RESISTANCE TRAINING, ATTITUDES TOWARD PHYSICAL ACTIVITY, AND PHYSICAL ACTIVITY LEVELS IN CHILDREN

by

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A Dissertation Proposal Submitted to
the Faculty of the Graduate School at
Middle Tennessee State University
in Partial Fulfillment
of the Requirements for the Degree
Doctorate of Philosophy

Murfreesboro, TN
August 2009

APPROVAL PAGE

RESISTANCE TRAINING, ATTITUDES TOWARD PHYSICAL ACTIVITY,

AND PHYSICAL ACTIVITY LEVELS IN CHILDREN

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DEDICATION

I would like to dedicate this work to the memory of my grandfather, Howard Ray Renfrow. Grandpa was a great supporter of my educational pursuits in my younger years. Although he hasn't been here physically to encourage me through my graduate work, my memories of him have been a source of encouragement during the past several years. He always stressed the importance of a good education to my dad, my brother, and me. Although he won't be able to cheer me on at graduation, I know he would be very proud of me. This one's for you, Grandpa.

ACKNOWLEDGEMENTS

I am so thankful to God for His gift of perseverance throughout the dissertation process. He has blessed me with wonderful people in my life who have enabled me to make get where I am today. He deserves the highest praise.

I would like to thank my wonderful wife, Hannah. Not only was she a great source of encouragement throughout my writing and data collection, she also helped me with data entry and other more tangible parts of my dissertation. Thank you, honey!

Certainly, my committee needs many thanks. Drs. Caputo, Farley, Eveland-Sayers, and Fuller were very gracious to work with me and were also very patient. Dr. Caputo deserves special thanks for how many hours she put into reading the numerous rough drafts, even over holidays and weekends. The end product would not be what it is had it not been for my committee.

I also want to thank the other professors who helped me with the data entry process. Drs. Owusu and Weatherby were kind enough to show me how to work EpiData which eventually streamlined the data entry process. Thank you, Dr. Owusu, for all of those extra meetings.

I would like to thank the faculty at Reeves Rogers who enabled me to train the children. Dr. Clark, Miss Kathy, Mrs. Turnbow, Mrs. Jones, Mrs. Davis-Louis, Mrs. Fleming, Mrs. Svarda, Mrs. Trussell, Mrs. Taylor, Mr. Winton, Mr. Jones, and Mr. Nuell. You were very flexible with your schedules which allowed me to finish everything in a timely manner. A special thanks to Lori Turnbow for all of her additional help with just about everything. Also, I'd like to thank the students. They worked very hard in

training and I was proud to get to work with some very intelligent children. To all of the boys and girls in the fourth and fifth grade classes, thank you!

Finally, I'd like to thank my friends and family whose encouragement and prayers were uplifting at the times I needed them most. I share this accomplishment with all of you. Thank you!

RENFROW, MATTHEW, S., Ph.D. Resistance Training, Attitudes toward Physical Activity, and Physical Activity Levels in Children. (2009).
Directed by Dr. Jennifer L. Caputo. 76pp.

Physical activity (PA) levels are decreasing in children while concurrent increases in childhood obesity are apparent. Innovative ways of increasing PA and consequently decreasing obesity rates are being sought. Therefore, the purpose of this study was to examine the effects of a 10-week school-based resistance (RT) program on body mass index (BMI), attitudes toward physical activity (ATPA), and general PA levels in children. The sample included 118 children in the fourth and fifth grade (average age of 10.0 years) at an elementary school in the Southeast. Height and body mass were used to calculate BMI. ATPA was assessed using the Children's Attitudes toward Physical Activity Inventory (CATPAI) and PA was measured with the Physical Activity Questionnaire for Older Children (PAQC). There was no interaction of time and group for BMI, overall CATPAI scores, or overall PAQC scores ($p > .05$). BMIs of children significantly increased over time for the full sample ($p = .031$). Although not statistically significant, weight increased by 2.6% more in children in the control group than children in the experimental group. There was a significant interaction of time and group for the health and fitness subdomain of attitude ($p = .007$). Attitude about participating in PA for health and fitness in children participating in the RT program worsened while attitude improved in children who did not participate in the program. PA levels significantly increased over time for the full sample ($p < .001$). RT can be used as a mode of activity to keep children physically active, though extended and unvarying RT programs may produce disinterest. Shorter RT programs with varying workouts may increase PA levels

and prevent weight gain in a young population that is becoming increasingly sedentary and heavier.

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CHAPTER I

INTRODUCTION

Physical activity (PA) levels are low in American children. According to National Health and Nutrition Examination Survey (NHANES) data, only 42% of children (Troiano et al., 2008) participate in the recommended daily amount of moderate-to-vigorous physical activity (MVPA). Child PA rates have declined from the previous NHANES and, as such, methods to reverse physical inactivity (PIA) are needed (Rao, 2008).

PIA has many negative physical health consequences including increased risk of cardiovascular disease (Prentice & Jebb, 2006) and metabolic disease (Lanza et al., 2008). Perhaps the most obvious result of PIA is obesity. A positive relationship between PIA and obesity, as measured by body mass index (BMI) and percent body fat, has been extensively documented (Dencker & Anderson, 2008; Must & Tybor, 2005). Various negative psychological and social ramifications are also evident as a consequence of childhood obesity (Edmunds, 2008; Messiah, Arheart, Luke, Lipshultz, & Miller, 2008).

Childhood obesity rates, along with childhood PIA, are rising in the U.S. (Ogden, Carroll, & Flegal, 2008). Obesity presents similar physical health risk factors to those of PIA such as increased cardiovascular diseases risk (i.e., metabolic syndrome) and an increased risk for developing type 2 diabetes (Messiah et al., 2008). Children who are obese may also have low self-esteem (Shin & Shin, 2008), be socially excluded (Booth, Wilkenfeld, Pagnini, Booth, & King, 2008), and be stigmatized (Edmunds, 2008).

Frighteningly, childhood obesity is correlated with later adult obesity (Serdula et al., 1993). As childhood obesity and PIA are linked, new ways to increase PA levels to reverse the trend towards obesity and PIA are needed.

Resistance training (RT) is becoming a more popular mode of exercise for children, albeit controversial. Concerns over safety of RT as a mode of exercise for physically immature children have been attributed to National Electronic Injury Surveillance System (NEISS) data tallying 17,000 RT injuries in 1979 and over 8,000 RT injuries in 1987 (Faigenbaum et al., 1996). Conclusions drawn from these data, however, are misleading, because the authors did not distinguish between RT and riskier Olympic weightlifting and powerlifting. Moreover, many injuries were attributed to poor training, excessive load, free access to equipment, and lack of qualified supervision (Faigenbaum et al.). Overall, RT in children can be safer than common sports like soccer (Hamill, 1994).

As with any type of PA, there are risks with RT, however, in a properly supervised environment, the benefits of RT supersede the risks. A well-known benefit of RT is increased muscular strength (MS). In prepubescent children, MS increases of 13% to 30% are common (Falk & Tenenbaum, 1996) from an increase in excitation-contraction coupling (Ramsay et al., 1990) and/or greater recruitment of muscle fibers (Ozmun, Mikesky, & Surburg, 1994; Ramsay et al.). RT may also increase insulin sensitivity in children (Shaibi et al., 2006). Perhaps the most important aspect of RT is its ability to reduce obesity in children. Although aerobic activity is an important part of weight management, RT in addition to aerobic activity is superior to aerobic training alone when reducing total body mass and fat mass, while increasing fat-free mass

(LeMura & Maziekas, 2002; Sothern et al., 2000). An 8-week RT-only intervention has been shown to reduce body fat, BMI, and waist-to-hip ratio in children (Benson, Torode, & Singh, 2008). The improvements were due to a decrease in total body adiposity as well as central adiposity. Interestingly, children who are obese view RT programs favorably (Sothern et al., 2000; Watts, Jones, Davis, & Green, 2005) which may improve their attitudes toward physical activity (ATPA) and, consequently, their overall PA levels.

Different determinants of PA exist. Some theories that have been developed include the impact of ATPA as an important determinant of participation in PA (Ajzen & Fishbein, 1975; Fishbein & Ajzen, 1980). Approximately 30% of the variance in exercise behavior in adults is attributable to the intent to perform PA (Godin, 1994). ATPA is significantly related to intent to perform PA and is, therefore, important when considering why individuals participate in PA. Based on the link between ATPA and participating in PA, the Attitudes toward Physical Activity Inventory (ATPAI), which measures ATPA in adults, was developed (Kenyon, 1968). Although the ATPAI is useful in adult populations, it is not appropriate for use with children. Instead, the Children's Attitudes toward Physical Activity Inventory (CATPAI) was constructed for use with children in fourth through sixth grade (Simon & Smoll, 1974). Because children's attitudes toward physical activity (CATPA) and participation in PA are related (Schutz, Smoll, Carre, & Mosher, 1985), interventions to improve CATPA might concomitantly increase PA levels (Block & Zeman, 1996). However, because the relationship between CATPA and participation in PA is not strong (Schutz et al., 1985), a measure of PA is desirable.

Measuring children's PA levels is difficult. Many different measurement tools for assessing children's PA levels exist, each with apparent strengths and weaknesses. Objective measurement tools, like pedometers and accelerometers, albeit valid and reliable (Welk, Corbin, & Dale, 2000), measure only walking- and running-based activities, are costly (Rice & Howell, 2000), and are easily forgotten or lost. Direct observation, a common criterion measure, can alter PA behavior (Rice & Howell), and is time-intensive. PA questionnaires for children can be used to record various types of activity and are useful in large scale studies (Kriska & Caspersen, 1997), although recall can be challenging (Sallis, 1991). One questionnaire, the Physical Activity Questionnaire for Older Children (PAQC), has been widely used to measure PA in children ages 8 years to 14 years old (Crocker, Bailey, Faulkner, Kowalski, & McGrath, 1997). The PAQC has demonstrated construct and convergent validity and significantly correlates to accelerometry (Kowalski, Crocker, & Faulkner, 1996; Kowalski, Crocker, & Faulkner, 1997). Because the PAQC has repeatedly been shown to have acceptable validity (Janz, Lutuchy, Wenthe, & Levy, 2008) it can be used to measure general PA levels of children.

As children are becoming less physically active (Le Masurier et al., 2008; Pate et al., 1995; Strong et al., 2005) and childhood obesity rates are increasing (Ogden et al., 2008), health organizations are working to reverse these trends. Various media have been used to increase CATPA (Huhman et al., 2007; Tsorbatzoudis, 2005) in an attempt to increase the PA levels of children. Improving CATPA is a primary goal of physical education (PE) programs where many children get a majority of their PA (DeMarco & Sidney, 1989). Experts suggest that interventions in the school system are an effective way to address childhood obesity and inactivity (Rao, 2008; Sallis & Mackenzie, 1991).

Indeed, up to 97% of children in elementary school participate in some form of PE. Children have few, if any, barriers to participate in school-based interventions. No extra time requirements are necessary on the part of families nor do families incur additional cost for these types of interventions, both of which are common barriers for children's participation in PA programs (Grimes-Robison & Evans, 2008).

Several school-based interventions have been used to improve the health of children. A study conducted by Foster et al. (2008) utilized the school-based intervention approach in a 2-year study of fourth through sixth graders in Mid-Atlantic schools. The intervention was a multifaceted approach including school assessment, nutrition education, nutrition policy, social marketing, and parent outreach. Children in the schools that received the treatment had a 50% reduction in the obesity rate. Another study conducted on 69 classes of fourth and fifth graders from Florida, Delaware, Kansas, and North Carolina produced similar positive results. The one-semester program implemented different modules to impact student behavior. Children in the experimental schools had greater increases in fruit and vegetable consumption, greater decreases in BMI by loss of total body mass, and greater increases in PA than children in the control schools (Spiegel & Foulk, 2006). Children in the experimental schools increased their school day PA from 59 minutes per week to 102 minutes per week as well as increasing their outside of school PA from 22 minutes per day to 37 minutes per day. Although RT may be used as a similar in-school intervention to increase CATPA and children's PA levels, RT is not commonly incorporated in the school environment (Sothern et al., 1999). This is likely due to the expense of equipment and staffing, the lack of physical space for the equipment, and the lack of qualified personnel. The goal of the current study was to determine if instructing children on safe, proper RT techniques yielded similar positive results on PA levels outside of the school environment as has been demonstrated in previous school-based research.

RT, which has been shown to be enjoyable for children (Sothern et al., 1999; Watts et al., 2005), may peak interest and confidence in children relative to their ability to be physically active. While completing RT workouts, which are individualized to be appropriate for the fitness level of each child, children experience success during each RT session. Likewise, as their muscular strength (MS) and muscular endurance (ME) improve, children are able to achieve specific fitness goals and receive positive feedback as they increase the amount of weight they are able to move or the number of repetitions they can perform. Hopefully, this self-empowerment will lead children to take ownership in their own learning and health and consequently lead to changes in their ATPA and increases in their general PA levels outside of the RT intervention (Cole, Waldrop, D'Auria, & Garner, 2006).

In conclusion, children are in need of new ways to become physically active to promote healthy living. The current study was conducted in the school setting through an intervention that is cost- and time-effective for both parents and children. The twice weekly RT program was administered during regular school hours on school property. Competent staff was in charge of monitoring, correcting, and encouraging children to ensure safety and efficacy. The aim of the study was to positively impact BMI, CATPA, and PA levels outside of the RT intervention.

Purpose Statement

The purpose of this study was to examine the effects of a school-based RT program on BMI, ATPA, and general PA levels in children.

Hypotheses

1) Children who participated in RT decreased their BMI more than children who did not participate in RT.

2) Children who participated in RT increased their PA levels outside of the program more than children who did not participate in RT.

3) Children who participated in RT improved their ATPA more than children who did not participate in RT.

Definition of Terms

1) Attitude: Attitude is a "latent or non-observable, complex but relatively stable behavioral position reflecting both direction and intensity of feeling toward a particular object, whether it be concrete or abstract" (Kenyon, 1968, p. 1).

2) Olympic Weightlifting: Olympic weightlifting is a sport in which athletes attempt to lift the maximal amount of weight in the clean and jerk exercise and the snatch exercise (Kleogh, Hume, Pearson, & Mellow, 2008).

3) PA Level: PA level is defined as PA that is measured by the PAQC.

4) Powerlifting: Powerlifting is a sport in which athletes attempt to lift the maximal amount of weight in the squat exercise, bench press exercise, and deadlift exercise (Kleogh et al., 2008).

5) RT: RT is a method of training involving resistance to increase the ability to exert or resist force (Baechle & Earle, 2000).

Basic Assumptions

1) It was assumed that participants truthfully answered all questions on the questionnaires.

2) It was assumed that participants understood the questions on the PAQC.

3) It was assumed that participants did not perform RT outside of the intervention.

Delimitations

1) The participants in this study were fourth and fifth grade boys and girls in a single elementary school in the Southeast.

2) The participants had been admitted to the elementary school based on high standardized test scores.

Significance of the Study

PIA rates are rising in children. Along with other diseases, PIA has been linked with childhood obesity. Childhood obesity is a serious health issue in the U.S. Children who are obese suffer many negative physical and psychosocial consequences. Different options have been proposed as a way of combating childhood obesity, including increasing levels of PA. RT has recently become a popular mode of exercise to reduce childhood obesity. Children enjoy this mode of exercise, perhaps because of the similar nature of RT to child PA patterns. Consequently, an RT program may increase children's ATPA and, ultimately, PA levels. Therefore, an RT intervention could improve the current and future physical, psychological, and social health of children which would have positive immediate and lasting impacts on national health.

CHAPTER II

LITERATURE REVIEW

This chapter begins with a description of PA levels of children. This is followed by information on the health implications of inactivity and a discussion of childhood obesity rates, including the negative health consequences of obesity. Next, RT in children is detailed along with how RT can combat obesity. Then, RT as a means to improve attitudes toward PA in children and child PA levels is discussed. The chapter ends with an overall summary and the purpose of the study.

PA Levels in Children

PA levels are often lamented as being low. An analysis of 2003 and 2004 NHANES data reveals that only 42% of children ages 6 years to 11 years old (Troiano et al., 2008) meet or exceed the recommended daily MVPA of 60 minutes (Pate et al., 1995) set forth by the American College of Sports Medicine (ACSM) and the Centers for Disease Control and Prevention (CDC). Just 8% of adolescents aged 12 years to 15 years old achieve the same goal for recommended daily MVPA (Troiano et al.). Although children and adolescents are among the most physically active subpopulations (Le Masurier et al., 2008), the recent decline in adolescent PA levels is concerning (Strong et al., 2005).

Children 9 years of age have been reported to average 3 hours per day of MVPA on weekdays and weekends. Yet, by the age of 15 years old, weekday MVPA decreases to 49 minutes and weekend MVPA decreases to only 35 minutes, with boys being more active than girls (Nader, Bradley, Houts, McRitchie, & O'Brien, 2008). Even young children ages 2 years to 5 years old are becoming less active (Strong et al., 2005). Creative ways to increase child PA levels should be sought to address PIA in children (Rao, 2008).

PIA. The negative health consequences of PIA are well-documented in adults and current studies reveal similar consequences in children (Prentice & Jebb, 2006). In a recent review, Dencker and Andersen (2008) linked several negative health consequences to PIA such as cardiovascular disease and low aerobic fitness. Specifically, cardiovascular disease risk factors such as hypertension and hypercholesterolemia have been associated with PIA (Prentice & Jebb) as well as impaired mitochondrial enzyme activity, which is associated with insulin-resistance and type 2 diabetes (Lanza et al., 2008).

One of the most common associations with PIA is childhood obesity. Several studies, as reported in one review (Dencker & Anderson, 2008), have shown a direct relationship between PIA and childhood obesity measured by BMI and percent body fat. A review by Must and Tybor (2005) also documented the direct relationship between PIA and BMI and percent body fat, respectively. Also, as will be discussed, numerous physical and psychosocial problems are correlated with childhood obesity (Edmunds, 2008; Messiah et al., 2008).

Childhood Obesity in the U.S.

National childhood obesity rates are increasing (Ogden et al., 2008) which has serious health consequences (Messiah et al., 2008). Although childhood obesity, defined as a BMI above the 95th percentile (CDC, n.d.), is a growing concern in the U.S., confusion surrounds the process of stratification. BMI, calculated by dividing mass in kilograms by height in meters squared, is commonly used to stratify adults and children in to categories of underweight, normal weight, overweight, and obese. However, adult and child criteria for classification are different. Adults, regardless of sex, have fixed classification cut points (ACSM, 2009). The adult classification for underweight is a BMI of less than 18.5 kg/m^2, normal weight is a BMI from 18.5 kg/m^2 to 24.9 kg/m^2, overweight is a BMI from 25.0 kg/m^2 to 29.9 kg/m^2, and obesity is a BMI over 30 kg/m^2. Child BMIs are compared to national norms for sex and age from ages 2 years to 20 years (Ogden et al., 2002). Underweight is a BMI less than the 5^{th} percentile, healthy weight is a BMI from the 5^{th} percentile up to the 85^{th} percentile, overweight is a BMI at the 85^{th} up to the 95^{th} percentile, and obese is a BMI equal to or greater than the 95^{th} percentile (CDC).

Different organizations have different BMI classification cut points and different sets of terminology which also adds to confusion. As noted above, the CDC (n.d.) defines childhood obesity as being above the 95^{th} percentile yet cites the increasing number children who are "overweight" with a BMI above the 95^{th} percentile. Attention must be paid to what cut points and terminology are being used for proper understanding of statistics and implications of obesity rates.

Childhood obesity statistics and consequences. The results of the most recent NHANES revealed that 16.3% of children and adolescents ages 2 years to 19 years are obese (Ogden et al., 2008). Results from the NHANES also revealed that children who are obese have a greater prevalence of metabolic syndrome risk factors such as a large waist circumference, high levels of fasting glucose and triglycerides, high blood pressure, and low high-density lipoprotein levels. These factors may put children at risk for type 2 diabetes and cardiovascular disease at a young age (Messiah et al., 2008). Also, childhood obesity is persistent. Epidemiological studies from 1970 to 1992 showed a consistently positive relationship between anthropometric measures of childhood obesity and adult obesity (Serdula et al., 1993). About 1/3 of preschool aged children who were obese and 1/2 of school aged children who were obese became adults who were obese. Across the reviewed studies for all ages, children who were obese were at least twice as likely to become obese adults.

Although physiological ramifications of obesity are negative, the psychosocial consequences can be worse (Dietz, 1998). Adults who are obese have lower self-esteem and lower control over eating impulses than the general population. Also, they fail to believe they function well in society (Lykouras, 2008). Often, children who are obese have similar concerns. Fifth and sixth grade children who are obese have lower self-esteem and lower body satisfaction than children who weigh less (Shin & Shin, 2008). Adolescents recognize the perils of being overweight and obese. One study revealed that adolescents aged 12 years to 17 years perceive others who are overweight and obese to be teased and bullied, socially excluded, physically inferior, and in poor health (Booth et al., 2008). A qualitative study revealed four areas of concern in children who are overweight or obese including reactions of others, coping with body size, buying clothes, and the impacts of teasing and bullying. Additionally, children who are overweight or obese are subject to negative stigmas, parental blame, and family ostracization (Edmunds, 2008). Children who are very obese (i.e., having a BMI above the 99.5^{th} percentile) have been reported to have a lower quality of life than those with lower BMIs (Tyler, Johnston, Fullerton, & Foreyt, 2007).

Summary. The number of children in the U.S. who are obese is alarming. According to national data, this number is rising quickly (Ogden et al., 2008). This is a serious problem because children who are obese are at risk of becoming obese adults (Serdula et al., 1993) and developing metabolic or cardiovascular disease (Messiah et al., 2008). Negative psychosocial affects are also concerns of childhood obesity, as children who are obese have lower self-esteem than children who are not obese (Shin & Shin, 2008). Adolescents perceived their overweight and obese peers to be physically inferior to other children as well as being socially excluded (Booth et al., 2008). Steps toward addressing this serious national and global crisis are being taken by professional health advocates worldwide. RT is a new approach being applied toward the effort to combat childhood obesity.

RT with Children

Several recommendations have been made to combat childhood obesity including various diet-based behavior modifications, limiting television viewing, and increasing PA levels (Rao, 2008). Conventional PA programs consist mainly of aerobic programs including walking and running (Watts et al., 2005). Recently, RT has gained in popularity as a means of improving health, wellness, and sports performance in children. Because children perform short bouts of PA that usually last less than 15 seconds (Bailey et al., 1995), RT can be enjoyable for children. RT involves anaerobic training in which an individual produces force against a resistance to MS and ME. Improving MS and ME affects the ability to perform activities of daily living by reducing the percentage of MS needed to perform a given activity. This reduction in the percentage of MS equates to less physiological stress and allows for the maintenance of functional independence throughout the lifespan (ACSM, 2009). Although RT is recommended without reservations for adults, the practice of RT by children has been scrutinized.

Safety. The role of RT as a mode of exercise for physically immature individuals has been a point of controversy. The NSCA released a position statement in 1996 addressing safety concerns, as well as advocating supervised RT in children. The experts linked concerns over RT to data from the NEISS. The NEISS accessed data from emergency rooms nationwide and tallied over 17,000 weight lifting-related injuries in children and adolescents in 1979 and over 8,000 injuries in 1987 (Faigenbaum et al., 1996). Strains and sprains were the most commonly reported yet least severe injuries. Fractures were the least reported and most severe injuries (Haff, 2003).

Although the results from the NEISS data set are concerning, the data must be interpreted correctly to properly assess safety issues. Many of the injuries were attributed to poor training, excessive load, free access to equipment, and lack of qualified supervision (Faigenbaum et al., 1996). Also, data were collected by what injuries the patients themselves attributed to lifting weights thereby questioning the validity of the data. Moreover, these data were not separated by mode of training. Olympic weightlifting and powerlifting injuries were also included in the NEISS data set. Olympic weightlifting includes explosive lifts requiring a high level of skill like the clean and jerk and snatch while powerlifting includes lifting maximal loads in exercises such as the bench press, squat, and deadlift (Kleogh et al., 2008). Although safe Olympic weightlifting and powerlifting is possible for children (Faigenbaum & McFarland, 2008), performing these types of exercises require more strength and skill than other RT exercises (e.g., those done with dumbbells or machines), and without proper supervision, could lead to more frequent and more severe injury than traditional RT exercises. A review by Malina (2006) supports the conclusion of RT as a safe mode of training citing only 3 articles of 22 reviewed which reported injury during RT, yielding injury rates of 0.18, 0.05, and 0.06, respectively per 100 participant-hours.

Improved MS through RT can actually reduce the risk of injury by increasing musculotendinous integrity, specifically in adults (ACSM, 2009). Although studies of RT as a preventative measure to sports injuries are few, an epidemiological study by Caine, Maffulli, and Caine (2008) included a few studies whose authors suggested strengthening exercises may be a useful preventative tool. This may be especially important given that children have a higher rate of injury in sports like soccer and rugby than they do in Olympic weightlifting (Hamill, 1994).

Another major concern of RT in children is the impact on stature. Epiphyseal injury which could cause premature epiphyseal fusing has been a traditional argument for the preclusion of children from RT (Haff, 2003). Yet, this concern seems largely unfounded. Although the NSCA's position statement on RT in children includes a few retrospective studies indicating epiphyseal distress from lifting weights, it is noted that the majority of these injuries are due to improper training and lack of supervision during various forms of RT, not simply RT alone (Faigenbaum et al., 1996). Overall, RT is safe for children to perform under correct supervision (Faigenbaum et al.; Haff; Hamill, 1994; Malina, 2006).

The NSCA has developed guidelines to enhance the safety of children while participating in RT (Faigenbaum et al., 1996). Each child should be psychologically and emotionally ready to participate in an RT program and have realistic expectations of the outcome of the training. The training environment should be clear of hazards with machines that fit children and have the supervision of a properly trained fitness professional. Children should start with a relatively light load and progress in 5% to 10% increments as they increase in muscular fitness. Programs should be 2 to 3 days per week on non-consecutive days, including one to three sets per exercise with 6 to 15 repetitions. Ultimately, children should be given positive feedback to encourage an environment of learning and enjoyment.

Health benefits. Physical health benefits of RT are well-established in children. Perhaps the most recognized health benefit of RT is the increase of MS. Falk and Tenenbaum (1996) conducted a meta-analysis on data from nine studies on the impact of RT on strength in children under the age of 13 years. Falk and Tenenbaum reported that the majority of the interventions resulted in strength increases from 13% to 30%. MS may increase for different reasons. Ramsay et al. (1990) conducted a 20-week resistance training program with 9 year old to 11 year old prepubescent boys. After 20 weeks, boys in the experimental group gained no more muscle than the control group, nor did they have significant increases in their muscle mass from baseline values, suggesting that the resultant strength gains were independent of muscle cross sectional area. Muscle activation showed an increasing, yet statistically insignificant, trend in the trained boys which implies greater muscle unit recruitment may occur with RT. There was also indication that improved excitation-contraction coupling may have resulted from training.

Ozmun et al. (1994) conducted a similar study to that of Ramsay et al. (1990). The study included 16 participants, 8 boys and 8 girls, with a mean age of 10.3 years. Participants in the experimental group performed 7 to 11 arm curls, 3 days a week, for 8 weeks. The control group participants played table games. The researchers found significant increases in arm flexion strength in the experimental group along with increases in integrated electromyography activity. No significant changes were found in arm circumference in the experimental group indicating that muscular hypertrophy did not occur. No significant changes were found in any measures of the children in the control group. Ozmun et al. concluded that the increase in strength was likely due to increased muscle fiber recruitment and not hypertrophy.

The benefits of resistance training in children also extend to physiologic health like metabolic fitness and bone integrity. A 2006 study by Shaibi et al. was conducted on the impact of a 16-week RT program on insulin sensitivity in Latino adolescents. Not only did the RT program significantly increase upper and lower body strength in the experimental group ($n = 11$) as compared to the control group ($n = 11$), it significantly increased insulin sensitivity in the children, independent of changes in body composition. Increased insulin sensitivity can be protective against type 2 diabetes. RT has also shown to increase bone density in children ages 7 years to 12 years who are obese (Sothern et al., 1999) and adolescent boys (Volek et al., 2003).

RT can effectively combat childhood obesity. In general, PA that is either aerobic in nature like walking or anaerobic in nature like RT can increase metabolic rate (Kuboonchoo, 2001). Sothern et al. (2000) studied RT with 67 preadolescent participants. The researchers found that a 10-week weight management program including RT decreased body mass, BMI, and percent body fat while maintaining fat-free mass. Similarly, a 2002 meta-analysis was conducted to discern factors affecting body fat, body mass, and fat-free mass in obese children (LeMura & Maziekas, 2002). Several variables positively impacted body fat, body mass, and fat-free mass, one of which was exercise mode. High-repetition resistance training, in addition to aerobic training, had a greater impact on body composition than aerobic training alone.

Weight management interventions typically include the combination of several different strategies. However, RT alone can be an effective tool in decreasing childhood obesity. In a study of 31 boys, Falk et al. (2002) found an inverse correlation between RT and body fat in 9 year olds. Benson et al. (2008) examined the effects of an RT program on 78 children who were normal weight, overweight, or obese with a median age of 12 years. The RT program was 8 weeks in duration, twice per week, including two sets for each of the 11 exercises. The program resulted in greater increases in upper and lower body strength and greater decreases in fat mass, BMI, and waist-to-hip circumference as compared to a control group. In addition, children who are obese view RT favorably (Watts et al., 2005) which may increase their adherence to the intervention (Sothern et al., 2000).

Summary. The safety of RT in children has been scrutinized but RT remains a safe mode of training when appropriately supervised (Faigenbaum et al., 1996) that mimics child activity patterns better than traditional aerobic-based programs (Bailey et al., 1995). Increased MS is a health benefit of RT that is attributed to neural adaptations rather than muscular hypertrophy (Ozmun et al., 1994). Metabolic fitness and bone integrity benefits are additional benefits of RT (Shaibi et al., 2006; Sothern et al., 1999;

Volek et al., 2003). RT can be used as a mode of training to combat childhood obesity (Benson et al., 2008) as well as reduce body fat in children who have a normal weight (Falk et al, 2002). Because of the favorability and compliance of children to RT programs (Sothern et al., 1999), children may also have positive attitudes towards RT. Attitude has been theorized to predict PA levels (Ajzen & Fishbein, 1980; Fishbein & Ajzen, 1975), yet the impact RT has on CATPA and, ultimately, PA levels, is unknown.

CATPA

PA levels are determined by many factors, one of significance being ATPA. Theories using attitude as a predictor have been developed based on its relation to intent to participate in PA (Ajzen & Fishbein, 1980; Fishbein & Ajzen, 1975). A review of several studies (Godin, 1994) revealed that attitude accounted for approximately 30% of the variance in intent, which was a significant predictor of exercise in adults.

Kenyon (1968) also developed a model to assess attitude toward PA in adults along with an inventory: the ATPAI. The model and inventory includes six subdomains for why people participate in PA: social experience, health and fitness, the pursuit of vertigo, aesthetic experience, cathartic experience, and ascetic experience.

PA participation for a social experience is characterized by PA with the intent of gaining social interaction. However, some engage in PA for the improvement of health and fitness while others participate to pursue vertigo. The pursuit of vertigo is behaving in a manner to achieve a thrill. PA, for some, is an aesthetic experience in which individuals perceive their actions as beautiful or artistic, yet for others it is a cathartic experience by which participants can relieve tension and frustration. Lastly, PA as an ascetic or competitive experience was characterized by Kenyon as individuals such as athletes who endure strenuous training for attainment of a championship.

The CATPAI. Although the ATPAI was useful in assessing attitudes toward PA in adults during the late 1960s, no such model existed for assessing CATPA. Because attitudes toward PA are developed during childhood, Simon and Smoll (1974) designed a measurement tool suitable for children in grades four through six: the CATPAI. The original six subdomains were kept from Kenyon's model, but the wording was changed so children could better comprehend the questions. A 7-point Likert scale, with eight bipolar adjectives, was used in the CATPAI to discern each subdomain of PA. However, a psychometric analysis of the original 1974 CAPTAI revealed that the 7-point Likert scale could be reduced to a 5-point Likert scale and the eight bipolar adjectives could be reduced to five without sacrificing strong internal consistency characteristics of average Chronbach's alphas of .80 (Wood, 1979). Also, the analysis revealed that social experience should be split into two subdomains: social continuation and social growth, the former meaning time with friends, the later meaning a chance to make new acquaintances. Based upon Wood's results and other findings, a revised version of the CATPAI was administered in the 1980 British Columbia physical education assessment project (Carre, Mosher, & Schutz, 1980). The psychometrics of the Revised CATPAI were found to be superior to the original version.

Reliability of the CATPAI. Internal consistency of the CATPAI has been reported to be high with Hoyt reliabilities of .80 and .90 (Schutz & Smoll, 1977; Schutz, Smoll, & Wood, 1981). Test-retest reliability for 6-weeks of the original CATPAI was initially lower than desired at .60 (Simon & Smoll, 1974). However, Smoll and Schutz (1983) indicated that 2-week and 9-week test-retest reliability had reasonably high median reliability coefficients of .71 and .67, respectively, for the Revised CATPAI. However, Schutz and Smoll (1980) warned against using the CATPAI as an individual assessment, especially in young children. The CATPAI has adequate reliability in the group setting only.

Validity of the CATPAI. The CATPAI has been shown to possess construct validity in various populations as has the ATPAI upon which it is based (Schutz et al., 1985). Smoll and Schutz (1977) established concurrent validity of the CATPAI relative to the original ATPAI. Concurrent validity of the CATPAI relative to behavior is not high which is common with most attitude inventories. That is to say, attitude inventories are not highly correlated to the behavior, in this case PA. However, the attitude-behavior relationship of the CATPAI is at least as strong as most social-psychological measures (Schutz et al., 1985). Although little empirical evidence for predictive validity exists, some research indicates convergent validity of the CATPAI. Meyers, Pendergast, and DeBacy (1978) found a significant correlation ($r = .43$) between the CATPA health and fitness subdomain and maximal oxygen uptake in girls.

PA levels are influenced by many factors, one of which being ATPA. Some theories assert that the major determinant of a behavior is the intent to adopt the behavior. Intent is largely affected by attitude toward the behavior (Ajzen & Fishbein, 1980; Fishbein & Ajzen, 1975). Kenyon (1968) developed the ATPAI in 1968 to assess adult ATPA, however, because children also have perceptions of PA, Simon and Smoll (1974) constructed the CATPAI. Carre et al. (1980) revised the CATPAI to be psychometrically superior to the original. Although the CATPAI is valid and reliable, using the scale on an individual basis is discouraged (Smoll & Schutz, 1980). Increasing CATPA may also increase PA levels (Block & Zeman, 1996), yet because attitude does not have a strong correlation to PA (Schutz et al., 1985), a measure of PA is warranted.

Measurement of PA

The measurement of PA can be challenging, especially in children. Several options exist to measure PA levels such as objective monitoring devices, as well as subjective direct observation, diaries, proxy reports, and self-report. Monitoring devices like pedometers and accelerometers are popular because of their objectivity. Accelerometers are especially useful due to the ability to measure the quantity, duration, and intensity of movement in the vertical plane, with some being able to detect horizontal movement as well (Rice & Howell, 2000). They provide valid and reliable measures of physical activity in children (Welk et al., 2000). However, a major limitation of monitoring devices is their inability to monitor activity aside from running or walking. Activities such as biking, swimming, or RT are undetectable by such devices. Also, the cost of pedometers and, more so, accelerometers preclude their use for large scale studies (Rice & Howell).

Direct observation serves many times as a criterion measure against which other measures are compared. Frequency and type of PA can be observed and recorded, yet those who choose to participate may differ from those who choose not to participate and direct observation may also influence behavior (Rice & Howell, 2000). Direct observation is also time-intensive for all observers.

Other subjective measures are useful for large scale studies due to cost effectiveness and the ability to tailor them to answer various research questions (Sallis &

Saelens, 2000), although subjective measures, as a whole, have some weaknesses. PA recall is a complex cognitive task (Warnecke et al., 1997) making it challenging for children to complete. Also, because inventories typically include a checklist of activities during specific time intervals, there is the possibility of overestimation of PA (Welk et al., 2000). Social desirability may also lead to overestimation on the part of a child or his or her proxy.

Diaries may be used with children who then record the day, time, and intensity of the physical activity, which can provide rich data. However, diaries pose numerous problems. They are time intensive both for the participants and the data analyst. Due to inconsistent recording, comparison between studies is difficult (Rice & Howell, 2000). Children also have difficulties remembering to write in journals as well as understanding frequency, intensity, and duration of different modes of activity.

Parent- or teacher-report measures, otherwise known as proxy measures, are another option for measuring children's PA. These measures allow a more competent individual to assess the PA frequency, intensity, time, and type of PA performed by the child. The obvious drawback of proxy measures is that neither teachers nor parents are with children at all times rendering certain aspects of the child PA levels unobservable (Rice & Howell, 2000).

Self-report or investigator-administered measures are used on a widespread basis to assess PA activity because of their feasibility in large populations and their low cost. Also, self-reports have the characteristic of non-reactiveness (Kriska & Caspersen, 1997) meaning self-reports have the advantage of not altering the behavior of those being surveyed. However, the validity of self-reports has been questioned. While some maintain that self-reports are valid and reliable (Kriska & Caspersen) other researchers have shown only moderate correlations between self-reports and objective measures of PA (Sallis, 1991). Previous-day recall questionnaires appear to be the most promising self-reports for children. The Physical Activity Questionnaire for Older Children (PAQC), designed for children ages 8 years to 14 years old, has been recommended for characterizing general levels of PA (Welk et al., 2000).

PAQC. The PAQC was developed by Crocker et al. (1997) for children. The PAQC is a self-report instrument with acceptable psychometric properties. It consists of nine questions regarding MVPA during the last 7 days. The first question contains a checklist of 22 common physical activities while the other eight use cue points (e.g., lunch time, after school, etc.) to aid PA recall. The PAQC was found to have acceptable item-scale correlations (greater than .30), strong internal consistency (average alphas of about .85), acceptable test-retest reliability (intraclass correlations of .75 and .82 for males and females, respectively), and average generalizability coefficients of .85 which suggest reliability for assessing yearly PA. The PAQC can also discern differences in PA between boys and girls across seasons of the year (Crocker et al.). A significant, albeit relatively weak, correlation exists between the Caltrac accelerometer and the PAQC with an r value of .39 (Kowalski et al., 1997).

Overall, the measurement of PA is especially challenging in children. Objective measures like pedometers and accelerometers provide accurate and reliable data in children (Welk et al., 2000) yet are unable to detect all types of PA. They are also more expensive than other measures. Direct observation, although valid, is time consuming (Rice & Howell, 2000). More subjective measures like diaries, proxy reports, and self-reports have questionable validity (Sallis, 1991). However, the PAQC is useful for reporting general PA levels (Sallis & Saelens, 2000) and has been reported to have a significant relationship with an objective measure of PA (Kowalski et al., 1997). Consequently, the PAQC may be used to monitor PA level changes due to an RT intervention. Because RT is enjoyable (Sothern et al., 1999; Watts et al., 2005) and increases physical fitness (Benson et al., 2008; Falk et al., 2002), RT may positively impact PA levels in children.

RT, CATPA, and PA Levels

PA is important for children, but recent trends indicate PA levels in children are declining (Le Masurier et al., 2008; Pate et al., 1995; Strong et al., 2005). PIA in children has been directly related to cardiovascular disease (Dencker & Anderson, 2008), metabolic disease (Prentice & Jebb, 2006), and obesity (Dencker & Anderson; Must & Tybor, 2005).

Childhood obesity also has implications for cardiovascular and metabolic diseases (Messiah et al., 2008) and persists into adulthood (Serdula et al., 1993). Children who are obese have lower self-esteem and lower body satisfaction than children who weigh less (Shin & Shin, 2008). They are teased and bullied (Booth et al., 2008) and often the target of blame, stigmatization, and ostracization (Edmunds, 2008) and even may have a lower quality of life (Tyler et al., 2007).

Because PIA and obesity have negative health consequences for children, ways to increase PA levels should be sought (Rao, 2008). Whereas conventional programs aimed at increasing PA are aerobic-based interventions that typically focus on walking and running (Watts et al., 2005), RT has gained popularity as a mode of exercise for children.

Although previously regarded as unsafe in children, RT can be safer than other sports in which children engage (Hamill, 1994; Malina, 2006). RT has numerous health benefits including increased MS (Falk & Tenenbaums, 1996), insulin sensitivity (Shaibi et al., 2006), and bone density (Sothern et al., 1999). RT is also being used to combat obesity (Benson et al., 2008; Falk et al., 2002).

RT more closely mimics children's PA patterns (Bailey et al., 1995) which may be why some children favor this mode of exercise over traditional aerobic-based programs (Sothern et al., 2000). Aerobic-based programs for children also lack good participant compliance and retention rates (Salmon, Booth, Phongsavan, Murphy, & Timperio, 2007) possibly indicating a negative attitude toward these aerobic-based programs. Theories have been developed regarding the relationship between attitude and intent (Ajzen & Fishbein, 1980; Fishbein & Ajzen, 1975) which can impact children's PA levels.

Many attempts have been made to improve CATPA. The CDC launched the VERB campaign in 2002 which was a multimedia campaign involving television, radio, and print advertisements for children that successfully impacted attitudes towards the benefits of PA and PA levels (Huhman et al., 2007). Informative presentations have also been used to improve ATPA (Tsorbatzoudis, 2005). Improving CATPA is a cornerstone of PE, where many children get a majority of their PA (DeMarco & Sidney, 1989). However, RT is not common in elementary school education (Sothern et al., 1999). Because RT programs have been well-accepted by children in the past (Sothern et al.), RT may improve CATPA and, consequently, PA levels.

RT is a form of exercise which increases PA levels. This mode of training is enjoyed by children (Sothern et al., 2000) perhaps indicating a positive ATPA in children. A positive ATPA is related to intent to perform PA (Ajzen & Fishbein, 1980; Fishbein & Ajzen, 1975) which can increase PA levels in children. Yet, children do not commonly participate in RT outside of interventions. Indeed, children spend most time in school where they are most likely only to be physically active in PE class (Pan, 2008). PE classes provide a systematic approach to developing fundamental motor skills and physical fitness (Guedes, 2007) and may be the best means of promoting physical activity to all children (Sallis & Mackenzie, 1991). Unfortunately, RT is not a systematic part of PE curricula (Sothern et al., 1999). Because RT is enjoyable for children (Sothern et al., 1999; Watts et al., 2005) and allows for the attainment of greater physical fitness (Benson et al., 2008; Falk et al., 2002), children may increase their ATPA and PA after participating in an RT program.

Overall Summary

A recent trend toward PIA in young children and adolescents has emerged which has negative implications for the future (Strong et al., 2005). Reviews of PA literature have linked PIA to levels of body fat and obesity in children (Dencker & Anderson, 2008; Must & Tybor, 2005). Not surprisingly, childhood obesity rates have risen by almost 50% (Ogden et al., 2008) placing children at risk for cardiovascular and metabolic disease (Messiah et al., 2008). Psychosocial problems are also common in children who are obese (Booth et al., 2008; Dietz, 1998; Edmunds, 2008; Lykouras, 2008; Shin & Shin, 2008; Tyler et al., 2007).

Steps toward addressing the childhood obesity epidemic are being taken. Recently, RT, despite misplaced accusations over safety (Caine et al., 2008; Faigenbaum et al., 1996; Faigenbaum & McFarland, 2008; Haff, 2003; Hamill, 1994; Malina, 2006), has been successfully used to combat obesity (Benson et al., 2008; Falk et al., 2002; Kuboonchoo, 2001; 2000; LeMura & Maziekas, 2002; Volek et al., 2003). In addition, children who are obese enjoy RT more than aerobic-based activity (Watts et al., 2005) which may indicate a positive attitude toward RT.

Attitude is an indicator of PA in adults (Ajzen & Fishbein, 1980; Fishbein & Ajzen, 1975; Godin, 1994) and children (Smoll et al., 1976). CATPA can be accurately and reliably measured by the CATPAI (Carre et al., 1980; Schutz & Smoll, 1977; Smoll & Schutz, 1980; Smoll & Schutz, 1983; Schutz et al., 1981; Schutz et al., 1985; Simon & Smoll, 1974; Wood, 1979). Various steps to improve CATPA have been taken (Block & Zeman, 1996; Huhman et al., 2007; Tsorbatzoudis, 2005) and CATPA is a cornerstone of PE (DeMarco & Sidney, 1989). Yet, because RT is uncommon in elementary school education (Sothern et al., 1999), the impact of an RT program on CATPA is unknown.

The correlation between attitude and PA behavior has been reported as only moderate (Schutz et al., 1985), making measurement of PA important. Numerous measures of PA levels in children exist, each with distinctive advantages and disadvantages (Rice & Howell, 2000; Sallis & Saelens, 2000; Warnecke et al., 1997; Welk et al., 2000). Objective measures like pedometers and accelerometers provide accurate and reliable data (Welk et al.), but they are unable to measure all types of PA such as RT (Rice & Howell). RT increases PA during participation and can be enjoyable for children (Sothern et al., 1999; Watts et al., 2005), but the impact of RT on other types of PA is unknown. A quality self-report like the PAQC, which correlates with accelerometer measures of PA (Kowalski et al., 1997), can be used to assess general PA levels (Welk et al.) as well as detect changes in PA levels.

In conclusion, as PIA and obesity in children increase, advances must be made on how to address these issues. Increasing PA is a common suggestion and has produced encouraging results. RT is a relatively new method of increasing PA and reducing obesity in children. However, the effect RT has on CATPA and PA levels outside of an RT program is unknown. Therefore, the purpose of this study was to examine the effects of an RT on BMI, ATPA, and PA levels in children.

CHAPTER III

METHODOLOGY

Participants

Students from a single elementary school in the Southeast region of the U.S. (N = 118) participated in the study. The sample included boys (n = 56) and (n = 62) girls in the fourth and fifth grade who were apparently healthy and who volunteered to participate. Participants were divided into control and intervention groups by intact classes with 58 students (3 classes) in the RT intervention and 60 students (3 classes) in the control group. Students completed an assent form (see Appendix A) and parents/guardians completed a consent form (see Appendix B).

Instrumentation

Body mass and height. Body mass was measured to the nearest tenth of a kilogram using a Seca electronic scale (Model #770) while wearing school clothing. Participants were asked to remove their shoes and extra sweaters, sweatshirts, or jackets prior to being weighed. Height was measured to the nearest tenth of a centimeter using a Seca stadiometer (Model #222). Participants were asked to remove their shoes prior to being measured. They stood on a flat surface with their feet together, facing away from the measuring device. Mass and height were used to calculate BMI (kg/m^2).

CATPAI. The Revised CATPAI (Carre et al., 1980) was used to measure CATPA. The CATPAI has demonstrated construct validity (Schutz et al., 1985) and a 2-week test-retest reliability of .71 (Smoll & Schutz, 1983). The Revised CATPAI has seven subdomains that are PA participation for health and fitness, for social continuation, for social growth, as the pursuit of vertigo, as an aesthetic experience, as catharsis, or as an ascetic experience. Each subdomain employs a 5-point Likert scale with five bipolar adjective word pairs (e.g. "good" versus "bad"). Each word pair is scored from 1 to 5 with 1 being associated with the negative adjective and 5 being associated with the positive adjective creating a maximal subdomain score of 25. Therefore, by averaging the seven subdomain scores, overall scores will range from 1, representing the lowest possible score (i.e. the most negative ATPA), to 5, representing the highest possible score (i.e. the most positive ATPA).

RT equipment. The equipment that was used in the RT intervention was the HOIST® KL Circuit. These machines are designed specifically for children: they are smaller than adult-sized machines, they are used for multi-joint exercise which spreads force across more than one joint for added safety, and they have a shielded weight stack that adds privacy to the exerciser along with additional safety from injury by pinched fingers. Upper body machines included the seated dip for the triceps, the chin-up machine for the latissimus dorsi and biceps, the mid row for the latissimus dorsi, the rhomboids, and the biceps, the chest press machine for the pectoralis major, pectoralis minor, and the triceps, and the shoulder press machine for the deltoids, the trapezius, and the triceps. Lower body machines included the squat press and seated leg press to exercise the gluteal muscles, the hamstrings, the quadriceps, and the calf muscles.

PAQC. The PAQC (Crocker et al., 1997) was used to measure general PA levels. The PAQC has acceptable test-retest reliability with .75 and .82 intraclass correlations for males and females, respectively. The PAQC is also significantly correlated (r = .39) to accelerometry (Kowalski et al., 1997).

The PAQC consists of 10 questions. The first question is in checklist format and children are asked the frequency, in days per week (none; 1-2; 3-4; 5-6; 7 or more), with which they performed common types of PA such as skating, playing tag, or biking. Questions 2 through 8 utilize a Likert scale and contain cues to assist children in recalling the frequency (in similar fashion to question 1) and nature of their PA. Question 9 is a Likert scale question regarding how much PA ("none"; "little bit"; "medium"; "often"; and "very often") the child accrued during each of the past 7 days. The last question is in open-response format where the child can indicate if his or her PA level for the past week was abnormal for any reason. If the child responded "yes," the primary investigator followed up to evaluate the validity of his or her data.

The first question on the PAQC is scored by summing the Likert scale frequencies (none = 1; 1-2 days = 2; etc.) of all of the listed activities in the checklist and then calculating the average. The average score can range from 1 to 5, with 1 representing participating in none of the activities listed in the past week and 5 representing participating in all of the activities listed seven times or more in the past week. Questions 2 through 8 are scored with 1 being "no" and 5 being "seven times or more." Question 9 is scored similarly to question 1 by determining the sum of the Likert scale frequencies of how much PA on each day of the week. The average score can range from 1 to 5, with 1 representing "none" and 5 representing "very often." Question 10 is not formally scored, but can be used to identify children who did not participate in their usual PA routine. The final activity summary score is calculated by summing the scores of questions 1 through

9 and dividing by 9 to form an overall mean ranging from 1 to 5. A score of 1 represents low PA and a score of 5 represents high PA.

Procedures

Approval for the study was granted by the Middle Tennessee State University Institutional Review Board (see Appendix C). Also, approval from the school principal and the school system superintendent were obtained. Informed consent forms were signed by parents or guardians of the children and assent forms were signed by the children.

The experimental and control groups were formed based on teachers' availability and included all but one fourth grade class and all fifth grade classes in the school. A total of 6 classes were studied, 3 in the experimental group and 3 in the control group. Each class was comprised of approximately 20 students.

Two weeks prior to the beginning of the RT intervention, the height and body mass of the children were measured by going to the classrooms during the school day. One week before the intervention, students who were in the intervention classes completed the CATPAI and the PAQC when the children were in the fitness room. Also, during this week, children were taught proper lifting techniques as part of an accommodation period. Children who were in the control classes completed the CATPAI and the PAQC during their PE class period.

The RT intervention was conducted twice a week, on Tuesday and Thursday, for 10 weeks. A brief warm-up including aerobic exercise preceded each exercise sessions. A similar cool down followed the exercise sessions. Each exercise session allowed for the rotation of each child through stations where he or she spent approximately 45 seconds exercising and 30 seconds of rest (for a total time of approximately 30 minutes). Each station was marked with a laminated number and quick guide sheet for identification and familiarization. Additionally, each station had hook and loop tape surrounding the station to form a "safety zone" which other students were not to enter. Children were prompted to begin and end at each station by one of two Exercise Science doctoral student staff members. Staff members were also with the children in the fitness room at all times to ensure the safety of the children, encourage and correct children, and to monitor the children's success.

Children were instructed on proper lifting and breathing technique, as well as increasing resistance or repetitions properly. Children were instructed to complete 8 to 15 repetitions (McCambridge & Stricker, 2008) in a controlled manner. When a child is able to complete more than 15 repetitions in a controlled manner for a given resistance exercise, he or she was instructed to increase the resistance. The setup of the fitness room included the aforementioned RT equipment interspersed with 14 other callisthenic and stretching stations. Therefore, there were a total of 21 (the most students in any one class) stations exist to ensure full class participation. The calisthenics included marching, lateral hops, step ups, jumping jacks, supine back extensions, two stations for Dance Dance Revolution®, an abdominal crunch station, and stations for a stationary bike and treadmill. The stretching stations included stretches for the hamstrings, the quadriceps, the groin, and the hip adductors. For stretches that incorporate a unilateral component, children were prompted by staff to switch sides of the body mid-way through the allotted times at each station. Children were encouraged to do more repetitions of calisthenics or a higher intensity on the treadmill and bike to continually improve fitness.

Children tracked their progress by keeping a training log (see Appendix D) including date, resistance selected, and number of repetitions completed for each resistance exercise. For stations that did not include resistance machines, the children were asked to make a check (e.g. for stretching the hamstrings) or to write down number of repetitions (e.g., 25 jumping jacks). Staff members checked the children's logs on a weekly basis to ensure students were completing their logs correctly and, consequently, increasing their resistance appropriately.

After 10 weeks of RT, the children completed the CATPAI and PAQC again. Height and body mass were measured. The post-test location and schedule followed that of the pre-test schedule.

Data Analyses

Descriptive statistics (e.g., height and body mass) were calculated for participants. Height and body mass were used to calculate BMI. Two-way repeated measures analyses of variance (RMANOVAs), with group (i.e., experimental and control) as a between-subjects factor and time (i.e., pre-test and post-test) as a within-subjects factor, were conducted for BMI, overall CATPAI scores, and overall PAQC scores to assess statistical significance. A significance level of $p < .05$ was set.

CHAPTER IV

RESULTS

A total of 118 children, with an average age of 10.0 years, volunteered to participate in this study. Complete data sets were available for 109 participants. Children were assigned by class to the control group or experimental group based on the availability of their teachers' schedules, with 3 classes in each group. Table 1 provides descriptive statistics for height and body mass. Table 2 provides descriptive statistics for BMI, PAQC, and CATPAI scores.

The two-way repeated measures analysis of variance (RMANOVA) procedure with group as a between-subjects factor and time as a within-subjects factor was used to compare BMI, PAQC, and CATPAI scores. The familywise alpha was set to .05. The main effect of time was significant for BMI, $F\,(1,110) = 4.80$, $MSE = 3.01$, $H\text{-}F\ p = .031$, $\eta^2 = .042$, *obs. power* = .58. Post-test BMI was significantly higher than pre-test BMI. The main effect of group was not significant, $F\,(1,110) = 0.58$, $MSE = 29.49$, $p = .45$, $\eta^2 = .005$, *obs. power* = .12. Experimental and control groups had similar BMI values. The interaction test was also not significant, $F\,(1,110) = 1.27$, $MSE = 3.01$, $H\text{-}F\ p = .26$, $\eta^2 = .011$, *obs. power* = .20. The effect of time was similar for the experimental and control conditions.

The main effect of time was significant for PAQC scores, $F\,(1,107) = 43.26$, $MSE = 0.14$, $H\text{-}F\ p < .001$, $\eta^2 = .29$, *obs. power* = 1.00. Post-test PAQC scores were higher

Table 1

Descriptive Statistics for Height and Body Mass

		Height (cm)		Body mass (kg)	
Group		Pre-test	Post-test	Pre-test	Post-test
Control	*M*	145.4	146.9	42.0	44.4
	SD	6.3	6.5	10.4	12.1
	n	56	58	56	58
Experimental	*M*	141.4	142.7	39.0	40.3
	SD	7.8	7.9	10.8	11.1
	n	56	58	56	58

Note. Unequal sample sizes are due to missing values.

Table 2

Descriptive Statistics for BMI, PAQC, and CATPAI Scores

Variable	Group		Pre-test	Post-test
BMI	Control (n = 56)	*M*	19.6	20.4
		SD	4.0	4.5
	Experimental (n = 56)	*M*	19.3	19.6
		SD	3.9	3.8
PAQC	Control (n = 55)	*M*	2.73	3.04
		SD	0.68	0.68
	Experimental (n = 54)	*M*	2.69	3.05
		SD	0.76	0.65
CATPAI	Control (n = 55)	*M*	4.02	4.09
		SD	0.56	0.50
	Experimental (n = 54)	*M*	3.88	3.88
		SD	0.53	0.52

Note. Unequal sample sizes are due to missing values.

than pre-test PAQC scores. The main effect of group was not significant, F (1,107) = 0.01, MSE = 0.82, p = .94, η^2 = .00, *obs. power* = .051. PAQC scores were similar for the control and experimental groups. Likewise, the interaction test was not significant, F (1,107) = 0.21, MSE = 0.14, *H-F* p = .65, η^2 = .002, *obs. power* = .074. The effect of time was similar for the control and experimental groups.

The main effect of time was also not significant for CATPAI scores, F (1,107) = 0.56, MSE = 0.12, *H-F* p = .46, η^2 = .005, *obs. power* = .12. CATPAI scores were similar for the pre-test and post-test conditions. The main effect of group was not significant, F (1,107) = 3.86, MSE = 0.44, p = .052, η^2 = .035, *obs. power* = .50. CATPAI scores were similar for the control and experimental groups. The interaction test was not significant, F (1,107) = 0.54, MSE = 0.12, *H-F* p = .46, η^2 = .005, *obs. power* = .11. The effect of time was similar for the experimental and control conditions.

CHAPTER V

DISCUSSION AND CONCLUSIONS

This study was conducted to determine if RT had an effect on BMI, PAQC, and ATPA in children. RT is becoming more popular as a mode of exercise for children. Because children's PA levels have been decreasing (Troiano et al., 2008), new ways of increasing PA in children, like RT, are important to aid in the prevention of childhood diseases such as obesity (Denecker & Anderson, 2008).

RT is a mode of exercise which mimics children's sporadic and anaerobic PA patterns (Bailey et al., 1995). Aside from providing various health benefits (Falk et al., 2002; Falk & Tenenbaum, 1996), RT has been shown, in children who are obese, to be viewed favorably (Watts et al., 2005) and potentially increase CATPA. Although attitude impacts behavior, the correlation between attitude and physical activity is not strong (Schutz et al., 1985). Therefore, in the current study, the PAQC was used to measure the impact RT had on PA levels of participants.

Students from the Southeast region of the U.S. ($N = 118$) participated in the study and had an average age of 10.0 years old. Descriptive statistics were calculated for participants, including BMI from height and body mass. Two-way RMANOVAs, with group and time as factors, were conducted for BMI, PAQC scores, and CATPAI scores to assess statistical significance. A significance level of $p < .05$ was set.

PIA and Obesity

PIA in children is a concern in the U.S. Children are becoming more inactive at increasingly younger ages (Strong et al., 2005). PIA in children has been linked to hypertension and hypercholesterolemia (Prentice & Jebb, 2006) and may increase the risk of type 2 diabetes (Lanza et al., 2008). Also, PIA has been directly correlated with BMI and percent body fat (Must & Tybor, 2005) and is commonly associated with childhood obesity.

Obesity in children, like PIA, is increasing. The 16% of children ages 6 years to 19 years old who are obese are at greater risk than children of a normal weight for numerous metabolic syndrome risk factors (Ogden et al., 2008). Children who are obese also suffer psychological consequences. These children have lower self-esteem and lower body satisfaction than children who weigh less (Shin & Shin, 2008). Also, children who are obese are often subject to negative stigmas and poor family treatment (Edmunds, 2008). Because of the serious physical and psychological health consequences, new ways to increase PA to reduce childhood obesity are being sought.

RT with children. RT is a common form of exercise for improving health in adults. However, several of the health benefits that adults can gain from RT may also be enjoyed by children (Falk & Tenenbaum, 1996; Ozmun et al., 1994; Ramsay et al., 1990; Shaibi et al., 2006; Sothern et al., 1999; Volek et al., 2003). The safety of RT in children who are not yet physically mature has been questioned. In 1979 and 1987, over 17,000 and over 8,000 weight lifting-related injuries were reported, respectively (Faigenbaum et al., 1996). Yet, many of these injuries were due to poor training, excessive load, free access to equipment, and lack of qualified supervision (Faigenbaum et al.). Indeed, common children's sports like soccer have been shown to have higher rates of injury than the perceived dangerous sport of Olympic weightlifting (Hamill, 1994).

RT has recently been used to treat obesity. In children, RT has been shown to be inversely correlated to body fat (Falk et al., 2002) as well as a positive addition to aerobic training when improving body composition (LeMura & Maziekas, 2002). AN RT intervention in 78 children resulted in greater increases in upper and lower body strength and greater decreases in fat mass, BMI, and waist-to-hip circumference as compared to a control group (Benson et al., 2008). In addition to a favorable impact on obesity in children, it has been reported that children who are obese enjoy RT training (Watts et al., 2005) which can increase adherence to training (Sothern et al., 2000).

Attitude and PA. Children's attitudes can have an effect on their PA levels which is why Simon and Smoll (1974) developed the CATPAI. Based on Kenyon's work in adults in the late 1960s, Simon and Smoll's CATPAI has been used to assess the subdomains of attitude in children. Although the CATPAI has been shown to possess construct validity (Schutz et al., 1985) and convergent validity (Meyers et al., 1978), predictive validity of, and concurrent validity to, behavior are not high. For this reason, a measure of the impact of RT on PA levels was needed in the current study.

The measurement of PA in children is especially challenging. Each measurement tool possesses strengths and weaknesses. Objective tools such as pedometers and accelerometers, although accurate (Welk et al., 2000), can be too expensive, precluding them from large scale studies (Rice & Howell, 2000). Subjective tools, like questionnaires, are more suitable for studies with larger sample sizes. Although recall is a complex cognitive task (Warnecke et al., 1997) which may pose a threat to children's ability to complete the task, questionnaire's such as the PAQC (Crocker et al., 1997) have been used to report general PA levels (Sallis & Saelens, 2000) while maintaining a significant relationship with an objective measure of PA (Kowalski et al., 1997).

RT is a different mode of PA that has been used recently to combat obesity. Because RT has been reported as being enjoyed by children, CATPA may improve with exposure to this more novel kind of PA. Consequently, as attitude can affect behavior, an improvement in CATPA may increase children's PA levels. However, the effects of an RT program on BMI, CATPA, and PA levels outside of RT are unknown.

Discussion of Results

BMI. BMI was not significantly different between groups (p = .45), but there was a significant difference from pre-test to post-test (p = .031) for the entire sample, with post-test BMI being higher than pre-test BMI. Participants in both the control group and experimental group increased in height and body mass. The average height of children in the control group increased 1.5 centimeters whereas the average height of children in the experimental group increased 1.3 centimeters. Further, the average body mass of children in the control group increased 2.4 kilograms whereas the average body mass of children in the experimental group increased 1.3 kilograms. A follow up analysis of body mass revealed that the interaction of group and time was not significant (p = .56). Although not statistically significant, the lower increase in mass in the experimental group by 1.1 kilograms is of practical significance. A mass of 1.1 kilograms represents 2.6% of total (post-test) body mass for the current sample. Preventing the gain of 2.6% of total body mass would be beneficial for children who are overweight or obese. If this prevention of weight gain is compounded over time, continued RT could be even more beneficial.

Increases in BMI at the age of the children in this study are common. Treuth, Hunter, Figueroa-Colon, and Goran (1998) studied the effect RT had on intra-abdominal fat in pre-pubescent girls (ages 7 years to 10 years) who were obese, having a BMI greater than the 95^{th} percentile. A sample of girls who were not obese was used as the control group. The RT program, which lasted 5 months and included a 3 day weekly frequency, had no significant impact on intra-abdominal obesity in the obese girls. However, similar to the current study, both groups significantly increased in height and mass, leading to an increase in BMI.

The study by Treuth et al. (1998) and the current study have many similarities. Both studies were on RT interventions with participants who were obese and not obese and of prepubescent age. Also, the children in both studies had increases in height and body mass, irrespective of group. Certainly, children of the age and pubertal stage in the Treuth et al. study and the current study are growing and maturing. The likely cause for such increases in height and body mass in all children is the growth process. While Treuth et al. only included girls in their study, the current study included boys and girls. However, because the children in both studies were of prepubertal age, the growth process was probably unaltered by the sex difference in the samples.

In the current study, there was a greater increase in BMI in the children in control group (mean change of +0.8 kg/m^2) than the children in the experimental group (mean change of +0.3 kg/m^2), however, the difference was not statistically significant (p = .26). This finding, though not significant, is similar to that of Benson et al. (2008). Benson and colleagues conducted a study on the effects of an RT program on 78 children of varying BMI classifications. The 8-week RT program consisted of two sets of eight repetitions at high intensity (rating of perceived exertion of 15 to 18) for 11 exercises. BMI increased less in children in the experimental group (mean change of -0.01 kg/m^2) than the children in the control group (mean change of +0.4 kg/m^2). The BMI of the children participating in the RT group remained almost unchanged while the BMI of the children in the control group increased. This is likely due to the significantly lower increase in fat mass in the children in the experimental group (mean change +0.2 kg) than in the children in the control group (mean change +1.0 kg).

Some variations between the current study and the study by Benson et al. (2008) may explain the difference in statistical significance. First, over half of the participants in the study by Benson et al. were overweight (33%) or obese (18%) based on BMI classifications. In the current study, only 17.9% of children were overweight and 20.5% were obese based on BMI classification. Because the two samples of children differed in initial BMI, an interaction of BMI classification with RT may have explained the significant interaction of time and group found in the Benson et al. study and not the current study. Children who are overweight or obese tend to be less active than children who have a normal weight (Morgan, Beighle, & Pangrazi, 2007). If children who are overweight or obese and less active become involved in a training program like in the study by Benson et al., the interaction of PA level and the RT program may have positively affected BMI more than in the current study which included a sample of children who began with a moderate PA level (average pre-test PAQC score of 2.71).

The difference in pubertal status between the Benson et al. study (2008) and the current study also may have impacted the interaction of group and time. Although no measure of maturity was employed in the current study, Benson et al. utilized self-reported Tanner staging. Most of the participants (87.2%) reported being in stages 2 through 4 (with an average Tanner stage of 3), a classification of pubertal. Because the average age of participants in the Benson et al. study was 12.2 years while the average age of the participants in the current study was 10.0 years, children in the current study were likely of a significantly lower Tanner stage and pubertal classification (i.e., prepubertal). The impact of pubertal differences on hormone levels may have allowed for greater benefits of RT on BMI in the participants of the Benson et al. study than the participants in the current study. Indeed, Ozmun et al. (1994) found that RT in prepubertal children (average age of 10.3 years) did not decrease arm circumference or biceps and triceps skinfold measurements. In light of the findings of Ozmun et al., the significant impact of puberty on RT outcomes seems probable.

In conclusion, BMI was not different for the control group and experimental group. BMI increased from pre-test to post-test in the entire sample, probably due to growth (Treuth et al., 1998). However, the interaction of group and time was not significant. Although another recent study involving RT resulted in a significantly greater decrease in BMI in the experimental group than the control group, differences in participant characteristics such as initial BMI and pubertal status may account for the differences in the results. However, the average body mass of the children in the experimental group in the current study did not increase as much as the children in the control group. The prevention of 2.6% of body mass gain may be practically significant, especially if such results can be maintained and improved with RT over time.

CATPA. CATPA did not differ by time (p = .56) or group (p = .50). The children in the experimental group and the control group had a similar ATPA which also did not significantly change from pre-test to post-test. Moreover, the interaction of time and group was not statistically significant (p = .46). Children in the experimental group did not develop more positive attitudes from pre-test to post-test than the children in the control group. Because RT has been reported to be positively viewed by children (Sothern et al., 1999), a greater increase in CATPA for participants in the RT program was hypothesized.

Attitude interventions aimed at increasing PA levels of children have been successful in other studies. The VERB campaign initiated by the CDC was a 2 year marketing campaign aimed at 9 year to 13 year old children that included advertisements on television and radio, in print, and through promotions in communities, schools, and on the internet. Self-reported PA levels and attitude about the benefits of PA, as measured by the Youth Media Campaign Longitudinal Survey, were positively impacted by the children who were exposed to the campaign (Huhman et al., 2007). A 12-week study by Tsorbatzoudis (2005) resulted in similar improvements. Tsorbatzoudis divided 366 high school students (mean age of 14.2 years) into a control group and an experimental group that was exposed to posters and lectures promoting PA. ATPA and self-reported PA levels increased in the experimental group.

The current study is the first known to have assessed the impact of an RT intervention on CATPA. Although the RT program did not affect overall attitude, further

RMANOVAs were conducted on each subdomain. Interaction tests (of group and time) were not significant ($p > .05$) except for the health and fitness subdomain ($p = .007$). The average score for children in the control group for the health and fitness subdomain increased slightly from 4.63 to 4.69 while the average score for the children in the experimental group decreased from 4.64 to 4.40. Children who participated in the RT program had worse attitudes towards health and fitness than those who did not participate in the RT program. One possible explanation for this phenomenon is that children may become bored with the repetitive nature of RT. Although the staff that worked with the children encouraged the students throughout their training, the children becoming bored towards the end of the program was evident. Work by Cowan (n.d.) involving CATPA produced similar results. A total of 149 fifth through eighth graders completed an 8-week RT program. Cowan found that CATPA decreased in both the experimental group, where students were instructed in a mastery-oriented manner, and the control group, where students were instructed in a traditional performance-oriented manner. The decrease in CATPA led Cowan to conclude that lack of student choice, redundancy, and, ultimately, boredom were due to the repetitive nature of RT.

In summary, no significant differences were found in CATPA. Although other modes of increasing CATPA have been successful, no study has been conducted on the effect of RT on CATPA. Further analyses of subdomains revealed that the health and fitness subdomain was significantly decreased in children after the RT program as compared to the children who did not participate in the program. This decrease in attitude may be due to the repetitive nature of RT that children may find boring. Verbal feedback from the children in the current study confirmed their enjoyment of the training.

Combining RT with other types of activities or alternating the mode of RT may help overcome children's boredom with repetition. Also, keeping RT programs shorter (e.g., a section in PE) may also hold student interest more as opposed to the 10-week intervention employed in this study.

PA levels. PA levels were not different between groups ($p = .94$). However, PA levels were different from pre-test to post-test ($p < .001$). Post-test PA levels were higher than pre-test PA levels. Because the pre-test was administered in late January and the post-test was administered in late April, these findings agree with the findings of past studies on seasonal variations in PA levels in children. Hagger, Lorraine, and Almond (1997) studied seasonal variations in PA levels of 45 elementary school children ages 9 years to 11 years of age. Utilizing a self-report measure of PA, Hagger et al. documented the average time the children spent performing MVPA in the winter months was 68 minutes while in the summer children spent significantly more time performing MVPA, on average 90 minutes. Less daylight and greater occurrence of inclement weather during the winter months versus summer months were reasoned to be the cause of the difference in PA levels.

Seasonal variations in the PA levels of children have also been confirmed using pedometry. Loucaides, Chedzoy, and Neville (2003) studied the PA levels of 256 children ages 11 years and 12 years of age. Like the results of Hagger et al. (1997) and the present findings, Loucaides et al. discovered that boys and girls accumulate more steps on average during the summer months (15,471 ± 5116) than in the winter months (13,429 ± 4,340). Similarly, Loucaides et al. reasoned that longer periods of daylight and ideal weather were responsible for higher recorded PA levels in the summer than in the winter.

The interaction of time and group was not significant ($p = .65$) in this study. Children who participated in RT did not increase their PA levels outside of the program more than children who did not participate in RT. Participating in an RT program was hypothesized to increase PA levels outside of the program more than not participating in an RT program for many reasons. RT resembles the sporadic nature of children's PA patterns more than traditional aerobic exercises or sports. Greater than 95% of the time children spend performing PA lasts less than 15 seconds (Bailey et al., 1995). In the current study, children spent only 45 seconds at each station before switching to a new station. Therefore, the hope was for children to be continuously moving and enjoying their experience with RT.

Watts et al. (2005) mentioned how most studies designed to reduce body mass in children employ aerobic exercise to positively influence caloric expenditure. However, Sothern et al. (2000) argued that heavier children may be unable to maintain aerobic exercises for longer periods of time. Salmon et al. (2007) indicated that aerobic-based PA interventions for children of a normal weight have high attrition rates possibly indicating a negative attitude in those children towards aerobic-based interventions. Consequently, in the current study, an RT intervention was employed so as to positively impact CATPA and, therefore, PA levels outside of the RT intervention.

CATPA in the experimental group did not increase, having the exact same average CATPAI score from pre-test to post-test (3.88). Because CATPA remained unchanged in the experimental group, an insignificant interaction of group and time was expected. As this study was the first to include the impact of an RT program on PA levels outside of the RT program, no comparisons to other studies including RT can be made. However, similar studies of various other PA interventions have been conducted to assess their impact on PA levels.

Shephard, Jéquier, Lavallée, La Barre, and Rajic (1980) conducted a study on the effect of increased time for PE on PA levels outside of school in elementary school children. PE time was increased from 40 minutes per week to 5 hours per week. Amount of PE did not significantly impact PA outside of school. Accordingly, students who participated in more PE accrued more total PA than those students who participated in less PE.

Morgan et al. (2007) conducted a study on 485 elementary school children with results similar to those of Shephard et al. (1980). On days when PE was offered, the least, moderate, and most active children accrued 1,700, 1,100, and 2,500 more steps of total PA per day than days when no PE was offered. Children did not participate in compensatory PA on days when PE was not offered. Furthermore, Morgan et al. found that 50% of the least active children were overweight or obese.

Finally, Dale, Corbin, and Dale (2000) conducted a study on compensatory PA in third and fourth grade children. Dale and colleagues compared accelerometry data between a control condition where the children spent recess inside at a computer and had no PE class and an experimental condition where the same children spent recess outdoors and had a scheduled PE class. Following the inactive school day, the children did not compensate for their low activity by increasing their PA after school. In fact, following the active school days, the children spent significantly more time being active after school than after the inactive school days. Although Dale et al. gave no explanation for why children were more active after an active day at school, they warned that restricting children's time for PA at school could be detrimental to overall PA levels.

In light of the studies on compensatory PA, the finding that RT did not increase PA outside of the RT program should not necessarily be viewed negatively. By the end of the program, children in the experimental group had similar average reported PAQC scores (3.05) to the control group (3.03). However, the questionnaire did not account for the RT in which the children in the experimental group participated. As such, children participating in experimental group possibly accrued more total PA than the children in the control group. Therefore, RT can be added to a school day, in PE or elsewhere, to help increase overall PA levels of children.

Overall, PA levels were the same for the control group and the experimental group. PA levels increased from pre-test to post-test, likely due to the seasonal increase in PA that is typical in children (Hagger et al., 1997; Loucaides et al., 2003). The interaction of group and time did not significantly impact PA levels. Although children participating in RT did not increase their PA levels outside of RT more than children who did not participate in RT, RT did not appear to negatively affect PA levels outside of the RT program. Therefore, total PA levels were possibly higher due to the additional PA from RT.

Summary of Results

In conclusion, BMI did not decrease in children in the experimental group more than the children in the control group. BMIs for all children increased over time, probably due to growth (Treuth et al., 1998). Although reduced BMIs have resulted from

RT (Benson et al., 2008), differences between the participants in other studies and the current study in initial BMI and pubertal status may explain the lack of significance found in the current study. Also, CATPA and PAQC did not increase in children in the experimental group more than the children in the control group. The lack of variation in RT might have led to the greater decrease in the attitude toward the health and fitness subdomain in the children in the RT program versus the children in the control group. PAQC increased for all children over time, probably because of the change in seasons leading to weather more conducive to PA. The inability of RT to increase PA levels outside of an RT program, however, should not necessarily be view negatively. Because children did not compensate their PA levels by becoming less active after participating in RT, their overall PA levels were likely higher.

Study Limitations and Future Research

Certain limitations exist with this study. Because of the size of each class (about 20), close monitoring of each child at each station was challenging. With two supervisors constantly correcting students, other students, at times, performed exercises incorrectly (i.e., too heavy/light of a load, lack of full range of motion, too fast of tempo, etc.). Despite supervisory challenges, students were successful at significantly increasing their training workload ($p < .001$) which was calculated by averaging the product of weight used and repetitions completed for each machine. Future studies in this area, though, may benefit from additional supervisors to ensure proper use of equipment and completion of each exercise.

Regarding BMI, the current study had relatively lower BMIs than other studies involving an RT program. Unlike the Benson et al. (2008) study which had more than half of the participants classified as overweight or obese, only about a third of the participants in the current study were classified as overweight or obese. Schools with a large number of overweight or obese children may benefit more from the inclusion of an RT program than schools who do not have a large overweight or obese population. Anecdotally, several students in this study who were classified as overweight or obese seemed to give the best effort of all the students. Perhaps, as other researchers have found, the ability of children who are bigger to excel in RT can increase their enjoyment of that mode of exercise as opposed to more traditional, aerobic-based training. The superiority of children who are bigger may also have a greater impact on ATPA that was not evident because of the normal distribution of children based on BMI in this study. Also, due to age differences in pubertal stages between boys and girls, future analyses may be conducted to determine if sex significantly impacts changes in BMI and ATPA.

This study only employed machines for RT. Although there are other ways to achieve benefits from RT (i.e., bands, dumbbells, and barbells), due to the age of the participants and the need for safety, children were restricted to machines. Because of this restriction on exercise selection, boredom on the part of students was apparent. Future studies with lower numbers or more supervisors may be able to include various modes of RT to prevent children's stagnating interest.

Another limitation of the study was lack of true random assignment of participants. The lack of true random assignment may have left some extraneous variables (e.g., diet) uncontrolled. Also, the RT program had been ongoing for 2 years in the school in this study. This resulted in two of the 3 classes in the control group having already participated in a similar RT program the semester prior to the current study.

Previous exposure to a similar RT program may have lead to the lack of a true control group. To assure that no carry over effects skew the results, future researchers should randomly assign participants to groups and be assured that all children have no previous RT experience.

Conclusions

In a sample of children with normally distributed BMIs, the RT protocol used in the current study did not impact BMI. Although the average BMI of children participating in RT increased less than the children who did not participate in RT, the difference was not statistically significant. However, the resulting lower increase in body mass in children who performed RT, although not statistically significant, may be practically relevant for children who are attempting to control their weight.

CATPA remained unchanged as well and even decreased more in one subdomain in children who participated in RT than children who did not participate. Because care was taken to maintain safety while training children, the selection of machines only to receive benefits of RT may have diminished the children's enjoyment of the program. Implementing a short RT section in a PE or health-related class could peak children's interest in this new mode of training without inducing boredom.

PA levels outside of the RT program were unaffected by participating in the RT program. Still, this maintenance of PA outside of training may be beneficial as overall PA levels probably increased. Future studies utilizing measures of PA better able to detect both RT and other common forms of PA in which children participate, like doubly labeled water or heart rate monitoring, are needed.

Finally, RT is a safe mode of exercise for children. Though BMI was not significantly impacted and overall CATPA was unaffected by the protocol used in the current study, an overall increase in PA levels most likely resulted. While caution and close supervision are needed when children participate in RT, the physiological benefits of RT and increased overall PA levels in children are well-established. Therefore, if implemented in a school setting, RT may be included as a safe and enjoyable alternative to conventional, aerobic based activities.

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APPENDICES

APPENDIX A

Child Assent Form

The Discovery School at Reeves Rogers
Physical Activity Questions

Assent Form

This is for you to read.

You are being given the opportunity to fill out two packets of questions at the beginning and the end of this semester. The questions will be about how you have been active and how much you enjoy being active.

These tests will be available during the school day. You do not have to do this if you do not want to. Your choice will not affect you in school.

These questions will help you to better understand how much physical activity you do each and also how much you enjoy being active. No one will see your information other than you.

You can ask Dr. Clark, your principal, or any of the people helping you with the fitness tests about any questions.

Your Name ____

Your Signature ____ Date ____________

APPENDIX B

Parental Consent Form

January 8, 2009

Dear Parents:

This is the last semester your child will have the opportunity to participate in the fitness program being run at the Discovery School by MTSU. Thank you for allowing us to work with your child and we hope that your child has had as much fun working out as we have had working with him/her.

During this last semester, your child will be completing two simple questionnaires to help determine his or her physical activity level and how he/she feels about being physically active. We hope participation in the fitness program will help your child be more active and increase his/her enjoyment of being active.

As always, we treat your child's information with the utmost confidentiality. Also, your child may choose not to fill out these questionnaires, with no impact on his/her participation in the fitness program.

I am one of the trainers and I work in the program each day. I am happy to answer any questions that you may have and you can reach me at 615-308-4299. You can reach Drs. Caputo, Farley, or Eveland-Sayers, my faculty supervisors, at 615-898-2811. Also, you may reach MTSU's compliance officer, Tara Prairie, at 615-494-8918.

Sincerely,

Mr. Matt Renfrow

I give my child permission to complete the questionnaires on physical activity and perceptions of physical activity as part of the fitness program.

____
Child's Name (please print)

______________________________ ______________________
Parent/Guardian Signature Date

APPENDIX C

Institutional Review Board Approval Letter

January 14, 2009

Dr. Jennifer Caputo, Dr. Richard Farley, Dr. Brandi Eveland-Sayers, & Matt Renfrow
Department of Health and Human Performance
jcaputo@mtsu.edu, rfarley@mtsu.edu, beveland@mtsu.edu, msr2p@mtsu.edu

RE: Protocol Title: "Strength Training at the Discovery School at Bellwood"
Protocol Number: 08-010

Dear Investigator(s):

I have reviewed your research proposal identified above and your requested changes. I approve of the following changes:

- Adding the Children's Attitudes Towards Physical Activity and the Physical Activity Questionnaires to your study and
- Updating the consent and assent forms to address the above questionnaires.

Please note that any unanticipated harms to participants or adverse events must be reported to the Office of Compliance at (615) 494-8918. Any change to the protocol must be submitted to the IRB before implementing this change.

You will need to submit an end-of-project report to the Office of Compliance upon completion of your research. Complete research means that you have finished collecting data and you are ready to submit your thesis and/or publish your findings. Should you not finish your research within the one (1) year period, you must submit a Progress Report and request a continuation prior to the expiration date. Please allow time for review and requested revisions. Your study expires **June 30, 2009**.

According to MTSU Policy, a researcher is defined as anyone who works with data or has contact with participants. Anyone meeting this definition needs to be listed on the protocol and needs to provide a certificate of training to the Office of Compliance. If you add researchers to an approved project, please forward an updated list of researchers and their certificates of training to the Office of Compliance before they begin to work on the project.

Please note, **all research materials must be retained** by the PI or **faculty advisor (if the PI is a student)** for at least **three (3) years after study completion**. Should you have any questions or need additional information, please do not hesitate to contact me.

Sincerely,

Tara M. Prairie
Compliance Officer
Middle Tennessee State University

APPENDIX D

Training Log

WEIGHT TRAINING LOG	NAME:												TEACHER:											
DATE																								
EXERCISE	R	W	R	W	R	W	R	W	R	W	R	W	R	W	R	W	R	W	R	W	R	W	R	W
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