2017

Determining the Optimal Amount of Physical Activity for Promoting Academic Benefit Among School-aged Children

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DETERMINING THE OPTIMAL AMOUNT OF PHYSICAL ACTIVITY FOR PROMOTING ACADEMIC BENEFIT AMONG SCHOOL-AGED CHILDREN

A MASTERS THESIS

SUBMITTED TO THE FACULTY

OF BETHEL UNIVERSITY

BY

MATTHEW E. FISCUS

IN PARTIAL FULFILLMENT OF THE REQUIREMENTS

FOR THE DEGREE OF

MASTER OF ARTS

NOVEMBER 2017

BETHEL UNIVERSITY

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November 2017

APPROVED

Steven Henkel, Ph.D._____

Molly Wickam, Ph.D._____

Acknowledgements

Writing this thesis has been difficult and rewarding. Like many other graduate students in the Master of Arts in Teaching degree program, I opted to start teaching before finishing this final requirement. One year turns into another and here I am a stay-at-home dad with a two-year old son. As with any other task in life, it is easy to tell yourself "I will get to it when things are less busy." As I've learned once again, there is no perfect time to begin a challenging project such as this. You have to make time for what is important and I would not have been able to do that without the support of my wife. She has been patient and encouraging as I have slowly worked to complete this task over the past six months. Thank you, Missy for picking up my slack so I could finish this project and fulfill my educational goals. I would like to thank my thesis advisor, Steve Henkel for spending several hours reading drafts and suggesting edits to help me make this thesis a quality product. Finally, I would like to thank my second reader, Bill Kron for selflessly offering his sharp mind and careful eyes to guide me in refining and completing this thesis.

Abstract

This paper explores the relationship between physical activity and academic performance, the optimal amount of physical activity to enjoy these benefits, and the best way to measure this optimal amount of activity. Research yielding positive associations between physical activity and academic performance has increased significantly over the past 20 years. Multiple articles reviewed in this paper support the following examples of academic benefits gained from participating in physical activity: improved standardized test scores, higher grade point average, enhanced cognitive skills, and improved academic behaviors. Parents, teachers, and administrators understand these relationships to some degree but often, the implementation of physical activity into an already busy school day is haphazard to say the least. The identification of a threshold level of physical activity that provides these types of academic benefits would afford administrators an efficient prescription for use. Physical activity prescriptions are present for health-based benefits, but the research available on this topic does not successfully address it directly. Trends, however, can be seen across the spectrum of literature and a dose-response relationship is drawn in this review. Schools would also benefit from measuring physical activity to identify their own relationships and provide data for future research. As with finding the optimal amount of activity, conclusions from the literature may be drawn based on trends. Recommendations based on current technology also offer further solutions for measuring the optimal amount of physical activity for school-aged children to enjoy academic benefits.

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CHAPTER I: INTRODUCTION

The level of physical activity that today's school-aged children experience has been scrutinized for several reasons and from multiple angles. The proliferation of technology with television, smartphones, and computer applications has undoubtedly reduced the level of physical activity children engage in. These advancements in technology have contributed to an already increasing sedentary pattern in young people, raising concerns about their health and wellness. Schools contribute to this pattern when they reduce physical education requirements in order to increase core subject classroom time to prepare for standardized tests. Benefits of physical activity are usually centered on longevity, physical ability, and quality of life. While these benefits are vitally important, something that is not discussed as frequently are the cognitive advantages gained from regular physical activity and how those may contribute to success in the regular education classroom.

As a professional educator, I have witnessed the rise in sluggishness, inability to focus, low confidence, poor memory function, stress, and depression among students. These types of symptoms do not support academic achievement in the classroom and though the causes are complex and often vary, a lack of physical activity could most certainly contribute. Aside from the health impacts, low self-esteem and poor decision-making are often associated with poor academic performance in school. Decreased energy levels and lack of focus negatively affect a student's engagement and motivation. Teachers need ways to positively motivate students and improve their academic performance. Concerns associated with achievement gap, standardized testing, and college readiness could arguably be assuaged with improved academic performance. The correlation between physical activity and academic performance could

possibly impact decisions made by administrators, physical educators, core subject educators, and parents.

Definition of Terms

Physical Activity-

Body movement caused by activation of the musculoskeletal system and generally accompanied by an increase in heart rate, though not always significantly. May be accomplished in a variety of settings and may or may not be structured or supervised by a licensed teacher.

Physical Education-

Instructional course in maintenance and movement of the human body in a school setting and delivered by a licensed physical education teacher.

Measured Core Subject Areas-

Relating to the primary core subjects as measured using standardized tests, such as mathematics and reading.

Academic Achievement-

Growth in educational outcomes as measured by standardized tests over a period of time.

Cognitive Skills and Attitudes-

The process of acquiring knowledge and understanding through attention, memory, judgment, evaluation, reasoning, problem solving, comprehension, and language production.

Academic Behaviors-

Behaviors that have an impact on academic performance, including on-task behavior, organization, planning, attendance, scheduling, and impulse control.

Background

Historical Perspective: The Early Years (Pre-2000)

As the founder of the first higher education institution of the Western world nearly 2,400 years ago, Plato believed that the mind and body must work in concert to perform optimally:

> In order for man to succeed in life, God provided him with two means, education and physical activity. Not separately, one for the soul and the other for the body, but for the two together. With these means, man can attain perfection (Plato, trans. 2008).

People have long posited the academic benefits of physical activity. The refinement of study to prove such claims was not immediately present, but as stated by Plato, the connection between physical activity and cognition was recognized.

Studies have been conducted for over half a century searching for concrete associations between physical activity and academic achievement in children and adolescents (Howie & Pate, 2012). An overwhelmingly large percentage of the studies have been done in the past 20 years, yielding the highest percentage of positive relationships. Though positive associations between physical activity and academic achievement were not largely established in earlier studies, the methodology of studies were a limiting factor to producing definitive findings. Specifically, quasi-experimental designs lacked random assignment, thereby reducing validity. Another problem with design of early studies was focusing heavily on male and female participation in physical education, particularly in aerobic intensity, as it related to achievement in the classroom (Castelli et. al, 2014). Furthermore, subjective grades were used as a measure

of academic achievement rather than standardized tests that have been prevalent in the past 15 to 20 years. Although many early studies did not find significant improvements in cognition or academic performance, very few instances of negative association were found. A literature review by Keays and Allison (1995) found most studies noted significant benefits in overall health, attitudes, discipline, behavior, and creativity. Most of the studies in this review were post-1980; however, a few landmark studies prior were included (Keays & Allison, 1995). Another issue with studies conducted between 1967 and 1999 was the infrequent inclusion of quantification and qualification of the physical activity being performed (Castelli et. al, 2014). Certainly, the type of physical activity, the specific amount, and how it is measured is paramount to how it may affect academic performance. To illustrate the results of early research on the relationship between physical activity and academic performance, a meta-analysis by Castelli, et al. (2014) calculated an effect size of 0.212 for eight studies conducted prior to 2000. An effect size of 0.2 is generally regarded as a small effect. This means that the studies reviewed for that period found some small positive associations, several found no significant effect, and very few had any negative effect.

Physical education has a storied history in the United States. Its inception into school curriculum was prompted more due to war readiness than development of the whole person or aspirations of improved academic performance. Programs have evolved over time in their content and duration. States have varied significantly on the time that students are required to attend physical education. This variation is likely due to state educational priorities and options, and the national education policy climate and/or funding. From 1991 to 2003, the percentage of high school students in physical education dropped from 42 to 28 percent (Cawley,

Meyerhoefer, & Newhouse, 2007). Many schools were likely pressed by financial strains and when this occurs, physical education is often the first program to be reduced or cut. Furthermore, the No Child Left Behind Act (NCLB) likely affected these numbers after its introduction in 2002. According to the 1993 Shape of the Nation report, only one state (Illinois) required daily physical education for every grade level, K-12 (NASPE, 1993). The same year, the National Association for Sport and Physical Education (NASPE) recommended that elementary and secondary students respectively receive 30 and 45-55 minutes of physical education daily. As of the NASPE report, only four states (Alabama, Delaware, Illinois, and Minnesota) met the elementary recommendation and two states (Alabama and Illinois) met the secondary recommendation (NASPE, 1993).

Considering that children spend a large percentage of their waking hours in school, it is an excellent platform for helping them get as close as possible to their recommended active daily minutes. Physical education typically represents the bulk of physically active time at school and should be programmed with a priority that maximizes its potential. Even when physical education is implemented in a manner that reaches the recommended time by NASPE, students need more options to achieve the CDC-recommended daily active minutes (30-45 minutes, three to five times per week). Along with physical education, opportunities before the year 2000 consisted primarily of recess and athletics.

Historical Perspective: The Modern Era (Post-2000)

The educational climate in the United States is swayed by the ever-changing influence of federal and state mandates. A large percentage of research done on physical activity and its

relationship to academic performance in children was used to make recommendations to school boards. Consequently, the educational environment at the time influenced these studies. The tenets of NCLB focused measureable progress on standard tests in core subjects and in many districts, forced reductions in physical education to increase time in core classes. In some regards, this movement slowed gains in research that was beginning to find more positive associations between physical activity and academic achievement. However, a literature review of over 850 articles from 1980 to 2005 revealed that cross-sectional studies positively associated physical activity with academic performance generally, and with concentration, memory, classroom behavior, and cognitive function more specifically (Strong et al., 2005). Perhaps even more influential during a time when physical education programs were being cut was the recommendations from this review. Strong et al. (2005) concluded that the activity level of youth from ages 6-18 should increase from 30-45 minutes three to five times per week to 60 minutes daily. This bold recommendation became the foundation of what we now know as today's youth activity standard. A reflection of study design improvements is clear when looking at the body of recent research in this area. An average effect size of 0.496 was calculated from five studies on the association between physical activity and academic achievement from 2000-2009 and 0.564 from 2009-2012 (Castelli et al., 2014). The Hedges' effect size of 0.5 is regarded as a finding of medium effect. As compared to the pre-2000 effect size of 0.212, there is a greater likelihood of finding a relationship between physical activity and academic achievement. In 2017, Lorenz, Stylianou, Moore, and Kulinna found a significant influence of aerobic fitness on grades in reading, writing, mathematics, and science using the Progressive Aerobic Cardiovascular Endurance Run test (PACER). The growing body of research

with positive associations is encouraging for refining study and developing sound policy recommendations to school boards.

One of the consequences of cutting physical education is an increase in obesity in children. According to a 2015 report by the Center for Disease Control (CDC), 17.2% of youth ages 2-19 were currently classified as obese compared with 13.9% in 2000. These numbers, coupled with increasing positive correlations of physical activity and academic performance, pressed school districts to find more time for physical activity opportunities. Options for fitness electives became more prevalent, school activity options grew, and activity breaks became more popular in classrooms. Though opportunities for activity increased, physical education time has not increased. In a 2016 Shape of the Nation report, only two states (Montana and Oregon) and the District of Columbia met the recommended number of minutes for students in both elementary and secondary schools (NASPE, 2016). Surprisingly, the recommended minutes in physical education had not changed from the 1993 report, 150 and 225 minutes per week respectively. Part of the problem is funding. NASPE reports that the median annual budget for United States schools is $764.00 (2016). Though this is a national average, it is hardly a significant sum of money to reasonably support annual equipment needs. Many teachers and administrators know there are several good reasons for students to meet the recommended 60+ minutes of physical activity per day. However, time and resources often limit their ability to help them meet that goal.

Problem

Schools are restricted by time and money while trying to balance requirements of adequate yearly progress (AYP) and the needs of students. Politicians, school boards, and administrators do not always recognize that maximizing opportunities for physical activity may likely improve test scores. The existing research is clear enough to substantiate an argument for keeping physical education programs alive. Physical education programs are not the only means by which students have the opportunity to engage in physical activity, but are a foundation and can be a requirement. The implementation of extracurricular fitness programs and core classroom activity breaks is often well intended. However, those programs lack the consistent focus and purpose of the physical education curriculum. Even if all schools in the United States reached the recommended 150-225 minutes of physical education time per week and were active the entire time, students would only be achieving 30-45 minutes of the recommended 60 active minutes per day. This leaves a remaining burden on core classroom teachers and extracurricular programs to help children reach their daily recommendation. As ideal as it would be, there simply is not enough time at school for students to fulfill the 60-minute recommendation. However, school officials can still try to maximize the time to the greatest extent possible. Although a large body of research in the last 20 years yields a positive association between physical activity and academic performance, the restrictive nature of a school day limits physical activity applications. Determining the best use of time and resources could be accomplished by understanding how much physical activity provides an academic benefit.

Purpose

Academic achievement is something that administrators and teachers want for every student. That is often one of the things that draws them to the profession and supports one of the aims of public education, to develop citizens who contribute to the success of this country. People have experienced improved cognition with a physically active lifestyle, but science has not always done a clear job of substantiating the improvement. The first purpose of this review is to answer the basic question: How does physical activity affect the academic performance of school-aged children?

In a society filled with so many things to do in a 24-hour day, efficiency becomes paramount. This is also true in a school setting where administrators and teachers must be diligent with their use of time. If improved academic performance is indeed derived from physical activity, it would be helpful to know the optimal amount of physical activity necessary to provide the academic benefit. The recommended 60 minutes per day for children is based on research that supports health objectives more than academic benefits. Certainly there must be a threshold of duration, activity type, and intensity that yields the most benefit. This leads to the second purpose of this review: What is the optimal amount of physical activity that would contribute to improved academic performance in school-aged children?

If administrators knew how much physical activity was necessary to stimulate the most academic benefit, they could more efficiently allocate time and resources. Considering that physical activity takes place in more than one environment at school, a process by which the time is measured would be helpful in reaching that goal. Furthermore, in determining how much physical activity relates to improved academic performance, a standard method of

measure needs to include not just duration but also the type of activity, its intensity, and the academic tools to substantiate a change. The final purpose of this review is to answer this question: What is the best way to measure the optimal amount of physical activity?

CHAPTER II: LITERATURE REVIEW

In searching for the literature to guide this thesis, ERIC, Academic Search Premiere, Educator's Reference Complete, Scopus, Physical Education Index, and Google Scholar were utilized to locate peer-reviewed published material primarily from 2000 to present. The focus on journals covering health, kinesiology, and exercise science narrowed the list of possible contributions to the guiding questions. The key word used in these searches was *physical activity* combined in different arrangements with *intensity, type, time, duration, academic performance, academic achievement, academic behavior, and cognition*. Since the focus of this review is on school-aged children, studies that involved only adults were omitted. This chapter is structured in a way that attempts to answer the three guiding questions: What is the relationship between physical activity and academic performance? What is the optimal amount of physical activity for improved academic performance? What is the best way to measure the optimal amount of physical activity?

Benefits of Engaging in Recommended Physical Activity

Societal trends often dictate the amount of physical activity that youth engage in. For many years there was no need for research-based recommendations on the physical activity of children. For instance, there was a time when most families grew their own food and incorporated the help of the entire family. There also used to be a time when children began working jobs at a much younger age than today. During times like these, children clocked many more physically active minutes than today's recommended minimum, and likely had an easier time doing so without the technological advances available now. The United States Department of Health and Human Services (USDHHS) established today's recommendation of 60 minutes of

moderate to vigorous physical activity per day in 2008, a change from the prior recommendation of 30-45 minutes, three to five days per week. A sharp decrease in children's physical activity, an increase in obesity, and an escalation in sedentary time sounded the warning bell and prompted change. Research cites a host of benefits to influence politicians, educators, parents, and childcare providers to support children in meeting this recommendation. Associated benefits can be categorized into physical development, psychosocial growth, and academic performance.

Children who engage in the recommended physical activity realize physical benefits important to health. The Physical Activity Guide (2008) issued by the USDHHS cites strong evidence for the following benefits as associated with regular physical activity in children and adolescents: improved cardiorespiratory and muscular fitness, increased bone health, improved cardiovascular and metabolic biomarkers, and more favorable body composition. Also noteworthy are the disease prevention aspects of regular physical activity. Although heart disease, hypertension, and diabetes are not as prevalent in youth, establishing regular physical activity as a staple in the lives of children and adolescents helps reduce risks later in life (NASPE, 2016). Additional positive outcomes that extend to the social and psychological realm also benefit children who are physically active.

Psychosocial health refers to psychological, emotional, and social aspects of one's well being. As these relate to children and adolescents, evidence for positive relationships have been observed in self-efficacy, self-concept, self-worth, attitudes about school, motivation, goal orientation, friendships, task orientation, and team building (Cook, Kohl, National Academies, National Academy of Sciences, & Institute of Medicine, 2013). Self-efficacy, in particular, is

crucial to continued engagement in physical activity as it is based on the confidence that one can be active in specific situations. This self-assurance provides a platform for social engagement at a stage in life that may be difficult for many children. A positive physical self-concept has also been found to have a favorable impact on mental health (Dishman et al., 2006). As reviewed in longitudinal studies, physical activity has reduced symptoms of depression and anxiety while improving overall mood (Cook et al., 2013).

The aforementioned benefits, focused clearly on health, have been used to influence school districts to increase physical activity opportunities. While these are valuable associations, they have not proven productive in creating widespread policy change. There is reason to believe that what motivates administrators to reduce physical education could support doing the opposite if they had the right information. Academic performance is another benefit of physical activity that has been researched heavily in the past 20 years. A meta-analysis by Fedewa and Ahn (2011) disclosed that physical activity has a significantly positive impact on children's cognitive outcomes and academic achievement.

Relationships Between Physical Activity and Academic Performance

Although our ancestors believed that a sound body led to a sound mind, today's politicians, school administrators, and board members require scientific-based research substantiating such claims to influence policy. Answering the question about the effect physical activity has on academic performance could prove extremely important in several respects. The literature on this topic generally categorizes findings as positive, negligible, or negative. A report published by the Center for Disease Control and Prevention (2010) reviewed 50 studies from 1985-2008 and found a negative correlation in 1.5%, a negligible correlation in 48%, and a

positive correlation in 50.5%. In an effort to reduce bias, research findings in all three areas are discussed.

An increase in the number of studies conducted on this topic has been propelled by the need for conclusive evidence. It is no coincidence that a higher proportion of positive associations have been discovered as the intensity and frequency of research have escalated. Furthermore, the types of studies conducted and the manner in which they were executed have improved their scientific credibility significantly.

As most people would surmise, healthier students learn better. There are a host of health issues that school-aged children face that affects their performance at school and physical activity is among them (Basch, 2010). Considering that the various health benefits of physical activity are well established, one may conclude that a physically active child is more likely to be a healthy child when compared to a child who is not physically active. This does not suggest that physical activity is the only aspect of human health, but research does suggest that it is a very important contributor.

Physical activity is delivered in a school setting by physical education, recess, the classroom, or extracurricular activities – including athletics or fitness programs. The studies and meta-analyses reviewed examined physical activity and fitness performed in one or all of the aforementioned avenues in school.

Settings Linking Physical Activity and Improved Academic Performance

Physical Education

Several studies focusing on the benefits of physical education were prompted by program cuts following the No Child Left Behind Act (NCLB). Pressure to maintain Adequate

Yearly Progress (AYP) via standardized tests generated tentativeness among administrators. Although an increase of childhood obesity begged reprogramming physical education, there was fear that doing so would cut into core subject time and reduce test scores. Conversely, studies show that reducing core classroom time to participate in physical education does not adversely affect academic performance (Coe et al., 2006; Sallis et al., 1999; Cook et al., 2013). A study involving over 300 fourth-graders in Massachusetts found that students who spent 56 hours per year in physical education performed significantly better on standardized tests in English and language arts than their peers who spent half the time (Tremarche, Robinson, & Graham, 2007). Additionally, reducing time in physical education does not guarantee improvement in academic achievement (Smith & Lounsbery, 2009). Nine studies examining physical activity performed in physical education found 49.5% of the associations with academic performance positive, with the remaining associations showing no relationship (Rasberry et al., 2011). In an intervention study, physical education was increased from two days per week to daily and resulted in improvements in reading, writing, and math test scores (Ericsson, 2008). In a review of a longitudinal Canadian study, Shepard and Trudeau (2005) revealed that students in grades one through six who received five hours per week of physical education performed better academically than their peers who only received 40 minutes per week. Fitness is a measure of physical activity and is often tested in physical education settings; two studies measuring fitness and its impact on academic achievement concluded that students with higher fitness scores performed better academically than their less fit peers (Coe, Peterson, Blair, Shutten, and Peddie, 2013; Chomitz et al., 2009). Findings of no relationship between physical education and academic performance can be important too. Results of no

association suggest that youth participating in physical education do not do any better *or* worse than those who do not participate (Coe, Pivarnik, Womack, Reeves, & Malina, 2006). Of 52 total performance outcomes considered in a meta-analysis on studies concerning physical education and academic performance, only one negative association was discovered. Recess is another steadfast avenue of school-based physical activity. Although recess is less structured than physical education, its value to academic performance is discussed in the next section.

Recess

Recess has been a part of the primary level school day for as long as can be remembered; its value has been debated for almost as long. Though no records indicate the beginning of recess, photographs from the late 19th century indicate children playing outside of schoolhouses. Most people would agree that children, just as adults, need a mental break from prolonged concentration in a structured environment. Recess provides an outlet in which children can interact on their own terms and often return to the classroom ready to focus again. Before eliminating or reducing recess, administrators may want to consider its impact on academic performance. In a meta-analysis, six of eight studies involving the effect of recess on academics yielded a positive association with improved cognitive skills, attitudes, and academic behaviors (Rasberry et al., 2011). Young children receive cognitive benefits (attention and memory) by drastically changing activities that require focus to one that does not, such as recess (Pellegrini, 2008). When young children engage in physically strenuous play, they receive brain health benefits from both physical activity and play. Cognitive developments of the physical, social, and intellectual realm take place when this occurs and results in improved cognitive readiness in the classroom (Sattelmair & Ratey, 2009). However, physically strenuous

play does not take place in every school recess environment. Some schools enlist the help of a teacher to coach or guide children in more physically active games and activities. One such program called Playworks uses this framework and has found positive results. In an intervention study, students subjected to the program at recess were reported as having better classroom behavior and attention (James-Burdumy et al., 2013). Pellegrini and Bohn (2005) contend that recess should be playful rather than structured and nets positive cognitive benefits that transfer to the classroom. A review of eight studies about the effect of recess on academic performance found that 59% of the outcomes were positively associated, 41% not associated, and 0% negatively associated (Rasberry et al., 2011). The classroom is yet another environment where students can experience academic benefits from physical activity.

Classroom

Classroom teachers implement physical activity into their lessons for a variety of reasons. Regardless of why activity is integrated, it has been an effective means to help children get closer to reaching their daily-recommended minutes of physical activity. Movement is employed in the classroom in one of two ways - with a temporary break in the subject lesson (activity break) or integrated within the lesson for the duration of the class or activity (content activity). Both methods have merit and can yield academic benefits. For example, an intervention study that included second- and third- graders from six elementary schools showed that students who participated in a lesson combined with moderate-to-vigorous physical activity (content activity) exhibited a higher incidence of on-task behaviors and improved baseline mathematics test scores (Mullender-Wijnsma et al., 2015). A 2012 study (Erwin, Fedewa, & Ahn, 2012) observed the effects of individual bouts of physical activity in a

third grade classroom and found significantly improved scores on mathematics and reading assessments when compared to pre-intervention scores and the control group. In an analysis of nine studies involving classroom-based physical activity, positive associations were made with improved achievement test scores (math, reading, and language arts), classroom behavior, concentration, and spatial skills (CDC, 2010). Though physical education, recess, and classrooms are the typical outlets for physical activity during normal school hours, extracurricular activities (e.g. athletics and fitness classes) are another great resource for students to engage in quality physical activity in a school-based environment.

Extracurricular Activities

Competitiveness, socialization, and curiosity are a handful of factors that drive students to take advantage of physical activity opportunities before or after school. These types of physical activities can take the form of intra- and extramural athletics or an organized fitness development course. Students who participate in these types of activities are likely to reach their daily-recommended physical activity minutes and also enjoy academic benefits as a result. A review of 19 studies involving the effect of interscholastic sports on academics revealed that over half of the associations measured were positive. Students who participated in sports were reported as having improved overall grades in mathematics, higher standardized test scores in mathematics, and grade point averages higher 12 of the 22 times it was measured (Rasberry et al., 2011). Though positive associations are generally found in all extracurricular sports, Broh (2002) found that a greater academic benefit was realized in interscholastic sports when compared with intramurals and cheerleading. Some researchers hypothesize that that factors due to social networks, such as information and opportunities, not physical activity, are the real

link between extracurricular activities and improved academic performance (Busch et al., 2014). Extracurricular physical activities are generally offered in secondary school settings, although interventions on the primary level have yielded positive associations. One such study involved implementation of a 40-minute exercise program before school at five elementary schools in Massachusetts for three years. The results indicated significant improvements in executive cognitive functioning - specifically with working memory and shift (Hall, Poston, & Harris, 2015). A meta-analysis of 17 studies involving the relationship between extracurricular activities and academic performance identified 135 academic performance outcomes, of which 46% were found to have no association (primarily with academic behaviors) and only 2% negative association (CDC, 2010).

In addition to examining the four avenues that schools use to deliver physical activity opportunities, the tools used to measure academic performance must be evaluated to fully understand the influence of physical activity. Academic performance is a broad term that is affected by three clearly definable areas: academic achievement, academic behavior, and cognitive skills/attitudes.

A strong point of more recent studies is the use of verifiable means to measure performance versus less reliable methods. Standardized test scores, grade point averages, and cognitive function assessments lend more credence to academic performance than the subjective nature of questionnaires, observations, and self-reported grade data. While the latter still has a place in current research, it now exists in a lower percentage and is likely less influential than hard data to administrators.

Aspects of Academic Performance Influenced by Physical Activity

Academic Achievement

Standardized tests represent a divisive matter among educators, administrators, politicians, and parents. The Every Student Succeeds Act reduced the amount of required standardized testing in 2015, however it still exists to achieve accountability. Regardless of one's position, their value in examining the academic performance of a student, or students, over time cannot be overstated. In this regard, standardized tests represent an excellent tool for recording progress on studies relating physical activity to academic performance.

A 2009 cross-sectional study in Cambridge, Massachusetts used Massachusetts Comprehensive Assessment System (MCAS) data from 2004-5 against a five-part fitness test for students in fourth, sixth, seventh, and eighth grade to determine a relationship between fitness and academic performance. Fitness was measured in five domains and compared to the MCAS data by the number of fitness domains passed. When comparing one versus five fitness domains passed, the percentage of mathematics tests passed improved from 51 to 80 percent (Chomitz et al., 2009). While the English test improvements were not as impressive, there was still a five percent increase for the same comparison. In this particular study, standardized test data represents a reliable means to relate physical activity with academic achievement in the past or present.

Academic achievement and physical fitness were linked with another study using standardized tests in 2012. The study included over 1,700 third, sixth, and ninth grade students across 20 districts from the Midwestern United States. Measurements in fitness were done using a five-part fitness assessment (FITNESSGRAM) and academic achievement by using

standardized tests in mathematics, English, and social studies. When compared with students who passed two or fewer components, students in sixth and ninth grade who passed all five components performed significantly higher on standardized tests. As seen in Figure 1, A-C, sharp increases in mathematics and social studies were found with sixth and ninth grade students who passed all five fitness components (Coe et al., 2013).

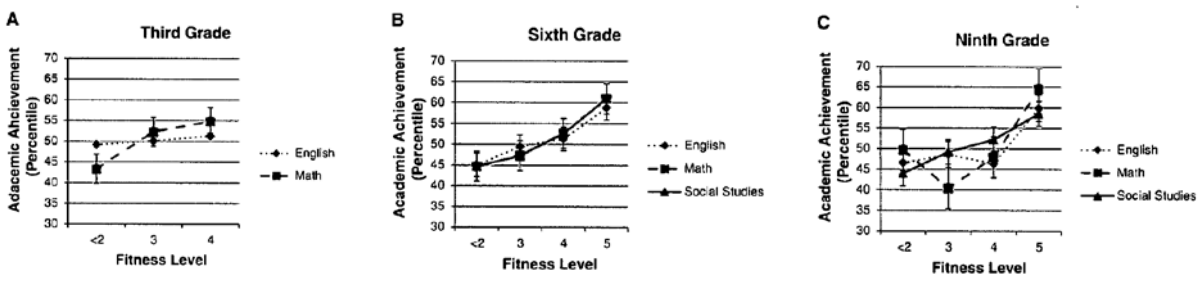

Figure 1. Associations Between Fitness Levels and Academic Achievement in Third-, Sixth-, and Ninth-Grade Students. Adapted from "Physical Fitness, Academic Achievement, and Socioeconomic Status in School-Aged Youth," by Coe, et al., 2013, *Journal of School Health*, *83*(7), 500-507.

In these examples, standardized tests have been utilized as an excellent, unbiased tool used to show the relationship between academic achievement and physical activity. Another useful metric that illustrates this relationship is student grades, or grade point average.

Several studies also use grade point average or grades as a means to demonstrate academic achievement as associated with physical activity. An argument against grades that is used to show achievement is that teacher bias could prevent a standard assessment of performance and may consider academic behaviors versus achievement. While this may be true, cross-sectional and longitudinal studies with large numbers of students and thus, teachers, reduce bias by sheer volume. Furthermore, grade point average across a single

student's class load incorporating grades from several different teachers, is an indicator of academic success, and is used as a standard for college entrance.

A review of 19 studies dealing with the relationship between interscholastic sports, extracurricular activities and academic performance found a positive association with grade point average and grades, particularly in math (Rasberry et al., 2011). Eighty 4th grade students from the Southwestern United States participated in a study in which their fitness was assessed via FITNESSGRAM in the middle of an academic quarter and compared with their teacher-assigned grades at the end of the quarter. Lorenz et al. (2017) found that the cardiovascular component of the fitness test positively affected grades in reading, writing, mathematics, and science by 7, 15, 9, and 11 percent respectively. Another meta-analysis on sports participation found an overall positive association with improved grades and grade point averages (Busch et al., 2014).

Academic achievement can be measured by other means, such as classroom assessments and observations, but neither is as prevalent or concrete as standardized tests and grades. Another form of academic performance that is positively affected by physical activity is academic behavior.

Academic Behavior

Academic behaviors represent a foundational aspect of academic performance. The types of academic characteristics that can set a child up for success in the classroom include being on-task, planning, and controlling impulses to name a few. While these types of behaviors are difficult to measure tangibly, they can be important contributors to the success of a

student. A host of studies cite academic behavior as a key improvement area with regard to the relationship between academic performance and physical activity.

Physical activity done in single bouts and in breaks from focused learning time can result in improved attention and reduced off-task behaviors, both important influences on academic performance (Cook et al., 2013; Pellegrini, 2008). Extracurricular physical activities have been noted as a means to build social skills in secondary school while also positively influencing academic performance. The Center for Disease Control and Prevention (CDC, 2010) reviewed six studies relating specifically to extracurricular physical activity and academic behaviors and found a positive association with student attendance, an important behavior that is a foundation of academic performance. Physical activities such as recess and classroom-based movement have shown the most impact on academic behaviors, though that may only be representative of the number of studies that included academic behaviors. Behavior can only be measured by observation or self-reporting, both of which are subjective. However, the influence these behaviors have on academic performance is clear and should not be discounted, especially as it relates to a positive outcome of physical activity. Students that are on-task, plan, organize, attend class, and control impulses are more apt to achieve better in the classroom. The final area of academic performance that is positively related to physical activity is student cognition.

Cognitive Skills and Attitudes

The aspect of academic performance related to physical activity that has garnered more research attention in recent years is cognitive skills and attitudes. Cognitive skills and attitudes include executive function, attention, memory, motivation, satisfaction, and self-concept. Self-

concept is the awareness of oneself and belief in one's ability to accomplish something based on some experience. In regard to academics, a positive self-concept is a powerful mindset that may influence academic performance. A nationwide study involving over 10,000 fifth grade students found that participation in physical education at least two days per week netted a positive association with academic self-concept (Simms, Bock, & Hackett, 2014). Executive function is responsible for planning, paying attention, initiating tasks, staying focused, regulating emotions, and monitoring oneself. It is a facet of cognition that researchers believe to be most impacted by physical activity (Tomporwski, Davis, Miller, & Naglieri, 2008). A cluster-randomized controlled trial of over 1,200 fifth graders in Norway found that aerobic fitness was positively associated with all measures of executive functions (inhibition, working memory, and cognitive flexibility) in a bivariate analysis (Aadlund et al., 2017). In a meta-analysis of 44 studies, Sibley and Etnier (2003) found an effect size of 0.32 (significant) positively relating physical activity to improved cognition in children. An analysis of brain structure and function revealed that physical activity interventions improve white and gray brain matter volume while increasing overall cognition, especially executive functions (Erickson, Hillman, & Kramer, 2015). Contrary to popular belief, children with learning difficulties or cognitive impairments benefit even more from physical activity than typically developing children (Fedewa & Ahn, 2011).

The relationship between physical activity and academic performance is still debated, but scientific information available points to over half of the associations as positive (CDC, 2010). At the very least, findings of no relationship indicate that continuing or implementing physical activity programming does not hinder academic performance. Examples of physical activity delivered in physical education, recess, classrooms, and extracurricular activities have

demonstrated a relationship to improved academic performance. Furthermore, positive relationships were made in academic achievement, academic behaviors, and cognition in an effort to strengthen the credibility of this review. Considering that administrators and parents may choose to use this information for programming or encouraging physical activity, it is also important to know how much activity is necessary to realize improvements in academic performance.

Research Recommendations and Identifying the Optimal Amount of Physical Activity for Improved Academic Performance

When parents and school administrators have fully accepted the notion that being physically active is a good thing for children, subsequent questions may be: How often should they be physically active? How vigorous, or intense should the activity be? What type of exercise should they be doing? How long should they be active? These are all excellent questions and reflect the level of care and interest that would be a national ideal. Unfortunately, various factors may sometimes inhibit action for support and guidance in this regard. If students engaged in physical activity in a manner based on answers to the above questions and academic performance were improved as a result, perhaps more parents and administrators would be inclined to find ways to implement and support it.

Most people have some level of awareness about the recommended amount of physical activity for children and adolescents. Increases in childhood obesity and sedentary behavior have prompted national campaigns and increased media publicity to raise awareness among the U.S. population. National recommendations for children and adolescents (ages 6-17) start with the USDHHS and are endorsed by other national organizations like the CDC and American

Heart Association. The guidelines, last published in 2008, prescribe 60 minutes or more of activity every day. There are three major areas within the recommendation that further define physical activity: aerobic exercise, muscle strengthening, and bone strengthening. Without giving a specific number or percentage, USDHHS (2008) recommends that *most* of the 60 minutes be spent doing moderate to vigorous aerobic activity. The other key recommendation classifications are at least three days per week of vigorous aerobic activity, muscle strengthening activity, and bone strengthening activity. The guidelines stem from research that shows a positive dose-response relationship between 500-1000 METs, or metabolic equivalents – a unit of measure that describes energy expenditure during physical activity (USDHHS, 2008). Other organizations with national influence have created spinoff programs to help promote physical activity through their own platform. One such example is the Play60 program sponsored by the National Football League. It encourages 60 minutes of activity every day and is used in school programs, communities, and contests. Although many people may have heard that 60 minutes per day is the recommended amount of activity for children and adolescents, it is doubtful that those same people know the recommended intensity or types of activity appropriate for their child.

The central rationale for the USDHHS recommendation is based on health benefits. Academic benefits are discussed as a corollary but not as the basis of the research in determining the amount of activity to be recommended. The collective research reviewed in this document suggests that the community of professionals evaluating this topic have not come to a shared conclusion on how much physical activity is needed to promote improved academic performance. However, thoroughly evaluating the research available using a step-by-

step approach through each component of the FITT (frequency, intensity, type, and time) model will aid in determining the optimal amount of physical activity to experience academic benefit. Although the focus of this review is determining the *amount* of physical activity, it would not be practical to discuss physical activity prescriptions without also including frequency, intensity, and type.

Frequency

As related to this topic, frequency is the incidence in which physical activity is performed. The USDHHS recommends that children and adolescents engage in physical activity daily. This recommendation entails some activity for 60 minutes every day but does not propose doing the same thing every day. For instance, the suggested frequency of vigorous aerobics, muscle, and bone strengthening activities is at least three days per week. Of course, more health benefits can be realized with increased frequency. The basic daily activity recommendation is what most people are familiar with and is the threshold to benefits of any type. This recommendation can serve as a starting place to determine how often children should engage in physical activity to reap academic benefits as well.

NASPE, one of the largest organizations of SHAPE America, supports the recommendations of the USDHHS and sets recommendations for physical education frequency through its Shape of the Nation report every four years. Although states set their own specific physical education requirements, NASPE (2016) recommends 30 minutes, five days per week for elementary school and 45 minutes, five days per week for secondary school. As of the 2016 report, only five states and the District of Columbia had time, and thus frequency requirements for elementary school (NASPE). Secondary schools did even less to mandate physical activity

frequency through physical education. Only two states plus the District of Columbia had specific time requirements but not equivalent with the recommendations (NASPE, 2016). Physical education is an avenue for delivering physical activity that administrators can control and should be maximized, in terms of frequency, to increase activity minutes for children and thereby improve academic performance. Increases of physical education frequency from two to five days per week has resulted in improved attention and higher test scores in reading, writing, and math (Ericsson, 2008).

Considering the well-established brain health benefits gained from engaging in daily physical activity (Erickson et al., 2015), it would stand to reason that a daily frequency would be recommended to make improvements in academic performance as well. Given that these recommendations are based on health outcomes, it has been found that healthier students are indeed better learners (Basch, 2010). A dose-response relationship has also been established that shows improved cognitive performance as a function of increased physical activity engagement (Donnelly et al., 2016). A study of Korean adolescents who participated in physical activity at various frequencies found that those who engaged two, three, or four times per week had significantly greater odds (ratios between 1.2 and 1.4) of achieving above average academic performance than those who did not participate at all (Wi-Young So, 2012). It is clear that more studies need to focus on frequency as a function of dose in physical activity and its impact on academic performance. The research that is available in this area either suggests no relationship (Daley & Ryan, 2000) or that participating in physical activity at greater frequencies improves academic performance. Another point of view to consider in prescribing frequency is to look at the positive associations between physical activity and academic performance, in

general. Exercising daily, as recommended by USDHHS, would seem to maximize the positive academic benefits previously stated. Another important aspect of physical activity that influences its effect on academic performance is energy expenditure, or intensity.

Intensity

Intensity is the facet of physical activity that represents how much work the body does to accomplish a given activity or exercise. It is expressed scientifically as a metabolic equivalent, or MET, and is the ratio of the working metabolic rate to the resting metabolic rate. Referring back to the USDHHS recommendations, physical activity intensity suggestions for children and adolescents are based on intensity relative to their fitness levels. Conversion approximations are given for absolute intensities in the physical activity guide (USDHHS, 2008), but it is more practical for young people to interpret their own intensity by monitoring their heart rate and breathing. For reference, one MET is the standard for rest, one to three METs is light intensity, three to six METs is moderate intensity, and six METs or greater is considered vigorous or high intensity. USDHHS (2008) recommends that children and adolescents engage in aerobic activity that is moderate most of 60 minutes daily and vigorous aerobic activity three days per week. Health-based recommendations for activity intensity do not necessarily translate seamlessly into academic benefits, however.

In evaluating the literature that relates specific intensity of physical activity to academic performance, few studies expressly compared different levels of effort. This is an area that obviously needs more research with robust experimental study design. The research that does consider intensity suggests that the most academic benefit is gained from vigorous physical activity (Cook et al., 2013, Coe et al., 2006). Physical education is a school setting in which

physical activity has been called into question most, particularly because it is often cut in favor of more time in academics. Opponents often argue that time is not used well and the amount of active time is not meaningful (i.e. few minutes of moderate to vigorous intensity). Regardless, physical education likely represents the best platform for in-school physical activity in which intensity is controlled, monitored, and sustained. A study in Michigan evaluated intensity levels of sixth graders in physical education and compared their activity to academic achievement over the course of a school year. Students showed the most significant improvements in academic achievement (GPA) when engaged in vigorous physical activity in physical education and at least three days per week of vigorous activity outside of school (Coe et al., 2006). While this study did not observe differences of effect by gender, others have found disparities in this regard. One study found a positive correlation between academic performance and vigorous physical activity in boys and moderate physical activity in both boys and girls (So, 2012), while another only found positive relationships between vigorous physical activity and academic performance in girls (Kwak et al., 2009). Some research has found positive correlations with light intensity physical activity and academic performance too, particularly in lower performing students (Zhang et al., 2015). Cognitive skills are also positively affected by vigorous activity, especially executive function, attention, and general academic behaviors (Aadland et al., 2017; Rasberry et al., 2011). An intervention study of Canadian children 9-11 years old found that four-minute bouts of in-classroom vigorous physical activity significantly reduced off-task behaviors and increased selective attention, both important to academic performance (Ma, Mare, & Gurd, 2015). Brain derived neurotrophic factor (BDNF) and the hormones cortisol (C) and testosterone (T) have long been theorized to affect neuron

development and cognitive performance. A study of 60 ninth graders found that 12-minute stints of vigorous intensity exercise elevated C and T levels linearly and related increased cognitive functions of the students, especially in low performers (Budde et al., 2010). Another intervention study evaluating 40 middle school students participating in stretching, low intensity, moderate intensity, or high intensity activities found that those in the high intensity group significantly improved levels of BDNF and working memory as compared with the other intensities (Jeon & Ha, 2017).

The reviewed articles suggest that engaging in physical activity of any intensity can elicit some academic benefit. However, more consistent support exists in favor of vigorous intensity relating to an optimal change in academic performance, especially cognitive functioning. Certainly, it appears that intensity matters when considering the effect of physical activity on academic performance. More focused research is necessary to draw concrete conclusions about intensity and academic performance. Nevertheless, prescribing intensity aligned with the USDHHS recommendations is a good start for children and adolescents. Based on this review, increasing the vigorous intensity from three to five or more days per week would seem to further maximize benefits realized in the academic performance realm. Another component of physical activity that should be considered is the type of activity performed.

Type

There are numerous ways that students can engage in physical activity in or out of school. Each type of activity has its own benefits and limitations based on the goal of the activity. For example, playing a game of soccer in an after school athletics program would be an excellent activity for cardiovascular health and would include a lot of moderate to vigorous

activity. Conversely, in-classroom activity breaks or lessons would not include the same volume or intensity of aerobic work based on the space limitations. Considering what type of physical activity best supports improved academic performance may be helpful for administrators, teachers, and parents in planning and providing opportunities.

The types of physical activity recommended by the USDHHS are aligned with goals for intensity levels. For instance, skateboarding, bicycling, or brisk walking is recommended for moderate intensity activities and running, martial arts, or sports, such as basketball and soccer, for vigorous intensity activities (USDHHS, 2008). However, since improved academic performance is not the foundation of these recommendations, a review of available research in this area may provide further information to consider.

A meta-analysis that reviewed studies in physical education, recess, classroom, and extracurricular activities found the most positive correlations to academic performance in physical education and extracurricular activities (Rasberry et al., 2011). While these platforms also had the greater number of studies, the percentages still showed greater association in those areas. One possibility for the higher correlation is a greater percentage of activities in physical education and sports that include coordinated movements. Coordinated exercise has been positively related to improved concentration, attention, and other cognitive skills (Budde, Voelcker-Rehage, PietraByk-Kendziorra, Ribeiro, & Tidow, 2008). Another possible explanation is the opportunity for more moderate to vigorous activity in physical education and extracurricular activities. Physical fitness is a common measurement in research used to illustrate a connection between physical activity and academic performance. Aerobic fitness, in particular, is a facet of physical fitness that has recently shown a consistent positive correlation

with academic performance (Castelli et al., 2007; Van Dusen, Kelder, Kohl, Ranjit, & Perry, 2011; Coe et al., 2013; Aadland et al., 2017). Other aspects of physical fitness, such as flexibility and strength, have also shown positive associations to academic performance, but not with the same frequency as aerobic fitness.

Physical activity selection is primarily based on goals for intensity and duration. When considering what types of activities to prescribe to children and adolescents, the USDHHS Physical Activity Guide (2008) is helpful in relating activity ideas to intensity goals. Providing that research so strongly favors aerobic fitness as it relates to academic performance, selecting activities with moderate to vigorous intensity demands would likely better serve students. Furthermore, increasing the USDHHS vigorous activity recommendations from three days per week to five may likely improve those benefits. Another type of activity that correlates well to cognitive skills, especially executive function, is any coordinated movement that works on motor skills (Aadland et al., 2017). While it may be difficult to achieve vigorous intensity in all school platforms, motor skill activities can be done anywhere. The final consideration in determining the optimal amount of physical activity for academic benefit is the duration of the activity.

Time

The duration of physical activity refers to some unit of time that it is performed. In a school environment, activity time is typically limited by the scheduling of a class period or transportation demands. Teachers and coaches often plan activities to meet the intended goals in an allotted period of time. How might physical activity planning be affected if parents, teachers, coaches, and administrators were aware of a duration threshold that provided

improved academic performance? That is difficult to predict, however people generally make better decisions when more information is available. As with the other components of physical activity planning, a look at the health-based daily-recommended activity duration provides a platform for exploring this topic. The 2008 Physical Activity Guide (USDHSS) recommends that children and adolescents are physically active for one hour or more every day. It is important to note that *most* of the 60 minutes should be spent in activity that requires moderate to vigorous intensity. Furthermore, encouragement for additional time beyond the 60 minutes daily is based on research showing even greater health benefits (USDHHS, 2008). Additionally, NASPE recommends 150 minutes per week of physical education for primary school and 225 minutes per week for secondary students. Considering that only 21.6% of 6 – 19 year olds are physically active for at least 60 minutes, five days per week, the above health driven recommendations for activity duration are a good initial goal (CDC, 2015). Again, these recommendations are made on research showing benefit to health with improved academic performance as a footnote. While no conclusive data has been discovered that provides a concrete benefit threshold for academic performance, reviewing the collective work on this topic does suggest a trend in terms of physical activity duration and the associated academic benefits.

In determining the optimal amount of physical activity to promote academic benefit, a review of the research with positive associations and various activity durations helps form some interpretations. The existing body of research in this area that included duration as a factor are few, and those that have are in a narrow application with specific hypotheses. One such example is a study that evaluated the impact of in-class, short-duration exercise on executive function. Sixth-graders who engaged in one-minute bouts of jumping jacks in class performed

12% better in executive function as compared to a group who did participate (Duoos, Wittry, & Weiers, 2016). In another examination of dose-response outcomes, 9-12 year-old students gained significant improvements in math performance, on-task behavior, alertness, and general positive interest after 5- and 10- minute classroom exercise breaks (Howie et al., 2014). These examples represent the low end of duration typically delivered in a classroom, yet still yield positive academic benefits in the realm of cognitive skills. Working memory and shift are other cognitive skills that have improved significantly in before-school elementary programs that average 20 minutes of moderate to vigorous physical activity (Hall et al., 2015). Even in unstructured environments like recess, at least 15 minutes of play netted improved classroom behavior among 10,000 third grade students (Barros, Silver, & Stein, 2009). When 106 second grade students engaged in activity periods of 0, 20, 30, 40, and 50 minutes in their regularly scheduled physical education class, they performed significantly higher on a math test after the 50-minute bout of physical activity (Gabbard & Barton, 1979). In a comparison of two schools that provided 28 and 56 hours of physical education throughout a school year, results revealed a higher mean score on a mathematics standardized test and a significantly higher mean score on the English and Language Arts (ELA) standardized test for the fourth graders with double the time in physical education (Tremarche, Robinson, & Graham, 2007).

A review of the available research reiterates the identified need for deeper research in this area. There have been instances of improved academic performance with both short and longer bouts of physical activity. To determine a prescription for time, an evaluation of the platform and goals yields additional support or limitations. For example, a teacher wanting to improve attention during a social studies lecture may want to consider a five-minute physical

activity break. An after school interscholastic sports program is limited by the activity bus departure and has activity goals of conditioning and skills practice. Physical education time is limited by class duration and must also consider education, warm-ups, and stretching in addition to the body of the lesson. How academically beneficial the time in each platform is for students depends in part on the other aspects of physical activity planning – frequency, intensity, and type. The strongest point of the reviewed data with regard to time is that the inclusion of physical activity in the classroom can improve executive function. When teachers incorporate movement – either woven into the lesson or as breaks from the material – students can perform better and at the same time increase their active minutes for the day. If a higher percentage of students met the USDHHS recommended 60 minutes of physical activity daily, perhaps more of these children and adolescents would enjoy the associated academic benefits. Health is the basis of the recommendations discussed here and it has been established that healthier students are indeed better learners (Basch, 2010). Physical activity is just one influence on health and since it is something that can be controlled, it should be maximized in the school setting. A good place for states to contribute is by requiring that all of their schools schedule the recommended weekly minutes for physical education. Only 12% and 6% of U.S. schools require the recommended weekly minutes of physical education in primary and secondary school respectively (NASPE, 2016).

When evaluating all aspects of physical activity planning, it is difficult to identify a single activity that is optimal for academic benefit based on the literature. Regarding amounts of activity, the culmination of this review section suggests that physical activities which include coordinated movements, are aerobic, require vigorous intensity, have durations of

approximately 20 – 60 minutes, and are performed daily may provide improvements to academic performance. It is also noteworthy that short bouts of physical activity performed in classrooms provide benefit in the realm of executive function. As with all disciplines of science, measurement is a key tool for documentation and validation. If schools embrace the calculated implementation of physical activity for the purpose of improving academic performance, a means of measuring the amount and quality of the activity would be beneficial to substantiate their investment.

Measurement of Physical Activity and its Impact on Academic Performance

Physical activity is a complex and dynamic endeavor that can be performed and measured in a great variety of ways. This review has covered four major avenues in which physical activity is delivered in a school setting, all of which may offer different types of activities. Within each activity, there are measurement considerations of frequency, intensity, type, and time. Furthermore, one must consider how best to relate the successful implementation of said activity based on academic performance metrics.

Outside of scientific studies, many schools already utilize some measurement of physical activity. For instance, several of the cross-sectional studies in this review used physical education fitness test scores as a source of information to compare with student academic performance. Though physical education fitness tests can vary in their construct, several schools across the nation have this measurement tool in place already. However, physical activity can also take place before school, during recess, in the classroom, and after school. Measuring the activity in those domains with the same tool as the fitness test in physical education would not be practical. Therefore, a single measurement tool that could be used

across all platforms would be the most efficient and financially responsible. A review of the measurement tools utilized in the literature helps determine a possible best practice when trying to answer the question: How is the optimal amount of physical activity that provides academic benefit best measured? Specifically, an evaluation of all physical activity platforms in school follows with the goal of revealing an answer to this question.

Physical education

Physical education likely represents the largest portion of available time for physical activity in secondary school. It can be significant in primary settings as well but some states have more time allotted for recess than physical education. The mission of this program is to develop the motor skills and fitness of students through instruction and repetition with the hope of instilling lifelong activity habits. Part of the learning process includes understanding the components of physical fitness. To this end, physical fitness tests are commonplace in physical education across the country and some of the information from such tests has been used in cross-sectional studies. FITNESSGRAM, for example, is a popular fitness measurement program designed by The Cooper Institute. It includes measurement of aerobic capacity, body composition, muscular strength, muscular endurance, and flexibility and yields an overall rating of “Healthy Fitness Zone,” “Needs Improvement,” and “Needs Improvement – Health Risk.” Considering that physical fitness has been associated with improved academic performance (Chomitz et al., 2009: Roberts et al., 2010), measurements like FITNESSGRAM may be a good option. Students who have met or exceeded the Healthy Fitness Zone rating in FITNESSGRAM have performed better than peers with lower ratings on state tests in reading, language, math, science, and social studies (Roberts et al., 2010; Wittberg et al., 2009). Based on literature

reviewed in the previous section, aerobic exercise was an area that showed a high correlation with academic achievement. The measurement of aerobic capacity in FITNESSGRAM is accomplished through the Progressive Aerobic Cardiovascular Endurance Run (PACER), a type of shuttle run that spans 20 meters and requires increasing effort over time. One study that used the PACER to measure the aerobic capacity portion of the test found that it yielded the highest impact on math, English, and social studies standardized tests as compared with the other FITNESSGRAM components (Coe et al., 2013).

FITNESSGRAM appears to be a comprehensive analysis tool for measuring fitness levels in physical education, however it does not account for coordinated movements, activity during recess, or short classroom activity breaks. Another analysis tool that is used in some research is an observation method called SOFIT, or System for Observing Fitness Instruction Time. It was often employed in studies focusing on the efficacy of physical education programs (Coe et al., 2006). Observation of physical activity could conceivably be used in all physical activity platforms at school.

Recess

Students in primary education need a break from school activities that require prolonged attention in a sedentary position (Pellegrini, 2008). Recess, whether structured or not, provides an opportunity for children to take a mental break and move their bodies. The literature reviewed only measured recess activity in terms of length of time. Although recess exists in 90% of the school districts surveyed, the length of time varies considerably (Pellegrini, 2008). One can assume that students are physically active to some degree for a large percentage of their recess time. Obviously, that does not account for intensity or activity type.

Trained observers represented the measurement of physical activity in the reviewed literature. Though intensive in work and time, teacher or paraprofessional observation could be a method to provide more information on the activity level of students during this time. Self-reporting is not considered extremely reliable, but it does represent another way that activity during recess could be measured. The only way to truly capture the intensity and duration of each child during this time would be to have them wear some type of fitness tracker or accelerometer. Because unstructured recess entails a large variety of activity types, this information would best be self-reported. For children and adolescents in secondary schools who do not get a recess break, physical activity in the classroom is a viable option.

Classroom

Physical activity within the classroom environment typically occurs in one of two ways – linked directly as part of the content lesson (content activity) or as a break from the material (activity break). The reviewed literature measured the physical activity in the classroom via a few different methods – observation (SOFIT), indirect calorimetry, heart rate, and pedometer. The following examples all showed a positive association to academic performance and the most common method was observation. An intervention study focused on physical activity woven into the lesson measured student movement and heart rate by teacher observation and student self-reporting (Mullender-Wijnsma et al., 2015). Another reviewed intervention used the SOFIT observation method and indirect calorimetry to measure activity levels and verify intensity in a class where lessons were delivered using moderate to vigorous physical activity (Donnelly et al., 2017). The classroom teachers were the trained observers in both cases. Utilization of a pedometer was used in conjunction with teacher observation in a study that

evaluated the effect of 20-minute activity breaks in a classroom (Erwin, Fedewa, & Ahn, 2012). The time and type of activity in a classroom environment is easily measured with the clock and teacher observation. However, considering that intensity is such an important aspect of optimal physical activity for academic performance, manual heart rate measurement or an accelerometer could effectively measure effort levels. The final area where physical activity is performed in school concerns before or after school extracurricular activities.

Extracurricular Activities

Fitness instruction and interscholastic sports represent examples of extracurricular activities that take place in a school setting. Measuring the physical activity of students in such programs may be difficult given the variety that exists. A majority of the literature reviewed in this domain simply compared academic performance of those participating in extracurricular activities to those who did not (Rasberry et al., 2011). Since the frequency, intensity, type, and time of an extracurricular activity is typically known, a coach or trained observer could easily set a standard for those factors in each activity. One of the reviewed studies evaluated the relationship between a before school program and the academic performance of those that participated. The measurement of the physical activity therein was an established program called BOKS, or Build Our Kids' Success, and had an average moderate to vigorous activity level for 20 minutes per session (Hall et al., 2015). Outside of observation, the only plausible measurement tools for extracurricular activities may be self-reporting or a personal fitness tracking device.

Measurement Summary

After examining the measurement techniques used in the studies reviewed, it is clear that measurement tools were chosen based on scientific value and their practical nature in relation to the activity being measured. Consequently, the highest recurring use of measures in each platform of physical activity was human observation. In each study examined, the person doing the observation required some sort of training. In the case of physical education, licensed teachers are likely qualified to observe aspects of optimal physical activity as they relate to their impact on academic performance. They know how to choose activities that involve coordinated movement and require moderate to vigorous aerobic activity. Physical education instructors also understand the physical traits exhibited by students that represent particular levels of effort. Outside of physical education, using observation to measure physical activity would require training and could be time intensive with regard to documentation. Most teachers would likely argue, regardless of the positive outcome, that extra time is something that is not available in the framework of a school day. Considering that, a review of another measurement option seems necessary.

Understanding the supports and limitations of schools provides a realistic foundation in determining the best method of measuring physical activity and its impact on academic performance. Between federal, state, and local sources, schools spend roughly $11,000 per child per year. Only a small percentage of that figure actually contributes to student support or technology, which would likely be the category of resources to purchase measurement equipment. When schools spend precious dollars on equipment or staffing for any reason, there is typically a need to validate that investment with some sort of data. In the realm of this

topic, that documentation would include some sort of software to track data obtained through measurement. This would further increase the cost of whatever measurement means were selected. Sometimes schools are able to successfully hold fundraisers or pass levies to increase access to technology. Grants are yet another avenue to finance measurement equipment at a pilot district to gather more data.

A measurement tool that was used in some of the studies reviewed is a motion tracker or accelerometer. An accelerometer is a device that senses changes in accelerative forces. Based on these sensations, the unit can calculate when a person is moving, how fast they are moving, how long it takes them, and based on some personal information, caloric expenditure. Some models incorporate heart rate sensors, but that feature increases the individual cost significantly and has not been more effective for analyzing energy expenditure than standard accelerometer units (Reiches, Ellison, Moore, Sharrock, & Prentice, 2009). Considering that such a device would capture active minutes and intensity, this seems like an attractive option for schools. In regard to cost, the low end in this market is around ten dollars per unit. A school of 1,500 students would incur an expense of approximately 15,000 dollars. That figure does not include the software needed to track the information and report it in a way that justifies the purchase while providing meaningful information for making decisions in the future. Aside from equipment and software costs, there would still be a requirement for time to synchronize or download the information to a central database or website. There is also the potential for the device to cause distraction during the school day. Despite these negative aspects, an accelerometer represents a viable option to accurately measure an individual student's optimal physical activity with frequency, intensity, type, and time.

CHAPTER III: DISCUSSION AND CONCLUSION

Summary

Research about the impact of physical activity on academic performance has been taking place for over 70 years. Much has been learned about this relationship over that span, particularly in the last 20 years. The methods in which studies have been conducted have improved significantly in recent years, especially in reducing quasi-experimental subject selection and the utilization of more longitudinal constructs. These changes have led to more consistent and increased effect sizes as they relate to the positive associations of physical activity and academic performance. These types of evolutions in research are necessary to provide a solid platform from which sound decisions can be made in the education community. Proliferation of technology has made our lives easier and as a result, activity levels have declined. As a competitive country striving to remain among the world leaders in education, we need to find balance in developing children wholly. Leaders in different sectors of society have suggested for years that academic success and physical activity are linked. The purpose of this review was to answer questions about this connection and provide information for potential policy change in schools.

How Does Physical Activity Affect Academic Performance?

The literature review revealed that numerous benefits result from engaging in regular physical activity. The well-established health benefits of physical activity were reviewed and are important for a generation of young people that are experiencing a concerning rate of obesity and other unhealthy conditions. The relationship between physical activity and academic performance was explored by reviewing the different settings activity is delivered in school and

by examining each aspect of academic performance that is affected. Physical education, recess, classrooms, and extracurricular activities are all settings in school that were reviewed and found to have positive associations between physical activity and academic performance. Most existing literature linked activity in physical education with academic performance, which is likely due to the availability of fitness test data that is already collected on a regular basis and can be used for cross-sectional studies. Though the available research was not abundant, physical activity at recess primarily showed improvements in academic behaviors and cognition. Classroom based physical activity is a newer trend to get students moving and the academic benefits in this area ranged from improved attention to higher test scores. The literature indicated that students who engage in extracurricular activities like sports and fitness classes may experience improved grade point averages, higher scores on math tests, and improved executive function.

In regard to academic performance, three areas were evaluated: academic achievement, academic behaviors, and cognitive skills and attitudes. Positive associations were found in all three aspects of academic performance as they relate to physical activity. Improved academic achievement was shown to be a result of having engaged in physical activity by comparing standardized test scores in much of the literature reviewed. An interesting note is the observation that of all content areas, mathematics standardized tests showed the most consistent positive association with physical activity. Other areas of academic achievement positively affected by physical activity were grade point average and subject specific formal assessments. Academic behavior is another area of academic performance that has been positively affected by physical activity, especially from short bouts in the classroom and recess.

The types of improvements discovered in academic behaviors are impulse control, attendance, staying on task, and social connections. The final facet of academic performance positively linked to physical activity is cognitive skills and attitudes. Academic benefits related to cognition were found in all evaluated platforms of physical activity in school and a focus of research in the past 10 to 15 years. Specific cognitive benefits realized as a result of participating in physical activity are improved executive function, better working memory, and positive academic self-concept.

The literature supports positive associations between physical activity and academic performance in over 50% of all data reviewed. The majority of cases where no positive relationship exists were categorized as having no association. Very few studies exist (less than 5%) that showed negative associations between physical activity and academic performance. Overall, the literature supports the belief that physical activity positively affects academic performance in school-aged children.

What is the Optimal Amount of Physical Activity That Promotes Improved Academic Performance?

Having established that physical activity contributes to improved academic performance in students, a quest to determine the optimal amount of activity to experience these benefits guided the next phase of research. An evaluation of the FITT model (frequency, intensity, type, and time) for physical activity planning was used to determine the optimal amount of activity. Positive and science-based connections relating a specific amount of physical activity in frequency, intensity, type, and time to improved academic performance were weak at best. The available literature that specifically studies the dose is rare and in the articles reviewed, none

provided concrete relationships. However, generalizations can be made by other studies that positively associate physical activity to academic performance in any of the facets of dosage reviewed. In each aspect of the FITT model, the United States Department of Health and Human Services (USDHHS) physical activity dose recommendations guided the discussion. Intensity and time dominate the relationships in the available literature and in some regard, drive the type of physical activity and how often it is performed. Based on the review of literature, the positive associations of each FITT component suggests that physical activities that are aerobic, have coordinated movements, are vigorous in intensity, are approximately 20 – 60 minutes in duration, and are performed daily provide the best opportunity for experiencing improvements in academic performance. Of important note are the abundant findings in positive associations with short bouts of physical activity. Classroom-based physical activity studies found academic benefits for activity time as little as one minute.

What is the Best Way to Measure the Optimal Amount of Physical Activity?

The data used to answer this question came from the methods section of relevant articles, since no research was discovered that directly studied the best means of measurement. Methods of measurement were chosen on scientific value and based on research monetary limitations to some degree. Despite this, trends were found among the reviewed literature that suggested human observation as a prevalent means of measuring physical activity as it affects academic performance. The benefit of this method is that there is trainable staff that could accomplish this and it can be applied in all four delivery platforms in a school. The problem with observation is that staff would require training, costing additional time and money, neither of which are abundant commodities in a school. There is also the

consideration of documentation and tracking, something that must be done regardless of the measurement means. Though used infrequently, a more expensive but less subjective method of measurement is the individual accelerometer. The technology is available at a reasonable cost, since the accuracy of individual measurement in frequency, intensity, type, and time could be improved significantly.

Professional Application

School districts across the nation are still feeling some of the unintended consequences of the No Child Left Behind Act. Several schools cut physical education in favor of additional time in subjects that fall under standardized testing. These actions coupled with increased sedentary time due to technological advances have put the health of our nation's youth at risk. Furthermore, the achievement gap has barely changed despite efforts at state and federal levels. School has historically provided a platform for influencing young people. The goal of administrators and educators is to prepare students for life as productive citizens. Establishing the importance of healthy lifestyle choices is certainly something that can be instilled in school. Why not then, maximize the capability of schools to deliver physical activity to students, when it has been shown to enhance health and improve academic performance?

Perhaps one of the more influential tenets of this review in regard to policy is the conclusion that a considerable percentage of no associations were found between physical activity and academic performance. This may sound contrary but in fact, it provides a sound argument in objection of those that favor cutting physical education for more class time. The finding of no association disproves any conceived value in replacing physical activity time with more time in class. In fact, all reviewed instances with 'no association' conclusions showed that

students who participated in physical education for the regularly scheduled time did just as well on standardized tests as students who had extra time in the classroom (Rasberry et al., 2011). This point helps support the argument that physical education should be in place in all schools. Physical education represents the best opportunity for students to accumulate moderate to vigorous active minutes under trained instruction. As discussed in this review, time spent in physical education not only contributes to establishing healthy habits for a lifetime; it also has been shown to improve academic performance significantly. Eliminating cuts of established physical education programs is essential to promoting improved academic performance. Equally important is reforming the requirements for time spent in these programs.

The National Association for Sport and Physical Education (NASPE, 2016) recommends 150 minutes of physical education programming per week for elementary students and 225 minutes per week for secondary students. When spread over the course of a five-day school week, these numbers equal 30 minutes per day for the elementary level and 45 minutes per day for the secondary level. As discussed, less than 12% of states mandate these recommended minutes and in effect, miss opportunities for students to improve academic performance. If the minimum weekly time recommendations were required by all states, students would accumulate at least half of their daily-recommended active minutes in one class, enjoy associated health benefits, and would have a better opportunity to improve academic performance. Physical education also represents the best school delivery mode whereby students can reach the optimal intensity of physical activity.

Every possible minute of physical activity counts. Based on this review, this statement should be massaged into the culture of schools across the nation. If opportunities for physical

activity existed more frequently in classrooms, before or after school, and at recess, students and staff may better understand the importance of its impact on academic performance. Improved executive function and academic behaviors were found in physical activity as short as one minute in the classroom. Before and after school fitness programs have improved academic behaviors and boosted grade point averages. Although administrators and teachers typically balk at the notion of giving up more classroom time, they will find that doing so may actually improve productivity if applied well.

Academic achievement is the area of academic performance noted most often in the literature reviewed and is, in part, due to the tangible nature of its measurement. Although some physical activity does not translate well to improved standardized test scores, the value of academic behavior and cognitive skills cannot be overstated. Academic behaviors and cognition are a part of overall academic performance and although changes are best measured in observation, they are equally important in terms of academic success. Therefore, administrators and educators should not discount the physical activity that translated to improvements in these academic performance realms.

Physical activity measurement devices, such as fitness trackers or accelerometers, should be considered for implementation at pilot schools. Surely, more research needs to take place to justify their widespread use, but they do represent the best means to accurately measure the optimal physical activity of students for promoting academic benefit. Wearing a fitness device has the tendency to stimulate motivation and accountability in people that wear them. Doing so would also help administrators fine-tune a school's physical activity offerings to

maximize the number of students reaching optimal activity levels. The data collected from these devices could be used to support future studies and more extensive application.

Limitations of the Research

The history of research on this topic was explored and it was discovered that the amount of available research became significantly greater around the year 2000 and later. Despite the improvements in methods and the scientific interest in this topic, every facet of physical activity's impact on academic performance has not been successfully studied. Although much is known about physical fitness and the values of physical activity, its relationship with brain health and academics are complex and dynamic to say the least. None of the literature reviewed specifically addressed dose by using the FITT model as was done in this document. Several individual articles suggest that exercise intensity plays a significant role in academic performance and that a threshold seems to exist (Esteban-Cornejo, Tejero-Gonzalez, Sallis, & Veiga, 2015). However, more research needs to be conducted that addresses all aspects of activity dosage; frequency, intensity, type, and time. The way that activity was measured in the reviewed literature was simply stated in the methods section of each article. A comparison was done to aid in drawing some conclusions based on positive connections to academic performance. No articles were found that directly studied measurement as a corollary to an activity's impact on academic performance.

Implications for Future Research

As pointed out by authors of several reviewed articles, more research needs to be done on this topic. Specifically, studies that vary the activity dose in regard to frequency, intensity, type, and time would be beneficial in better supporting the questions in this review and

providing solid evidence for schools to justify decisions. Additionally, further research in the area of physical activity measurement as it relates to academic performance could be helpful. For example, a longitudinal study in which student activity is measured by an accelerometer or observation against a control group without said measurement. Evaluating academic achievement via test scores over the course of a school year may indicate their value versus their cost. Fitness tests in physical education do a good job of assessing fitness levels but they cannot be applied as a means of measurement to all the activity delivery modes. Finally, more research in this area should utilize longitudinal and randomized control design versus the predominant quasi-experimental and cross-sectional constructs to improve scientific legitimacy.

Conclusion

Public school has been and will continue to be a major center of influence for children and adolescents. In an effort to maximize that effect, carefully programmed opportunities for physical activity could arguably address the challenging academic and health issues that our youth face today. At this point in time, the research supporting the notion that physical activity is positively related to improved academic performance is too prevalent to dispute reasonably. New research is necessary to more narrowly define a dose and means of measurement. However, a combination of national health-based recommendations and existing research helps shape a sound prescription for improved academic performance. The implementation of required physical education five days per week in addition to opportunities in recess, the classroom, and extracurricular activities can collectively account for most of a student's daily physical activity. Careful planning can provide the optimal physical activities that are coordinated, aerobic, vigorous intensity, 20 – 60 minutes, and done daily. Measuring this

activity will optimize the academic benefits gained and refine the prescription. Schools should encourage and program physical activity for students to the greatest extent possible. Developing the whole student will improve their lives beyond measure, both in health and academic performance.

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