The Effects of Physical Activity on Academic Success in Mathematics

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Abstract

The purpose of this study was to examine the effects of physical activity on the achievement of middle school students in mathematics. This study, occurring over five-weeks, used a pre-test/post-test design. All students were receiving regular instruction in mathematics, using the Everyday Math program, for 45 minutes each day. Students in the treatment group participated in vigorous physical activity for six minutes as a warm-up for their physical education class. Students in the control group received a less vigorous warm-up. All students received instruction in physical education every other day. There was no significant difference between the groups in performance on a common math unit test. However, additional studies are recommended involving more students over a longer period of time in order to further knowledge about the role of physical activity in promoting academic achievement.

CHAPTER I

INTRODUCTION

Exercise on a regular basis maintains a healthy lifestyle and helps individuals live a long life. Technology geared towards the nation's youth has resulted in a society with less activity and an increase in unhealthy habits. Thirty-one percent of Americans can be considered obese, which is over 59 million adults in the United States (American Obesity Association, 2009). Education can impact these figures in the future by providing a quality physical education program, allowing all students the opportunity to learn about how to be physically active and to maintain healthy exercise levels for life.

Funding for physical education programs in school has often been one of the most problematic areas in difficult economic times, leaving boys and girls with fewer opportunities for exercise. Physical education teachers have been able to find ways to introduce learning about physical education through cross-curricular means for years, but now they are especially challenged to find ways to engage students in vigorous physical activity. As schools are pressured to improve reading and math achievement, evidence to suggest physical education's effect on academic success becomes important. The impact physical activity has on learning can be a driving force to increase funding, allowing children the opportunity to continue moving for a healthy lifestyle (Coe, Pivarnik, Womack, Reeves, & Malina, 2006).

The California Department of Education (2004) suggested that not only is there insufficient time for physical education in schools, but there is also insufficient funding for quality physical education. The California Department of Education's survey results indicated an increased number of obese and diabetic students enrolled in California schools and concluded that students scoring higher on fitness tests will be more likely to achieve academic success.

Data from the research revealed that when students improve one's fitness level, scores on academic achievement tests improved.

Researchers Tremarche, Robinson, and Graham (2007) reported that one way to improve overall test scores is to engage students in more physical education. They showed that students who received more hours of quality physical education per school year scored higher on math and reading tests. Their findings support a greater emphasis on a quality physical education program, which includes opportunities for students to participate in vigorous physical education. Their research suggests that increasing the amount of quality physical education may hold promise for students struggling in math. Specifically, looking at the relationship between increasing one's target heart rate into their target heart rate zone for maximal time and performance in mathematics may produce promising results.

Statement of the Problem

The purpose of this study is to determine whether increased physical activity will lead to an increase in math achievement.

Hypothesis

Students who participate in increased vigorous physical activity during physical education class will demonstrate no increase in math achievement compared to peers who participate in regular physical education classes.

Operational Definitions

A variety of terms are used throughout this paper. *Vigorous physical activity* refers to movement and exercise that increases a person's heart rate into one's target heart rate zone. *Heart Rate* is the measure of the number of heart beats in one minute. *Target heart rate zone* refers to a predetermined goal for one's heart rate produced through vigorous exercise, based

upon age, to improve the cardiovascular system. The formula to determine a target heart rate zone is 220 – (age) x (0.6) and 220 – (age) x (0.9).

CHAPTER II

A REVIEW OF THE LITERATURE

This literature review seeks to examine math achievement in middle school. The first section will explain how math achievement is measured and define math achievement. Section two explores how physical education can improve physical activity levels. Section three discusses the connection between math achievement and physical activity.

Math Achievement

An event driving education over the past decade has been the No Child Left Behind Act (NCLB). This piece of legislation has fueled major education-related decisions since 2001. NCLB featured four components: accountability for results, choices for parents, more control and flexibility of local jurisdictions, and an emphasis on best practices. According to the United States Department of Education's *What Works Clearinghouse*, math achievement is described by three successes: "standardized tests, nationally-normed achievement tests, standardized state or local tests of mathematics, and research-based or locally developed tests or instruments that assess student's mathematical concepts or skills" (Ellis, 2007, p. 223).

Middle school mathematics plays an important transition role between elementary and high school. During the middle school years, students extend and refine prior knowledge taught in elementary schools while preparing to be challenged in high school. Students at the middle school level require a strong foundation for algebra and geometry in order to achieve mastery during high school. Specifically, students will be introduced to "numbers and operations, measurement, and data analysis and probability" (What Works Clearinghouse, 2007, p. 1).

According to the Harford County Public Schools Curriculum Guide (2008), students should have a strong foundation for math in elementary school by being introduced to algebra patterns and functions, geometry, measurement, number relations, statistics, and probability. Students should be able to make real world connections through problem solving activities, working in groups, and by reasoning and proof.

Middle school is a time for students to develop and build on relationships in order to create a network where challenges can be overcome (Seed, 2008). This critical time during the middle years is also used to eliminate misconceptions that many students have about mathematics. Teachers with developed strategies to implement curriculum foster an environment that promotes success. A classroom that promotes math achievement will utilize the diversity to develop a fully educated child (Brown, 2005).

Math achievement can be affected by the classroom environment, the grouping of students, and faculty concerns. Classroom environments are one driving force that will help determine whether or not a child is able to learn in direct and indirect ways (Linares, Rosbruch, Stern, Edwards, Walker, Abikoff, & Alvir, 2005). Directly, a positive climate encourages greater student achievement. Indirectly, classroom environment can cause achievement to improve, and it may influence a student's level of engagement and sustained effort. A positive classroom environment may allow students to take risks and answer questions without fear of being wrong. In any classroom, the grouping of students is very important and works hand-in-hand with allowing the classroom environment to be successful. Students who are grouped homogeneously usually perform better than if they were heterogeneously grouped.

Teachers and administrators have an impact on student groupings in schools. They also play a role in "developing curricular materials that are appropriate for diverse groups of students

and training teachers to use it in ways that students will understand" (Bottge, Rueda, Serlin, Ya-Hui, & Kwon, 2007, p. 45). When teachers are able to develop a learning-centered community, students take ownership in learning. Learning-centered communities have an emotional climate that encourages learning, relationships that motivate and raise attainment, encouragement of self-management, a common purpose, and lifelong learning potential (Deakin, McCombs, Haddon, Broadfoot, & Tew, 2007). Teachers play a direct role in establishing classroom environments that allow students to take risks while maintaining a leadership role.

Classrooms are known for the diversity and individual needs of students. Each individual has characteristics that may alter his or her ability to learn; these are known as student factors of learning. Some factors of learning include one's ability to learn, one's emotional or behavior concerns, one's anxiety, and one's past successes. A student's ability to learn is the most important factor to consider. Students who have a learning disability may work harder than other students, but they still may not be able to find success in mathematics (Martinez & Semrud-Clikeman, 2004). Students with multiple learning disabilities struggle even more in math, due to a decreased ability to emotionally adjust and function in school. A strong classroom will allow these students to interact and build social skills (Mooney, Ryan, Uhing, Reid, & Epstein, 2005). Students will build on past success, improving self-efficacy (Linares et al., 2005). Self-efficacy has been associated with higher math achievement, as students are more likely to be socially accepted if one's efficacy is higher.

Not only does self-efficacy play an important role in math achievement, but past success in math is also very important. Students who have confidence in themselves are more likely to achieve success because they are willing to take risks in order to overcome challenges (Bottge, Rueda, & Skivington, 2006). Anxiety, "defined as a feeling of tension, apprehension, or fear that

interferes with math performance," (Aschcraft, 2002, p.181) can adversely affect math achievement. Anxiety reduces storage and processing in the brain, which forces students to devote extra time and effort in order to maintain performance (Hopko, McNeil, Gleason, & Rabalais, 2002). Students suffering from anxiety rush through work in order to get through it, which can create an increase in errors. Boys tend to have more trouble with school maladjustment, having difficulty adjusting to the everyday demands and sensation seeking than girls (Martinez & Semrud-Clikeman, 2004).

Teacher preparation is another concern of math achievement. The ability to meet the needs of all learners in mathematics is vital to success, including those with special needs (Maccini & Gagnon, 2006). Coordination between general educators and special educators in meeting these students' needs will impact how well they learn. "If middle school teachers were better prepared to manage their middle school classrooms, the statistical correlation between their mathematics background and the attainment of their students would allow for increased math achievement" (Tooke, 1997, p. 51). Schools and universities can influence the level of training by developing professional learning communities. Brown (2005) adds that program goals of banding teachers together in order to talk about curriculum implementation, mentoring programs, sharing and collaborating lessons, management of duties assigned, and encouragement new teaching techniques can have an impact on math achievement.

Physical Activity in Middle School

Physical activity in middle school children has decreased for many decades (Guthrie, 2003). Physical activity is measured through an increase in heart rate over the duration of activity. Benefits of physical activity improve immensely when activity is vigorous (Coe et al., 2006). Vigorous physical activity is measured by increasing an individual's heart rate into

his/her target heart rate zone for a period of 30 minutes. One's target heart rate training zone is defined by working between an upper limit and lower limit. To calculate an individual's upper limit, one should subtract an individual's age from 220, and then multiplying by 0.9 (Physical Best, 1999). A lower limit is found by subtracting an individual's age from 220 and multiplying by 0.6.

The burden of increasing physical activity among middle school aged children to improve healthy lifestyles has fallen on schools. The basis for physical education to be incorporated into schools was to "contribute to the physical well-being of children, as well as to their social, emotional, and intellectual development" (Guthrie, 2003, p. 1887). According to the *American Alliance for Health, Physical Education, Recreation and Dance*, the major physical education organization, a quality physical education program for middle school students should allow for 225 minutes of physical education per week, taught by qualified physical education specialists (Guthrie, 2003).

Physical activity levels among middle school aged children can best be determined by having the student demonstrate their physical fitness level. The President's Challenge and FitnessGram physical fitness testing have been in physical education programs to emphasize goals and determine a baseline for physical fitness (Guthrie, 2003). In order to increase accountability, there has been a trend towards a national assessment in physical education. This assessment will determine cognitive goals established in curriculum.

A strong physical education program promotes opportunities for students to participate in a variety of physical activities to increase fitness levels. In order to increase fitness levels, students must be involved in vigorous physical activity, which has been found to produce higher academic success (Coe et al., 2006). Vigorous physical activity should be completed at least 3

times a week for a minimum of 30 minutes. In order to get the most out of exercise, students should be working within their target heart rate training zone.

Connection Between Math Achievement and Physical Activity/Education

Some schools offer students increased time in physical education, thus allowing less time for students in other academic classes. Researchers such as Ahamed, Macdonald, Reed, Naylor, Liu-Ambrose, & McKay (2007) indicate that extra time in physical education has no impact on academic achievement. However, schools devoting academic instructional class time for physical education did not score lower on achievement tests. In fact, Tremarche, Robinson, and Graham (2007) emphasize that by participating in more physical education, students will have an increase in test scores. "Despite devoting twice as many minutes per week to physical education, the health-related physical education program did not interfere with academic achievement" (Sallis & McKenzie, 1999, p.127).

Physical education's impact may have gender differences. A significant benefit for academic achievement was observed in girls enrolled in higher amounts of physical education (Carlson, Fulton, Lee, Maynard, Brown, Kohl et al., 2008). Others, like Grissom (2005) agreed that there is a relationship between fitness and higher achievement in females. Outcomes of regular participation in physical education classes consist of an increase in social skills, improved emotional health, alertness, and increase favorable adolescent risk behaviors. These outcomes of physical education promote self-esteem (Nelson & Gordon-Larsen, 2006). The development of self-esteem in adolescents through physical activity has been indirectly linked to an increase in academic performance. In fact, "exercise may prove to be a simple, yet important, method of enhancing those aspects of children's mental functioning central to cognitive development" (Tomporowski, Davis, Miller, & Naglieri, 2008, p.125).

When students participate in physical education classes that increase heart rate through vigorous physical activity over the course of a year, students can improve their fitness level. Improving fitness can encourage improved academic achievement. It has been suggested that there is a strong positive relationship between physical fitness and academic achievement in mathematics and reading (California Department of Education, 2004). Students who score higher on physical fitness tests, such as the President's Challenge or FitnessGram Fitness Test, perform better on reading and mathematics assessments. Studies of adolescents have also suggested aerobic capacity being positively associated with achievement. When students score higher on cardiovascular endurance activities, the mile-run test or the PACER test, there is significant improvement in academic achievement on aptitude tests (Castelli, Hillman, Buck, & Erwin, 2007).

Summary

Mathematics achievement in middle school is heavily influenced by the classroom environment, the grouping of students, and faculty concerns. Vigorous physical activity will improve the emotional health and alertness of individuals, which will improve self-efficacy. Physical education's curriculum can impact math achievement in a positive way by incorporating strong fitness goals. Physical education does not only impact the physical health of children, but it also can impact math achievement.

CHAPTER III

METHODS

The purpose of this study was to examine the effect of vigorous physical activity on academic achievement in math.

Design

A pretest-posttest quasi-experimental design was used in the study.

Participants

The participants in this study were randomly selected sixth graders enrolled in two sections of physical education classes in a middle school in northeastern Maryland. A quasi-experimental design was used in this study because students were assigned to one of two classes at the beginning of the school year. One class, which served as the control group, included 18 students, of which 11 students were girls and 7 students were boys. The other class, which served as the experimental group, consisted of 16 students, of which 10 students were girls and 6 students were boys.

The school enrolls approximately 1,249 students, of which 87% of students are white, 5% are African American, 3% are Hispanic, 4.4% are Asian, and 0.6% are American Indian. There are 112 students that qualify for free or reduced lunch. The middle school includes students in grades six, seven and eight, where student attendance is at 96%.

Instrument

Participants taking part in this study use a textbook called *Everyday Mathematics* (Bell, 2007), which is followed closely by their teachers. At the conclusion of each unit, students complete the chapter test. At the beginning of the unit, students are given a pre-assessment. The

assessment is repeated at the end of the unit. The mathematics unit used in this study consisted of angles of measure and the relationships of angles. The test consisted of 28 questions: true/false questions, several fill in the blanks, and some short answer. Students needed to have a protractor for part of the last set of questions. At the conclusion of the test, the mathematics teachers scored and reported the test to the researcher. The three math teachers developed this test based upon content used in the *Everyday Mathematics* textbook. No reliability or validity information for the assessment is available.

PROCEDURES

The researcher, a physical education teacher, received permission to complete the five-week research project. Participants used in this study were not given any instructions and were not told that they were part of the study. Students were asked to participate in regular physical activity, which is performed throughout the year. The students selected for the research were students who attend physical education every other day. Students in both groups were taught by the same physical education teacher.

In addition to regular physical education classes, students also participated in regular math classes. Participants in both groups were randomly assigned a teacher for math instruction. No specific instruction was given to the three classroom teachers who taught the students math. All students participating in the study, including the control and experimental group, completed the same chapter, used the same text book, and were assessed using the same test.

Each day that students attended physical education, they participated in warm-up activities that involved vigorous physical activity for at least 3 minutes. The experimental group participated in at least 6 minutes of vigorous physical activity as part of their daily warm-ups.

The control group, which had physical education on even days, was given the same instruction during warm-ups as the control group. Only the length of activity differed. Although the types of activities varied, all students participating in class raised their heart rates into their target heart rate zone during warm-ups.

At the conclusion of the five-week unit, participants in both groups were given the same post-assessment. The results of the mathematics pre-test and post-test were compiled to include every student in both the control and experimental group and were compared by the researcher.

CHAPTER IV

RESULTS

At the conclusion of the unit of instruction, students were given the chapter test (Appendix A). The results of the pre-test, post-test, and MSA scores were scored. The results of the tests are shown in Table 1. Table 1 indicates that both groups scored similarly on the MSA tests, but not on the pre-test. The mean scores for the post-test indicate that both groups had similar competencies at the conclusion of the unit.

Table 1: MSA and HCPS Math Test Performance

Instructional Group	Number of students	Pretest Mean/SD	Posttest Mean/SD	MSA Mean/SD
Treatment	16	33.37/12.36	72.87/17.07	423.75/23.24
Control	18	37.12/14.22	71.62/21.42	423.12/31.95

The researcher analyzed the scores and indicated the results in Table 2. MSA math and pre-test scores were used as the covariates. The dependent variable was the students' post-test scores. Table 2 indicates that there were no significant differences in teacher instruction and no significant differences between treatment groups.

Table 2: Analysis of Covariance: Group Performance on Math Posttest

Source of Variance	Sum of Squares	DF	Mean Square	F
Math Pretest	3241.99	1	3241.99	46.81**
Math MSA	1014.25	1	1014.25	14.64*
Teacher	743.57	2	371.78	3.65 (n. s.)
Treatment Group	339.95	1	339.95	1.95 (n. s.)
Teacher X Group	189.95	2	97.97	2.09 (n. s.)
Within (error)	1315.78	19	69.25	

**p<.000 * p<.001

CHAPTER V

DISCUSSION

The null hypothesis that participation in an increased amount of vigorous physical activity during physical education will have no impact on math achievement was not rejected. The results of this study are important; however, there are limitations to the generalizations that can be made based on the results.

Validity

There are several external factors that affect the validity of this study. The study was completed over a five-week period. Along with attending regular mathematics class, students participated in physical education class which provided the treatment. During the five-week period, there were many circumstances which may have affected the validity of the study. The testing sample was rather small and was chosen due to convenience. The 34 students were assigned to the treatment or control group randomly due to the scheduling of students taking place at the beginning of the year. In addition to the sample, the validity of the study could have been impacted by the duration of time the study was completed. Five weeks and one unit of instruction is a short time. It is possible that the treatment would have an effect on mathematics over an extended amount of curriculum.

Every student who participated in the study completed the pre- and post-tests, and only one did not take the MSA math test. However, students missed the treatment due to several reasons: attendance, medical concerns (hurt ankle, illness, etc.), and snow days. There were even days students weren't allowed to participate in physical activity due to not having a physical education uniform to wear. The entire study took place in one particular school, which affects the validity of the study.

Internal factors that affected the validity of the study were also present. The four teachers who participated in the study could have some bias to influence the scores through encouragement levels. The mathematics teachers that assisted in the research did know which students were included in the study, although they did not know whether a student was in the treatment or control group. The interaction of the students with the experimenter may also influence the outcome of the study. There were influences in the class schedule due to prior school-wide events. One day, students did not attend physical education because there was a special schedule. The researcher may have adjusted the model of vigorous activity, or treatment, in order to maintain student interest. Students were not provided a heart rate monitor or a device to ensure the level of treatment. Therefore, even though students were asked to jog or run so that their heart rate level was within their target heart rate zone, the researcher was not able to ensure the validity of exercise.

Relationship to Previous Studies

Tremarche, Robinson, and Graham (2007) emphasize that by participating in more physical education, students will have an increase in test scores. Students were provided extra time in physical education, as compared to the treatment group. In 2003, Guthrie studied physical activity levels among middle school aged children. Academic success improved as physical fitness levels increased. In 2006, Coe et al. also concluded in order to increase fitness levels, students must be involved in vigorous physical activity, which has been found to produce higher academic success.

The California Department of Education (2004) has suggested that a strong positive relationship exists between physical fitness and academic achievement in mathematics. The concern with this study is that there was not enough time for the effects of the treatment to take

place. A five-week period of treatment will not enable someone to considerably improve one's physical fitness.

Implications for Future Research

Future studies should allow for an entire year of treatment, placing strong emphasis on comparing MSA math scores in subsequent years. Including an entire school, multiple schools, or an entire county of schools in the sample would provide sufficient data to ensure the validity of the study. By using the larger sample of students, attendance, forgetting of physical education uniforms, and medical concerns would be minimized, thus creating valid research.

Internal factors of validity, such as teacher instruction, can be minimized by splitting all math classes into a control and treatment group, rather than physical education classes. Therefore, the same instruction would be given to both groups. Physical fitness testing should be included in the research design. As previous studies have suggested, alertness is an important factor in learning. By participating in higher levels of activity, students may be able to raise alertness levels. In either case, future analysis may be able to determine more conclusive results to indicate whether or not physical activity positively impact academic achievement in mathematics.

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