 2005; Faigenbaum et al, 1993; Falk & Elkaim, 200; Lillegard et al, 1997; Pfeiffer et al, 1986; Payne et al, 1997; Ramsay et al, 1990; Sadres et al, 2001; Sailors & Berg, 1987; Siegal et al, 1989; Szymanski et al, 2007; Tsolakis et al, 2004; Weltman et al, 1987; Westcott, 1979). In addition to these findings, clinical observations and evidence based reviews indicate increased strength gains beyond those that can normally be attributed to growth and maturation (Blimkie, 1992; Faigenbaum, 2007; Guy & Micheli, 2001; Kraemer & Ratmess, 2004; Malina, 2006; Sale, 1989).

Studies have shown children as young as five have benefited from regular participation in a RT program (Annesi et al, 2005; Faigenabum et al, 1993). Most subject samples spanned several years of age. The majority of training studies span 8 to 20 weeks in length (Faigenbaum et al, 2005; Faigenabum et al, 2002; Falk et al, 2002; Hetzler et al, 1997; Lillegard et al, 1997; Ramsay et al, 1990; Sale, 1989; Siegal et al, 1989; Wedderkopp et al, 2003). Studies lasting two to three school years have been reported (Falk & Tenenbaum, 1996; Sadres et al, 2001). In these studies a wide variety of protocols have been administered from single set sessions using weight machines (Westcott et al, 1995) to more progressive programs utilizing different types of equipment and multiple sets and repetition ranges (Benson et al, 2008; Faigenbaum et al, 2004; Gonzales-Badillo et al, 2005; Ramsay et al, 1990; Sadres et al, 2001). A number of different protocols, contraction types and pieces of equipment have proven to be effective in achieving strength adaptations (Docherty et al, 1987; Faigenbaum et al, 2005; Faigenbaum et al, 2002; Faigenbaum et al, 1996; Payne et al, 1997; Westcott, 1979).

Following eight weeks of RT children have shown strength gains of up to 74%. Typically gains of 30% are observed following short-term RT programs (8 to 20 weeks).

Reported relative strength gains achieved during preadolescence are equal to or greater than the relative gains observed during adolescence (Lillegard et al, 1997; Pfeiffer & Francis, 1986; Westcott, 1992). There is no clear evidence of any major strength difference between preadolescent girls and boys (Blimkie, 1992; Faigenbaum et al, 2003; Sale, 1988). Adult athletes have greater absolute strength then adolescent athletes when (Baker, 2002) and they make greater gains in strength than young adolescents following training (Sailors & Berg, 1987). It appears that adolescents make greater gains than children (Blimkie, 1992; Faigenbaum et al, 2005; Sale, 1988). Findings by Wescott (1979) conflict with this suggestion.

2.6 Physiological Mechanisms for Strength Development

The strength gains experienced by children have been attributed to primarily neural mechanisms (Kraemer et al, 2006; Myer et al, 2005; Ozmun et al, 1994; Rowland, 2005). In comparison to older populations children do not experience the same muscle mass gains as a result of a RT program (up to 20 weeks) (Ozmun et al, 1994; Roberts et al, 2008). Children do not have adequate levels of circulating testosterone to stimulate increases in muscle size (Kraemer et al, 1989), although in young adult males high physiological levels of systemic testosterone do not appear to be required to increase protein synthesis and ultimately muscle hypertrophy following resistance exercise (Stuart Phillips, unpublished results). There are, however, a number of studies that have shown increases in muscle mass in children (Fukunga et al, 1992; Mersch & Stoboy, 1989). As a result a conclusive statement that children will not increase muscle mass with RT is not appropriate. Introducing more sensitive measuring techniques could contribute to determining the effects of RT on fat free mass relative to those associated with gains due to growth and development.

It appears that neural adaptations (Ozmun et al, 1994; Sale, 1988) and possibly intrinsic muscle adaptations (Ramsay et al, 1990) are the primary factors responsible for strength gains during preadolescence. The learning that takes place around motor skill performance and muscular coordination may play a significant role because training induced strength gains are greater than changes in neuromuscular activation (Sale, 1989; Rowland, 2005).

Developmental changes in muscle fiber composition and changes in central inhibitory influences on maximal muscle strength, which are still speculative, should also be considered (Rowland, 2005). Several training studies have reported significant improvements in strength during preadolescence in the absence of hypertophic changes, as compared to a similar control group (Faigenbaum et al, 1993; Lillegard et al, 1997; Payne et al, 1997; Sailors & Berg, 1987).

In pubertal males there are considerable increases in fat free mass and linear growth, which are associated with testicular testosterone secretion (Kraemer et al, 1989; Rowland, 2005). Strength gains that are observed following RT during puberty, in males, may therefore be associated with the presence of testosterone and other hormonal influences (Kraemer et al, 1989). In females, there are smaller amounts of testosterone and as a result the magnitude of hypertrophic gains following resistance training is limited (Rowland, 2005; Sale, 1988). Other hormones and growth factors may be partly responsible for muscle development in females (Kraemer, 1988).

The evaluation of the detraining that takes place in children following the reduction or elimination of a training stimulus is complicated by the growth-related strength increases that are taking place during this time period. Information regarding the effects of detraining on younger populations is not extensive, it does suggest that gains made during the training phase regress to pre training values or those of the control group during the detraining period (Blimkie et al, 1996; Faigenbaum et al, 1993; Ingle et al, 2006; Sewall & Micheli, 1986; Tsolakis et al, 2004). The precise mechanisms of the detraining response are unknown and require further research.

2.7 Neural Adaptations

Due to the limited evidence of muscle hypertrophy in children and its minor relative contribution to strength gains in this population, strength gains have been attributed mainly to neurological adaptations. Neurological adaptations are difficult to define and quantify but have been viewed as modifications in coordination and learning that facilitate more efficient recruitment and activation of muscles involved in specific motor tasks (Folland & Williams, 2007; Sale et al, 1983). Appropriate methods for measurement of neurological adaptations have not been determined and as such neurological adaptations are mainly based on indirect evidence.

When analyzing adaptations achieved in an adult population, indirect evidence of neural adaptations are the disproportionally greater increase in muscle strength in relation to hypertrophic increases in muscle size. In the case of adolescents, there is some hypertrophy demonstrated, but not enough to explain the increase in muscle strength. In children it is inferred that the strength gains are primarily neurological in origin, as they are not accompanied by hypertrophic increases. In the majority of cases, children, adolescents and adults, there is an increase in the specific tension (torque/ size) of the muscle. However, in research by Folland and Williams (2007), this increase in specific tension can be explained not only by neurological adaptations, but also by physical changes such as increases in tendinous stiffness.

In research conducted by Ramsay et al (1990), using the interpolated twitch technique, following 10 weeks of RT subjects demonstrated an increase of 9% and 12% in motor unit activation of the elbow flexors and knee extensors, respectively. Following an additional 10 weeks of RT subjects showed increases of 3% in elbow flexors and 2% in knee extensors. The observed strength changes following the RT stimulus were much greater than the increases in neuromuscular activation. In a study by Ozmun et al (1994), integrated electromyography amplitude (IEMG) was used to show an increase in neuromuscular activation of agonist muscles following 8 weeks of RT in prepubertal boys and girls. The increase in IEMG was smaller than the increase in strength (16.8% in comparison to 27.8%). The increase in agonist activation is likely to result in enhanced force production. The force increase would also be a result of a decrease in antagonist activation, or improved inter-muscular coordination.

Neurological adaptations are believed to occur predominately in the early phases of training (Moritani, 1992; Sale, 1989). In research conducted by Ramsay et al (1990) a greater increase in motor activation in children is found in the first 10 weeks of training in comparison to the second 10 weeks of training, as referenced earlier. In the first phase of training it is likely that learning or improved inter-muscular coordination (agonists, antagonists and synergists) produced the improvements. As suggested by Folland and Williams (2007) the degree of the learning is dependent on prior experience with the specific tasks. This suggests that we would see greater neurological adaptations from participation in RT in children as they have less experience with these tasks than adults have. Due to the lack of morphological changes in children this idea has been identified previously (Blimkie 1989; Sale and Spriet 1996). In adults, low repetition, with high loads have been recommended to increase maximal strength. In 5 to 12 year old children Faigenbaum et al (1999), demonstrated that low load with high repetition and high load, low repetition training resulted in similar strength outcomes. It is therefore unclear as to whether neurological adaptation are due to specific training parameters, as are experienced in adults.

Training induced strength gains in children and adolescents may be explained in part by muscle hypertrophy, but are primarily the result of neurological adaptations (Kraemer et al 1989; Ozmun et al 1994; Ramsay et al 1990).

Chapter 3: Methods

The primary aim of this study was to determine if there were significant strength gains achieved by participants in the Hamilton Wentworth District School Board Sport Academy Program. The secondary aim was to determine if the children participating in the 26-week program achieved greater gains or if a plateau in strength adaptations occurred following the 13-week session. The tertiary aim was to determine if there were varying levels of response to the training stimulus between grade 7, grade 8 and grade 9 subjects.

3.1 Experimental Protocol

Ninety-eight (n=98) subjects (39 girls, 59 boys) were recruited from the Hamilton Wentworth District School Board Sport Academy Program. This program was designed by the Hamilton Wentworth District School Board and McMaster University to promote life long participation in health and fitness. The program was designed to provide an opportunity for children who demonstrate an interest and ability in athletics to develop that ability and to have a flexible curriculum to allow for the pursuit of athletic endeavors. Admittance in the Sport Academy Program required that the applicant have a coach and their principal write a letter of reference on the student's behalf. Applicants were selected from this process and were invited to an assessment day at the host school where a series of fitness tests were administered and formal interviews were conducted. A number of spots were reserved for students who demonstrated financial need. Subjects from a variety of sporting backgrounds and levels of performance were admitted into the program. Following acceptance into the program all participants and their families were invited to a Sport Academy Program information night at McMaster University. At this point a presentation was given about the goals of the program and its design, and the opportunity to participate in the research study was explained. Families were given letters of invitation and consent forms to be signed by both the participants and their guardians for participation in the research. Groups trained at McMaster University once per week and at their home schools once per week. Grade 7 students trained on Mondays, Grade 8 students on Tuesdays and Grade 9 students on Wednesdays. Due to the size of the group and limited space and equipment available to train with these larger groups participants were randomly assigned into training groups with a ratio of six to eight participants to one certified personal trainer. The program was divided into four different full body workouts with the groups rotating through one of the workouts each week at McMaster (Appendix D). The participants completed a full body circuit at their home school on one additional day (Appendix D). The participants completed one workout at McMaster and one workout at their home school under the supervision of a physical education teacher. The Brock University Research Ethics Board (REB) approved the research study. After receiving acceptance through the Brock University REB, McMaster University's REB and the Director of Athletics and Recreation gave written permission for the study to take place. The Hamilton Wentworth District School Board's research body approved the study and requested that a presentation of the study's findings is made to school board officials upon completion.

Participants in the study came from a variety of sporting backgrounds and competitive levels. Many participants were multisport athletes competing in more than one competitive season at any given time. A small percentage of the sample were sport specialized (gymnasts, dancers and figure skaters). The majority of participants competed in team sports such as basketball, hockey and soccer. We did have individual sport athletes such as gymnasts, dancers, swimmers, downhill ski racers, boxers and track and field athletes.

Table 3-1. Subject Characteristics

	Grade 7 (N=51; M=27, F=24)	**Grade 8 (N=21; M=15, F=6)**	**Grade 9 (N=26; M=17, F=9)**
Age (years)	*Pre* **11.7±0.1** *13 wks* **12.5±0.1**	*Pre* **12.5±0.1** *13 wks* **13.1±0.1** *26 wks* **13.5±0.1**	*Pre* **13.5±0.1** *13 wks* **14.1±0.1** *26 wks* **14.5±0.1**
Height (cm)	*Pre* **156.3±1.4** *13 wks* **157.7±1.5**	*Pre* **157.5±2.1** *13 wks* **160.2±2.3** *26 wks* **161.3±2.2**	*Pre* **171.4±2.1** *13 wks* **171.6±1.9** *26 wks* **172.4±1.8**
Weight (kg)	*Pre* **48.2±2.3** *13 wks* **49.2±1.7**	*Pre* **49.1±2.0** *13 wks* **52.1±2.5** *26 wks* **51.7±2.2**	*Pre* **59.9±1.7** *13 wks* **61.6±1.8** *26 wks* **61.4±1.5**
Body Fat (%)	*Pre* **17.5±2.9** *13 wks* **15.4±3.1**	*Pre* **16±5** *13 wks* **15.2±4.5** *26 wks* **17.3±4.9**	*Pre* **17.2±4.9** *13 wks* **16.3±3.8** *26 wks* **17.8±4**
BMI	*Pre* **19.7±4.3** *13 wks* **19.72±2.49**	*Pre* **20.7±4.3** *13 wks* **20.1±2.5** *26 wks* **19.8±2.7**	*Pre* **21.6±5.8** *13 wks* **21.9±5.7** *26 wks* **21.9±5.6**
LBM (kg)	*Pre* **39.26±10.4** *13 wks* **41.47±6.42**	*Pre* **43.8±7.5** *13 wks* **44.2±8.8** *26 wks* **43.2±8.4**	*Pre* **49.4±6.0** *13 wks* **51.4±6.9** *26 wks* **50.5±6.1**

BMI=body mass index; LBM= lean body mass. All values are means ± SD.

3.2 Training Groups

Training groups were created based on grade (grade 7, grade 8 and grade 9). They were divided by grade because the program was structured around their school schedules. In the grade 7 group there were twenty-seven (27) male subjects and twenty-four (24) female subjects. In the grade 8 group there were fifteen (15) male subjects and six (6) female subjects. In the grade 9 group there were seventeen (17) male subjects and nine

(9) female subjects. The mean age, at the beginning of the program, of the grade 7 students was 11.7 years, grade 8 students mean age was 12.5 years and grade 9 students mean age was 13.5 years. Grade 7 participants were broken into two groups or classes by their teachers with the first group of grade sevens, referred to as 7(3), training at McMaster for the first 13-week session and the second group, referred to as 7(4), attending the second 13-week session. They were divided into two groups because two classes of grade 7 students were admitted into the program instead of the originally agreed upon group of 25 students. As a result one group of grade 7 students, 7(3), attended the first 13-weeks of the program and the second group of grade 7 students, 7(4), attended the second 13-week session. Within these larger groups participants were randomized into smaller training groups of six to eight participants working with one certified personal trainer. Training groups stayed the same throughout the program with one of six different certified personal trainers working with each group each week. Grade 8 and Grade 9 students trained over the full length of the 26-week program.

3.3 Training Protocol

Subjects participated in a 13-week RT program with 6RM strength testing conducted at week one and week thirteen of the Sport Academy Program. Grade 8 and grade 9 subjects continued on for a second session of RT with a third and final 6RM strength testing conducted at week twenty-six. See Figure 3-1 Program Schematic.

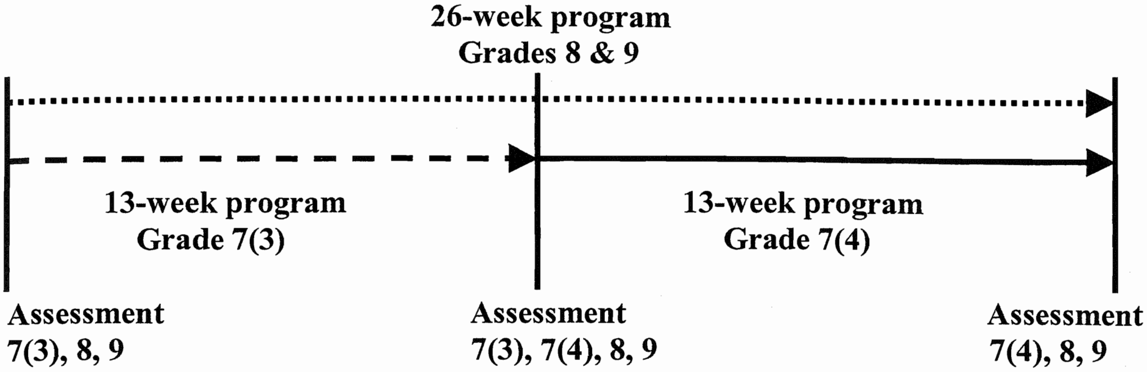

Figure 3.1. Sport Academy Program Schematic

Subjects participated in a twice-weekly strength and conditioning training program for the duration of the study. Grade 7 subjects were broken up into two separate training groups with the 7(3) group training for the first 13-weeks and 7(4) training for the second 13-weeks. The two separate sessions were administered as a result of an enrollment error by the school board. Double the participants were accepted into the program. One training session was administered at McMaster University and the second session at the participant's home school under the supervision of a physical education teacher. Each session was 90 minutes in duration and consisted of a warm-up, strength training, aerobic/anaerobic conditioning and flexibility training.

Day 1	Day 2	Day 3	Day 4
Medicine Ball Workout	**Dumbell Workout**	**BOSU/ Stability Ball Workout**	**Cable/ Plyometrics Workout**
Squat	Squat	Squat	Plyo-Squat
Stationary Lunge	Reverse Lunge	Lateral Lunge	Single leg hop
Chest Pass	Pec-Fly	Push-up	Pec-Fly Cable
Overhead Toss	Row	Back Extension	Row Cable
Underhand Toss	Lateral Raise	Shoulder Raise	Shoulder Press Cable
Under hand Rotation Toss	Bicep Curl	Hammer Curl	Bicep Curl Cable
Sit up	Supine Tricep Extension	Overhead Tricep Extension	Tricep Extension Cable
V-sit with rotation	Crunch	Partner Push	Decline Chop Cable
Low Back Extension	Contralateral Crunch	Hand Tracking	Incline Chop Cable

Table 3-2. List of sample exercises for the four days of full body RT exercises included in the program

Warm-ups were done as a large group and consisted of a five to ten minute full body aerobic activity and dynamic movement patterns such as carioca, grape vine, backward and lateral movement patterns. Participants moved into their smaller groups and did their respective programs. The programs were broken up into four different full body resistance training workouts and cardiovascular activities varied with each of the programs. As shown in Table 3-2, each of the full body resistance training days included exercises to target: the back, chest, legs, arms and core (abdominals and muscles of the low back). A variety of apparatus was used to engage the participants such as free weights, stability balls, BOSU balls, cables, tubing, aerobic steps and body bars. Participants lifted in a repetition range of 8-10RM, 10-12RM, or 12-15RM and lifted for 2 to 3 sets depending on the week of the program and the exercise. If the participant did not feel challenged or if they were able to lift two additional repetitions without a failure in technique beyond the repetition range for two consecutive workouts the weight was increased. Workouts were structured as circuits with active recovery built in between exercises that targeted the same muscle groups.

Cardiovascular conditioning consisted of a 20-minute interval session of either running, skipping, cycling or ladder drills. Flexibility training was done over a 15-min time frame and included static stretching for the full body. Flexibility sessions were done as an entire group and were led by a certified personal trainer. Flexibility training included Ashtanga or flow style yoga, static stretching (30 second hold), and proprioceptive neuromuscular facilitation (PNF) with antagonist contraction for 6 seconds and agonist stretch being held for 30 seconds. PNF stretches were repeated 3 times. Static stretches were done for one pass and yoga poses were done in the form of sun salutations and were repeated 2 - 3 times.

3.4 Anthropometric Measurements

Height, weight and skinfold measurement's were taken at week one, week thirteen and week twenty-six of the program. This allowed the researcher to identify Growth and maturation changes that may have had an impact on the strength adaptations. Increases in lean body mass (LBM) have been highly correlated with strength gains in adults and by subtracting participants body fat from their weight we were able to track LBM changes that over the course of the study. A series of two trials of height and weight measures were taken on each of the testing days and values for height (cm) and weight (kg) were recorded for each participant by averaging the two measures. Skinfold measurements were taken on the right side of the body at the tricep and calf. Two measures were taken at each of the testing sites. If the measure varied by greater than 0.2mm then a third measurement was taken and an average of the two closest measures was the accepted value. Body Mass Index (BMI), body fat percentage and Lean Body Mass (LBM), in kilograms, was determined according to equation 1, 2 and 3 as listed below.

Equation 1: BMI=weight (kg)/ height $(m)^2$.

Equation 2: (Earle & Baechle, 2004)

BF% boys = (sum of 2 SKF (tricep+calf)*.735

BF% girls = ((sum of 2SKF(tricep+calf))*.610) +5.1

Equation 3: Fat Mass = Body Mass (kg) * BF%

LBM (kg) = Body Mass (kg) – Fat Mass (kg)

3.5 Strength Measurements

Strength adaptations were determined using 6RM testing protocols for the seated row, seated chest press, and the leg press. All testing was conducted on Universal machines that loaded appendages unilaterally. These tests were administered as determinants of base level strength coming into the program and were administered at week 13 and week 26 of the program to track changes in strength. We chose to examine

6RM as opposed to 1RM testing due to concerns around the safety of the participants. Although research has shown that children are capable of safely completing 1RM testing (Gaul, 1996) these studies were done in a much more controlled environment than was available during this research study. Sport Academy participants were tested in the University fitness centre where a number of potential distractions are present and for this reason we chose to utilize a 6RM protocol (Payne et al, 1997; Kraemer et al, 2006).

During the 6RM testing participants performed a warm-up set of 10-repetitions of a very light resistance. The warm-up set allowed for coaching of the participants on proper technique and safety. A conservative near maximal load, as determined by the personal trainer, was lifted for 6 repetitions. A two-minute rest period was given between sets and 5lbs to 10lbs were added to the upper body exercises or 10lbs to 15lbs on the lower body exercises until failure or a break in technique was reached. The greatest load that the participant completed for 6-repetitions prior to failure was the value recorded by the personal trainer.

3.6 Statistical Analysis

Grade 7, 8 and 9 data from the 13-week Sport Academy program for the 6RM chest press, seated row and leg press were compared using a two way analysis of variance (ANOVA). The two factors being assessed were time and strength changes. Pre strength values were compared to post Sport Academy participation strength values to determine whether each group achieved significant strength gains. A Tukey post-hoc analysis was used to confirm significance and to isolate where significant change was found.

Grade 8 and grade 9 data from the 26- week Sport Academy program for the 6RM chest press, seated row and leg press were compared using a two way repeated measures

ANOVA. A one-way ANOVA was used to compare percentage and absolute change in strength from pre-intervention to 13 weeks and 26 weeks. A Tukey post-hoc analysis was used to locate significant differences. Significance was accepted as $p<0.05$.

A hierarchical linear regression was utilized to predict change in strength over 13 and 26 weeks of intervention based on changes in LBM and the grade of the subjects.. Separate multiple regressions analyses were used to test the impact of LBM, pre intervention strength values and the grade of the subject on strength changes. In step one, we controlled for baseline variables pre intervention strength and LBM measures. In step two, we controlled for prediction variables such as change in strength, change in LBM, and the grade the participant was in.

Chapter 4: Results

A total of 98 participants were included in the data analysis. An overview of subject characteristics is shown in Table 3-1. Each group's mean age, sex, height, weight, body fat percentage, body mass index (BMI) and lean body mass (LBM) are presented in Table 3-1. These values were taken prior to the intervention, at week 13 of the intervention and for the grade 8 and grade 9 participants at week 26 of the intervention.

All research participants engaged in a strength and conditioning program two times per week. The researcher supervised one session per week and one session was done at the subject's home school under the supervision of a teacher. Participants were split up into groups of between five and eight students to a personal trainer. The program was made up of a series of four different full body RT workouts and participants rotated through workouts each week. Each of these workouts is presented in Table 3-2. Figure 4-1 represents the 6RM chest press strength changes in grade 7, grade 8 and grade 9 subjects over the 13-week exercise training study. Significant gains ($p<0.05$) in strength in the 6RM chest press were found in grade 7, grade 8 and grade 9 subjects. Absolute mean strength measures showed the grade 9 students being stronger than the grade 8 students and the grade 8 students being stronger than the grade 7 students. When looking at strength gains relative starting points there was no significant ($p<0.05$) difference between groups.

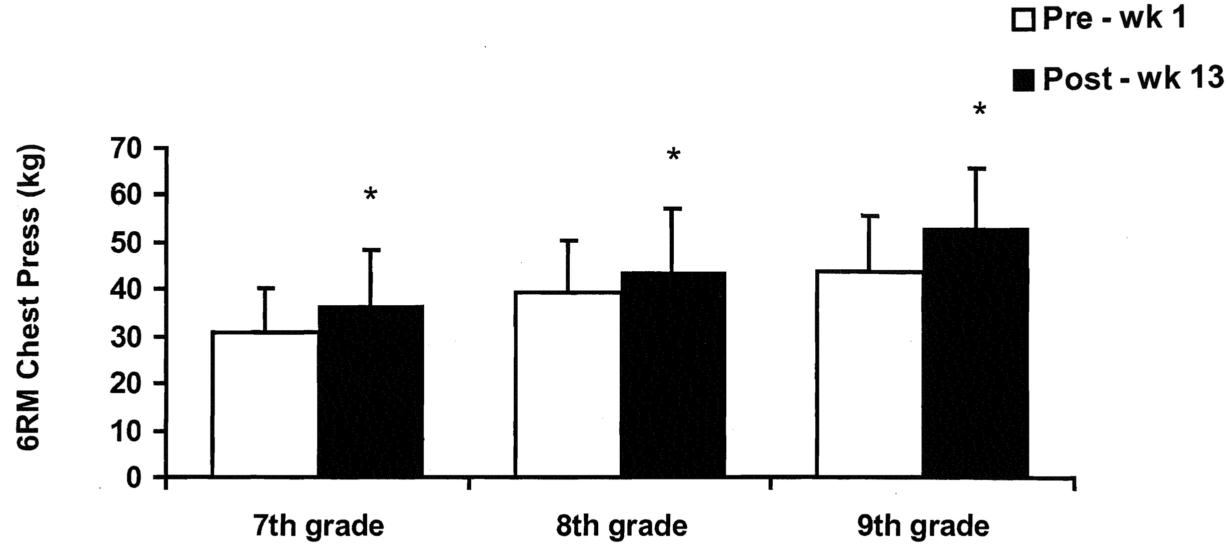

Figure 4-1. 6RM Chest Press strength adaptations made over 13-weeks of strength and conditioning training in grade 7, grade 8 and grade 9 Sport Academy participants. All values are expressed as mean ±SD. * Denotes significant difference ($p<0.05$) from pre intervention values.

Figure 4-1 represents the 6RM chest press strength changes in grade 7, grade 8 and grade 9 subjects over the 13-week exercise training study. Significant gains ($p<0.05$) in strength in the 6RM seated row were found in grade 7, grade 8 and grade 9 subjects. Absolute mean strength measures showed the grade 9 students to be stronger than the grade 8 students and the grade 8 students being stronger than the grade 7 students. There was no significant ($p<0.05$) difference between groups when looking at relative strength gains.

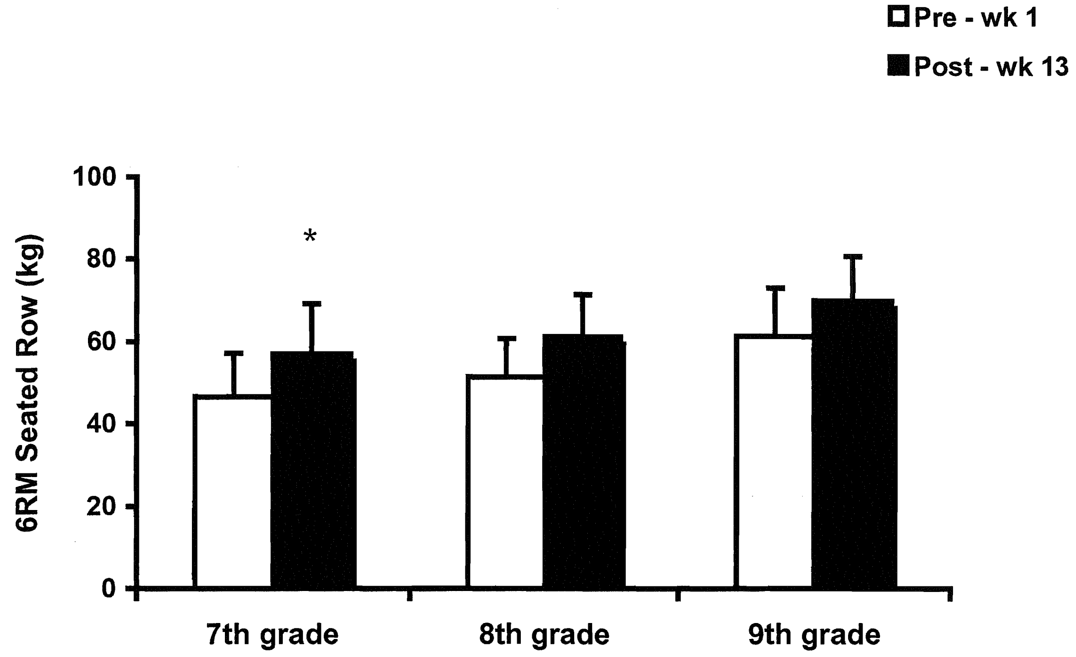

Figure 4-2. 6RM Seated Row strength adaptations made over 13-weeks of strength and conditioning training in grade 7, grade 8 and grade 9 Sport Academy participants. All values are expressed as mean ±SD. * Denotes significant difference ($p<0.05$) from pre intervention values.

Figure 4-2 represents the 6RM seated row strength changes in grade 7, grade 8 and grade 9 subjects over the 13-week exercise training study. Significant gains ($p>0.05$) in strength in the 6RM seated row were found in grade 7, grade 8 and grade 9 subjects. Absolute measures showed the grade 9 students being stronger than the grade 8 students and the grade 8 students being stronger than the grade 7 students. However, there were significantly greater ($p>0.05$) strength gains achieved in the leg press by grade 9 subjects relative to grade 7 and grade 8 subjects.

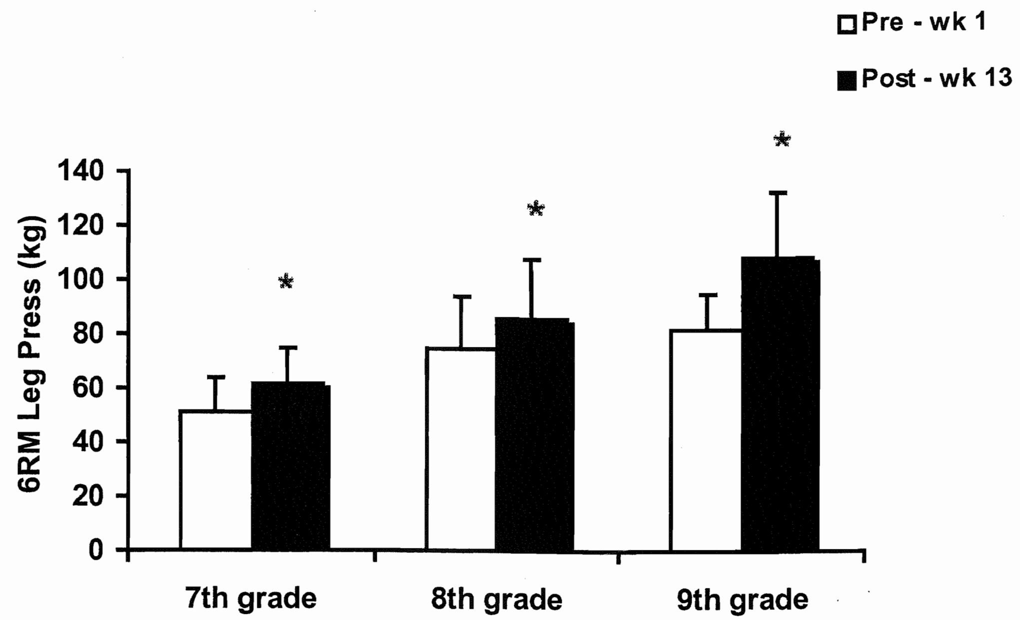

Figure 4-3. 6RM Leg Press strength adaptations made over 13-weeks of strength and conditioning training in grade 7, grade 8 and grade 9 Sport Academy participants. All values are expressed as mean ±SD. * Denotes significant difference ($p<0.05$) from pre intervention values.

Figure 4-3 shows the strength adaptations achieved by grade 8 and grade 9 subjects in the 6RM leg press over a 26-week strength and conditioning program. Grade 8 and grade 9 subjects showed significant ($p<0.001$) improvement in 6RM strength in the chest press from pre intervention to week 13 assessment values. Grade 9 subjects had significantly ($p<0.05$) greater strength adaptations at week 13 in the chest press than those achieved by grade 8 subjects. At week 26 there were significant ($p<0.05$) strength adaptations in both grade 8 and grade 9 subjects in comparison to week 13 values.

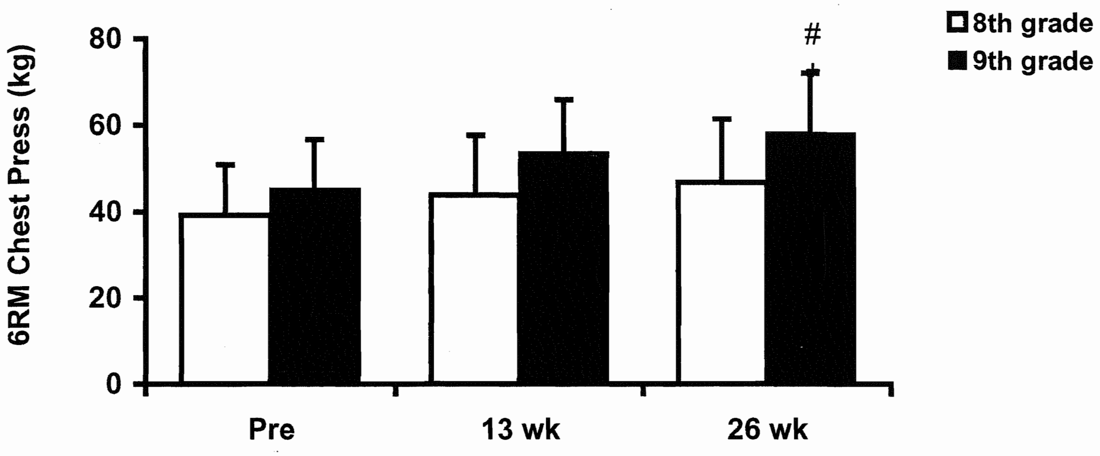

Figure 4-4. 6RM chest press strength changes in grade 8 and grade 9 subjects over the twenty-six week exercise training study. Values are means ± SD. * Significantly different from pre ($p<0.001$). # Significantly different from 8th grade initial values ($p<0.05$). + Significantly different from 13-week values ($p<0.05$).

Figure 4-4 shows the strength adaptations achieved by grade 8 and grade 9 subjects in the 6RM Chest Press over a 26-week strength and conditioning program. Grade 9 subjects were significantly ($p<0.05$) stronger in the 6RM seated row at the pre intervention assessment. Grade 8 and grade 9 subjects showed significant, ($p<0.001$), improvement in 6RM strength in the chest press from pre intervention to week 13 assessment values. Grade 9 subjects had significantly, ($p<0.05$), greater strength adaptations at week 13 in the seated row than those achieved by grade 8 subjects. At week 26 there were significant ($p<0.05$) strength improvement in both grade 8 and grade 9 subjects in comparison to week 13 values.

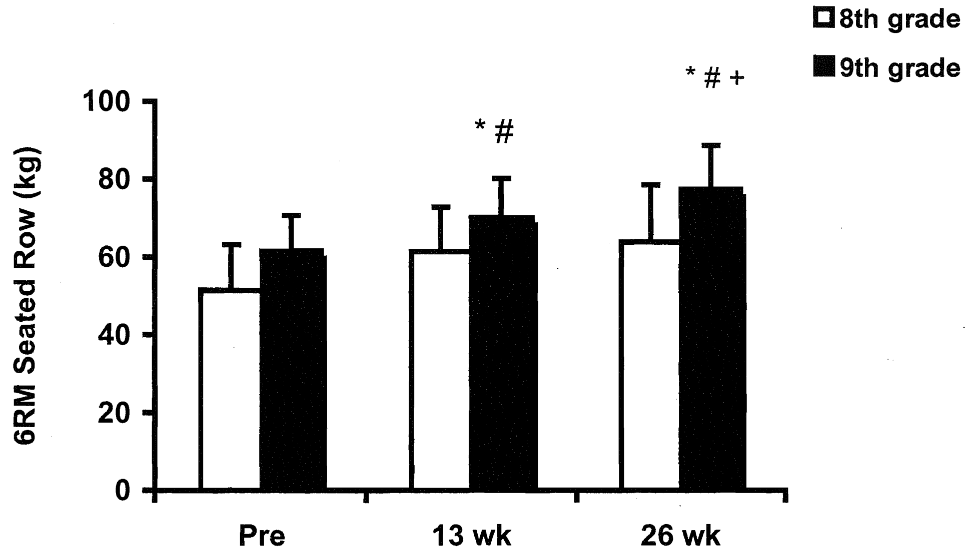

Figure 4-5. 6RM seated row strength changes in grade 8 and grade 9 subjects over the twenty-six week exercise training study. Values are means ± SD. * Significantly different from pre ($p<0.005$). # Significantly different from 8th grade initial values ($p<0.05$). + Significantly different from 13-week values ($p<0.05$).

Figure 4-5 shows the strength adaptations achieved by grade 8 and grade 9 subjects in the 6RM seated row over a 26-week strength and conditioning program. Grade 8 and grade 9 subjects showed significant ($p<0.001$) improvement in 6RM strength in the seated row from pre intervention to week 13 assessment values. At week 26 there were significant ($p<0.05$) strength improvements in the seated row in the grade 8 and grade 9 subjects in comparison to week 13 values.

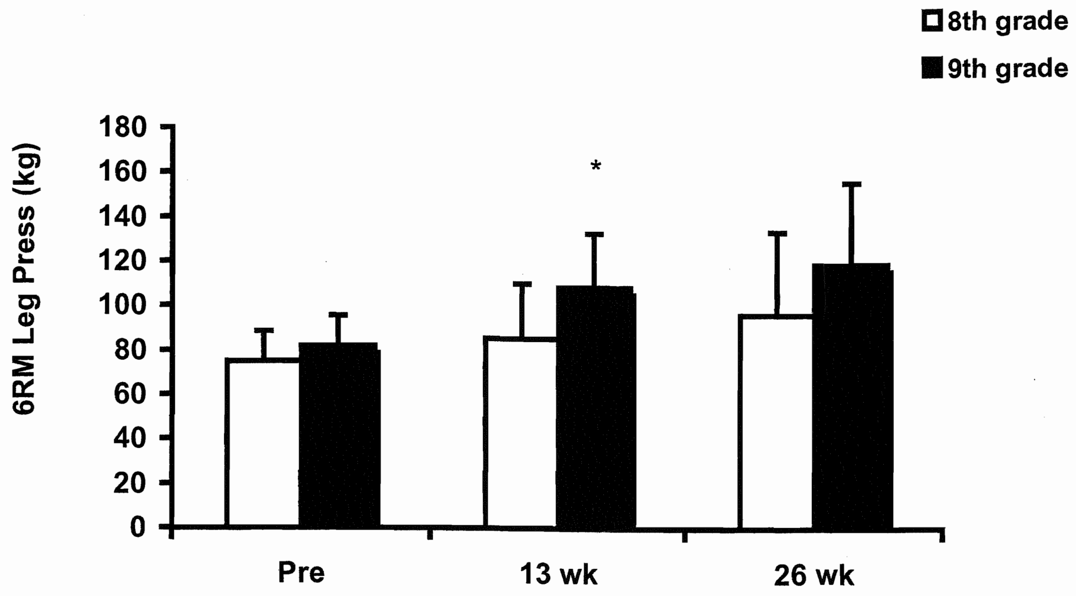

Figure 4-6. 6RM leg press adaptations in grade 8 and 9 participants over the 26 week exercise training study. Values are means ± SD. * Significantly different from pre ($p<0.001$). + Significantly different from 13-week values ($p<0.05$).

Figure 4-6 shows the strength adaptations achieved by grade 8 and grade 9 subjects in the 6RM leg press over a 26-week strength and conditioning program. Grade 8 and grade 9 subjects showed significant ($p<0.05$) improvement in 6RM strength in the leg press from pre intervention to week 13 assessment values. At week 26 there were significant ($p<0.05$) strength improvements in the leg in the grade 9 subjects in comparison to week 13 values.

Table 4-1 Descriptive statistics for LBM, 13-week 6RM values and 26-week 6RM values

	7th grade		8th grade		9th grade	
	Mean	SD	Mean	SD	Mean	SD
Pre LBM	39.3	10.4	43.8	7.5	49.4	6.0
13 Week LBM	41.5	6.4	44.2	8.8	51.4	6.9
26 Week LBM	NA	NA	43.2	8.4	50.5	6.1
Pre Intervention						
6RM CP	30.75	9.47	39.09	11.31	45.05	11.48
6RM Row	46.47	10.46	51.42	9.28	61.01	11.07
6RM LP	57.47	7.94	75.00	18.97	82.02	13.57
13 Week						
6RM CP	36.22	12.05	43.66	13.71	53.56	12.24
6RM Row	57.03	12.18	61.24	10.04	70.04	11.00
6RM LP	65.32	12.73	85.76	22.06	108.97	24.69
26 Week						
6RM CP	NA	NA	42.23	11.66	58.26	14.24
6RM Row	NA	NA	71.42	14.74	77.36	11.36
6RM LP	NA	NA	123.53	37.35	119.45	36.78

Abbreviations: LBM, lean body mass; CP, chest press; LP, leg press; SD, standard deviation

Table 4-1 contains descriptive statistics for mean values and standard deviations for LBM, 6RM Chest Press, 6RM Row and 6RM Leg Press at pre-intervention, 13 weeks and 26 weeks in grade 7, grade 8 and grade 9 subjects.

Table 4-2 Hierarchical linear regression predicting change in 6RM strength over 13 and 26 weeks in the 6RM chest press

	$R^2 \Delta$	R^2	P	ß	ES
13 weeks					
Step 1					
Pre I LBM	.912	.912	< .000	.819	.32
Pre I CP				.000	
Step 2					
Change LBM	.004	.916	< .184	.068	
Grade				.861	
26 weeks					
Step 1					
Pre I LBM	.762	.762	< .000	.416	.32
Pre I CP				.000	
Step 2					
Change LBM	.015	.776	< .330	.488	
Grade				.147	

Abbreviations: LBM, lean body mass; I, intervention; CP, chest press; ES, effect size

Table 4-2 contains descriptive statistics for the 6RM chest press strength adaptations and the degree of variance that could be explained by the grade of the subjects, pre intervention strength values and the changes in LBM across the 13 weeks and 26 weeks of the intervention. At week 13 the pre intervention 6RM chest press strength measures were significantly related ($p < .000$) to strength adaptations and there was a trend ($p < .184$that LBM was related. At week 26 the pre intervention 6RM row values ($p < .000$) were significantly related to strength adaptations.

Table 4-3 Hierarchical linear regression predicting change in 6RM strength over 13 and 26 weeks in the 6RM row

	$R^2 \Delta$	R^2	P	ß	ES
13 weeks					
Step 1					
Pre I LBM	.796	.769	< .000	.584	.39
Pre I Row				.000	
Step 2					
Δ LBM	. 032	.776	< .009	.004	
Grade				.110	
26 weeks					
Step 1					
Pre I LBM	.830	.789	< .000	.289	.48
Pre I Row				.000	
Step 2					
Δ LBM	.048	.800	< .009	.002	
Grade				.633	

Abbreviations: LBM, lean body mass; I, intervention; ES. effect size

Table 4-3 contains descriptive statistics for the 6RM row strength adaptations and the degree of variance that could be explained by the grade of the subjects, pre intervention strength values and the changes in LBM across the 13 weeks and 26 weeks of the intervention. At week 13 the pre intervention strength measures and the change in LBM were significantly, ($p< .009$), related to the strength adaptations in the 6RM row. At week 26 pre intervention strength measures and the change in LBM were again shown to have a significant correlation to strength adaptations ($p < .009$).

Table 4-4 Hierarchical linear regression predicting change in 6RM strength over 13 and 26 weeks in the 6RM leg press

	$R^2\Delta$	R^2	P	ß	ES
13 weeks					
Step 1					
Pre I LBM	.799	.799	< .000	.957	.39
Pre I LP				.000	
Step 2					
Change LBM	.023	.821	< .028	.252	
Grade				.009	
26 weeks					
Step 1					
Pre I LBM	.373	.373	< .000	.931	.59
Pre I LP				.001	
Step 2					
Change LBM	.088	.461	< .089	.693	
Grade				.030	

Abbreviations: LBM, lean body mass; I, intervention; LP, leg press; ES, effect size

Table 4-4 contains descriptive statistics for the 6RM leg press strength adaptations and the degree of variance that could be explained by the grade of the subjects, pre intervention strength values and the changes in LBM across the 13 weeks and 26 weeks of the intervention. At week 13 the pre intervention strength measures and the grade of the participants were significantly, ($p< .028$), related to the strength adaptations in the 6RM row. At week 26 pre intervention strength measures and the grade of the participants were again shown to have a significant correlation to strength adaptations ($p < .089$).

Chapter 5: Discussion

5.1 Study Design

The current study was novel because the intervention was 26 weeks in length with previous studies being predominantly 8 to 20 weeks. Because the research was conducted on participants in the Sport Academy program the research was conducted in a "real-world" situation. Specifically, the study was 26 weeks in length and the previous longest documented training study in this population was 20-weeks. It should be noted that the Sport Academy program was an existing program and this study was structured to fit into the parameters of the program.

5.2 Body Composition Changes

We report here that there were significant strength adaptations achieved by study participants in all strength measures across 13 weeks of RT. Participants in the 26-weeks of RT showed significant strength gains in the chest press, seated row and grade 8 subjects in the leg press. Also, there were no significant changes in the grade 9 subjects leg press and there were no significant ($p<0.05$) changes in anthropometric measures which included; height (cm), weight (kg), BMI, and LBM (kg). When we ran the hierarchical linear regression we found that the changes in the LBM over 13 and 26 weeks were strongly related to strength changes in the 6RM row and there was a trend at 13 weeks in the chest press. In a research study by Sadres et al (2001), subjects engaged in RT twice weekly for a period of 21 weeks and a control group participated in regular physical education classes. Similarly, in this research study participants engaged in a long term training study with RT sessions twice per week and as in Sadres study there were no significant anthropometric changes in subjects.

In a review by Malina (2006), RT studies showed significant improvements in muscular strength during childhood and adolescence. Growth, height and weight as well as changes in body composition were variable and quite small in research subjects in this study. It has been suggested that strength gains in the absence of morphological changes can be attributed to neural adaptations, such as motor learning and motor recruitment. Further research and more precise measures (i.e., magnetic resonance imaging) of determining morphological changes are required to determine if there are mechanisms for tissue changes and their exact contribution to the strength adaptations achieved. Further research utilizing more sensitive anthropometric measures are required. For example, utilizing magnetic resonance imaging, a Bod Pod or taking muscle and or tendon biopsies to get a more detailed picture of the tissue changes in the participants with training in order to pinpoint mechanisms for these strength adaptations.

5.2 Strength Adaptations

It is generally accepted that RT can successfully and safely increase muscular strength (Blimkie, 1992; Blimkie 1993; Kraemer et al, 1989). In 1997, Payne et al conducted a meta-analysis of 28 studies looking at the impact of RT in children under the age of 18 years. These studies showed similar relative gains in children and adolescents to those that can be observed in young adults. In accordance with the meta-analysis presented by Payne et al, the findings in the 13-weeks RT phase of the program found grade 7, grade 8 and grade 9 subjects showed significant strength gains in the 6RM chest press, the 6RM seated row and the 6RM leg press from pre-intervention strength measures.

The results from the present investigation suggest that the participants in the Sport

Academy program experienced upper body strength adaptations over the course of both a 13-week and 26-week RT program. Participants lifted in repetition ranges from 8RM to 15RM. In a study by Faigenbaum et al (2005), participants showed strength adaptations in both the low repetition ranges as well as the high repetition ranges. In relation to normative data as presented by the NSCA (2004) the pre intervention strength tests showed the grade 7 Sport Academy participants mean score on the chest press exercise puts them in the 70th percentile and for the leg press the mean score puts them in the 50th percentile. Grade 8 participants scored in the 75th percentile for the mean on the chest press and in the 50th percentile for the leg press. There were not any normative data available for the seated row exercise or for the grade 9 aged participants. Based on these norms it can be proposed that the grade 9 subjects were in the lower percentile for leg strength and as a result had a greater window for improvement in this area than did the grade 8 subjects.

The improvements in local muscular strength in the present study support the observations of others who reported increases in local muscular strength in children who participated in a progressive RT program (Faigenbaum et al, 1996; Ramsay et al, 1995).

Training induced improvements in strength were in some cases more prevalent in pubescent boys and greater in lower body than in upper (Vrjens, 1978; Faigenbaum et al, 2002). In contradiction, the current study showed significant gains in the upper body across the 13-week and 26-week programs but did not show significant gains in the lower body strength at the completion of the 26-week program.

It can be speculated that the smaller incremental strength gains achieved by participants in the second half of the 26-week training study, across all of the participants, are due to the lack of adequate concentrations of circulating growth factors and androgens (Kraemer et al, 1989), which may provide anabolic support for muscle growth and as a result strength adaptations. Further research is required as to the relationship between hormonal factors and strength adaptations in this population. The lack of significant improvements in the grade 8, leg strength from 13 weeks to 26 weeks can be partially explained by their pre intervention strength measure. The grade 8 subjects started the programming scoring in the 50th percentile in leg press strength in relation to the general population while the grade 9 subjects would be projected to score lower. Given the grade 9 subjects had a greater opportunity for improvement based on pre intervention measures this may have allowed for significant adaptations from week 13 to 26. When the hierarchical linear regression was conducted pre intervention strength measures were significantly ($p < .005$) related to strength adaptations in all 6RM strength testing. The 6RM chest press, row and leg press strength adaptations were all significantly related to pre intervention strength measures. In the pre intervention assessment grade 7 subjects scored in the 75th percentile for the chest press and the 70th percentile for the leg press at the conclusion of the study they scored in the 85th percentile in the chest press and the 75th percentile for the leg press (Hoffman, 2006). At pre intervention assessment grade 8 subjects scored in the 70th percentile for the chest press and the 65th percentile for the leg press at 13 weeks grade 8 subjects scored in the 80th percentile for the chest press and the 80th percentile in the leg press. (Hoffman, 2006). At week 26 grade 8 subjects reached the 85th percentile for the chest press and the 85th percentile for the leg press (Hoffman, 2006).

5.3 Neural Adaptations

Strength gains that are achieved in the absence of hypertrophic morphological changes to the muscle may be primarily attributed to neural adaptations such as motor learning and motor recruitment. In this study participants showed strength adaptations in the absence of significant changes in body composition, when determined by skin fold calipers. Perhaps a more sensitive measurement protocol such as a bod pod is required to identify subtle tissue changes. Certainly, training induced strength gains in children and adolescents may be partially explained by muscle hypertrophy. However, the current findings would suggest that the gains in strength in the present study can largely be explained by neurological adaptations such as increased motor unit activation, inter-muscle coordination or neuromuscular learning (Kraemer et al 1989; Ozmun et al 1994; Ramsay et al 1990).

Chapter 6: Conclusion

In conclusion, significant gains in strength can occur in grade 7, grade 8, and grade 9 subjects participating in the Sport Academy Program. Specifically, significant strength gains were experienced in the 6RM chest press, 6RM seated row and 6RM leg press exercises across the 13-week RT training study. While Grade 8 subjects showed significant strength gains in the 6RM chest press, 6RM seated row and 6RM leg press exercises from pre-intervention to week 13, they showed further significant strength gains from week 13 to week 26 in the chest press and the seated row but not in the leg press. Because we observed significant strength adaptations in the grade 9 subjects in the leg press but failed to see the same adaptations in the grade 8 group we can speculate that because the grade 9 subjects showed lower starting values in the leg press in relation to percentile norms they had a greater opportunity for improvement. Ultimately, a higher initial starting level of strength leaves less opportunity to gain (Hanson et al; 2006). Lastly, Grade 9 subjects showed significant strength gains in the 6RM chest press, 6RM seated row and the 6RM leg press from pre intervention to 13 weeks and from 13 weeks to 26 weeks of RT.

With respect to lean body mass (LBM) it was found that increases in strength were achieved outside of the presence of significant improvements in the grade 7 and grade 9 subjects. Grade 8 subjects did show significant improvement in LBM from pre intervention to week 13 of the RT program. Grade 8 and grade 9 subjects did not show significant improvements in LBM from week 13 to week 26. When looking at strength adaptations relative to changes in body composition (BF%, BMI, LBM) hypertrophic changes cannot be cited as the primary or greatest contributing mechanism for the achieved strength gains. When changes in LBM were factored in using the hierarchical linear regression method a significant ($p < .005$) relationship was found in the week 13 and 26 row strength adaptations and a trend ($p < .184$) was found in week 13 for the chest press.

6.1 Study Limitations

The results of the study clearly showed that participants in the Sport Academy Program experienced strength gains at both 13 weeks of training and 26 weeks of training. The gains achieved are beyond those that could be attributed to growth alone, as there were significant adaptations in strength in the absence of significant morphological changes. What is less clear is to what degree the changes can be described as neural adaptations, motor learning, or tissue changes.

The study is novel in that it is a "snap shot" or naturalistic study that looks at a program that would run in the presence or absence of the research study. Working with the Sport Academy sample did not allow for comparison or reference to the application of these results to the general population. It could be speculated that any adaptations we observe in this "trained" population may be amplified in an untrained population. Due to the structure of the Sport Academy program the amount of weight lifted by each participant each session was not recorded. As such, total volume was not a variable that was assessed. This could have been a factor in why continued adaptation was observed in the grade 9 participants and not in the grade 8 participants in the 26-week program.

A group of age-matched children would have provided a control group. Having a control group within the program that was not permitted to participate would have made it possible to compare those who participated in the intervention to those who did not.

Because the strength and conditioning training is part of the Sport Academy program we are unable to de-select program participants for the purpose of the study. As with any scientific investigation the inclusion of a control group is important to ensure the changes experienced are due to the exercise intervention and not due to some other variable (i.e, growth, maturation, or everyday activity). However, the confines of the study would not allow for randomization of subjects into control groups and intervention.

Furthermore, participants in the study came from a variety of sporting and training backgrounds. The participants were not engaging in regularly scheduled RT prior to participation in the Sport Academy program but had been identified as having athletic potential by program administrators at the HWDSB. It could be speculated that the results seen in this study would be amplified in the general population, as they would have a reduced familiarity with RT movement patterns and less exposure to training stimulus as children who regularly participate in sport.

The Sport Academy program is a joint project between the Hamilton Wentworth District School Board and McMaster University and as a result of this partnership the study was subject to scheduling conflicts such as scheduled school holidays, snow days, student sick days and the Christmas and March Break. Attendance of the participants was not under the control of the researcher. If the subject was away, the training day was not made up and if they were absent on a scheduled assessment day data were not collected and analyzed for the subject. Subjects with an incomplete data set on any of the strength assessment protocols were thrown out for that given assessment. Absences were documented on an attendance sheet and the trainer supervising the training group noted participant compliance with the training program.

When working with children and pre-adolescents it is difficult to keep motivation and, as a result effort, consistent. The effort being put forth by the participants on both training and testing days could not be controlled for. However, the subject did receive positive reinforcement in the form of cheering and verbal cueing from the personal trainer administering the assessment.

When the program was run previously there was subject sensitivity expressed around the invasiveness and psychological maturity of subjects and the anthropometric measures. As such it was decided that a pubertal assessment would not be appropriate for the program and that fewer skinfolds would be taken. In future research with this group a pubertal status assessment would be strongly recommended to determine what impact the state of puberty has on strength gains in this population. It is difficult to determine if the study participants were early developers in comparison to the general population and if this played a role in the strength adaptations they were able to achieve.

Anthropometric measures have not proven to be sensitive enough to measure muscle hypertrophy in children and preadolescents so implementing more sensitive methods of measurement, such as magnetic resonance imaging and ultrasound, may provide further insight as to the contribution of morphological adaptation to the strength gains achieved by this population through RT. Unfortunately, given the time constraints and number of program participants these types of assessments were not feasible within the parameters of this research study.

6.2 Future Directions

Further research is necessary regarding the physiological mechanisms of strength gains in children and adolescents as a result of RT. There are a number of specific mechanisms that require more detailed investigation such as hypertrophy, angle of pennation, motor unit recruitment, muscle activation and many others. To determine the impact of RT training on these mechanisms requires a more controlled environment to identify and quantify changes than this field study could provide. Specifically, there is limited information available on the mechanism of neural adaptations. There has not been a protocol referenced in the literature to specify or quantify neural changes in children as a result of RT and as a result further research in these areas is required.

It has been suggested that detraining may happen at an increased rate in children and adolescents. Participants in the Sport Academy program have the opportunity to return and train over the course of four years if they enroll as grade 7 students. It would be of interest to determine the detraining that takes place over the two-month time frame that students are away for the summer months (July and August). Given that subjects have the opportunity to return to the program over the period of four years it would be of interest to track the longitudinal strength adaptations achieved by the subjects. There are very few longitudinal studies of this nature with the majority of published studies being between 8 and 20 weeks. It would be of benefit to do further analysis to determine if there is a correlation between the strength adaptations achieved by the program participants and sport performance outcomes. Individual sports such as track and field, gymnastics, figure skating and dance would lend themselves to assessment more readily than team sports. The stipulation of being an individual sport athlete would greatly impact the sample size for the program.

Lastly, qualitative surveys could be included to determine the psycho-social impact of participation in a selective program like the Sport Academy on the subjects. They could serve as a means to determine the motivation for participation and the level of enjoyment of participants in the program.

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APPENDIX A
LETTER OF INVITATION

LETTER OF INVITATION

January 15th, 2008

Title of Study: A comparison between the strength gains made by grade 7, grade 8 and grade 9 students in the HWDSB Sport Academy over 13-weeks and 26-weeks of Resistance Training

Principal Investigator: Alana Harris, graduate student, Faculty of Applied Health Sciences, Brock University

Faculty Supervisor: Dr Maureen Connolly, Professor, Department of Physical Education and Kinesiology, Brock University

I, Alana Harris from the Faculty of Applied Health Sciences, Brock University, invite you to participate in a research project entitled A comparison between the strength gains made by grade 7, grade 8 and grade 9 students in the HWDSB Sport Academy over 13-weeks and 26-weeks of Resistance Training

The purpose of this research project is to contribute to the understanding of the effect of 13 weeks of resistance training on children aged eleven years to fifteen years and to determine if there is difference in the strength adaptations between participants over 13-weeks of resistance training and 26-weeks of resistance training.

The expected duration of the research study is 26-weeks. The research will commence on January 15th, 2008.

This research should benefit the participants by improving their fundamental fitness as well as contribute to improved performance in sport. The research will contribute to the field of exercise prescription in children and preadolescents and the development of the HWDSB Sport Academy Program. The research will support the continuation of programs like the Sport Academy offered by the Department of Athletics and Recreation at McMaster University in association with the Hamilton Wentworth District School Board.

A sample of research participants for this research study will be collected from the Sport Academy Program, which is offered by McMaster University in a joint effort with the Hamilton Wentworth District School Board. Alana Harris will be the primary investigator and is a graduate student in the Faculty of Applied Health Sciences at Brock University.

If you have any pertinent questions about your rights as a research participant, please contact the Brock University Research Ethics Officer (905 688-5550 ext 3035, reb@brocku.ca)

If you have any questions, please feel free to contact me.

Thank you

Alana Harris
Graduate Student, Brock University
905 525-9140 ext 23192
alanah@mcmaster.ca

Professor Maureen Connolly
Professor in the Department of PEKN
905 688-5550
mconnoll@brocku.ca

This study has been reviewed and received ethics clearance through Brock University's Research Ethics Board 07-077 HARRIS

APPENDIX B
INFORMED ASSENT

Informed Assent

Date:

Participants Name :

I, the participant, understand that my participation in the Sport Academy will involve participation in strength and conditioning training over a 26-week program and that I will participate in fitness testing in the first week, thirteenth week and twenty sixth week of the program.

I give permission for the information collected to be used for research purposes. After giving my permission for the information that is collected to be used for research I understand that I still have the right not to participate and that I can withdraw myself at any point without penalty.

Participants Printed Name

Signature of Parent/ Guardian Date

Signature of Participant Date

Signature of Researcher Date

APPENDIX C
INFORMED CONSENT

Informed Consent

Date: Research Start - January 15th, 2008
Project Title: A comparison between the strength gains made by grade 7, grade 8 and grade 9 students in the HWDSB Sport Academy over 13-weeks and 26-weeks of Resistance Training

Principal Investigator:
Alana Harris, student
Department of Applied Health Science
Brock University
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Faculty Supervisor:
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INVITATION

Your child is invited to participate in a study that involves research. The purpose of this study is to determine the degree of physical strength gains experienced by the Sport Academy participants, who participate in a 13-week resistance training program and to determine if there is a difference between adaptations achieved in a 13-week program compared to a 26-week resistance training program.

WHAT'S INVOLVED

You have been invited to participate in this research project because your child is already participating in a the HWDSB Sport Academy program -- the Sport Academy program at McMaster University. If you consent to participate, you will be providing the researchers, Alana Harris and Maureen Connolly, permission to access data that the Sports Academy collects with regards to your child's level of physical fitness height, weight, waist circumference flexibility, power, endurance, strength, coordination and current training and sport participation.

POTENTIAL BENEFITS AND RISKS

By participating, you will be contributing to the understanding of the impact of strength training on youth populations. Participation could assist in providing information that would support the continuation of strength and conditioning programs for youths and impact how coaches train youth interested in long-term sport performance. There are not risks anticipated with participation in this research project.

CONFIDENTIALITY

All information that you provide is considered confidential; the participants name will not be included or, in any other way, associated with the data collected in the study.

Furthermore, because our interest is in the average responses of the entire group of participants, you will not be identified individually in any way in written reports of this research.

Data collected during this study will be stored on a computer with a password in a locked office. All paper documents will be stored in the researcher's office in a filing cabinet under lock and key. Data will be kept for seven years time at which point all documents will be shredded. Access to the raw data will be restricted to the researcher, Alana Harris and the researcher's supervisor Professor Maureen Connolly. In rare cases, it will not be possible to ensure confidentiality because of mandatory reporting laws (e.g. suspected child abuse) or the possibility of third party access to data (e.g., court subpoena of records). When this is the case, the prospective research participant should be aware of any potential limitations.

VOLUNTARY PARTICIPATION

Participation in this study is voluntary. If you wish, you may decline to answer any questions or the participation of your child in any component of the study. Further, you may decide to withdraw your child from this study at any time and may do so without any penalty or loss of benefits to which you or your child are entitled. Withdrawal from this research project will in no way affect your child's standing in the Sport Academy Program.

PUBLICATION OF RESULTS

Results of this study may be published in professional journals and presented at conferences. Feedback about this study will be available from Alana Harris, the researcher, in September of 2008 following the analysis and formal write up of the results of the research study. You may reach Alana by email at alanah@mcmaster.ca

CONTACT INFORMATION AND ETHICS CLEARANCE

If you have any questions about this study or require further information, please contact the Principal Investigator or the Faculty Supervisor (where applicable) using the contact information provided above. This study has been reviewed and received ethics clearance through the Research Ethics Board at Brock University 07-077 HARRIS. If you have any comments or concerns about your rights as a research participant, please contact the Research Ethics Office at (905) 688-5550 Ext. 3035, reb@brocku.ca.

Thank you for your assistance in this project. Please keep a copy of this form for your records.

CONSENT FORM

I agree to have my child participate in the study described above. I have made this decision based on the information I have read in the Information-Consent Letter. I have had the opportunity to receive any additional details I wanted about the study and understand that I may ask questions in the future. I understand that I may withdraw this consent at any time.

Name: ______________________________

Signature: __________________________________ Date: ______________________________

APPENDIX D
RT PROGRAMS

R.A. Riddell
Sport Academy
Phase 1- September/October

Workout/Date		1/	2/	3/	4/	5/	6/	7/	8/
Exercise (2s down, pause 1s, 1-2s up) **Warm up set - no weights**									
Dumbbell squat	Warm up set	12x	12x	12x	12x	12x	12x	12x	12x
	Set 1	12x	12x	12x	12x	12x	12x	12x	12x
Dumbbell step-up press	Warm up set	12x	12x	12x	12x	12x	12x	12x	12x
	Set 1	12x	12x	12x	12x	12x	12x	12x	12x
Dumbbell bench press	Warm up set	12x	12x	12x	12x	12x	12x	12x	12x
	Set 1	12x	12x	12x	12x	12x	12x	12x	12x
Dumbell single arm row (Right)	Warm up set	12x	12x	12x	12x	12x	12x	12x	12x
	Set 1	12x	12x	12x	12x	12x	12x	12x	12x
Dumbell single arm row (Left)	Warm up set	12x	12x	12x	12x	12x	12x	12x	12x
	Set 1	12x	12x	12x	12x	12x	12x	12x	12x
Dumbbell bicep curl	Warm up set	12x	12x	12x	12x	12x	12x	12x	12x
	Set 1	12x	12x	12x	12x	12x	12x	12x	12x
Dumbbell tricep kickback	Warm up set	12x	12x	12x	12x	12x	12x	12x	12x
	Set 1	12x	12x	12x	12x	12x	12x	12x	12x
Back raise/ bridge	Set 1								
	Set 2								
Curl up	Set 1								
	Set 2								
to follow with at least 5 lower and 5 upper body stretches (Dynamic or Static)									

R.A. Riddell
Sport Academy
Phase 2- November/ December

Workout/Date		1/	2/	3/	4/	5/	6/	7/	8/
Exercises (2s - pause 1s -2s)									
Squat on stability discs	Set 1	10x	10x	10x	10x	10x	10x	10x	10x
	Set 2	10x	10x	10x	10x	10x	10x	10x	10x
	Set 3	10x	10x	10x	10x	10x	10x	10x	10x
Push ups (alt – feet/hands on ball)	Set 1	10x	10x	10x	10x	10x	10x	10x	10x
	Set 2	10x	10x	10x	10x	10x	10x	10x	10x
	Set 3	10x	10x	10x	10x	10x	10x	10x	10x
Forward lunges	Set 1	10x	10x	10x	10x	10x	10x	10x	10x
	Set 2	10x	10x	10x	10x	10x	10x	10x	10x
Reverse lunges	Set 1	10x	10x	10x	10x	10x	10x	10x	10x
	Set 2	10x	10x	10x	10x	10x	10x	10x	10x
Chins	Set 1	5x	5x	5x	5x	5x	5x	5x	5x
	Set 2	5x	5x	5x	5x	5x	5x	5x	5x
Reverse chins	Set 1	5x	5x	5x	5x	5x	5x	5x	5x
	Set 2	5x	5x	5x	5x	5x	5x	5x	5x
Skull crushers	Set 1	10x	10x	10x	10x	10x	10x	10x	10x
	Set 2	10x	10x	10x	10x	10x	10x	10x	10x
Bicep curls	Set 1	10x	10x	10x	10x	10x	10x	10x	10x
	Set 2	10x	10x	10x	10x	10x	10x	10x	10x
Back extentions/ bridges	Set 1	12x	12x	12x	12x	12x	12x	12x	12x
	Set 2	12x	12x	12x	12x	12x	12x	12x	12x
	Set 3	12x	12x	12x	12x	12x	12x	12x	12x
Rotational planks (30sec per side)	Set 1								
	Set 2								

	Set 3								
to follow with at least 5 lower and 5 upper body stretches (Dynamic or Static)									

R.A. Riddell
Sport Academy
Phase 3 – January/February

Workout/Date		1/	2/	3/	4/	5/	6/	7/	8/
Exercises									
Squat on stability discs (slow! – 3sec down/hold 3/up 3)	Set 1	10x	10x	10x	10x	10x	10x	10x	10x
	Set 2	10x	10x	10x	10x	10x	10x	10x	10x
	Set 3	10x	10x	10x	10x	10x	10x	10x	10x
Push ups (feet on stability ball)	Set 1	10x	10x	10x	10x	10x	10x	10x	10x
	Set 2	10x	10x	10x	10x	10x	10x	10x	10x
	Set 3	10x	10x	10x	10x	10x	10x	10x	10x
Forward lunges (slow and controlled)	Set 1	10x	10x	10x	10x	10x	10x	10x	10x
	Set 2	10x	10x	10x	10x	10x	10x	10x	10x
Chin-ups (reverse grip)	Set 1	5x	5x	5x	5x	5x	5x	5x	5x
	Set 2	5x	5x	5x	5x	5x	5x	5x	5x
Reverse chins (reverse grip)	Set 1	5x	5x	5x	5x	5x	5x	5x	5x
	Set 2	5x	5x	5x	5x	5x	5x	5x	5x
Side lunges	Set 1	10x	10x	10x	10x	10x	10x	10x	10x
	Set 2	10x	10x	10x	10x	10x	10x	10x	10x
Shoulder Press	Set 1	10x	10x	10x	10x	10x	10x	10x	10x
	Set 2	10x	10x	10x	10x	10x	10x	10x	10x
Rotational planks (front/side/back/side -hold 30 sec)	Set 1	12x	12x	12x	12x	12x	12x	12x	12x
	Set 2	12x	12x	12x	12x	12x	12x	12x	12x
	Set 3	12x	12x	12x	12x	12x	12x	12x	12x
Stretches Hold for 12 seconds each- hip flexor, hamstrings, upper back (grabbing wall and curving back), calves, arm across chest and behind back.									

R.A. Riddell
Sport Academy
Phase 4 - March/ April

Part A - Speed & Agility - Complete the following activities with a partner—you will rest after each set while your partner Completes the set. Once Part A is completed, turn page and complete Part B.

Workout	1/	2/	3/	4/	5/	6/	7/	8/
Pylon touches (30sec)	Set 1	Set 1	Set 1	Set 1	Set 1	Set 1	Set 1	Set 1
	Set 2	Set 2	Set 2	Set 2	Set 2	Set 2	Set 2	Set 2
	Set 3	Set 3	Set 3	Set 3	Set 3	Set 3	Set 3	Set 3
Alt. Foot bench hops; 30sec per set. 45 sec rest after each set	Set 1	Set 1	Set 1	Set 1	Set 1	Set 1	Set 1	Set 1
	Set 2	Set 2	Set 2	Set 2	Set 2	Set 2	Set 2	Set 2
	Set 3	Set 3	Set 3	Set 3	Set 3	Set 3	Set 3	Set 3

Part B – Strength & Flexibility

Workout		1/	2/	3/	4/	5/	6/	7/	8/
Exercises									
Squat on stability discs (using plate/ dumbbell, medball)	Set 1	10x	10x	10x	10x	10x	10x	10x	10x
	Set 2	10x	10x	10x	10x	10x	10x	10x	10x
Push ups (feet on stability ball)	Set 1	10x	10x	10x	10x	10x	10x	10x	10x
	Set 2	10x	10x	10x	10x	10x	10x	10x	10x
Side lunges	Set 1	10x	10x	10x	10x	10x	10x	10x	10x
	Set 2	10x	10x	10x	10x	10x	10x	10x	10x
Chin-ups (reverse grip)/ Alternative lat pulldown (10x)	Set 1	5x	5x	5x	5x	5x	5x	5x	5x
	Set 2	5x	5x	5x	5x	5x	5x	5x	5x
Romanian Deadlifts (with Dowel-progress to light barbell)	Set 1	10x	10x	10x	10x	10x	10x	10x	10x
	Set 2	10x	10x	10x	10x	10x	10x	10x	10x
Alt. Foot balance on stability pad (eyes closed)	Set 1	15sec	15sec	15sec	15sec	15sec	15sec	15sec	15sec
	Set 2	15sec	15sec	15sec	15sec	15sec	15sec	15sec	15sec
V-sit (hundreth)/ back bridge	Set 1								
	Set 2								
Stretches Hold for 12 seconds each- hip flexor, hamstrings, upper back (grabbing wall and curving back), calves, groin & inner thighs.									

R.A. Riddell
Sport Academy
Phase 5 May- June

Part A - Speed & Agility - Complete the following quickness drills with a partner—your break will be when your partner completes the set. Each set will be 30 seconds in length.

Workout	1/	2/	3/	4/	5/	6/	7/	8/
Pylon touches	Set 1	Set 1	Set 1	Set 1	Set 1	Set 1	Set 1	Set 1
	Set 2	Set 2	Set 2	Set 2	Set 2	Set 2	Set 2	Set 2
	Set 3	Set 3	Set 3	Set 3	Set 3	Set 3	Set 3	Set 3
Pylon box drill (think about planting and exploding)	Set 1	Set 1	Set 1	Set 1	Set 1	Set 1	Set 1	Set 1
	Set 2	Set 2	Set 2	Set 2	Set 2	Set 2	Set 2	Set 2
	Set 3	Set 3	Set 3	Set 3	Set 3	Set 3	Set 3	Set 3

Part B - Strength & Flexibility

Workout		1/	2/	3/	4/	5/	6/	7/	8/
Exercises									
Squat on stability discs (using plate/ dumbbell, medball)	Set 1	10x	10x	10x	10x	10x	10x	10x	10x
	Set 2	10x	10x	10x	10x	10x	10x	10x	10x
Push ups (feet on purple stability ball)	Set 1	10x	10x	10x	10x	10x	10x	10x	10x
	Set 2	10x	10x	10x	10x	10x	10x	10x	10x
Romanian Deadlifts (with Dowel-progress to light barbell)	Set 1	10x	10x	10x	10x	10x	10x	10x	10x
	Set 2	10x	10x	10x	10x	10x	10x	10x	10x
Chin-ups (reverse grip)/ Alternative lat pulldown (10x)	Set 1	5x	5x	5x	5x	5x	5x	5x	5x
	Set 2	5x	5x	5x	5x	5x	5x	5x	5x
Alt. Foot balance on stability pad (eyes closed)	Set 1	15sec	15sec	15sec	15sec	15sec	15sec	15sec	15sec
	Set 2	15sec	15sec	15sec	15sec	15sec	15sec	15sec	15sec
Bicep curl (slow)	Set 1	10x	10x	10x	10x	10x	10x	10x	10x
	Set 2	10x	10x	10x	10x	10x	10x	10x	10x
Skull crushers	Set 1	10x	10x	10x	10x	10x	10x	10x	10x
	Set 2	10x	10x	10x	10x	10x	10x	10x	10x
V-sits (count to hundred)/ back bridge	Set 1								
	Set 2								
Stretches Hold for 12 seconds each- hip flexor, hamstrings, upper back (grabbing wall and curving back), calves, groin & inner thighs.									

Sport Academy
General Athletic Prep Program

Grade 7

An Active Start and the FUNdamentals of Training

"If you have the courage to begin,
you have the courage to succeed."

McMASTER
the Pulse

Education

We will provide brief pre-training educational presentations about strength and conditioning and athlete training.

Topics include:

1) The benefits of Warm-up and the structure of an effective warm-up
2) Nutrition for young athletes
3) Motivational presentation from a varsity athlete
4) Recovery, flexibility and injury prevention
5) Strength training for activity and sport

Warm-up

Group warm-ups will be conducted before each session and will be lead by one of our training coaches.

WARM UP 1	**Total Time - 15 min**
Total Body Focus	**Distance / Time**
Continuous Dynamic Warm-up	
Light Jog	**2 Laps**
Skips with Arm Circles (Forward & Backward)	**40 m**
Carioke (Left & Right)	**40 m**
High Knees	**20 m**
Butt Kicks	**20 m**
Continuous Movement Prep	
3 Step - Hip Opening	**x 5***
3 Step - Knee Hug to 45 Degree Lunge	**x 5***
3 Step - 747 (Inverted Hamstring)	**x 5***
Spiderman Crawl	**20m**
Stationary Movement Prep	
Leg Swings - Front to Back	**x 8***
Leg Swings - Side to Side	**x 8***
Med Ball - Linear Wood Chop	**x 8**
Med Ball - Rotations	**x 8***
Activity Prep - Neural Activation	
Burpies	**5**
Explosive Push Ups	**5**
Tuck Jumps	**2 x 10**

WARM UP 2	**Total Time - 15 min**
Total Body Focus	**Distance / Time**
Continuous Dynamic Warm-up	
Light Jog	**1 Lap / 2 Mins**
Skips with Arm Circles (Forward & Backward)	**40 m**
Lateral Jacks with Arm Flaps (Left & Right)	**40 m**
High Knees	**20 m**
Power Carioca (Left & Right)	**20 m**
Continuous Movement Prep	
3 Step - Knee Hug	**x 5***
3 Step - Warrior Lunge	**x 5***
3 Step - Quad Stretch to Deadlift	**x 5***
Tarzan Shuffle	**x 5**
Stationary Movement Prep	
Eagle kicks	**x 8***
Scorpions	**x 8***
Hip Crossovers	**x 8***
Dowell Dislocates (or Arm Swings Forwards & Backwards)	**x 8***
AIS Calf Stretch (Straight & Bent Leg)	**x 4***
Ball (Med/Volley) - Around the World (High/Low)	**x 8***
Activity Prep - Neural Activation	
Lateral Line Hops	**2 x 10 sec**
Linear Line Hops	**2 x 10 sec**
Alternating Linear Line Hops	**2 x 10 sec**
Tuck Jumps	**2 x 10**

Flexibility Training

Dynamic stretching will be used in the warm-up and a group stretch will be conducted by a training coach for the last 15-minutes of every session.

Type : Goal	Description (Remember - close eyes, deep breathing, relaxed state)
Static: Re-lengthen	Hold a stretch for a minimum of 20 – 30 seconds. Deep breaths and try to move deeper into the stretch. Repeat 2-3 times.
PNF: Re-lengthen	Hold a stretch for 10 – 20 seconds. Then using the same muscle push back 10% isometric contraction for 6 seconds. Take a deep breath and move into the stretch deeper than before. Repeat 3-6 cycles.
AIS: Re-teach	Fluid stretching: Opposite muscle works to teach re-lengthened muscle how far it can now go. 2 second contraction followed by 2 second stretch with overpressure. Repeat 8-10 cycles.

FLEXIBILITY 1

TYPE / EXERCISE	REPS X DURATION
Anterior Fascia Ball Stretch (Largest Stability Ball)	**1 x 45 seconds**
Lat Ball Stretch - reach and roll - palms up (Stability Ball)	**1 x 30 seconds each side**
Static Wall Calf Stretch (Straight Leg = Gastroc)	**2 x 30 seconds each side**
AIS Calf Stretch (Straight Leg = Gastroc)	**8 cycles each side** cycle = 2 seconds at top (inhale) & 2 seconds at bottom (exhale)
Static Hip Flexor Stretch - lunge position - head forward - chest up - back leg 45 degrees	**1 x 30 seconds each side**
Static Glute Stretch - push up position - foot to hand - sit down overtop - other leg straight back - DO NOT substitute this exercise	**1 x 30 seconds each side**
PNF Butterfly Stretch - use elbows to push down (Groin = Short Head Adductors)	**10 seconds stretch - 6 second pressing legs up 10% strength into elbows - repeat 4 times**
Static Two Leg Seated Hamstring Stretch	**2 x 30 seconds**
Static X-Body Sprial Stretch - lying supine - take knee across body and hold to ground - rest arm diagonally up in opposite direction	**1 x 30 seconds each side**
PNF Shoulder Capsule - lying on top of shoulder - slowly rotate arm towards ground - add pressure	**10 seconds stretch - 6 second pressing back against hand 10% strength - repeat 4 times**

FLEXIBILITY 2

TYPE / EXERCISE	REPS X DURATION
Downward Dog to Cobra	**8 x 5 seconds each position**
Static Rope Hamsting (Origin) - lying supine - use rope to pull straight leg into stretch and hold	**1 x 30 seconds each side**
Static Rope Hamsting (Insertion) - lying supine - bring knee to chest - use rope to pull bent leg into straight position	**1 x 30 seconds each side**
AIS Rope Hamstring - actively raise leg to face - use rope for overpressure once at end range	**8 cycles each side** cycle = 2 seconds at top (inhale) & 2 seconds at bottom (exhale)
Static Splits - as far as you can go - sit down - hold front and both sides (Long Head Adductors)	**1 x 30 seconds front and each side**
Static Seated Figure 4 - sitting tall with straight back cross one leg over - hug across and tight to	**1 x 30 seconds each side**
Static Rope Quad - prone lying - pull foot toward your head and into the air using rope	**1 x 30 seconds each side**
PNF Rope Rotator Cuff - both hands behind back - 1 up and 1 down - grasp rope - pull up	**10 seconds stretch - 6 seconds pulling down at 10% strength - repeat 4 times**
Static Rope Pec Stretch - if you have should problem be cautious - try using a resistance band	**2 x 30 seconds**

Training Programs

The program is broken up into 4 different full body workouts. The participants are broken up into smaller training groups, 6 to 1, with a training coach and will do a full body circuit. Each of the groups will complete the 4 different workouts two times over the 8-weeks program.

Tips:

- 2-minutes rest between circuits
- Set up as stations and move from station to station
- Technique is the focus/ not weight lifted or completing the reps
- Provide options: **beginner-intermediate-advanced**
- If you can make it fun they are more motivated to complete it
- Encourage them to take water

Strength Circuit 1 – Medicine Ball Workout

Exercise	Week 1-3	Week 4-5	Week 6-8
Squat	2 x 15	2-3 x 12	3 x 10
Chest Push	2 x 15	2-3 x 12	3 x 10
Lunge	2 x 12 each side	2 –3 x 10	3 x 8
Overhead Toss	2 x 15	2-3 x 10	3 x 10
Med Ball Step Up	2 x 12 each side	2-3 x 10	3 x 10
Underhand Rot Toss	2 x 12 each side	2-3 x 10	3 x 10
Calf Raise	2 x 12	2-3 x 10	3 x 10
Push up	2 x 10-12	2 x 12-15	2 x 15

Strength Circuit 2 – Dumbells

Exercise	Week 1-3	Week 4-5	Week 6-8
Squat (trip flex – trip ext)	2 x 15	2-3 x 12	3 x 10
Push-up	2 x 15	2-3 x 12	3 x 10
Walking Lunge	2 x 12 each side	2 –3 x 10	3 x 8
Row	2 x 15	2-3 x 10	3 x 10
Deadlift	2 x 12	2-3 x 10	3 x 10
Bicep Curl	2 x 12 each side	2-3 x 10	3 x 10
Calf Raise	2 x 12	2-3 x 10	3 x 10
Tricep Ext	2 x 10-12	2 x 12-15	2 x 15
45 degree Lunge	2 x 12	2-3 x 10	3 x 10
Shoulder Press	2 x 10-12	2 x 12-15	2 x 15

Strength Circuit 3 – BOSU

Exercise	Week 1-3	Week 4-5	Week 6-8
Squat	2 x 15	2-3 x 12	3 x 10
Push-up	2 x 15	2-3 x 12	3 x 10
Lunge	2 x 12 each side	2 –3 x 10	3 x 8
Dips	2 x 12	2-3 x 10	3 x 10
Single Leg Deadlift	2 x 12 each side	2-3 x 10	3 x 10
Bicep Curl	2 x 12 each side	2-3 x 10	3 x 10
Jump and Hold	2 x 12	2-3 x 10	3 x 10
Tricep Ext	2 x 10-12	2 x 12-15	2 x 15
Calf Raise	2 x 12	2-3 x 10	3 x 10
Shoulder Press	2 x 10-12	2 x 12-15	2 x 15

Strength Circuit 4 – Cables/ Tubing/ Plyos

Exercise	Week 1-3	Week 4-5	Week 6-8
Drop Squat (step)	2 x 15	2-3 x 12	3 x 10
Walking Push-up	2 x 15	2-3 x 12	3 x 10
Single Leg Hop	2 x 12 each side	2 –3 x 10	3 x 8
Row (cable or tube)	2 x 12	2-3 x 10	3 x 10
Lateral Single Leg Hop	2 x 12 each side	2-3 x 10	3 x 10
Chest press (cable or tube)	2 x 12 each side	2-3 x 10	3 x 10
Lateral Step Squat (tube)	2 x 12	2-3 x 10	3 x 10
Tricep Pull Down	2 x 10-12	2 x 12-15	2 x 15
Cross over/ hip Adduction (tube/ cable)	2 x 12	2-3 x 10	3 x 10
Bicep Curl to Shoulder Press	2 x 10-12	2 x 12-15	2 x 15

Cardiovascular Training (20-minutes)

Strength Circuit 1 – Motor Pattern Drills
- Suicides (slow /med/fast and simple to complex)
- Forward, backward, lateral, combo's

Strength Circuit 2 – Intervals on Spin Bikes or Cardio Equip
- Speed play
- Hills to flats

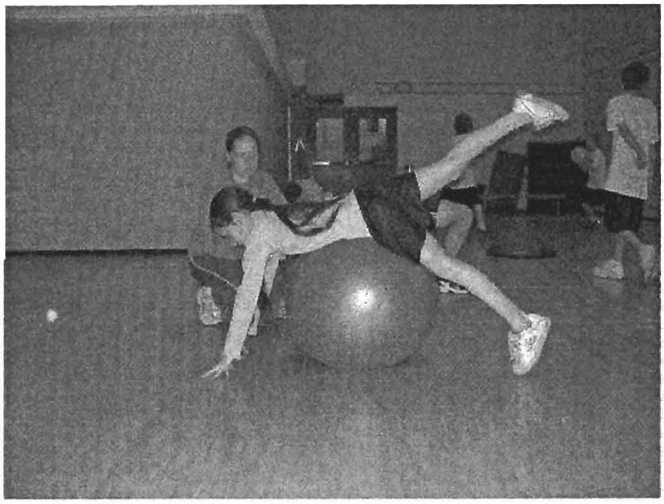
Strength Circuit 3 – Coordination
- Agility Ladders
- Skipping Ropes
- Cone Drills

Strength Circuit 4 – Fartlek on Track
- Group jog
- Person at back of group accelerates to the front
- 20-minutes including cardio cool down of 5-minutes

Sport Academy
General Athletic Prep Program

Grade 8

FUNdamentals and Learning to Train



“Desire is the most important factor
in the success of an athlete.”

McMASTER

the Pulse

Education

We will provide brief pre-training educational presentations about strength and conditioning and athlete training.

Topics include:

1) The benefits of Warm-up and the structure of an effective warm-up
2) Nutrition for young athletes
3) Motivational presentation from a varsity athlete
4) Recovery, flexibility and injury prevention
5) Strength training for activity and sport

Warm-up

Group warm-ups will be conducted before each session and will be lead by one of our training coaches.

WARM UP 1	**Total Time - 15 min**
Total Body Focus	**Distance / Time**
Continuous Dynamic Warm-up	
Light Jog	**2 Laps**
Skips with Arm Circles (Forward & Backward)	**40 m**
Carioke (Left & Right)	**40 m**
High Knees	**20 m**
Butt Kicks	**20 m**
Continuous Movement Prep	
3 Step - Hip Opening	**x 5***
3 Step - Knee Hug to 45 Degree Lunge	**x 5***
3 Step - 747 (Inverted Hamstring)	**x 5***
Spiderman Crawl	**20m**
Stationary Movement Prep	
Leg Swings - Front to Back	**x 8***
Leg Swings - Side to Side	**x 8***
Med Ball - Linear Wood Chop	**x 8**
Med Ball - Rotations	**x 8***
Activity Prep - Neural Activation	
Burpies	**5**
Explosive Push Ups	**5**
Tuck Jumps	**2 x 10**

WARM UP 2	**Total Time - 15 min**
Total Body Focus	**Distance / Time**
Continuous Dynamic Warm-up	
Light Jog	**1 Lap / 2 Mins**
Skips with Arm Circles (Forward & Backward)	**40 m**
Lateral Jacks with Arm Flaps (Left & Right)	**40 m**
High Knees	**20 m**
Power Carioca (Left & Right)	**20 m**
Continuous Movement Prep	
3 Step - Knee Hug	**x 5***
3 Step - Warrior Lunge	**x 5***
3 Step - Quad Stretch to Deadlift	**x 5***
Tarzan Shuffle	**x 5**
Stationary Movement Prep	
Eagle kicks	**x 8***
Scorpions	**x 8***
Hip Crossovers	**x 8***
Dowell Dislocates (or Arm Swings Forwards & Backwards)	**x 8***
AIS Calf Stretch (Straight & Bent Leg)	**x 4***
Ball (Med/Volley) - Around the World (High/Low)	**x 8***
Activity Prep - Neural Activation	
Lateral Line Hops	**2 x 10 sec**
Linear Line Hops	**2 x 10 sec**
Alternating Linear Line Hops	**2 x 10 sec**
Tuck Jumps	**2 x 10**

Flexibility Training

Dynamic stretching will be used in the warm-up and a group stretch will be conducted by a training coach for the last 15-minutes of every session.

Type : Goal	Description (Remember - close eyes, deep breathing, relaxed state)
Static: Re-lengthen	Hold a stretch for a minimum of 20 – 30 seconds. Deep breaths and try to move deeper into the stretch. Repeat 2-3 times.
PNF: Re-lengthen	Hold a stretch for 10 – 20 seconds. Then using the same muscle push back 10% isometric contraction for 6 seconds. Take a deep breath and move into the stretch deeper than before. Repeat 3-6 cycles.
AIS: Re-teach	Fluid stretching: Opposite muscle works to teach re-lengthened muscle how far it can now go. 2 second contraction followed by 2 second stretch with overpressure. Repeat 8-10 cycles.

FLEXIBILITY 1

TYPE / EXERCISE	REPS X DURATION
Anterior Fascia Ball Stretch (Largest Stability Ball)	**1 x 45 seconds**
Lat Ball Stretch - reach and roll - palms up (Stability Ball)	**1 x 30 seconds each side**
Static Wall Calf Stretch (Straight Leg = Gastroc)	**2 x 30 seconds each side**
AIS Calf Stretch (Straight Leg = Gastroc)	**8 cycles each side** cycle = 2 seconds at top (inhale) & 2 seconds at bottom (exhale)
Static Hip Flexor Stretch - lunge position - head forward - chest up - back leg 45 degrees	**1 x 30 seconds each side**
Static Glute Stretch - push up position - foot to hand - sit down overtop - other leg straight back - DO NOT substitute this exercise	**1 x 30 seconds each side**
PNF Butterfly Stretch - use elbows to push down (Groin = Short Head Adductors)	**10 seconds stretch - 6 second pressing legs up 10% strength into elbows - repeat 4 times**
Static Two Leg Seated Hamstring Stretch	**2 x 30 seconds**
Static X-Body Sprial Stretch - lying supine - take knee across body and hold to ground - rest arm diagonally up in opposite direction	**1 x 30 seconds each side**
PNF Shoulder Capsule - lying on top of shoulder - slowly rotate arm towards ground - add pressure	**10 seconds stretch - 6 second pressing back against hand 10% strength - repeat 4 times**

FLEXIBILITY 2

TYPE / EXERCISE	REPS X DURATION
Downward Dog to Cobra	**8 x 5 seconds each position**
Static Rope Hamsting (Origin) - lying supine - use rope to pull straight leg into stretch and hold	**1 x 30 seconds each side**
Static Rope Hamsting (Insertion) - lying supine - bring knee to chest - use rope to pull bent leg into straight position	**1 x 30 seconds each side**
AIS Rope Hamstring - actively raise leg to face - use rope for overpressure once at end range	**8 cycles each side** cycle = 2 seconds at top (inhale) & 2 seconds at bottom (exhale)
Static Splits - as far as you can go - sit down - hold front and both sides (Long Head Adductors)	**1 x 30 seconds front and each side**
Static Seated Figure 4 - sitting tall with straight back cross one leg over - hug across and tight to	**1 x 30 seconds each side**
Static Rope Quad - prone lying - pull foot toward your head and into the air using rope	**1 x 30 seconds each side**
PNF Rope Rotator Cuff - both hands behind back - 1 up and 1 down - grasp rope - pull up	**10 seconds stretch - 6 seconds pulling down at 10% strength - repeat 4 times**
Static Rope Pec Stretch - if you have should problem <u>be cautious</u> - try using a resistance band	**2 x 30 seconds**

Training Programs

The program is broken up into 4 different full body workouts. The participants are broken up into smaller training groups, 6 to 1, with a training coach and will do a full body circuit. Each of the groups will complete the 4 different workouts two times over the 8-weeks program.

Tips:

- 2-minutes rest between circuits
- Set up as stations and move from station to station
- Technique is the focus/ not weight lifted or completing the reps
- Provide options: **beginner-intermediate-advanced**
- If you can make it fun they are more motivated to complete it
- Encourage them to take water

Strength Circuit 1 – Medicine Ball Workout

Exercise	**Week 1-3**	**Week 4-5**	**Week 6-8**
Squat	2 x 15	2-3 x 12	3 x 10
Chest Push	2 x 15	2-3 x 12	3 x 10
Lunge	2 x 12 each side	2 –3 x 10	3 x 8
Overhead Toss	2 x 15	2-3 x 10	3 x 10
Med Ball Step Up	2 x 12 each side	2-3 x 10	3 x 10
Underhand Rot Toss	2 x 12 each side	2-3 x 10	3 x 10
Calf Raise	2 x 12	2-3 x 10	3 x 10
Push up	2 x 10-12	2 x 12-15	2 x 15

Strength Circuit 2 – Dumbells

Exercise	**Week 1-3**	**Week 4-5**	**Week 6-8**
Squat (trip flex – trip ext)	2 x 15	2-3 x 12	3 x 10
Push-up	2 x 15	2-3 x 12	3 x 10
Walking Lunge	2 x 12 each side	2 –3 x 10	3 x 8
Row	2 x 15	2-3 x 10	3 x 10
Deadlift	2 x 12	2-3 x 10	3 x 10
Bicep Curl	2 x 12 each side	2-3 x 10	3 x 10
Calf Raise	2 x 12	2-3 x 10	3 x 10
Tricep Ext	2 x 10-12	2 x 12-15	2 x 15
45 degree Lunge	2 x 12	2-3 x 10	3 x 10
Shoulder Press	2 x 10-12	2 x 12-15	2 x 15

Strength Circuit 3 – BOSU

Exercise	**Week 1-3**	**Week 4-5**	**Week 6-8**
Squat	2 x 15	2-3 x 12	3 x 10
Push-up	2 x 15	2-3 x 12	3 x 10
Lunge	2 x 12 each side	2 –3 x 10	3 x 8
Dips	2 x 12	2-3 x 10	3 x 10
Single Leg Deadlift	2 x 12 each side	2-3 x 10	3 x 10
Bicep Curl	2 x 12 each side	2-3 x 10	3 x 10
Jump and Hold	2 x 12	2-3 x 10	3 x 10
Tricep Ext	2 x 10-12	2 x 12-15	2 x 15
Calf Raise	2 x 12	2-3 x 10	3 x 10
Shoulder Press	2 x 10-12	2 x 12-15	2 x 15

Strength Circuit 4 – Cables/ Tubing/ Plyos

Exercise	Week 1-3	Week 4-5	Week 6-8
Drop Squat (step)	2 x 15	2-3 x 12	3 x 10
Walking Push-up	2 x 15	2-3 x 12	3 x 10
Single Leg Hop	2 x 12 each side	2 –3 x 10	3 x 8
Row (cable or tube)	2 x 12	2-3 x 10	3 x 10
Lateral Single Leg Hop	2 x 12 each side	2-3 x 10	3 x 10
Chest press (cable or tube)	2 x 12 each side	2-3 x 10	3 x 10
Lateral Step Squat (tube)	2 x 12	2-3 x 10	3 x 10
Tricep Pull Down	2 x 10-12	2 x 12-15	2 x 15
Cross over/ hip Adduction (tube/ cable)	2 x 12	2-3 x 10	3 x 10
Bicep Curl to Shoulder Press	2 x 10-12	2 x 12-15	2 x 15

Cardiovascular Training (20-minutes)

Strength Circuit 1 – Motor Pattern Drills
- Suicides (slow /med/fast and simple to complex)
- Forward, backward, lateral, combo's

Strength Circuit 2 – Intervals on Spin Bikes or Cardio Equip
- Speed play
- Hills to flats

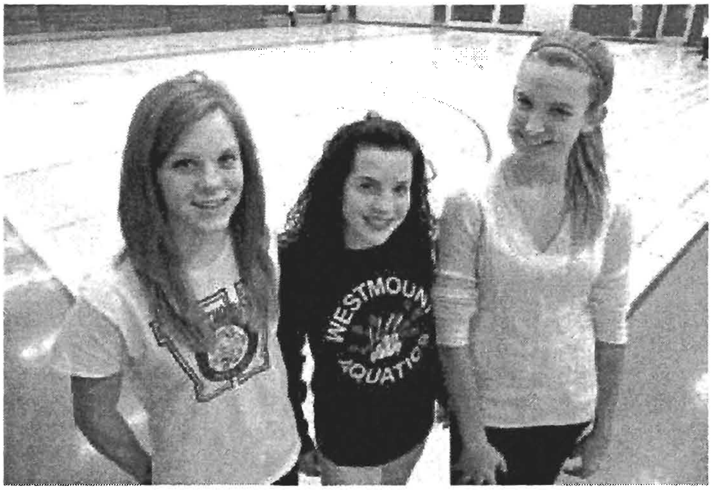
Strength Circuit 3 – Coordination
- Agility Ladders
- Skipping Ropes
- Cone Drills

Strength Circuit 4 – Fartlek on Track
- Group jog
- Person at back of group accelerates to the front
- 20-minutes including cardio cool down of 5-minutes

Sport Academy
General Athletic Prep Program

Grade 9

FUNdamentals and Learning to Train



"Sport does not build character, it reveals it!"

McMASTER
the Pulse

Education

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Topics include:

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Warm-up

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WARM UP 1	**Total Time - 15 min**
Total Body Focus	**Distance / Time**
Continuous Dynamic Warm-up	
Light Jog	**2 Laps**
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Carioke (Left & Right)	**40 m**
High Knees	**20 m**
Butt Kicks	**20 m**
Continuous Movement Prep	
3 Step - Hip Opening	**x 5***
3 Step - Knee Hug to 45 Degree Lunge	**x 5***
3 Step - 747 (Inverted Hamstring)	**x 5***
Spiderman Crawl	**20m**
Stationary Movement Prep	
Leg Swings - Front to Back	**x 8***
Leg Swings - Side to Side	**x 8***
Med Ball - Linear Wood Chop	**x 8**
Med Ball - Rotations	**x 8***
Activity Prep - Neural Activation	
Burpies	**5**
Explosive Push Ups	**5**
Tuck Jumps	**2 x 10**

WARM UP 2	Total Time - 15 min
Total Body Focus	**Distance / Time**
Continuous Dynamic Warm-up	
Light Jog	**1 Lap / 2 Mins**
Skips with Arm Circles (Forward & Backward)	**40 m**
Lateral Jacks with Arm Flaps (Left & Right)	**40 m**
High Knees	**20 m**
Power Carioca (Left & Right)	**20 m**
Continuous Movement Prep	
3 Step - Knee Hug	**x 5***
3 Step - Warrior Lunge	**x 5***
3 Step - Quad Stretch to Deadlift	**x 5***
Tarzan Shuffle	**x 5**
Stationary Movement Prep	
Eagle kicks	**x 8***
Scorpions	**x 8***
Hip Crossovers	**x 8***
Dowell Dislocates (or Arm Swings Forwards & Backwards)	**x 8***
AIS Calf Stretch (Straight & Bent Leg)	**x 4***
Ball (Med/Volley) - Around the World (High/Low)	**x 8***
Activity Prep - Neural Activation	
Lateral Line Hops	**2 x 10 sec**
Linear Line Hops	**2 x 10 sec**
Alternating Linear Line Hops	**2 x 10 sec**
Tuck Jumps	**2 x 10**

Flexibility Training

Dynamic stretching will be used in the warm-up and a group stretch will be conducted by a training coach for the last 15-minutes of every session.

Type : Goal	Description (Remember - close eyes, deep breathing, relaxed state)
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FLEXIBILITY 1

TYPE / EXERCISE	REPS X DURATION
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Static Hip Flexor Stretch - lunge position - head forward - chest up - back leg 45 degrees	**1 x 30 seconds each side**
Static Glute Stretch - push up position - foot to hand - sit down overtop - other leg straight back - DO NOT substitute this exercise	**1 x 30 seconds each side**
PNF Butterfly Stretch - use elbows to push down (Groin = Short Head Adductors)	**10 seconds stretch - 6 second pressing legs up 10% strength into elbows - repeat 4 times**
Static Two Leg Seated Hamstring Stretch	**2 x 30 seconds**
Static X-Body Sprial Stretch - lying supine - take knee across body and hold to ground - rest arm diagonally up in opposite direction	**1 x 30 seconds each side**
PNF Shoulder Capsule - lying on top of shoulder - slowly rotate arm towards ground - add pressure	**10 seconds stretch - 6 second pressing back against hand 10% strength - repeat 4 times**

FLEXIBILITY 2

TYPE / EXERCISE	REPS X DURATION
Downward Dog to Cobra	**8 x 5 seconds each position**
Static Rope Hamsting (Origin) - lying supine - use rope to pull straight leg into stretch and hold	**1 x 30 seconds each side**
Static Rope Hamsting (Insertion) - lying supine - bring knee to chest - use rope to pull bent leg into straight position	**1 x 30 seconds each side**
AIS Rope Hamstring - actively raise leg to face - use rope for overpressure once at end range	**8 cycles each side** cycle = 2 seconds at top (inhale) & 2 seconds at bottom (exhale)
Static Splits - as far as you can go - sit down - hold front and both sides (Long Head Adductors)	**1 x 30 seconds front and each side**
Static Seated Figure 4 - sitting tall with straight back cross one leg over - hug across and tight to	**1 x 30 seconds each side**
Static Rope Quad - prone lying - pull foot toward your head and into the air using rope	**1 x 30 seconds each side**
PNF Rope Rotator Cuff - both hands behind back - 1 up and 1 down - grasp rope - pull up	**10 seconds stretch - 6 seconds pulling down at 10% strength - repeat 4 times**
Static Rope Pec Stretch - if you have should problem be cautious - try using a resistance band	**2 x 30 seconds**

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Chest Push	2 x 15	2-3 x 12	3 x 10
Lunge	2 x 12 each side	2 –3 x 10	3 x 8
Overhead Toss	2 x 15	2-3 x 10	3 x 10
Med Ball Step Up	2 x 12 each side	2-3 x 10	3 x 10
Underhand Rot Toss	2 x 12 each side	2-3 x 10	3 x 10
Calf Raise	2 x 12	2-3 x 10	3 x 10
Push up	2 x 10-12	2 x 12-15	2 x 15

Strength Circuit 2 – Dumbells

Exercise	**Week 1-3**	**Week 4-5**	**Week 6-8**
Squat (trip flex – trip ext)	2 x 15	2-3 x 12	3 x 10
Push-up	2 x 15	2-3 x 12	3 x 10
Walking Lunge	2 x 12 each side	2 –3 x 10	3 x 8
Row	2 x 15	2-3 x 10	3 x 10
Deadlift	2 x 12	2-3 x 10	3 x 10
Bicep Curl	2 x 12 each side	2-3 x 10	3 x 10
Calf Raise	2 x 12	2-3 x 10	3 x 10
Tricep Ext	2 x 10-12	2 x 12-15	2 x 15
45 degree Lunge	2 x 12	2-3 x 10	3 x 10
Shoulder Press	2 x 10-12	2 x 12-15	2 x 15

Strength Circuit 3 – BOSU

Exercise	**Week 1-3**	**Week 4-5**	**Week 6-8**
Squat	2 x 15	2-3 x 12	3 x 10
Push-up	2 x 15	2-3 x 12	3 x 10
Lunge	2 x 12 each side	2 –3 x 10	3 x 8
Dips	2 x 12	2-3 x 10	3 x 10
Single Leg Deadlift	2 x 12 each side	2-3 x 10	3 x 10
Bicep Curl	2 x 12 each side	2-3 x 10	3 x 10
Jump and Hold	2 x 12	2-3 x 10	3 x 10
Tricep Ext	2 x 10-12	2 x 12-15	2 x 15
Calf Raise	2 x 12	2-3 x 10	3 x 10
Shoulder Press	2 x 10-12	2 x 12-15	2 x 15

Strength Circuit 4 – Cables/ Tubing/ Plyos

Exercise	Week 1-3	Week 4-5	Week 6-8
Drop Squat (step)	2 x 15	2-3 x 12	3 x 10
Walking Push-up	2 x 15	2-3 x 12	3 x 10
Single Leg Hop	2 x 12 each side	2 –3 x 10	3 x 8
Row (cable or tube)	2 x 12	2-3 x 10	3 x 10
Lateral Single Leg Hop	2 x 12 each side	2-3 x 10	3 x 10
Chest press (cable or tube)	2 x 12 each side	2-3 x 10	3 x 10
Lateral Step Squat (tube)	2 x 12	2-3 x 10	3 x 10
Tricep Pull Down	2 x 10-12	2 x 12-15	2 x 15
Cross over/ hip Adduction (tube/ cable)	2 x 12	2-3 x 10	3 x 10
Bicep Curl to Shoulder Press	2 x 10-12	2 x 12-15	2 x 15

Cardiovascular Training (20-minutes)

Strength Circuit 1 – Motor Pattern Drills

- Suicides (slow /med/fast and simple to complex)
- Forward, backward, lateral, combo's

Strength Circuit 2 – Intervals on Spin Bikes or Cardio Equip

- Speed play
- Hills to flats

Strength Circuit 3 – Coordination

- Agility Ladders
- Skipping Ropes
- Cone Drills

Strength Circuit 4 – Fartlek on Track

- Group jog
- Person at back of group accelerates to the front
- 20-minutes including cardio cool down of 5-minutes