

ABSTRACT

MCNEELY, C. M. A Comparison of the effects of bouldering wall and resistance band activities on upper body strength and grip strength in elementary school children. MS in Exercise and Sport Science-Physical Education Teaching, August 2000, 39 pp. (M. Anderson)

This study compared the effects bouldering wall activities to resistance band exercises on upper body strength and grip strength in elementary school children. Fifty-five ($n = 55$) subjects in grades 4-6 participated in the study. The subjects were randomly assigned to the bouldering wall group or resistance band group. Both groups participated in a training period of 6 weeks. During the six weeks, climbers were on the bouldering wall for approximately ten minutes, 2-3 times per week. The subjects who were assigned to the resistance bands performed 8 exercises that trained the muscles of the upper body. These subjects performed 2-3 sets of 12 repetitions for each exercise 2-3 times per week. Pre/post tests for the flexed arm hang and right and left hand grip strength were given to each subject. The ANCOVA results show a significant difference ($p < .05$) between pre and posttest scores for both males and females in both groups. Chi Square results show that there were significantly fewer participants below the Healthy Fitness Zone, and significantly more in the Healthy Fitness Zone ($X^2 = 8.22$, $df = 2$, $p = .016$) after treatment. There was not a significant difference ($p > .05$) between the groups before or after the training period. This study indicated that bouldering wall and resistance band activities were equally effective in developing upper body and grip strength in elementary students.

**A COMPARISON OF THE EFFECTS OF BOULDERING
WALL AND RESISTANCE BAND ACTIVITIES
ON UPPER BODY STRENGTH
AND GRIP STRENGTH IN ELEMENTARY SCHOOL CHILDREN**

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**BY
COURTNEY M. MCNEELY**

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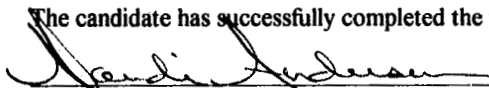
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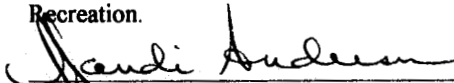
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Date


Thesis Committee Member Signature 8/28/00
Date


Thesis Committee Member Signature 7/21/00
Date

This thesis is approved by the College of Health, Physical Education, and Recreation.


Associate Dean, College of Health,
Physical Education, and Recreation 9/11/00
Date


Dean of Graduate Studies 9-13-00
Date

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Dedicated in memory of Grandpa. I love you Pops!

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CHAPTER 1

INTRODUCTION

“When health is absent, wisdom cannot reveal itself, art cannot become manifest, strength cannot be exerted, wealth is useless and reason is powerless.” Herophiles, 300 B. C.

Physical activity is essential for maintaining our health. Diseases and conditions such as diabetes, cardiovascular disease, obesity, and high blood pressure are on a rise in this country due to the lack of physical activity (CDC, 1996). Besides medical professionals, the group with the biggest influence in the area of health and physical activity are physical educators.

Some K-12 physical education programs have added lifetime fitness education that focuses on developing skills and interest in lifetime activities to the curriculum. With this addition, the trend in physical education seems to be moving away from the traditional physical education activities that include team and individual sports, and calisthenics. With the introduction of innovative activities such as adventure activities, weight training, aerobics, cardio kickboxing, yoga and other alternative activities, children are learning to take better care of themselves while hopefully preparing for life as a physically active and healthy person. However, there are areas of concern for physical educators.

Physical educators throughout the United States are struggling with muscular strength, endurance, and overall fitness deficiencies among today’s youth (American Alliance for Health, Physical Education, Recreation and Dance, 1992; Corbin & Pangrazi, 1992). The

problem seems to lie with finding appropriate and fun activities for elementary students to participate in that may increase muscular strength and endurance, particularly in the upper body. According to the Healthy People 2010 report (U.S. Dept. of Health and Human Services, 2000), children and adolescents need strength training or resistance training exercises to have normal and strong skeletal development. However, it has been difficult for elementary students to truly understand the benefits of strength training and other exercises. On the other hand, many teenage students are concerned with their body image and can be persuaded to participate in activities such as weight training, circuit training and other exercise regimens that develop strength and increased fitness levels (Rupnow, 1985).

Teachers are involved in a mission to find the activities that spark the interest of students as well as make them healthier. One lifetime activity that is receiving more and more attention is that of rock climbing or wall climbing. Rock climbing gyms and walls are going up in colleges and even in K-12 schools around the United States (Mittelstaedt, 1997). The schools that are unable to afford the expenses of a climbing wall usually construct bouldering walls. These are usually between six and eight feet tall, and can be any desired length. Students climb sideways, or traverse, along the wall. As a result of this trend, children are literally climbing the walls in physical education classes around the country. This development seems to hold potential benefits for the students. Climbing reportedly has four major fitness benefits, including increased muscular strength, muscular endurance, cardio-respiratory fitness and flexibility (Mittelstaedt). This could possibly be one strategy to increase upper body strength in children.

If climbing walls or bouldering walls are not accessible, there are many alternative and inexpensive activities that help increase fitness levels in children. One of the most affordable is resistance bands. Resistance bands are becoming more and more popular in schools around the nation.

Statement of the Problem

The purpose of this study was to compare the effects of wall climbing and resistance band exercises on upper body strength and endurance and grip strength in elementary students.

Need for the Study

Based on a review of literature, there is a lack of significant research directly related to the fitness benefits of wall climbing and resistance band exercises for children. Due to the significant weakness in upper body strength, physical educators are searching for new and innovative activities that will help their students increase muscular strength and endurance. This study will present two such activities that may or may not have a direct effect on muscular strength and endurance in children.

Hypotheses

The null hypotheses of this study were:

1. Bouldering wall climbing will have no significant effect on upper body strength and endurance and grip strength in elementary children ages 9-13.
2. Resistance band exercises will have no significant effect on upper body strength and endurance and grip strength in elementary students ages 9-13.

3. There will be no significant difference in upper body strength and endurance, and grip strength fitness scores of the participants who use the bouldering wall and the participants who use the resistance bands.
4. There will be no significant difference in the number of children who are categorized as being above, in, or below the *Healthy Fitness Zone* for the flexed arm hang.

Assumptions

This study had the following assumptions:

1. All students performed exercises to the best of their ability.
2. All resistance band subjects completed the correct number of sets and repetitions of each exercise each day.
3. All subjects did not begin or stop additional resistance training exercises other than those assigned during the study.

Delimitations

This study had the following delimitations:

1. Subjects for this study were limited to elementary students, ages 9-13 at Blessed Sacrament School in La Crosse, Wisconsin.
2. Training for this study was limited to six weeks.

Limitations

This study had the following limitations:

1. Class absences may have influenced the study.
2. School events, during which the students do not attend physical education class (i.e., field trips, special events, and school mass), may have influenced the study.

3. Students performing the resistance band exercises quickly or incorrectly may have influenced the study.

Definition of Terms

Bouldering Wall - A stable and stationary structure, usually constructed out of 4' x 8' panels of plywood. The panels have hand and foot holds bolted to them. The wall at Blessed Sacrament School is 8'h x 28'w and has approximately 105 hand and footholds bolted to the plywood. The students' feet are not more than 4.5 feet off the ground while climbing.

FITNESSGRAM - A comprehensive health-related fitness assessment and computerized reporting system. The test measures the five components of fitness for each child. The Cooper Institute for Aerobic Research produces this test.

Flexed Arm Hang - A test to measure upper body strength and endurance in students and is part of the FITNESSGRAM fitness assessment. The student uses an overhand grip on a horizontal bar and pulls him/herself above the bar and hangs for as many seconds as possible without the chin dropping below the bar.

Grip Strength - The force exerted by the hand and forearm muscles upon maximal contraction of the fingers while squeezing a hand dynamometer.

Hand Hold/Foot Hold - Small structures made out of wood, cement, plaster or resin combinations that are different shapes and sizes that simulate climbing in nature.

Hand Dynamometer - A device that measures grip strength in pounds force or kilograms force.

Resistance Bands - A strong flexible band made of latex or non-latex material used for exercises and rehabilitation by teachers, physical therapists, athletic trainers, and many other medical professionals.

Upper Body Endurance - The amount of force exerted by the muscles of the arms, shoulders, chest, and back for an extended period of time.

Upper Body Strength - The amount of force exerted by the muscles of the arms, shoulders, chest, and back during a maximal contraction.

CHAPTER II

REVIEW OF RELATED LITERATURE

Introduction

This chapter reviews literature that focuses on the following topics: the health and fitness of children, current trends in physical education, climbing and bouldering walls, resistance bands, and the testing protocols that were used in this study.

Youth Fitness

According to the National School Population Fitness survey, analyzed by Corbin and Pangrazi (1992), children in the United States are still scoring low on fitness tests given to them annually. Most of the problems are with the lack of flexibility in boys and the overall weakness of upper body strength in both girls and boys. For the last 25 years, upper body strength has been a concern for elementary physical educators. Strength is the ability to overcome a resistance through muscle exertion. A child needs muscular strength to perform motor skills and everyday tasks (Rupnow, 1985).

Some children are unable to lift their own body weight, and it is their weight that tends to cause the problems in fitness testing. In a study done by Folsom-Meek, Herauf, and Adams (1992), results showed that there was a significant correlation ($p < .05$) between age and percent body fat to scores on the flexed arm hang and the pull up tests. The researchers concluded that there should be a learning progression for upper body strength and fitness testing. It has been suggested that a child start with the modified pull

up, and once proficient, move on to the flexed arm hang, and eventually perform a regular pull up. With this progression, most teachers will find a significant increase in upper body strength in their students year to year (Folsom- Meek, Herauf, & Adams, 1992).

To improve upper body strength, a physical education teacher can implement a variety of strength building activities into each lesson. If children work their muscles regularly and correctly, they can increase their muscle strength over a period of time. However, weight training (use of dumbbells or weight machines) for children has been a concern of researchers, teachers and doctors for years. The risk of injuries to growth plates and joints has prevented teachers from using weight training with young people. However, a properly designed program that is supervised by a qualified person is safe for children. The National Strength and Conditioning Association (NSCA) recommends that when a young child begins weight training, a light load or resistance should be used. A program with high repetitions is also recommended for young children. The NSCA also suggests that proper training and supervision of a program can help prevent injuries in youth sports and activities (Saunders, 1997).

Current Trends in Physical Education

In recent years, traditional physical education activities such as team sports and individual sports are becoming less attractive to educators compared to the new trends of adventure education and alternative physical activities that focus on lifetime fitness. One adventure activity that is gaining more and more attention is the sport of rock climbing.

Resistance bands are also becoming more popular with teachers and students who want a safe and inexpensive way to train their muscles.

Climbing Walls

In the last few years, the development of indoor climbing facilities has increased dramatically and has become one of the newest trends among people of all ages (Mittelstaedt, 1997). Climbing walls were actually a phenomenon back in the 1960s and 1970s. In the United States and Britain, numerous climbing walls were built and implemented in the physical education curriculum (March and Toft, 1979). By 1990, more than 25 universities had climbing facilities. Even more impressive is the number of climbing facilities directed towards children. There are climbing tread walls, where the climber will climb as the wall moves vertically on a motorized track, popping up in YMCA/YWCAs, county fairs, and even in rental stores. Climbing walls are being constructed in public school gymnasiums all over the United States. For example, in Worthington, Ohio there are climbing walls in eight of the district's elementary schools (Mittelstaedt).

Fitness Benefits of Climbing

There are numerous fitness benefits of climbing for children and adults. The four major components of fitness include muscular strength, muscular endurance, cardio-respiratory fitness, and flexibility. While rock climbing and bouldering enhance all the components of fitness, they also increase body awareness, self-confidence and problem solving ability (McNamee, Gravatt, & Steffen, 2000).

According to Kascenska, Dewitt and Roberts (1992) muscular endurance is the body's ability to exert force for an extended amount of time. If a climber trains on a consistent basis, his/her body will develop the muscular endurance needed to complete a climb with less fatigue than a non-trained climber. This requires the climber to develop a workout program that will promote muscular endurance.

Cardio-respiratory fitness is defined as the ability of the heart, lungs, and blood vessels to supply oxygen to muscles. Aerobic activity is involved in all climbs. It is especially evident in the speed climbs, where the climber is required to climb as fast as possible to the top.

Flexibility is greatly improved in climbers as well. Flexibility is defined as the range of motion of a joint. In climbing, children and adults need to be aware of the possible strain on the shoulder and knee joints. An effective flexibility-training program should be established prior to climbing (Kascenska, Dewitt & Roberts, 1992; Mittelstaedt, 1997).

Although fitness should be emphasized, a teacher must point out to students that to be a good rock climber, you do not necessarily need to be the strongest person. A child only needs the will to try and to succeed. Rock climbing is an appropriate activity for all ability levels. A final thing that teachers must mention is the incidence of injuries caused by insufficient training and over use of the muscles and joints. In the past, there have been a number of physical education teachers that have focused on the safety and liability issues that arise in climbing wall situations. This concern of liability had been turning

people away from climbing wall in physical education and took the attention away from the fitness aspect of climbing (Kasenska, et al. 1992, Mittelstaedt, 1997).

Resistance Bands

Resistance training can be implemented at the elementary level in the 4th, 5th, and 6th grades. Resistance bands can come in many forms. These include surgical tubing, rubber cords, or bands. Some of the well-known names for these resistance bands are: Exertube, Dyna Band, Flexi-Cord, and Theraband. Resistance bands are safe, inexpensive and easy to maintain (AAHPERD, 1999). There is a lack of research dealing with resistance band training and the benefits for children. More studies are necessary to determine how much of an effect resistance bands can have on the muscular systems of our youth.

Fitness Benefits of Resistance Bands

Resistance bands are a fun way to incorporate resistance training into a curriculum. Students improve their overall physical fitness with the variety of exercises that are available. Improvements have been made in the areas of muscular strength, endurance and flexibility. Resistance bands can also aid students in maintaining a good posture and body alignment during exercise. Around the world, more and more schools are purchasing and using resistance bands in their classes to improve their students' health (Liddell, 1989).

Testing Protocols

FITNESSGRAM

In recent years, two major assessment tools, FITNESSGRAM and Physical Best have combined together to make a complete educational health-related fitness program. In the past, Physical Best stood alone with its own assessment tool. Now, Physical Best endorses the use of the FITNESSGRAM to complete the program (AAHPERD, 1999). FITNESSGRAM is a criterion-referenced health-related fitness assessment tool that assesses an individual's level of aerobic capacity, flexibility, muscular strength, muscular endurance and body composition (Cooper, 1999). The FITNESSGRAM assesses the fitness levels of K-12 students. However, intense fitness testing should not be the focus in the K-2 grades; form and correct techniques along with vital health information are.

The children are assessed on the five components of fitness and are given ample opportunities to retest to get their best score. The physical educator has a variety of activities or assessment items from which to choose. For aerobic capacity, one can choose the PACER test, one-mile run, or the walk test (for secondary students). For body composition, the educator can choose the traditional and time-consuming skin fold measurements or the body mass index. An educator must select the curl up and the trunk lift for abdominal strength and endurance. For upper body strength, there are the push up, modified pull up, the pull up and the flexed arm hang. For flexibility, there are the back saver sit and reach and the shoulder stretch to choose from.

The scores are recorded and compared to the standards set by the Cooper Institute of Aerobic Research, which is called the Healthy Fitness Zone (HFZ). The HFZ is the

range between the minimum and maximum scores necessary to be considered healthy. If scores fall below the HFZ, the computer program will make a suggestion on the FITNESSGRAM report to the student on how to improve. The computer congratulates the student on their healthy living habits if their score falls in or above the HFZ (Cooper, 1999).

Fitness testing in general gives students feedback on how their actions in everyday life affect their fitness levels, in turn helping students to set realistic and achievable goals for maintaining or reaching a healthy level of fitness. Fitness testing also gives educators feedback on the effectiveness of the health-related activities they are implementing in their classrooms. The new FITNESSGRAM released in the fall of 1999 offers the educator the opportunity to allow students to keep track of their activity levels throughout a specified amount of time. The ACTIVITYGRAM, allows students to choose activities, pick the intensity and follow through on goals they set (Cooper).

Grip Strength

Grip strength has become one of the direct ways of measuring strength and determining physiological growth (Svehla, 1991). Grip strength is measured using a hand dynamometer, which measures applied force. Therapists, fitness instructors, and physicians use initial grip strength as a baseline from which to assess improvement. When accessible, teachers use hand dynamometers to measure grip strength as an alternative to the push up and pull up tests (Gayle, Schiltz, & Blazek, 1998). Results of a study by Svehla show that elementary aged males have greater grip strength than females, and that as age increased, grip strength also increased. Svehla also found a significant

difference ($p < .0001$) in right and left hand grip strength measures. In a study by Gayle, et al. (1998), children were tested on grip strength using two different elbow positions. Results showed that the zero degree flexion produced higher scores in 88% of the children on the grip strength measurement than the 90-degree flexion. However, most hand dynamometers require that a 90-degree elbow flexion be used to get an accurate measurement.

Summary

The implementation of health-related fitness and adventure activities is becoming more and more important. More research is being developed that will justify a health-related fitness and adventure curriculum in the schools throughout the United States. Alternative physical education activities tend to spark interest with students of all ages. The increasing number of climbing walls being constructed verifies the interest teachers and students have in adventure education and developing healthy levels of fitness.

CHAPTER III

METHODS AND PROCEDURES

Introduction

This chapter reviews the methods and procedures that were used to complete this research. Topics to be discussed are as follows: subject selection, test instruments, procedures, and data analysis.

Methods

Subjects

The focus of this study was to compare the effects of bouldering wall activities and resistance band activities on upper body strength and endurance and grip strength. The students selected for this research were a convenience sample from Blessed Sacrament School in La Crosse, Wisconsin. Fifty-five ($n = 55$) fourth through sixth grade students participated in this study. One half of each class was randomly assigned to either the "wall" or "band" group. Twenty-seven ($n = 27$) students participated in the bouldering wall activities and the remaining twenty-eight ($n = 28$) participated in the resistance band activities. All subjects in this study were informed of the testing procedures for this research. A letter of informed consent was sent to each student's parent or guardian with the explanation of the study. The parents were asked to return the form if they agreed to have their child's fitness test results used in this study.

Instruments

The flexed arm hang was used to test the student's initial and final upper body strength and endurance. This test is part of AAHPERD's FITNESSGRAM assessment. The procedure for the flexed arm hang can be summarized as follows: the student grasps the bar with an overhand grip. With assistance, the student raises his/her body off the floor so that the chin is above the bar, elbows are flexed, and the chest is close to the bar. The test administrator starts the stopwatch as soon as the student takes the position. The student holds this position for as long as possible. The administrator will stop the watch if any of the following occur: the chin touches the bar, head tilts back to keep chin above bar, or chin drops below the bar. The test administrator then records the number of seconds the student was able to hang following the test protocol.

The students were then tested on their handgrip strength. The test administrator used the JAMAR Hand Grip Dynamometer, which measures grip strength in pounds force or kilograms force. The dynamometers were adjusted for hand size and comfort for each student and noted on their test cards for use on the posttest. The students performed two trials for each hand, squeezing as hard as they could for 3 seconds. Scores were recorded as the average of the two trials. Students were tested while standing with shoulders in a neutral position, elbow was flexed to 90° degrees, and the palm facing the medial plane of the body.

Methods and Procedures

All students in this study went through an initial training program for the resistance bands and the bouldering wall as part of the regular curriculum before the start of the study. The training protocols for the wall and bands were in a block plan format for the curriculum (see Appendix B). The bouldering wall block plan included lessons, games, and safety concerns. Lessons began with safety protocols and basic climbing techniques and concluded with route climbing. The block plan for bands included lessons, safety concerns, and exercise descriptions. Lessons began with safety and care of the bands and concluded with a demonstration of each exercise with the students.

A fitness pretest was given to all students participating in the study. The test included the flexed arm hang and the handgrip dynamometer. To randomly divide each class into the "wall" and the "band" groups, each student drew a labeled piece of paper from a box. The students were not allowed to trade pieces of paper.

The "wall" group ($n = 27$) had a treatment period of six weeks. The school runs on a six day cycle, meaning that the students have physical education 5 times every two weeks. In these six weeks, the students used a number of hand and foot techniques while traversing on the bouldering wall for 10 minutes per class period, two to three times a week. There were a number of different climbing routes marked with colored tags and the students could use only those routes to climb across. Each student picked her/his own level of difficulty for each climb.

The "band" group (n = 28) had a treatment period of two or three 10- minute sessions per week for six weeks. During those ten minutes, the students performed three sets of 12 repetitions of the following exercises:

1. Triceps Extension
2. Triceps Press
3. Biceps Curl
4. Lateral Raise
5. Forward Raise
6. Shoulder Press
7. Upright Rows
8. Forearm/Wrist Curls

The students completed their workouts each day and recorded each set on a data card.

The data card listed each exercise, number of sets, and repetitions the participants performed (see Appendix C).

Data Analysis

Data were analyzed by comparing group means. An analysis of variance (ANOVA) was used to determine equality among the groups. Pre and posttest means were compared using an analysis of covariance (ANCOVA) to determine if there was a change in fitness levels. Pre and post flexed arm hang scores were compared to the standards of the FITNESSGRAM assessment and categorized as being above, in, or below the "Healthy Fitness Zone" (HFZ). The Chi Square test of goodness of fit was used to identify changes in the number of students in each zone from the pre to posttest. The .05 level of confidence was used for all significant statistical tests.

CHAPTER IV

RESULTS AND DISCUSSION

Introduction

This study compared the effects of bouldering wall and resistance band activities on upper body strength and endurance and grip strength in elementary school children. Fifty-five fourth through sixth grade students participated in this study. Presented in this chapter are the results of pre test ANOVAs, posttest ANCOVAs, and Chi Square Test for flexed arm hang, followed by a discussion of the results and evaluation of the null hypotheses.

Subjects

The total number of participants was 55. Twenty-seven students (13 females and 14 males) participated in the bouldering wall activities. Twenty-eight students (12 females and 14 males) participated in the resistance band activities (see Table 1). All Participants were students at Blessed Sacrament School in La Crosse, Wisconsin. There were 20 fourth grade students, 12 fifth grade students, and 23 sixth grade students. The fifth grade class at Blessed Sacrament is smaller than the fourth and sixth grade classes, resulting in a lower number of subjects from that grade in the study.

Table 1. Number of Participants by Group, Gender and Grade (n = 55)

| Group/Grade | Males | Females |
|-------------|-------|---------|
| Wall | 14 | 13 |
| 4 | 6 | 3 |
| 5 | 2 | 3 |
| 6 | 6 | 7 |
| Band | 16 | 12 |
| 4 | 6 | 5 |
| 5 | 4 | 3 |
| 6 | 6 | 4 |

Results

ANOVA was used to determine equality among the groups for flexed arm hang (see Table 2). The results of the analysis showed that there were no significant differences ($p > .05$) for the main effects of group, gender, or grade. Also, there were no significant interactions.

Table 2. ANOVA for Flexed Arm Hang Pre Test

| Source | Sum of Squares | df | Mean Square | F | Significance |
|---------------------------|----------------|----|-------------|-------|--------------|
| Test Grp | 95.107 | 1 | 95.107 | 1.410 | .242 |
| Gender | 171.616 | 1 | 171.616 | 2.544 | .118 |
| Grade | 53.224 | 2 | 26.612 | .395 | .676 |
| Test Grp x Gender | 13.895 | 1 | 13.895 | .206 | .652 |
| Test Grp x Grade | 2.607 | 2 | 1.303 | .019 | .981 |
| Gender x Grade | 47.312 | 2 | 23.656 | .351 | .706 |
| Test Grp x Gender x Grade | 18.680 | 2 | 9.340 | .138 | .871 |

ANOVA was used to determine equality among the groups for right hand grip strength (Table 3). There were no significant differences between groups or genders, but there was a significant difference ($F = 11.434$, $df = 2$; $p = .000$) in grip strength by grade. Also, there were no significant interactions.

Table 3. ANOVA for Right Hand Grip Strength

| Source | Sum of Squares | df | Mean Square | F | Significance |
|---------------------------|----------------|----|-------------|--------|--------------|
| Test Grp | 37.217 | 1 | 37.217 | .501 | .483 |
| Gender | 233.343 | 1 | 233.343 | 3.141 | .083 |
| Grade | 1698.539 | 2 | 849.269 | 11.434 | .000* |
| Test Grp x Gender | 141.920 | 1 | 141.920 | 1.911 | .174 |
| Test Grp x Grade | 104.854 | 2 | 52.427 | .706 | .499 |
| Gender x Grade | 162.378 | 2 | 81.189 | 1.093 | .344 |
| Test Grp x Gender x Grade | 13.345 | 2 | 6.672 | .090 | .914 |

*Indicates a significant difference between the groups ($p < .05$)

Table 4 presents the ANOVA results for left hand grip pretest. Again, there were no significant differences between groups or genders. There was a significant difference ($F = 14.437$, $df = 2$; $p = .000$) among grades.

The ANCOVA was used to determine pre and posttest differences. Results for the flexed arm hang are presented in Table 5. The ANCOVA showed a significant difference ($F = 94.76$, $df = 1$; $p = .000$) between pre and posttest scores for both the wall and band groups. There was a significant interaction ($F = 4.030$, $df = 2$; $p = .025$) for test group and grade.

Table 4. ANOVA for Left Hand Grip Strength

| Source | Sum of Squares | df | Mean Square | F | Significance |
|---------------------------|----------------|----|-------------|--------|--------------|
| Test Grp | 9.965E-02 | 1 | 9.965E-02 | .002 | .969 |
| Gender | 144.878 | 1 | 144.878 | 2.206 | .145 |
| Grade | 1896.150 | 2 | 948.075 | 14.437 | .000* |
| Test Grp x Gender | 95.491 | 1 | 95.491 | 1.454 | .234 |
| Test Grp x Grade | 76.107 | 2 | 38.053 | .579 | .565 |
| Gender x Grade | 234.832 | 2 | 117.416 | 1.788 | .180 |
| Test Grp x Gender x Grade | 15.824 | 2 | 7.912 | .120 | .887 |

*Indicates a significant difference ($p < .05$)

Table 5. ANCOVA for Flexed Arm Hang (Posttest)

| Source | Sum of Squares | df | Mean Square | F | Significance |
|---------------------------|----------------|----|-------------|--------|--------------|
| PreFAH | 797.636 | 1 | 1797.636 | 94.761 | .000* |
| Test Grp | 6.495 | 1 | 6.495 | .342 | .562 |
| Gender | 8.399 | 1 | 8.399 | .443 | .509 |
| Grade | 27.667 | 2 | 13.833 | .729 | .488 |
| Test Grp x Gender | 7.670E-02 | 1 | 7.670E-02 | .004 | .950 |
| Test Grp x Grade | 152.891 | 2 | 76.446 | 4.030 | .025* |
| Gender x Grade | 110.679 | 2 | 55.340 | 2.917 | .065 |
| Test Grp x Gender x Grade | 25.182 | 2 | 12.591 | .664 | .520 |

*Indicates a significant difference ($p < .05$)

Table 6 presents the ANCOVA results for right hand grip strength. A significant difference ($F = 46.64$, $df = 1$; $p = .000$) was found between pre and posttest scores. There was also a significant difference for the gender main effect ($F = 4.657$, $df = 1$; $p = .037$). Pre and posttest means and standard deviations for boys were 43.75 (10.92) and 45.00 (11.82) respectively. Means and standard deviations for girls were 39.60 (9.11) and 45.70 (10.88).

Table 6. ANCOVA for Right Hand Grip Strength (Posttest)

| Source | Sum of Squares | df | Mean Square | F | Significance |
|---------------------------|----------------|----|-------------|--------|--------------|
| PreGRPR | 2197.127 | 1 | 2197.127 | 46.641 | .000* |
| Test Grp | 50.622 | 1 | 50.622 | 1.075 | .306 |
| Gender | 219.363 | 1 | 219.363 | 4.657 | .037* |
| Grade | 264.031 | 2 | 132.016 | 2.802 | .072 |
| Test Grp x Gender | 3.032 | 1 | 3.032 | .064 | .801 |
| Test Grp x Grade | 7.590 | 2 | 3.795 | .081 | .923 |
| Gender x Grade | 3.465 | 2 | 1.732 | .037 | .964 |
| Test Grp x Gender x Grade | 206.480 | 2 | 103.240 | 2.192 | .124 |

*Indicates a significant difference ($p < .05$)

Presented in Table 7 are the posttest ANCOVA results for left hand grip strength. A significant difference ($F = 35.726$, $df = 1$; $p = .000$) was found between pre and posttest scores. There were no significant differences among the main effects or interactions.

Table 7. ANCOVA for Left Hand Grip Strength (Posttest)

| Source | Sum of Squares | df | Mean Square | F | Significance |
|---------------------------|----------------|----|-------------|--------|--------------|
| PreGRPL | 1773.737 | 1 | 1773.737 | 35.726 | .000* |
| Test Grp | 8.544 | 1 | 8.544 | .172 | .680 |
| Gender | .358 | 1 | .358 | .007 | .933 |
| Grade | 261.666 | 2 | 130.833 | 2.635 | .084 |
| Test Grp x Gender | 85.384 | 1 | 85.384 | 1.720 | .197 |
| Test Grp x Grade | 17.513 | 2 | 8.756 | .176 | .839 |
| Gender x Grade | 42.498 | 2 | 21.249 | .428 | .655 |
| Test Grp x Gender x Grade | 125.843 | 2 | 62.922 | 1.267 | .292 |

*Indicates a significant difference ($p < .05$)

Table 8 presents the number of students whose scores fell above, in, or below the Healthy Fitness Zone (HFZ) according to FITNESSGRAM standards. Results of the Chi Square test indicated that there were significantly fewer students below the HFZ and significantly more students in the HFZ ($X^2 = 8.222$, $df = 2$; $p = .016$). There was no significant change in the number of children who were above the HFZ.

Table 8. Chi Square Results for Healthy Fitness Zone

| Healthy Fitness Zone Category | Observed N | Expected N | Residual |
|--------------------------------|------------|------------|----------|
| Above the Healthy Fitness Zone | 18 | 17.0 | 1.0 |
| In the Healthy Fitness Zone | 21 | 13.0 | 8.0 |
| Below the Healthy Fitness Zone | 16 | 25.0 | -9.0 |

Test of Hypotheses

Based on the results of this study, the following null hypotheses were rejected or failed to be rejected:

1. There was a significant effect of the bouldering wall activities on upper body strength and endurance and right and left grip strength in elementary children ages 9-13, thus the null hypothesis for these variables was rejected.
2. There was a significant effect of the resistance band exercises on upper body strength and endurance and right and left grip strength in elementary students ages 9-13, thus the null hypothesis for these variables was rejected.
3. There was not a significant difference in posttest scores on flexed arm hang, right hand grip strength or left hand grip strength between the participants who used the bouldering wall and those who used the resistance bands, thus the researcher failed to reject the null hypothesis for these variables.
4. There was a significant difference in the numbers of children who were categorized as being above, in, or below the healthy fitness zone for the flexed arm hang, thus the null hypothesis for this variable was rejected.

Discussion

Results of this study indicated that the bouldering wall group and the band group were no different in the flexed arm hang or in grip strength prior to the treatment. ANOVA results for right and left hand grip strength show a significant difference among grades as one would expect due to maturation. However, flexed arm hang scores were equal throughout the grades. There were no significant differences between genders, which

contradicts Svehla's (1991) findings that males ages 9-11, have higher grip strength than females ages 9-11.

At the conclusion of this study, there was still no difference between the groups in flexed arm hang or grip strength. However, there were significant differences between pre and posttest scores for all variables. These results indicate that both of these activities as implemented in this study can improve upper body strength and endurance in elementary children. The increased fitness scores among the bouldering wall group in this study are consistent with the findings of McNamee, Gravatt and Steffen (2000) that climbing increases muscular strength and endurance.

Results of ANCOVA for all variables show no significant differences by grade. Differences by grade were expected in the posttests. Maturation would account for the grade differences in the pretest, however, due to the results of the ANCOVA, the researcher can assume that maturation did not have an effect on the strength of the children in this study. The ANCOVA for right hand grip strength showed a significant difference between genders. Females had greater increases in grip strength on the right hand than males in this study. There were no significant differences in left hand grip strength between boys and girls. At this age level, the researcher did not expect to find gender based differences because prepubescent boys and girls should be equal in strength.

The results of the flexed arm hang pretest, where 25% of students fell below the Healthy Fitness Zone, reinforced Rupnow's (1985) findings that there is an overall weakness in upper body strength in both girls and boys. However, the posttest results

show an increase in strength among children in this study. Chi Square results show a significant increase in the number of children in the healthy fitness zone. There were also significantly fewer children below the healthy fitness zone. Children's fitness levels can improve with the implementation of strength building activities that this study demonstrates. Fun and innovative ways to add resistance to a workout can have a positive impact on children.

It appears that both of these activities were equally effective in increasing upper body strength and endurance and grip strength, particularly in the absence of expected maturational differences. Both males and females in elementary school can benefit from bouldering and resistance band activities in a short period of time. These are two of the many activities that physical educators and researchers can use to increase strength and improve fitness scores.

CHAPTER V

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

Summary

The purpose of this study was to compare the effects of bouldering wall activities and resistance band activities on upper body strength and endurance and grip strength in elementary school children. Fifty-five (27 wall and 28 band subjects; 25 females and 30 males) successfully completed the study. Flexed arm hang and grip strength were measured prior to and after completion of the 6-week training period.

Strength and endurance improved significantly from pre-to-post testing for both groups. There was not a significant difference ($p > .05$) between the wall group and the resistance band groups.

Conclusions

According to the statistical analysis of the data collected, the following conclusions were reached:

1. The bouldering wall activities significantly improved upper body strength and endurance and grip strength among elementary school students.
2. The resistance band activities significantly improved upper body strength and endurance and grip strength among elementary school students.
3. A significant number of students showed enough improvement in upper body strength and endurance to move from “below” to “in” the HFZ according to FITNESSGRAM assessment standards.

Recommendations

The researcher recommends that additional research be done on the subject of upper body strength and endurance and grip strength in elementary students. There are several suggestions the researcher would like to make.

1. To prevent boredom and repetitiveness, a combination of the two activities should be implemented. Participants needed change after 3 consecutive weeks of treatment.
2. To increase the level of performance among climbers, holds should have been moved or removed from the wall. Increasing difficulty could potentially increase the effects of the activity. The resistance band group should set goals to move up to higher levels of resistance once able.
3. A larger sample size is needed for a study similar in nature to obtain equal groups among grade levels.
4. A control group should be used to determine if maturation has an effect on the strength and endurance gains of elementary students for similar studies.
5. Other fitness components should be emphasized during the activities to determine if these activities also increase flexibility and cardiovascular endurance.

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APPENDIX A
INFORMED CONSENT FORM

THE EFFECTS OF TWO TYPES OF PHYSICAL ACTIVITY ON UPPER BODY STRENGTH AND HAND GRIP STRENGTH IN ELEMENTARY STUDENTS

INFORMED CONSENT

I have been informed that my child will be participating in a research study that will compare the effects of two different physical education activities on upper body strength, and handgrip strength. I have been informed that my child's participation in this study may include resistance band workouts, stretching and push-ups. I also have been informed that my child may be a participant in the bouldering wall (8' x 28' foot climbing wall that students climb sideways or traverse) group, which will have weekly sessions on the bouldering wall. I have been informed that with this research, my child will be tested on the flexed arm hang, sit and reach test and hand grip strength. I have been informed and have discussed the importance of this study with my child.

I have been informed that participation in this research study will require a minimum of two-ten minute sessions per week for six weeks. All activities will take place in physical education class and are part of the normal curriculum. All testing items are part of the normal fitness testing procedures in physical education. There are no additional risks to your child other than the risks faced in regular physical education class.

To my knowledge, my child is in good health and has no physical limitations or conditions that would put my child at risk. I consent to the publication or publication of this research study as long as the information remains confidential so that no identification can be made after the research is completed. I have been informed about the nature of this study and the investigator will answer any questions I have. Therefore, I voluntarily consent my child's fitness information to be used in this research study. Furthermore, I have been informed that if any time my child wants to withdraw his/her permission to use the information from this study, there will be no penalties.

Concerns or questions about this study can be addressed to Courtney M. McNeely, principal investigator, 782-5564 and thesis advisor Dr. Mandi Anderson, 785-8187. Questions regarding the protection of human subjects may be addressed to Dr. Garth Tymeson Chair, University of Wisconsin- La Crosse Institutional Review Board (IRB) for the Protection of Human Subjects at (608) 785-8155.

RETURN THIS FORM IF YOU AGREE TO HAVE YOUR CHILD'S INFORMATION
USED IN THIS STUDY

Please sign both copies, keep one for your files and please return the second form in back in the family folder. Thank you for your cooperation

Parent/Guardian

Date

Researcher

Date

Student (Assent)

Date

APPENDIX B

**BOULDERING WALL AND RESISTANCE BAND
BLOCK PLANS**

BOULDERING WALL BLOCK PLAN**DAY 1**

1. Introduction to climbing
2. Safety protocols
3. Climbing hold discussion
4. Dome cone practice

DAY 3

1. Discussion of routes
2. Climb red route for practice
3. Climb blue route for practice
4. Partner Challenge

DAY 5

1. Discussion of Bouldering Games Assignment.
2. Develop and practice games

DAY 2

1. Review of safety
2. Dome cone stations
3. Free time on wall

DAY 4

1. Review of route climbing
2. Stick Game
3. Blind fold climb
4. Speed Challenge

DAY 6

1. Presentation of games
2. Review of unit

*** Each day is started with a 5 minute warm up and stretching session. Objectives for this unit are not included in the block plan.***

RESISTANCE BAND BLOCK PLAN**DAY 1**

1. Introduction
2. Care and maintenance of bands
3. Safety tips
4. Training guidelines
5. Demonstration
6. Leg Extension

DAY 2

1. Review
2. Abdominal curl
3. Bench Press
4. Lat Pull Down
5. Shoulder Press

DAY 3

1. One Arm Tricep Extension
2. Leg Curl
3. Review of Day 2 exercises
4. Upright Row
5. Palm Up Forearm Curl

DAY 4

1. Lateral Raise
2. Forward Raise
3. Tricep Press
4. Review

***Each day started with a 5 minute warm up and stretching session. Students were in physical education every other day. Two sets of 10 repetitions were performed for each exercise.

APPENDIX C

RESISTANCE BAND WORKOUT CARD

Resistance Band Workout Record Sheet

Name: _____

Age: _____

Grade: _____

| EXERCISE | WEEK 1 | WEEK 2 | WEEK 3 | WEEK 4 | WEEK 5 | WEEK 6 |
|--------------------------|----------|----------|----------|----------|----------|----------|
| Bicep Curl | 12 12 12 | 12 12 12 | 12 12 12 | 12 12 12 | 12 12 12 | 12 12 12 |
| | 12 12 12 | 12 12 12 | 12 12 12 | 12 12 12 | 12 12 12 | 12 12 12 |
| | 12 12 12 | 12 12 12 | 12 12 12 | 12 12 12 | 12 12 12 | 12 12 12 |
| One Arm Tricep Extension | 12 12 12 | 12 12 12 | 12 12 12 | 12 12 12 | 12 12 12 | 12 12 12 |
| | 12 12 12 | 12 12 12 | 12 12 12 | 12 12 12 | 12 12 12 | 12 12 12 |
| | 12 12 12 | 12 12 12 | 12 12 12 | 12 12 12 | 12 12 12 | 12 12 12 |
| Tricep Press | 12 12 12 | 12 12 12 | 12 12 12 | 12 12 12 | 12 12 12 | 12 12 12 |
| | 12 12 12 | 12 12 12 | 12 12 12 | 12 12 12 | 12 12 12 | 12 12 12 |
| | 12 12 12 | 12 12 12 | 12 12 12 | 12 12 12 | 12 12 12 | 12 12 12 |
| Upright Row | 12 12 12 | 12 12 12 | 12 12 12 | 12 12 12 | 12 12 12 | 12 12 12 |
| | 12 12 12 | 12 12 12 | 12 12 12 | 12 12 12 | 12 12 12 | 12 12 12 |
| | 12 12 12 | 12 12 12 | 12 12 12 | 12 12 12 | 12 12 12 | 12 12 12 |
| Forward Raise | 12 12 12 | 12 12 12 | 12 12 12 | 12 12 12 | 12 12 12 | 12 12 12 |
| | 12 12 12 | 12 12 12 | 12 12 12 | 12 12 12 | 12 12 12 | 12 12 12 |
| | 12 12 12 | 12 12 12 | 12 12 12 | 12 12 12 | 12 12 12 | 12 12 12 |
| Lateral Raise | 12 12 12 | 12 12 12 | 12 12 12 | 12 12 12 | 12 12 12 | 12 12 12 |
| | 12 12 12 | 12 12 12 | 12 12 12 | 12 12 12 | 12 12 12 | 12 12 12 |
| | 12 12 12 | 12 12 12 | 12 12 12 | 12 12 12 | 12 12 12 | 12 12 12 |
| Shoulder Press | 12 12 12 | 12 12 12 | 12 12 12 | 12 12 12 | 12 12 12 | 12 12 12 |
| | 12 12 12 | 12 12 12 | 12 12 12 | 12 12 12 | 12 12 12 | 12 12 12 |
| | 12 12 12 | 12 12 12 | 12 12 12 | 12 12 12 | 12 12 12 | 12 12 12 |
| Palm Up Forearm Curl | 12 12 12 | 12 12 12 | 12 12 12 | 12 12 12 | 12 12 12 | 12 12 12 |
| | 12 12 12 | 12 12 12 | 12 12 12 | 12 12 12 | 12 12 12 | 12 12 12 |
| | 12 12 12 | 12 12 12 | 12 12 12 | 12 12 12 | 12 12 12 | 12 12 12 |