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Classroom Physical Activity Breaks Effect on Executive Function and Academic Achievement in Elementary School Students

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Classroom Physical Activity Breaks Effect on Executive Function and Academic Achievement in Elementary School Students

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by

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Abstract

Objectives: There were three aims in conducting this pilot study. First, determine the Plus Minus Task assessment's reliability to measure the executive function of shifting. Second, determine the feasibility and acceptability of CPAB by students and teachers. Finally, determine the preliminary dose-response of acute physical activity on shifting in elementary students. Methods: This was a pilot study of a classroom physical activity break intervention. Utilizing a within-subject, cross-over design, students participated in a practice day and then all three treatment conditions: a 10-minute seated lesson (control condition) and 5 and 10 minutes (experimental conditions) of classroom physical activity breaks. A Latin Square Design was employed to randomize the treatment conditions by classroom. Students participated in two treatments each week over two weeks. Data was collected through parent/guardian pre-study questionnaires and pre and post-tests of the Plus Minus Task. All methods and procedures were approved by the University of Arkansas Internal Review Board. Letters with information regarding this study were sent home to parents/guardians alerting them to the opportunity to participate along with their child. Consent and assent forms were made available to both parents and students to review and consider participation. Students who returned signed parent consent and student assent forms were allowed to participate. Participating teachers also signed consent forms. Both teachers and students participated in a post-study questionnaire and focus group interviews. Results: To our knowledge, this was the first study to find that the Plus Minus Task was a reliable test measure for assessing shifting in children aged 10 to 12. We also discovered that students enjoyed CPAB, looked forward to school on days they had CPAB, and expressed that these breaks helped them feel more awake and alert for future learning. Teachers were supportive of incorporating physical activity breaks in the future but time and specific benefits associated with activity breaks were

concerns regarding future implementation. Lastly, it was determined that neither 5 nor 10 minutes of classroom physical activity promoted a positive change in a student's shifting ability when compared to a 10-minute seated activity. Conclusions: This study found that students support CPAB and feel they are beneficial to their learning environment. We also determined that the Plus Minus Task was a reliable assessment tool to use with school-aged students to measure the executive function skill of shifting. Finally, while we did not find that acute physical activity positively affected students' shifting abilities, research should continue to investigate the impact classroom physical activity has on students' learning environment. CPAB provides students an enjoyable way to receive more physical activity during the school day while feeling more awake and on-task for future learning.

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Chapter 1 - Introduction

Since the passage of the No Child Left Behind legislation in 2002, America's schools have focused on core subjects to raise student performance on standardized exams (Pickering, 2003). The increased focus on core subjects has "narrowed the curriculum," reducing weekly minutes in non-core subjects including art, music, physical education, and recess (Centers for Disease Control and Prevention, 2013) ("Instructional Time in Elementary Schools," 2008). Consequently, students are spending more time seated in classrooms and less time being physically active ("Instructional Time in Elementary Schools," 2008). An ingredient is missing from student's school days to be at their academic best. Research demonstrates that physical activity has a positive relationship with student's academic achievement (Barr-Anderson et al., 2011) (Donnelly & Lambourne, 2011) (Kibbe et al., 2011). A promising avenue for increasing physical activity during the school day is with classroom physical activity breaks, which may positively impact academic achievement.

For students to be academically successful students must navigate daily classroom tasks which require executive function skills. These skills include paying attention, time management, organization of thought and materials, staying on task, problem-solving, following directions, and controlling emotions and impulses. Each allows students to be increasingly successful in the classroom (BookSmart, n.d.) Executive function skills are considered higher-order processes that are important in the learning development for children and have been identified as predictors of future academic achievement (Best et al., 2011) (Pickering, 2003) (St Clair-Thompson & Gathercole, 2006).

Physical activity research indicates that both acute and chronic exercise promote executive function (de Greeff et al., 2018). Additionally, an increase in daily physical activity is

related to higher academic achievement in elementary students (Barr-Anderson et al., 2011) (Donnelly & Lambourne, 2011) (Kibbe et al., 2011). Recognizing the daily importance of executive function skills within the classroom and the educational benefits linked to an increase in physical activity has cultivated a new line of research, classroom physical activity breaks (Álvarez-Bueno et al., 2017) (Abbott-Chapman et al., 2014) (Best & Miller, 2010). Incorporating short activity breaks into the classroom may have multifaceted benefits, including increased physical activity during the school day and greater academic achievement (Tomporowski et al., 2011) (Best & Miller, 2010) (Sibley & Etnier, 2003) (Keeley & Fox, 2009) (Singh et al., 2012) (Efrat, 2011) (A. Fedewa, 2011).

The relationship between acute bouts of physical activity and cognitive performance in children is inconclusive, likely due to methodological differences (Donnelly et al., 2016). A positive relationship has been observed between physical activity and executive function skills (Best, 2010). Acute physical activity research in schools has yet to determine the duration and intensity necessary to heighten these skills. Before classroom physical activity breaks are used more readily in schools, more research must be conducted to determine its effect on students.

Only a few researchers have explored acute physical activity within the classroom setting, with only one study comparing varying exercise levels (Howie et al., 2015). Mixed results were observed across all studies, ranging from slightly positive to neutral effects as studies explored time on task, attention, working memory, and inhibition. Task switching, or switching, has been largely ignored in this type of research. Switching is the concept of completing one task, disengaging, and then engaging in a new task (Miyake et al., 2000). Students constantly utilize task-switching within a classroom setting. To our knowledge, this will be the first study to explore physical activity's effect on task switching. This pilot study consists

of three aims. The first is to determine the reliability of the Plus Minus Task in elementary students between multiple trials. The second aim is to determine the feasibility and acceptability of classroom physical activity breaks within the school day. Finally, we desire to determine the preliminary dose-response of acute physical activity on switch costs in elementary students.

Definition of Terms

Physical activity – any bodily movement produced by skeletal muscles that require energy expenditure (Donnelly et al., 2016)

Classroom physical activity breaks – any physical activity that takes place in the classroom at any time during the school day. Physical activity may or may not be integrated with planned academic instruction. (Integrate Classroom Physical Activity in Schools, n.d.)

Sedentary – an energy expenditure more than resting and less than light physical activity to include behaviors such as watching TV, working on a computer or at a desk, or sitting and socializing. (R. R. Pate et al., 2011; Russell R. Pate et al., 2008)

Curriculum narrowing – the practice of focusing classroom instructional attention toward a limited number of subjects at the expense of others. (Newberg-Long, n.d.)

Cognition or cognitive function – the overarching mental process that contributes to perception, memory, intellect, and action (Donnelly et al., 2016)

Executive function – a set of cognitive operations underlying the selection, scheduling, coordination, and monitoring of complex, goal-directed processes involved in perception, memory, and action. (Donnelly et al., 2016)

Working memory - composed of multiple components whose coordinated activity is responsible for the temporary storage and manipulation of information. (Tracy Packiam Alloway & Alloway, 2010)

Task switching – the ability to shift between mental states, rule sets, or tasks. (Miyake et al., 2000)

Inhibition - Attentional processes that can control a person's attention, behavior, thoughts, and/or thoughts, and emotions to block out or overcome internal or external desires or distractions to accomplish what is needed or appropriate at the moment. (Diamond, 2013)

Academic achievement – the extent to which a student, teacher, or institution has achieved their educational goals, commonly measured by examinations or continuous assessment. (Donnelly et al., 2016)

Moderate to vigorous activity – moderate activity (3-6 METs) could be brisk walking, dancing, gardening, household chores, walking an animal. Vigorous activities (>6 METs) could be running, fast cycling, aerobics, fast swimming, competitive sports, or games. (WHO | What Is Moderate-Intensity and Vigorous-Intensity Physical Activity?, n.d.)

Metabolic equivalents (METs) – commonly used to express the intensity of physical activity. They are a ratio of a person's working metabolic rate relative to their resting metabolic rate. 1 MET = energy cost of sitting quietly or 1 kcal/kg/hour. (WHO | What Is Moderate-Intensity and Vigorous-Intensity Physical Activity?, n.d.)

Research Aims

Aim #1: Determine the reliability of the Plus/Minus Task measure in elementary students between multiple trials.

Aim #2: Determine the feasibility and acceptability of implementing classroom physical activity breaks within the school day.

Aim #3: Determine the preliminary dose-response of acute physical activity on switch cost in elementary students.

Chapter 2 - Review of Literature

Physical Activity in Children

Physical activity (PA) is described as any bodily movement produced by skeletal muscles that require energy expenditure (*WHO | Physical Activity*, n.d.). These movements can include exercise, play, work, household chores, active transportation, and recreational activities (*WHO | Physical Activity*, n.d.). Being physically active is a top way to improve one's overall health while reducing chronic disease (CDC, 2020). The result of being physically inactive results in Americans spending more than $117 billion in health care costs and while one in four young adults is too heavy to serve in our military (CDC, 2020).

PA provides numerous health benefits observable in children. Benefits include improved cardiorespiratory and muscular fitness, bone health, body composition, increased attention in school, reduced risk of depression, and academic performance (US Department of Health and Human Services, 2018). Research suggests these health benefits will continue into adulthood (US Department of Health and Human Services, 2018).

The 2018 Physical Activity Guidelines for Americans suggested that children beginning at age 3 could improve overall health by participating in regular physical activity (US Department of Health and Human Services, 2018). Recommended amounts of physical activity, duration, and intensity vary depending on age. In addition to physical activity, there are additional recommendations for building muscle and bone strength.

School-aged children fall into two groups with slightly different guidelines. The first group is the preschool population, ages 3 to 5 years old, a newly created group for the second edition. Students at this age should be physically active throughout the day, focusing on active play and the use of various types of activities. PA aids in growth and development for this age

group (US Department of Health and Human Services, 2018). The second age group includes children and adolescents aged 6 through 17 years old.

In contrast to the previous age group, students of this age should aim for 60 minutes or more of daily moderate to vigorous physical activity (MVPA). These activities should be enjoyable and age-appropriate. In addition to aerobic activity, this age group should also spend at least three days each week in muscle and bone-strengthening activities. (US Department of Health and Human Services, 2018). While guidelines target different ages and populations, the general goal is to move more and spend less time inactive. Physiological benefits can be attained right away and will continue as additional physical activity is achieved (US Department of Health and Human Services, 2018).

Despite numerous known health benefits, America's youth choose physically inactive behaviors. The 2016 United States Report Card on Physical Activity for Children and Youth graded American youth with a D- for overall physical activity, a D- for sedentary behaviors, and a C- for organized sports participation (Katzmarzyk et al., 2016). The report cited concerning statistics such as 80% of 6 to 19 year-olds not participating in a minimum of 60 minutes and that boys are slightly more active than girls (Katzmarzyk et al., 2016). 63% of this sample spend more than two hours of screen time each day (Katzmarzyk et al., 2016). While no formal recommendation currently exists for the amount of screen time like that of physical activity, the Heart, Lung and Blood Institute and American Academy of Pediatrics suggest limiting screen time to less than two hour daily (Council on Communications and Media, 2011) (“Expert Panel on Integrated Guidelines for Cardiovascular Health and Risk Reduction in Children and Adolescents,” 2011). Investigation in organized sports participation found that 56% of 6 to 12-

year-old participate in at least one team or individual sport each year, while only 37% report participating in a team sport regularly (2018 US Report Card Summary, 2018).

Physical Activity in Schools

The school setting provides an ideal environment to reach a large segment of the United States population and create an environment capable of implementing more PA for children. Nearly 60 million students attended a K-12 public or private school in the United States during the 2019-2020 school year (*The NCES Fast Facts Tool Provides Quick Answers to Many Education Questions (National Center for Education Statistics)*, n.d.). The regular school day presents students with three opportunities for PA: 1) physical education class, 2) recess, and 3) other unstructured times that take place before and after school activities or PA breaks (Nicholson, 2012).

National organizations view schools as a viable avenue for encouraging PA. The National Association of Sport and Physical Education (NASPE) and the American Heart Association recommend elementary students receive at least 150 minutes of physical education each week (*Increasing and Improving Physical Education and Physical Activity in Schools*, n.d.; *Position Statement*, 2008). The NASPE also suggests students have at least one recess session lasting a minimum of 20 minutes as part of the typical school day (*Position Statement*, 2008). The American Heart Association continues by calling for a physically active culture that is cultivated in the schools and one that extends into the community (Goh et al., 2013). The Institute of Medicine invites all persons involved in school functions to work to "operate in a coordinated and dynamic manner to provide access, encouragement, and programs that enable all students to engage in vigorous or moderate-intensity physical activity 60 minutes or more each day" (Committee on Physical Activity and Physical Education in the School Environment et al.,

2013). Schools and their members have an opportunity to influence America's youth academically and personal wellness.

Despite the recommendations by many organizations for more daily PA time in schools, there remains no national legislation that requires schools to have a minimum number of days or minutes for physical education time per week (Committee on Physical Activity and Physical Education in the School Environment et al., 2013). Schools have little incentive to pursue meaningful policies toward increasing PA programs. Programs, including physical education, have lacked support for many years as schools have been forced to focus their attention on core academics ("Instructional Time in Elementary Schools," 2008).

In 2002, the No Child Left Behind (NCLB) Act was signed into law by former President George W. Bush. The act was intended to improve America's elementary and secondary public schools by implementing sweeping change and required increased accountability (*The Elementary and Secondary Education Act (The No Child Left Behind Act of 2001)*, 2010). The stated goal of NCLB "is to ensure that all children have a fair, equal, and significant opportunity to obtain a high-quality education, and reach, at a minimum, proficiency on challenging state academic achievement standards and state academic assessment" (Simpson et al., 2004).

While objectives were well intended, NCLB created a shift for America's public schools. Student performance in reading, math, and science became the focus. Schools were held accountable for the student's academic performance with consequences for falling short. Schools that achieve yearly goals would receive rewards, while those missing the mark for two consecutive years would be classified as "in need of improvement" with disciplinary action or corrective steps for these low-performing schools (Simpson et al., 2004). Heightened levels of accountability and a concerted focus to meet yearly goals created some unintended

consequences. Shifting the focus to math, reading, and science areas created a reallocation of time during the school day, resulting in a curriculum narrowing (*Comprehensive School Physical Activity Programs: A Guide for Schools*, 2013). The consequences were two-folded. First, with attention to these three subject areas, time priority was given at the expense of all other subject areas. Secondly, teachers focused only on content that would likely show up on test assessments. Each step taken was to maximize time and resources in hopes of raising test scores.

Elementary schools heightened focused attention toward two subjects, reading and math. National data showed that most schools saw an increase in the total number of minutes by 47% in reading and by 37% in math ("Instructional Time in Elementary Schools," 2008). These additional minutes were taken from other subjects, with recess and lunch being reduced (Table 1). NCLB affected time spent in subjects that were not math and reading ("Instructional Time in Elementary Schools," 2008).

Table 1: Changes Since 2001-02 in Instructional Time for Various Elementary School Subjects in Districts Reporting Decreases

Subject or Period	Average Total Instructional Time Pre-NCLB (Minutes per Week)	Average Total Instructional Time Post-NCLB (Minutes per Week)	Average Decrease (Minutes per Week)	Average Decrease as a Percentage of Total Instructional Time
Social Studies	239	164	76	32%
Science	226	152	75	33%
Art and Music	154	100	57	35%
Physical Education	115	75	40	35%
Recess	184	144	50	28%
Lunch	*	*	*	*

* Sample size was too small to allow reporting of data on minutes per week.
** Data were taken from Instructional Time in Elementary Schools, 2008.

Table 1 shows elementary students saw a significant reduction of time in non-core subjects, specifically in physical education and recess. An increase in sedentary behaviors may lead to increased health risks both during childhood and adolescence but likely set a behavior pattern that carries over into adulthood.

The school day is characterized as a sedentary environment with multiple barriers preventing students from achieving daily recommended PA. This is especially concerning since school-aged students receive about 70% of their MVPA while at school (Guinhouya et al., 2009). Exploring avenues to increase a student's opportunity for more PA is necessary. Outside of physical education classes and recess, other ways exist for students to increase PA during school. One possible solution is utilizing classroom physical activity breaks.

Physical Activity in Academics

Classroom physical activity breaks (CPABs) are short periods of physical activity in the classroom. Time values can vary but are usually less than twenty minutes and can be conducted with academic material or purely as physical activity. The intensity of activity can range from light to vigorous. The classroom teacher usually leads these exercise breaks.

These activity breaks add more PA to the school day, but they also provide much-needed movement while breaking up the typical day's monotony. There may be additional classroom benefits for students. Researchers have spent many years exploring the impact of physical activity and have continued to evolve by exploring the impacts of CPAB on students.

Physical Activity Research

Current research in CPABs is the result of many years of exploring physical activity and its impact on health, wellness, and eventually academics. A relationship between physical activity and academic achievement has existed for more than 200 hundred years. Thomas

Jefferson wrote a letter to his nephew, our third president, reminding him to remain physically active. Jefferson wrote, "In order to assure a certain progress in this reading, consider what hour you have free from the school and the exercises of the school. Give about two of them, every day, to exercise, for the health must not be sacrificed to learning. A strong body makes the mind strong." (*Founders Online*).

The first evidence of a direct effect of exercise on the brain was discovered through animal testing. Bouts of exercise caused a cascade of neurological changes in the hippocampus that have been linked to memory consolidation and skilled actions in rodents (Gomez-Pinilla & Hillman, 2013). Considerable animal research led to a term called neurogenic-reserve hypothesis (Kempermann, 2008). The Neurogenic-reserve hypothesis proposes that PA in early life optimizes brain networks involved in memory and creates a reserve of precursor cells that influence individuals' learning capabilities throughout the life span (Donnelly et al., 2016). These findings then led to an exploration of how exercise affected cognition in adults.

Cognition, or cognitive function (CF), is the overarching mental process that contributes to perception, memory, intellect, and action (Donnelly et al., 2016). Adult studies have shown a link between routine exercise and how exercise alters specific brain structures and functions, thus improving cognitive performance in older adults (Colcombe et al., 2006) (Colcombe et al., 2004) (Kramer et al., 1999). Tasks demanding greater cognition, or executive function skills, were observed to improve with regular exercise in older adults. These tasks were in working memory, response inhibition, and mental flexibility (Miyake et al., 2000) (Diamond, 2013). It is hypothesized that exercise can induce vascularization and neural growth and alter synaptic transmission, altering thinking, decision making, and behavior in the prefrontal cortex of the brain (Kopp, 2012). The prefrontal cortex controls executive functions (Stuss & Benson, n.d.).

Executive function (EF) falls under the broader cognitive function area but focuses on higher-order cognitive skills related to planning and decision making. Executive function skills include attention, working memory, problem-solving, cognitive flexibility, verbal fluency, decision making, task switching, and inhibitory control (Basso & Suzuki, 2017). EF skills are high-level cognitive processes that help facilitate new ways of behaving, especially in approaching new or non-routine circumstances that allow individuals to lead life independently (Gilbert and Burgess, 2008). Skills allow individuals to behave flexibly rather than being slaves to their environment and provide the ability to adapt to novel or changing situations (Gilbert and Burgess, 2008). Others describe EF skills as an umbrella term that encompasses the cognitive processes responsible for organizing and controlling goal-directed behavior (Banich, 2009). Attention, working memory, problem-solving, cognitive flexibility, verbal fluency, decision making, and inhibitory control are EF skills that receive the most benefit from PA's acute bouts (Y. K. Chang et al., 2012).

After understanding PA's benefits on cognition in older adults, research began to explore if the same was true in children. EF skills play an essential role in the learning process for students (Bull & Scerif, 2001) (Bull et al., 1999) (Lorsbach et al., 1996) (Mclean & Hitch, 1999). These self-regulation skills help students direct all aspects of the classroom and their productivity. One writer describes EF skills as the CEO of the brain in guiding students in planning, time management, organization, and maintaining self-control (Villaneda, 2016). Working memory, inhibition, and shifting are foundational components of EF (Miyake et al., 2000). Working memory, or updating, requires monitoring and coding incoming information, revising items, and replacing irrelevant information with new or updated information (Morris & Jones, 1990). Inhibition refers to the ability to resist temptation while resisting impulsivity

(Diamond, 2013). Shifting is described as moving backward and forward between several tasks, operations, or mental sets (Bruce & Bruce, 1996). When considering school readiness and academic achievement, the EF skills of inhibition, working memory, cognitive flexibility, or shifting are more important than IQ (Blair & Raver, 2015). These same skills act as predictors of later academic achievement (Best et al., 2011).

These skills can be observed in the classroom by a child's capacity to store and process information, known as their working memory, which plays a vital role as students seek to acquire knowledge and skills in the classroom (Tracy P. Alloway et al., 2008). Inhibition is a voluntary component that ignores certain stimuli while focusing on others or their ability to stay on task (Posner, M.I. & DiGirolamo, 1998). Shifting is shown by parsing out irrelevant information while focusing on what is essential in accomplishing a given task (Miyake et al., 2000).

As stated earlier, PA positively affects EF skills. EF skills are necessary for a student's academic success. A student's opportunity for PA has decreased in recent years. Knowing that research indicates that both acute and chronic MVPA intensity contributing to a student's EF skills makes exploring impacts of classroom physical activity breaks warranted (de Greeff et al., 2018) (Y.-K. Chang & Etnier, 2009) (Y.-K. Chang et al., 2011).

Classroom Physical Activity Breaks

Identifying a positive relationship between PA and a student's EF skills will go a long way in changing the recipe for academic success, a kind of "holy grail" for schools (Gibson et al., 2008; Howie & Pate, 2012). School-based studies investigating acute bouts of PA and the relationship with cognitive performance are limited. There have been twelve studies (fourteen articles) that have explored different impacts of CPABs. Studies varied in PA time, ranging from 1 to 20 minutes, while intensity varied from low to high. Table 2 illustrates the time lengths and

assessments used in these studies. Generally, researchers chose time lengths of 5 and 10 minutes, and assessments covered two main areas in working memory and inhibition. Results have generally been viewed as positive.

Study designs have differed, making it difficult to compare study outcomes. For example, only Howie et al. compared treatments across multiple time doses (Howie et al., 2015). Additionally, previous studies have spent much of their time assessing areas of working memory and inhibition and math and reading performances. To our knowledge, no study has chosen to examine task switching, which is one of the three main categories of EF. Finally, only two researchers sought feedback from teachers, and one asked students about their impression of the CPABs (Donnelly et al., 2017; Howie et al., 2014). Teachers and students are key stakeholders in determining if CPABs are a viable option to increase PA in schools. Without their support, the value may never be realized. As research continues in this area, working towards establishing a standardization for length and intensity of the physical activity will be necessary (Donnelly et al., 2016). The impact potential for single episodes of MVPA for students in the classroom and their ability to manage the school day's demands requires a thorough understanding.

There are three aims in conducting this pilot study. Since no researcher has yet targeted the impact of PA on task switching, we will aim to determine the reliability of Plus/Minus Task in elementary students between multiple trials. This measurement tool is a widely accepted way to measure switch cost, but its reliability is currently unknown (Baddeley et al., 2001; Jersild, 1927; Miyake et al., 2000; St Clair-Thompson & Gathercole, 2006). Our second aim is to determine the feasibility and acceptability of classroom physical activity breaks within the school day. Finally, we desire to determine the preliminary dose-response of acute physical activity on switch costs in elementary students.

Table 2: Previous Classroom Physical Activity Breaks Studies

Researcher	Year	Method	Assessment
Hill et al.	2010	10-15 minutes	Cognition
Howie et al.	2014	5, 10 & 20 minutes	On-Task
Howie et al.	2015	5, 10 & 20 minutes	Trail-Making Operational Digit Recall Math Fluency
Kubesch et al.	2009	5 minutes v. 30 Physical Education Class	Flanker Test Dot Test
Ma et al.	2015	4 minutes	d2 Test
Ma et al.	2014	4 minutes	Off-Task Behavior
Schmidt et al.	2016	10 minutes - PA or Sedentary & low/high CE	d2 Test
Van Den Berg et al.	2016	12 minutes Aerobic, Coordination, or Stretching	Letter Digit Substitution d2 Test
Szabo-Reed et al.	2017	2 x 10 minutes	Time on Task
Mavilidi et al.	2019	5 minutes	Math Achievement On-Task Flanker Test N-Back Task
Fedewa et al.	2018	10 minutes - Aerobic or Academic	Math Achievement Reading Achievement
Raney et al.	2017	1-minute Energizer	Academic Retention On-Task
Watson et al.	2018	3 x 5 minutes per day	Reading Achievement Math Achievement Individual Behavior Class Behavior
Donnelly et al.	2017	2 x 10 minutes	Welcher Individual Achievement Test

Practical Impact of this Study

Exploring the benefits of classroom physical activity breaks in elementary students is still a young but growing area of research. This pilot study seeks to add to the body of findings by determining reliability of the Plus/Minus Task, feedback and reaction from faculty and students about exercise breaks, and impact of varying doses of PA on student task switching. This study will give preliminary feedback while determining whether a larger study is warranted.

Chapter 3 - Methods

Study Design

This study was a mixed-methods pilot study of a classroom physical activity break intervention. Utilizing a within-subject, cross-over design students participated in a practice day and then all three treatment conditions: a 10-minute seated lesson, and 5 and 10 minutes of classroom physical activity breaks. A Latin Square Design (Figure 1) was employed to randomize the treatment conditions by classroom. A mixed-methods approach was used to gain a comprehensive view. Students participated in two treatments each week over two weeks. In addition to quantitative data analysis, a qualitative component was used with administration, teachers, and students to gain insight into how classroom physical activity breaks were perceived.

	Practice Day	Seated Lesson	5 Minutes of PA	10 Minutes of PA
Classroom A	Day 1	Day 2	Day 3	Day 4
Classroom B	Day 1	Day 3	Day 4	Day 2
Classroom C	Day 1	Day 4	Day 2	Day 3

Figure 1

Participants

The participants were 28 students (18 girls and 10 boys) from three fifth-grade classroom from a public elementary school in Ohio. The students ranged in age from 10-12 years old. Students who could participate in regular classroom activities and did not have accommodations preventing participation in the Plus Minus Task or physical activity were eligible. All instructions by staff were given in English.

The researcher had no previous relationship with the school, its administration, teachers, or the students before beginning this study but has twenty years of teaching experience in the P-

12 school setting. All methods and procedures were approved by the University of Arkansas Institutional Review Board.

Measures

Physical Activity Intensity

To assess the level of physical exertion for each treatment, students used the Modified Borg's Rating of Perceived Exertion Scale (Appendix A) to indicate how they felt immediately after exercise. Borg's scale is an appropriate measure for anyone from age 9 or 10 and older (Williams et al., 1994). The Modified Borg Scale has a range of 1 to 10 with a 1 rating equal to resting up to a 10 which is maximum exertion to the point where the body is telling the child to stop exercising.

Plus-Minus Task

The Plus-Minus Task assessment was used to measure a student's EF skill of task switching (Jersild, 1927). The version used by St. Clair-Thompson et al. consisting of three 2-minute math assessments examined the same target age range (St Clair-Thompson & Gathercole, 2006). The first two-minute assessment is composed of 30 addition problems where students added 3 to a two-digit number. The second assessment also consists of 30 problems but requires the student to subtract 3 from a two-digit number. The final assessment alternating alternate adding and subtracting 3 from two-digit numbers. The cost of shifting was assessed by calculating the difference in correct answers on the alternating test and the average of correct answers on the addition and subtraction tests. The difference between this study and the one conducted by St. Clair-Thompson is our use of physical activity (St Clair-Thompson & Gathercole, 2006). Two-digit numbers were randomly generated by Microsoft Excel using their random number generator.

Questionnaires

Following the two-week study, participating students as well as teachers and administrators completed a short questionnaire to gain feedback on their impression of the classroom physical activity breaks. The questionnaire consisted of Likert-type questions. Refer to Appendix D for questions.

Focus Group Interviews

Immediately following completion of the questionnaire focus group interviews took place in each classroom as well as one with all participating teachers, to gather feedback on their experience with the classroom physical activity breaks. Semi-structured interview questions were used with students and teachers. Open response questions allowed participants to share in their own words their impressions of exercise breaks. Refer to Appendix C for questions.

Procedures

Students were assigned into one of three classrooms labeled as A, B, and C. The order of conditions was randomized for each classroom with students participating in one condition per test day. Using a Latin square design provides a counterbalance for learning effects. Task switching was measured before and after each exercise condition. Testing took place over two weeks.

Students began each test day with a 10-minute pre-planned seated activity. Following the seated activity, they took the Plus-Minus Task and then participate in one of the three physical activity treatments, 10 minutes of a seated activity, 5 minutes of GoNoodle, or 10 minutes of GoNoodle. Upon completing the physical activity period, the students gave their Modified Borg's Rating of Perceived Exertion before taking the posttest assessment of the Plus-Minus Task. The total time for each procedure was approximately 30 minutes each treatment day.

Before testing, parents completed a short questionnaire (Appendix B) that asked about their educational backgrounds, socioeconomic status, and child's height/weight. Standardized height and weight were collected to determine Body Mass Index (BMI).

Treatments

GoNoodle, an internet-based physical activity site, was used for the classroom exercise break interventions. Each day a predetermined video was used for the daily physical activity treatment for the appropriate amount of time. Videos were chosen for time length and means of achieving moderate to vigorous physical activity. All participants used the same videos for each treatment length. Upon completion of each treatment length, students rated their perceived level of physical exertion by using Borg's Rating of Perceived Exertion Scale.

Durations of 5 and 10 minutes are realistic time periods teachers can implement into the normal classroom. Many classrooms are equipped with computers or laptops, internet service, and means of projection. GoNoodle is easy to navigate and teachers with relative ease can implement this type of physical activity into their classroom for durations of 5- and 10-minutes segments.

Statistical Analyses

Statistical Analysis Software (SAS 9.4) was used to examine the result of this study. Descriptive statistics were calculated for the total group and each classroom group using SAS 9.4. A repeated measures ANOVA was used to analyze both within-subject and between-subject factors. Switch cost, the difference of correct answers on the alternating test and the average of the addition and subtraction test, served as the dependent variable. There were three levels of physical activity (no activity, 5 minutes, and 10 minutes) that were the independent variable. Covariates consisted of grade, gender, BMI, SES, PA level, and parent education level.

The analysis began with checking the assumptions of a repeated-measures ANOVA by conducting tests for normality and sphericity. Assuming no violations no corrections were needed.

Aim #1: Determine the reliability of the Plus/Minus Task in elementary students between multiple trials.

Aim #1 Outcome Measure: The Plus/Minus Task is an acceptable switch cost measure but the reliability of task switching is currently unknown (Baddeley et al., 2001; Jersild, 1927; Miyake et al., 2000; St Clair-Thompson & Gathercole, 2006). This task has been adapted for use with elementary students and this adaption will be used for this study (St Clair-Thompson & Gathercole, 2006). Analysis of between day scores for each group will be used to determine the reliability of the plus/minus task. The reliability of the Plus/Minus Task will be assessed by conducting an intraclass correlation coefficient using pre-test scores.

Aim #2: Determine the feasibility and acceptability of implementing classroom physical activity breaks within the school day.

Aim #2 Outcome measure: Focus group interviews with teachers, administrators, and students allow for authentic responses. Using semi-structured interview questions allows each group to express their impression of classroom physical activity breaks. Likert questioning and thematic analysis to interview responses will determine the feasibility and acceptability of implementing classroom physical activity breaks within the school day. Exploring acceptability and feasibility of classroom physical activity breaks Likert responses will be evaluated with descriptive statistics and open-ended responses will be organized and assess using Thematic Analysis (Braun & Clarke, 2006).

Aim #3: Determine the preliminary dose-response of acute physical activity on switch costs in elementary students.

Aim #3 Outcome measure: Students' ability to move back and forth between tasks during the school day is an important part of the learning process. Exploring acute physical activity's effect on task switching in elementary students has yet to be studied. This pilot study will provide initial information and a guide for future studies. Following a repeated measures design switch cost scores will be compared across treatments. Examining the difference of post-test scores on the Plus/Minus task between the physical activity conditions while controlling for pre-test scores informs about the impact of exercise dose and its effect on switch cost. Planned linear contrast will be conducted to investigate the difference between durations of physical activity breaks comparing post-test scores for each condition with sedentary treatment scores.

Time Line

Time considerations for this study will coincide with the start of the fall 2020-2021 school year. Recruitment and data collection are planned to take place during August and September. Analysis of data would then take place during October and completion of this project by December 2020.

Limitations

The ongoing coronavirus pandemic may impact this study in several ways. This is a school-based study and even though most K-12 schools have plans to hold face-to-face classes this fall, the reality of this taking place is uncertain. The unknown effects of a second outbreak would limit this study in several ways. Schools may be forced to adjust their mode of delivery which could impact students' attendance and thus their ability to participate. Even if schools

continue to hold classes, a second outbreak would affect student attendance and could cause incomplete data sets.

If schools must adjust from in-seat instruction to a remote/home school instructional environment this study would pivot similarly. Delivery and participation would be in a remote fashion. Parents would become part of the equation in this scenario. Parents would be asked to monitor the treatment of GoNoodle sessions along with all pre and posttest measurements. Parents would be given a schedule to follow for each day with the appropriate length of treatment. Parents have been monitoring their children's academic lessons for some time now and should have a routine established. Providing instructions or lessons for parents to follow and monitor should be reasonable.

A third option would be to conduct remote participation via a Zoom/Team Meeting platform with each classroom at designated day/time. Parents would still be involved in the monitoring of their child as well as making sure all technology is ready and students are prepared with necessary materials to participate in seated lessons and testing.

Chapter 4 - Title: Students and Teachers Give A Thumbs Up for Classroom Physical Activity Breaks

Abstract

Objectives: To determine acceptability and feasibility of implementing classroom physical activity breaks (CPAB) for elementary school students. Methods: This mixed-methods study design included focus groups for teachers (n=3) and fifth-grade students (n=28). Utilizing a within-subject, cross-over design, students participated in two durations of classroom exercise breaks and a control condition of a 10-minute seated lesson. Results: Students shared their enjoyment of the physical activity breaks and how they felt it positively impacted the school day. Teachers observed student enjoyment and expressed their openness to experiment with implementation in the future as long as there was research supporting this intervention. Conclusions: Classroom physical activity breaks are an enjoyable way for students to increase physical activity during school while also acknowledging being more awake and alert for learning. Movement integration training during preservice teacher education programs may eliminate barriers and result in more effective classroom implementation.

Introduction

Physical inactivity is a health concern in the United States and around the world. A sedentary lifestyle leads to the increased possibility of chronic disease development such as heart disease, type II diabetes, several cancers, and psychosocial problems (CDC, 2020). Inadequate physical activity levels in the United States have led to Americans spending more than $117 billion annually in healthcare-related costs (CDC, 2020). Children are not achieving daily physical activity minutes, which has resulted in 18.4% of kids aged 6-11 years old classified at or above the 95th percentile for body mass index for their age and sex (Hales, 2017). This is

concerning as physical activity levels drop dramatically during the adolescent years (Katzmarzyk et al., 2016). Therefore, cultivating avenues for physical activity would be beneficial for students.

Schools present an arena to promote the benefits associated with being physically active. Students spend about half of their waking hours at school, making them a logical avenue to instill positive health choices and promote more physical activity. Nearly 60 million students attended a public or private K-12 school during the 2019-2020 school year (*The NCES Fast Facts Tool Provides Quick Answers to Many Education Questions (National Center for Education Statistics)*, n.d.). One study discovered that students receive about 70% of their daily recommended amounts of physical activity while at school (Guinhouya et al., 2009). Since students spend a large majority of the day at school, finding opportunities to increase physical activity would help build good health habits.

Students who regularly engage in physical activity are observed to be more attentive, engaged, on task, present fewer behavioral problems while missing fewer days of school, and express more enjoyment towards school (Budde et al., 2008; Donnelly & Lambourne, 2011; Hill et al., 2010; Mahar, 2011; Vazou & Smiley-Oyen, 2014). Physical activity during the school day has been shown to improve student's on-task and general classroom behaviors, cognition, and academic performance while also improving in-school activity levels (Best & Miller, 2010; Jarrett et al., 1998; Mahar et al., 2006; Shephard, 1996, 1997; Tomporowski et al., 2011).

While a report from the US Department of Health and Human Services like the 2018 Physical Activity Guidelines for Americans provides evidence that students' physical activity brings about positive academic and psychosocial results, many schools remain content with their emphasis on core academic subjects (US Department of Health and Human Services, 2018). In

America's schools, only 3.7% of school districts require daily physical education, 11% of districts? Require daily classroom physical activity breaks for elementary students, 8 states require daily recess, and Colorado is the only state the requires daily classroom physical activity (“Results from the School Health Policies and Practices Study 2014,” 2014; “Results from the School Health Policies and Practices Study 2016,” 2016; SHAPE America, 2013). Physical activity appears to be largely absent from school day activities despite positive benefits.

One explanation for few physical activity requirements in school may be repercussions from NCLB. No Child Left Behind legislation was passed, which has made schools a barrier to students physical activity opportunities, focusing on academic accountability standards. Accountability pressures placed on schools have increased classroom instruction in subjects like math and English, resulting in students spending less time in physical education and recess (“Instructional Time in Elementary Schools,” 2008).

To increase children’s physical activity, national organizations have issued policy statements and created committees calling on schools to be a part of the community solution by encouraging students' positive environment as they pursue daily physical activity. The American Heart Association, the Institute of Medicine, the Center for Disease Control and Prevention (CDC), along with the Society of Health and Physical Educators America (SHAPE), invite all persons involved in school functions to work and encourage students to meet the 60 minutes or more of moderate to vigorous physical activity daily. The CDC and SHAPE have developed the Comprehensive School Physical Activity Program (CSPAP) to help schools promote opportunities for movement beyond just physical education and recess (Centers for Disease Control and Prevention, 2013). However, it is essential to understand which physically active interventions are beneficial and realistic for teachers to implement.

One avenue to increase physical activity time during the school day is classroom physical activity breaks (CPAB). These are classroom-based activities that increase a student's physical activity minutes. These short bouts of physical activity have begun to show positive academic impacts for students. Research suggests classroom exercise breaks improve on-task behavior, heighten executive function skills, improved academic performance in areas of math and reading, and adding physical activity time during school (Bartholomew & Jowers, 2011; Donnelly et al., 2009; Egger et al., 2019; A. Fedewa, 2011; A. L. Fedewa et al., 2018; Hill et al., 2010; Howie et al., 2014; Ma et al., 2014; Mahar, 2011; Mavilidi et al., 2020a; Raney et al., 2017; Szabo-Reed et al., 2017). A growing body of evidence shows a positive association with increased student physical activity during school, yet consistent implementation by classroom teachers remains poor (Dinkel et al., 2017).

Even with positive student benefits, only 43% of elementary schools in the United States make CPAB a regular physical activity breaks ("Results from the School Health Policies and Practices Study 2014," 2014). Teachers have expressed that time, room space, classroom behavior, academic demands, and interference with the daily activities as to why they do not implement activity breaks in their classrooms (Dwyer et al., 2003; Erwin et al., 2011; Everson et al., 2009; Gately et al., 2013; Howie et al., 2014; McMullen et al., 2014; Parks et al., 2007; Stylianou et al., 2016). Additionally, a teacher's attitude towards CPABs has the power to influence the classroom atmosphere by engaging their students and reinforcing physical activity in the classroom setting (Donnelly & Lambourne, 2011). Their beliefs, perceptions, and values all play into how they approach the content they teach and the energy that goes into their preparation and instruction (Dinkel et al., 2017; Pajares, 1992).

The purpose of this study was to investigate if teachers and students, who are key stakeholders, are accepting of CPAB while also assessing the feasibility of implementation during the school day. Previous studies on teacher buy-in have explored their overall perceptions of CPAB. In this study, we want to know if teachers will support increased physical activity in the classroom if there is a positive link with student learning. Student support for CPAB so far has been linked with enjoyment or fun but was want to learn if students are more excited about school when physical activity is part of their school day and they if like Go Noodle (Allender et al., 2006; Martin & Murtagh, 2015; McMullen et al., 2014).

Methods

Design Summary

This pilot study used a mixed-method approach in examining the acceptability and feasibility of various durations of classroom physical activity breaks. All students participated in a practice day, which allowed them to become familiar with the testing procedures, then in three treatment conditions: a 10- minutes seated lesson and 5 and 10 minutes of physical activity. Each classroom experienced a different treatment condition for each test day. Students participated in two treatments each week over two weeks. Teachers and students completed questionnaires and participated in focus group interviews following the two-week study, sharing their impression of classroom physical activity breaks.

Rationale

Utilizing qualitative and quantitative collection methods presents a more holistic view when asking if classroom physical activity breaks are socially valid and how realistic it may be for teachers to implement them into the regular day. Both methods will provide a deeper insight into physical activity in the classroom while giving statistical evidence to support our findings.

Participants

The participants were 28 students (18 girls and 10 boys) from three fifth-grade classrooms from a public elementary school in Ohio. The students ranged in age from 10-12 years old. Students who could participate in regular classroom activities and did not have accommodation preventing participation in the Plus Minus Task or physical activity were eligible. All instructions by staff were given in English.

The researcher had no previous relationship with the school, its administration, teachers, or the students before beginning this study but has twenty years of teaching experience in the P-12 school setting.

Classroom Exercise Breaks

Go Noodle is a web-based physical activity site providing various activities and video lengths for teacher use. For our study, three videos were selected by the researcher, mainly around a time length. A four-minute video was selected for the practice day, and a five and ten-minute video was selected for the testing sessions. A wide range of activities were incorporated in each video, including air squats, toe taps, jogging in place, animal movements, dodging, and jumping over oncoming objects. Movements also included greater, less than, and equal to movements incorporating an academic math lesson. The goal of these physical activity videos was for students to achieve time in moderate to vigorous physical activity.

The modified Borg RPE Scale was used to measure student's level of activity following each video. See Appendix A. This modified scale ranged from 1 to 10 with a 1 rating equal to resting and a 10, which is maximum exertion to the point where the body is telling the child to stop exercising. After each movement video, students completed a self-rating of their perceived level of exercise.

Measures

Quantitative measures – questionnaires.

Parents/guardians completed pre-study questionnaires about educational backgrounds, socioeconomic status, and child's height/weight for body mass index purposes. See Appendix B. Following the two-week study, participating students and teachers completed a questionnaire to gain feedback on their impression of the classroom physical activity breaks.

Qualitative measure – focus groups.

Following the two-week study, participating students and teachers joined in a focus group interview to gain feedback on their impression of the classroom physical activity breaks. Semi-structured interview questions included in Appendix C were asked to each group for their impressions of the classroom physical activity breaks. Students participated by class, and teachers participated individually. Focus groups for both students and teachers were audio-recorded and transcribed.

Study Procedures

Before testing, parents/guardians completed a demographics questionnaire. This intervention took place over two weeks with two test sessions each week. The first testing session was a practice day for all students to orient them to the procedures. Each of the following test days was randomize the treatment condition by classroom. The treatments included a 10-minute seated lesson, 5 and 10 minutes of physical activity. Preselected Go Noodle videos directed physical activity. On the last day of the two-week intervention, both students and teachers completed a post-study questionnaire and participated in focus group interviews to share their impression of CPAB.

Statistical Analysis

Quantitative analysis: Descriptive statistics were used to calculate post-study questionnaire responses for teachers and students using SAS 9.4.

Qualitative analysis: Transcripts from student and teacher focus groups were written and coded, seeking themes that could be categorized as positive, negative, or neutral (Braun & Clarke, 2006). Themes were grouped, reviewed, and defined to understand better the impressions from both teachers and students towards classroom activity breaks. Receiving feedback from multiple stakeholders in various methods gives a complete analysis of this intervention's acceptability and feasibility.

Findings/Results

Focus Group Feedback

The following themes emerged following the focus group interviews with students. The students discussed the benefits of classroom physical activity breaks: 1) their enjoyment of physical activity breaks; 2) the benefits of physical activity; and 3) how physical activity impacted their learning. First, students were asked to describe the CPAB using one word. A quarter of the students who responded shared mostly positive feelings using words like "fun," "exciting," and "energetic," while two used the word “tiring” to describe the physical activity breaks. Next, students were asked to describe how they felt after physical activity, and eleven students participated by sharing they felt "good, more awake, and wanting more exercise.” Others shared they were “tired, out of breath, and worn out.” Third, students were asked if they would like CPAB every week and why or why not. Nine students responded expressing how physical activity breaks impacted their school day activities. One student shared, "it allows us to get up out of our seat." When ask why they shared that, they said, "We sit a lot during the day."

Another shared, "I feel like I was not as tired after the activity breaks." Others shared that they could focus more after the activity breaks, and one student said that the breaks “woke me up.”

The teacher’s responses in the focus group centered on the theme of implementation. First, teachers viewed the Go Noodle website positively for its ease of use, student enjoyment and could see themselves using the site in the future. Secondly, teachers shared somewhat mixed views on how often they would implement CPAB due to time, classroom behavior, and how it could impact the rest of the day's activities. One teacher already includes activity breaks into her daily routines and believes there are benefits for the students. The two other teachers expressed more caution and focus on classroom behavior and academics. Lastly, two teachers shared that before making adjustments to their current teaching methods, they wanted more research documentation about the link between CPAB and the benefits associated with student learning.

Quantitative results

The descriptive statistics for participating students (n=28) showed that 64% come from at least middle-income households, with 12% of their parents/guardians achieving a bachelor’s degree or above. See Table 2 for demographic information. Students completed a self-assessed rate of perceived exertion using the modified Borg's RPE scale after both physical activity videos. The mean rate of perceived exertion was 5.33 (SD of 1.90) for 5 minutes and 3.69 (SD of 1.64) for 10 minutes of physical activity. Student also completed a post-study questionnaire revealed 84% of students enjoyed the CPABs, and 88% looked forward to school on days they were going to participate in CPABs. Additionally, 80% felt more awake after the activity breaks, and only 4% felt less focused after physical activity. Finally, 96% of students were open to having CPABs as a regular part of their classroom activities. See Table 3 for student responses for post-study questionnaires.

All three teachers completed a post-study questionnaire composed of a three-point Likert scale. The first question was about their attitude related to classroom physical activity breaks before they took place in this study, and all three answer that they were excited to give them a try with this study. Teachers were then asked what their students were like after the physical activity breaks. Two observed students to be more attentive, while one said there were no differences. Next, they were asked for their overall impression of the activity breaks. Two mentioned that they enjoyed them, while one was neutral. Then teachers were asked about their student's academic focus following the physical activity, and two share they appeared more focused while one saw no difference. Question five ask if they observed if students were more excited about coming to school on days they had CPAB and all three said they did not observe any difference in the student's excitement. Finally, they were asked if they would implement CPAB in the future, and two answered that they would like to do so, and one was uncertain.

Discussion

This study found that students enjoyed classroom physical activity breaks, looked forward to school on days they had CPAB, and, more importantly, expressed they helped them feel more awake and alert for future learning. Teachers also observed student enjoyment and were supportive of incorporating these types of activity breaks in the future. Time and specific benefits associated with physical activity breaks were concerns teachers shared regarding future implementation.

Calella et al. and Masini et al. both explored the feasibility of CPAB with elementary-aged students finding that not only is this an excellent intervention to increase physical activity during school, students enjoyed the activity breaks, and they were realistic to implement into the school day (Calella et al., 2020; Masini et al., 2020). It is also important to note that elementary

students choose to participate in physical activities when they find enjoyment, experience social support, and experience positive feelings immediately following an activity (Allender et al., 2006; Bragg et al., 2009; De Bourdeaudhuij et al., 2005). Our findings fall in line with each of these reasons making CPAB a positive activity to promote during the school day. Students in our study expressed enjoyment while participating in physical activity. While we did not ask students about social influences, it was observed by their teachers that they enjoyed participating together. Students also shared positive feelings following physical activity, saying they were more awake and alert able to concentrate on their learning following physical activity (Hill et al., 2010; Howie et al., 2014; Ma et al., 2014, p. 201; Masini et al., 2020; Mavilidi et al., 2020a; Raney et al., 2017; Szabo-Reed et al., 2017). Finally, students shared that they looked forward to school when they participated in classroom physical activity breaks, leading to improved school engagement. More engaged students are more likely to learn, find education rewarding, and are more likely to graduate and pursue a post-secondary degree (Marks, 2000).

In past studies, teachers generally agree that classroom physical activity breaks are a positive activity promoting physical, affective, and academic learning benefits for students (Carlson et al., 2015; Cothran et al., 2010; Donnelly et al., 2017; Howie et al., 2014; Kibbe et al., 2011; Mahar et al., 2006; Martin & Murtagh, 2015; Parks et al., 2007; Stylianou et al., 2016). This was not evident in our study. Even though all three shared that they had used Go Noodle or another type of physical activity break, the more veteran teachers viewed these as short brain breaks. The youngest of the participating teachers was a former college student-athlete and believed that CPAB played an essential role in her students' learning environment.

Other researchers shared that teachers observed CPAB helped to build a positive community atmosphere in their classroom (Dinkel et al., 2017; Huberty et al., 2012; McMullen

et al., 2014; Stylianou et al., 2016; van den Berg et al., 2016; C. A. Webster et al., 2017). This study was likely too short of building the same community atmosphere, but student expression of enjoyment and looking forward to school are positive signs.

Participating teachers shared time, classroom behavior, interference with the daily activities as barriers which aligned with previous studies (Dwyer et al., 2003; Everson et al., 2009; Gately et al., 2013; Parks et al., 2007; Stylianou et al., 2016). These barriers may have more to do with their educational views and methods. The longer a teacher holds their views, the more established they become, making them difficult to alter (Pajares, 1992). New experiences that challenge old beliefs must render them unsatisfactory before experienced teachers are open to new instructional methods (Pajares, 1992; Prawat, 1992).

One benefit that was acknowledged was the ease of use Go Noodle provided. Many classrooms are equipped with computers and projectors, making a web-based product relatively easy to implement. All teachers shared this observation, and this was a significant selling feature for use in the future. Other websites similar to Go Noodle exist, providing teachers with multiple options while requiring little preparation for teachers to include these videos into the school day. Other movement integration avenues integrate academic lessons with movement, but these require more planning time for teachers. Even though academic lessons with movement have shown promising results, extra planning could be considered a downside for teachers.

While continuing to answer the questions of the time and intensity required to bring about specific academic and cognitive benefits is still needed, one strategy to overcome these barriers is integrating movement integration into part of the curriculum for preservice teachers. Preservice teachers are more malleable in their educational beliefs, still building confidence in affective instructional methods, and seeking to apply their understanding of theory through

numerous learning environments (Linker & Woods, 2018; C. A. Webster et al., 2019). Previous studies found preservice teachers developed a positive attitude toward CPAB, exhibited greater confidence implementing activity breaks, held few perceived barriers toward implementation, felted empowerment, and were more likely to implement CPAB in their classroom when they received movement integration training (Goh et al., 2013; C. Webster, 2011; C. Webster et al., 2010; C. A. Webster et al., 2013). Receiving training and practice under the guidance of a university education program allows preservice teachers the environment to learn and grow in their abilities just as they do for all other areas of their education preparation (Allsopp et al., 2006).

This study found that students and teachers are accepting of classroom physical activity breaks. Feasibly implementing activity breaks still has obstacles. Future research needs to answer what benefits are associated with specific time lengths and intensity needed to bring about students' positive academic and cognitive benefits. Training preservice teachers in the benefits and implementation methods of CPAB could bring about a new avenue for implementation with teachers who hold greater confidence and a stronger belief in the benefits that students receive as a result of regular participation in CPAB.

Table 2: Student Descriptive Statistics n (% or mean ± SD.)

	Total	Girls	Boys
N	28	18	10
Age	10.8 ± .5	11 ± .4	11 ± .6
% Income >45,000	16 (64)	12 (48)	4 (16)
Education ≥ Bachelor's	3 (12)	2 (8)	1 (4)
BMI	22.1 ± 6.48	21.7 ± 6.73	23 ± 6.28
% MBI ≥ 95th percentile	42	21.1	36.8

Table 3: Post-study Student Questionnaire Response n (%)

Questions	Yes	Not Sure	No
Did you enjoy the classroom physical activity breaks?	21 (84)	3 (12)	1 (4)
Did you like the Go Noodle videos?	17 (68)	7 (28)	1 (4)
Did you look forward to school on days you had CPABs?	22 (88)	2 (8)	1 (4)
	More Awake	Same	Tired/Sleepy
How did you feel after the activity breaks?	20 (80)	4 (16)	1 (4)
	More Focused	No Difference	Not Focused
Describe your schoolwork after the CPABs?	14 (56)	10 (40)	1 (4)
	Yes	Maybe	No
Would like to have CPABs every week?	12 (48)	12 (48)	1 (4)

Chapter 5 - Title: Pilot Study on Classroom Physical Activity Breaks Finds Task Switching Test Measure to Be Reliable in Elementary Aged Students

Abstract

Objectives: To determine the Plus Minus Task assessment measure's reliability and the preliminary dose-response of acute physical activity on shifting in elementary students' executive function.

Methods: This was a mixed-methods pilot study with fifth-grade students (n=28). Utilizing a within-subject, cross-over design, students participated in three treatment conditions, including a control condition of a 10-minute seated lesson and experimental conditions of 5 and 10 minutes of classroom physical activity breaks. Results: The Plus Minus Task assessment had excellent reliability. Physical activity breaks had a statistically significant (p = .009) negative impact on student shifting at 5 minutes and no effect after 10 minutes (p = .67). Conclusions: Although this study found the Plus Minus Task test measure for assessing switching in elementary students to have excellent reliability, continued research is needed to establish its reliability. Additional research is needed to determine if a combination of high cognitive engagement and high physical activity and/or a particular length of a classroom physical activity intervention are a requirement before shifting is heightened in elementary students.

Introduction

The 2018 Physical Activity Guidelines for Americans cite numerous health benefits for participating in regular physical activity, including improved bone and muscle health, reduced risk of chronic diseases, self-confidence and self-esteem, and reduced stress levels (US Department of Health and Human Services, 2018). Regular physical activity has also proven beneficial for students academically, cognitively, and behaviorally (Best & Miller, 2010; Efrat,

2011; A. Fedewa, 2011; Keeley & Fox, 2009; Sibley & Etnier, 2003; Singh et al., 2012; Tomporowski et al., 2011). Despite these benefits, only 24% of students age 6 to 17 achieve daily recommended physical activity minutes of 60 or more (Child and Adolescent Health Measurement Initiative (CAHMI), 2021). More concerning is that schools provide students with about 70% of their daily physical activity but have reduced students' physical activity opportunities to focus attention on core class instruction (Guinhouya et al., 2009). Holding teachers and schools accountable for student progress has increased sedentary behaviors for students. Removing avenues for students to be physically active may not promote student success. Castelli et al. found physically active students perform better academically than their inactive classmates (Ahamed et al., 2007; Carlson et al., 2008; Castelli et al., 2007; Trudeau & Shephard, 2008). Reducing physical activity during the school day may hinder students' physical and mental health and academic achievement.

The CDC and SHAPE have developed the Comprehensive School Physical Activity Program (CSPAP) to help schools promote opportunities for movement beyond just physical education and recess (Centers for Disease Control and Prevention, 2013). However, it is essential to understand which physically active interventions are beneficial and realistic for teachers to implement. One school day activity that has shown promise during school is classroom physical activity breaks (CPAB). CPAB is a short period of physical activity in elementary classrooms, usually led by classroom teachers, and with reduced time in physical education and recess are promising avenues for increasing a student’s daily physical activity during the school day.

These activity breaks have been explored for their effect on cognition, behavior, and academics, with some positive impacts observed in the learning environment. Executive function skills allow individuals to adapt to novel or changing situations (Gilbert & Burgess, 2008). These

skills play an essential role in the learning process for students. They are seen in the classroom when students exhibit the ability to store and process information (working memory), can ignore certain stimuli while staying on task (inhibition), and can move back and forth between tasks (shifting) (Tracy P. Alloway et al., 2008; Bruce & Bruce, 1996; Bull et al., 1999; Bull & Scerif, 2001; Lorsbach et al., 1996; Posner, M.I. & DiGirolamo, 1998).

Thus far, studies exploring CPAB, listed in Table 2, have explored on-task behavior, inhibition, academic subjects, working memory, cognitive function, and shifting. Thus far, seven studies have examined on-task behavior, all finding positive results regardless of time (Kubesch et al., 2009; Ma et al., 2015; Mavilidi et al., 2020b; Raney et al., 2017; Szabo-Reed et al., 2017; A. Watson et al., 2017). Five have explored inhibition with only one resulting in a significant difference after 10 minutes of activity (Egger et al., 2019; Kubesch et al., 2009; Mavilidi et al., 2020b; Schmidt et al., 2016; van den Berg et al., 2016). Five other researchers looked at impacts on academic subjects; three found positive results after 10 minutes of activity, two in the area of math and one in the area reading (Donnelly et al., 2017; Egger et al., 2019; A. L. Fedewa et al., 2018; Howie et al., 2014; Mavilidi et al., 2020a). Four researchers examined the impact on working memory with no significant effect (Egger et al., 2019; Howie et al., 2014; Kubesch et al., 2009; Mavilidi et al., 2020a). Two studies assessed cognitive function impacts with only Hill et al. find a positive result (Hill et al., 2010; Howie et al., 2014). Finally, only Egger et al. specifically explored the impact of physical activity on shifting and found that at least 10 minutes of physical activity along with high cognitive engagement produced a positive result in elementary school students (Egger et al., 2019). The outcomes of these studies show that CPAB positively influences on-task behavior regardless of time length, but at least 10 minutes of physical activity is required for educational benefits in math and reading.

Further examining these studies shows that effects vary across doses. At least 10 minutes of time inactivity contributed to positive benefits for academic subjects, cognition, inhibition, and shifting (Egger et al., 2019; A. L. Fedewa et al., 2018; Hill et al., 2010; Howie et al., 2015; Schmidt et al., 2016). On-task behavior studies found positive benefits at varying doses (Kubesch et al., 2009; Ma et al., 2015; Mavilidi et al., 2020a; Raney et al., 2017; Szabo-Reed et al., 2017; A. Watson et al., 2017). Determining the dose-response needed to bring about a positive result is essential for teacher implementation of physical activity breaks (Dwyer et al., 2003; Erwin et al., 2011; Everson et al., 2009; Gately et al., 2013; Howie et al., 2014; McMullen et al., 2014; Parks et al., 2007; Stylianou et al., 2016).

Past studies have focused on two principal executive function skills, working memory and inhibition. The third area, shifting, has mostly been left out with only one study to date (Egger et al., 2019). Shifting is a necessary skill because students must engage in one set of activities while disengaging from the previous set throughout the school day. Determining how acute bouts of physical activity impact switching in the classroom is an area that needs further exploration. Only one previous study has examined the effects of CPABs on switching. Egger et al. research intervention consisted of two 10-minute CPAB each day over 20 weeks with assessments before and after the invention (Egger et al., 2019). This study did not explore effects across more than one duration of CPAB length and examined chronic effects. Additionally, assessments 20 weeks apart, it is difficult to determine whether CPAB begins to impact shifting and if there are acute effects. Thus, research is needed to examine the dose-response of CPAB on switching.

Arthur T. Jersild developed the Plus Minus Task to assess a person's executive function skill of task switching (Jersild, 1927). Many of the previous studies using this test assessment

were with an adult population. Two particular studies with the adult population sought to determine if EF skills are separable. Each used the Plus Minus Task to assessing the role that shifting played with Hull et al. using an older test population (m age = 60.24) while Miyake et al. participants were undergraduate students (Hull et al., 2008; Miyake et al., 2000). Hull et al. found that shifting was not separable, while Miyake et al. found this skill to be separable in college students (Hull et al., 2008; Miyake et al., 2000). Only Hull et al. determined reliability for this assessment measure and found it excellent (.95) (Hull et al., 2008).

St. Clair-Thompson and Gathercole's study also looked at EF skills being separable, but instead of adults, they used 11 and 12 years of age. They also used the Plus Minus Task, along with the Local-Global Task, to measure switching. In addition to determining if EF skills are separable, they also sought the extent to which EF skills contributed to students' learning achievement in math, English, and science (St Clair-Thompson & Gathercole, 2006). In using the Plus Minus Task, they made one adaptation. Hull et al. and Miyake et al.'s studies used time to completion on each worksheet. Instead, St. Clair and Gathercole used a two-minute time limit for each worksheet, with switch cost being determined by the difference of correct answers on the alternating worksheet and the average of correct answers on the addition and subtraction worksheet within the given times. In the end, they determined that "no strong conclusions concerning the relationships between shifting and either other executive functions or learning can be drawn from this present study," and reliability was not determined for school-aged students (St Clair-Thompson & Gathercole, 2006).

This study seeks to determine the dose-response of 5 and 10 minutes of physical activity on the executive function area of task switching while also exploring the Plus Minus Task assessment tool's reliability to measure task switching.

Methods

Study Design

This was a pilot study of a classroom physical activity break intervention. Utilizing a within-subject, cross-over design, students participated in a practice day and then all three treatment conditions: a 10-minute seated lesson (control condition) and 5 and 10 minutes (experimental conditions) of classroom physical activity breaks. A Latin Square Design was employed to randomize the treatment conditions by classroom. Students participated in two treatments each week over two weeks. Data was collected through parent/guardian pre-study questionnaires and pre and post-tests of the Plus Minus Task. All methods and procedures were approved by the University of Arkansas Internal Review Board. Letters with information regarding this study were sent home to parents/guardians alerting them to the opportunity to participate along with their child. Consent and assent forms were made available to both parents and students to review and consider participation. Students who returned signed parent consent and student assent forms were allowed to participate.

Participants

The participants were 28 students (18 girls and 10 boys) and 3 teachers from three fifth-grade classrooms from a public elementary school in Ohio. The student ranged in age from 10-12 years old. Students who could participate in regular classroom activities and did not have accommodation preventing participation in the Plus Minus Task or physical activity were eligible. All instructions by staff were given in English. The researcher has no previous relationship with the school, its administration, teachers, or the students before beginning this study.

Procedures

Recruitment was conducted through direct school contact. The researcher contacted school principals to inquire about school and classroom participation through in-person visits and email invitations. Once school and teacher participation was granted, the researcher visited each of the participating classrooms to invite them to participate in the two-week study. Participating parents/guardians completed a demographics questionnaire. All classrooms participated in a practice day treatment to introduce assessment and physical activity delivery. The conditions were given in random order over two weeks with two treatments each week. Students began each session with 10 minutes of seated reading, followed by taking the Plus Minus Task pre-test. After the pre-test, students participated in one of three physical activity events (no physical activity, 5 minutes, or 10 minutes of physical activity) and then finished with a post-test assessment of the Plus Minus Task.

Treatment conditions

Go Noodle is a web-based physical activity site providing various activities and video lengths for teacher use. For our study, three videos were selected, primarily selected for video duration, age appropriateness, and activities that would bring about moderate to vigorous physical activity. A four-minute video was selected for the practice day, and a five and ten-minute video was selected for the testing sessions. A wide range of activities was incorporated in each video, including but not limited to air squats, toe taps, arm movements, jogging in place, animal movements, dodging, and jumping over oncoming objects. The physical activity video's goal was for students to achieve time in moderate to vigorous physical activity.

Assessments

Before testing, parents/guardians completed a demographics questionnaire about income background, educational level, and their child's height and weight to determine body mass index (BMI). This study used the CDC's BMI calculator for children and teens to determine each participating student's percentile rank and description.

The Plus Minus Task was used to assess switch costs in students. This assessment consisted of three two-minute math assessment worksheets consisting of thirty problems. The first worksheet was addition only. The second was subtraction only, and the third alternated between addition and subtraction problems. All problems were two-digit numbers, and students either added or subtracted three to or from the number. Switch cost was determined by calculating the difference between correct answers on the alternating test and the average of correct answers on the addition and subtraction tests (St Clair-Thompson & Gathercole, 2006).

The modified Borg RPE Scale was used to measure student's level of activity following each video. See Appendix A. This modified scale ranged from 1 to 10 with a 1 rating equal to resting and a 10, which is maximum exertion to the point where the body is telling the child to stop exercising. This assessment was chosen instead of the traditional Borg RPE scale because we believe that a 1 to 10 scale was more straightforward than a 6 to 20 scale for students. Students self-rated their perceived level of exercise after each movement video.

Analysis

Descriptive statistics were calculated for the whole group using SAS 9.4. The Plus Minus Task's reliability was assessed using the intraclass correlation coefficient (ICC) with all pre-test scores. Based on ICC estimates reliability was determined, values less than .5 (poor), .5 to .75 (moderate), .75 to .9 (good), and .9 or above (excellent) (Koo & Li, 2016). Using a repeated-

measures ANOVA, switch cost scores were compared between all treatments. Due to absences, complete data for 21 students were used to compute findings in this study. University of Arkansas computers containing Statistical Analysis Software (SAS 9.4) was used to examine this study's result.

Results

Students (n=28, 10 boys and 18 girls) from three fifth-grade classrooms participated in this study. The age range was 10 to 12 years of age, with a mean age of 10.8 years. Height and weight from parent/guardian pre-study questionnaires showed that half this group (53%) was a normal weight for their age and sex while 26% were overweight and 16% were obese. 64% of students came from at least a middle-class household, and 12% of their parents/guardians achieved a bachelor's degree or higher. Participation for each of the three test days varied due to absence. No physical activity (n=27), 5-minute of physical activity (n=24) and 10-minutes of physical activity (n=26).

The reliability of the Plus Minus Task was excellent at .97 across all pre-test scores. The objectively measured switch cost showed a significant negative difference after 5 minutes of physical activity at -2.4 (p =. 0084), and no difference was observed after 10 minutes at 1.6 (p = .6772) when compared to the seated lesson (no physical activity). Figure 2 and Table 4 shows switch costs for students across all pre and post-tests.

The result of how physical activity impacts shifting in students showed that 5 minutes of physical activity brought a significant negative switch cost difference (p=.0084) compared to no physical activity. Students ended up performing worse in their switching ability. After 10 minutes of physical activity, students performed better when compared to 5 minutes of physical

activity (p=.0026). However, no significant difference was observed when comparing 10 minutes of physical activity to no physical activity (p=.6772). See Table 5.

Discussion

This pilot study was the first, to our knowledge, to examine the reliability of the Plus Minus Task assessment tool in elementary school students, which is used to measure the executive function (EF) skill of task switching. Our study found excellent reliability of this assessment measure. This study also examined the effect of acute bouts of physical activity on students task switching across two different times. The results showed that five and ten minutes of physical activity were not enough to positively change a student's switch cost.

Test Reliability

Our first aim of this study was to determine the reliability of this long-used assessment measure. One study by Hull et al. found excellent reliability, but to our knowledge, no other study with school-aged students has determined its reliability (Hull et al., 2008). We chose this assessment because it replicates an everyday classroom activity. Math worksheets are typical activities, and addition and subtraction skills should be well established by fifth grade. We chose to use the same assessment modification that St. Clair and Gathercole used because we had participants of similar ages, which allowed us to compare results.

We sought to investigate how two different time doses of physical activity affected a student's shifting compared to no physical activity. In comparing results, they show a mean switch cost of 11.51. We assume this means a favorable switch cost of 11.5, but it was difficult to determine from the article's description and tables (St Clair-Thompson & Gathercole, 2006). We found very different results with our pre-test switch cost scores to be negative, ranging from -4.1 to -0.5 and our post-test scores ranging from -3.0 to -0.9. When we calculated the total

switch cost after physical activity (post-test switch difference – pre-test switch difference), we found a range of -2.4 to 3.3. See Figure 2 and Table 4. There is a large discrepancy in results between the two studies making an interpretation as to why difficult. Our use of the Plus Minus Task was slightly different in that we gave it as a pre and post-test around a physical activity treatment while St. Clair and Gathercole made a one-time assessment. Future studies with elementary students will have to use the Plus Minus Task in the same way to clarify our results, as only two studies have used this assessment tool with elementary students. Even though our reliability of the Plus Minus Task falls in line with Hull et al., future research should also explore this assessment tool's reliability with a larger pool of elementary students (Hull et al., 2008).

Dose-response

The second aim of this study was to determine if 5 or 10 minutes of physical activity would positively affect a student's shifting ability. Our results fall in line with previous studies that found that 5 minutes of physical activity moderate intensity does not bring about positive results for shifting but is similar to other studies on executive function skills like working memory and inhibition (Howie et al., 2015; Kubesch et al., 2009; Mavilidi et al., 2020a). Although we observed improvement from 5 to 10 minutes of physical activity, there was no difference when we compared the result with no activity. Many of the previous research found that at least 10 minutes of moderate to vigorous physical activity was necessary to bring about positive results (Egger et al., 2019; A. L. Fedewa et al., 2018; Hill et al., 2010; Howie et al., 2014; Szabo-Reed et al., 2017). Only studies with on-task behavior found positive improvements with less than 5 minutes of physical activity (Mavilidi et al., 2020a; A. J. L. Watson et al., 2019).

Comparing our results of switching to those of Egger et al., we found that a one-time acute bout of physical activity at 5 and 10 minutes were not enough to bring about a positive

result in students. Egger et al. found that there was a positive switching result after two ten-minute breaks over 20 weeks. Future studies will have to explore how CPAB interventions affect switching in students. Additionally, testing more regularly for extended studies will help determine how these benefits begin to show up.

Executive Function Skill of Shifting

This study found that acute doses of physical activity did not positively affect students shifting skills. There was a negative effect after 5 minutes of physical activity compared to no activity, and comparing 10 minutes of activity to no activity, there was no difference. While students found the activity breaks enjoyable and expressed that they were more awake and alert for learning, it did not positively translate in their ability to move back and forth between activities.

Comparing our results with Egger et al.'s findings, there are two items to note, time and method. First, the study was designed to have two ten-minute sessions per day over twenty weeks. Second, three test groups were used, a combo group with high levels of cognitive engagement and physical exertion, and aerobic group with low cognitive engagement and high physical exertion, and a cognition group with high cognitive engagement and low physical exertion. It was determined that only the combo group (high cognitive engagement and high physical exertion) found a positive shifting result.

Part of eliciting a positive result for shifting may be the dual requirement of high physical exertion and high cognitive engagement. Nevertheless, there may be another reason to consider our results; shifting is the last three EF skills to develop (Brocki & Bohlin, 2004). In Brocki and Bohlin’s research of students age 6 to 13, they share that inhibition is the first to develop, followed by working memory, and last is shifting (Brocki & Bohlin, 2004). It is crucial to keep

in mind that EF skills are not fully developed until after adolescents but can be developed during the school years (Verburgh et al., 2013). Since shifting is the last EF skill to develop, it may be too early for elementary students to show a response after only two acute doses of physical activity.

Future studies should consider a more extended intervention across multiple times, such as 10 and 15 minutes, and have more testing to determine what time length benefits begin for students. Additionally, using at least two assessment tools, like the Flanker Test and the Plus Minus Task, will help validate results. Our study, as well as Egger et al., used only one assessment for shifting.

Generalizability

CPAB provided students with an avenue to increase their physical activity during the school day. Short periods like 5 and 10 minutes video lengths made it easy to fit into the class day. School classrooms are usually equipped with computers and projectors making it easy to implement for our study.

The Plus Minus Task was a task that students were already familiar making it easy to use for executive function switching assessment. By 5th grade, students can add and subtract, making this assessment easy to implement.

Go Noodle videos provide a wide variety of fun movement activities that students enjoy. They are designed for the classroom, making them appropriate for CPAB.

Limitations

This pilot study had three main limitations. First, our sample size was small, which likely impacted our results when comparing switch costs across both time lengths. Secondly, this assessment's low-stakes nature could have contributed to the student's approach to testing. Since

students did not receive credit or a grade for their participation, it could be suggested that students may not have put forth their best effort. With a small sample size, one or two students' poor effort would significantly affect the whole and reduce the likelihood of a significant positive result. Third, the determination that CPABs did not positively impact a student's switch cost may have been due to the short exposure time to CPAB and the aerobic-only activities. Switching may require a more prolonged and more regular exposure to CPAB along with a high level of physical activity that is cognitively engaging.

Implications

Implementing classroom physical activity breaks into the regular school day is a positive step to increasing students' physical activity during the school day. Interventions such as this encourage an active lifestyle and can assist in combating the harmful effects of inactivity. While being more physically active is a positive health benefit, determining a positive academic relationship will hopefully encourage teachers and schools toward implementation. Additionally, establishing the amount of time needed to achieve cognitive, behavioral, and academic benefits would benefit teacher planning and implementation.

This pilot study found that the Plus Minus Task was a reliable assessment tool to measure shifting with elementary students. We also found that acute doses of 5 and 10 minutes of physical activity did not positively affect students shifting abilities. Additional research is needed to clarify the role that physical activity plays in a student's learning environment.

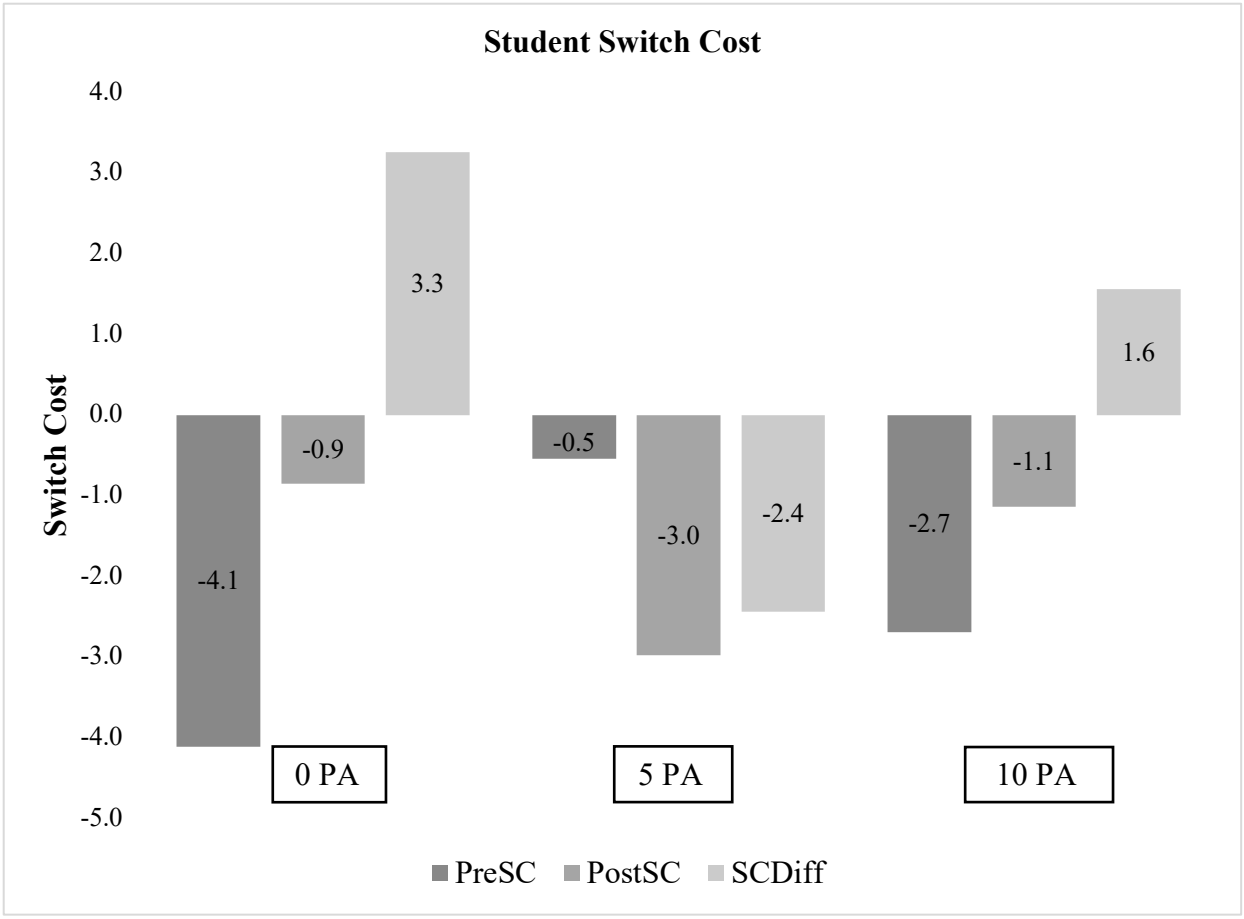

Figure 2

Table 4: Switch Cost Descriptive Statistics

Variable - Time	N	Mean	SD	Minimum	Maximum
0	27	3.259	6.565	-17.500	16.000
5	24	-2.438	4.066	-12.000	3.500
10	26	1.558	5.313	-8.000	14.000

Table 5: Switch Cost Comparisons Significant at the 0.05 Level

Time Comparison	F Value	P-value	Sig.
0 - 5	8.55	0.0084	***
0 - 10	0.18	0.6772	
5 - 10	11.79	0.0026	***

Chapter 6 - Discussion

There were three aims in conducting this pilot study. First, determine the reliability of the Plus Minus Task assessment used to measure switch cost. Second, determine the feasibility and acceptability of CPAB by students and teachers. Finally, determine the preliminary dose-response of acute physical activity on shifting in elementary students. To our knowledge, this was the first study to find that the Plus Minus Task was a reliable test measure for assessing shifting in children aged 10 to 12. We also discovered that students enjoyed CPAB, looked forward to school on days they had CPAB, and expressed that these breaks helped them feel more awake and alert for future learning. Teachers were supportive of incorporating physical activity breaks in the future but time and specific benefits associated with activity breaks were concerns regarding future implementation. Lastly, it was determined that neither 5 nor 10 minutes of classroom physical activity promoted a positive change in a student's switch cost when compared to a 10 minute seated activity.

Test Reliability

This study aimed to determine the Plus Minus Task assessment tool's reliability to measure a person's shifting ability. This tool has been used with adult populations and only recently has been adapted for use with school-aged students, but its reliability is unknown in both populations? (Baddeley et al., 2001; Hull et al., 2008; Miyake et al., 2000; St Clair-Thompson & Gathercole, 2006). A previous study by Hull et al. found excellent reliability when investing EF skill separability in an older adult population, but to our knowledge, no other study with school-aged students has taken steps to determine its reliability (Hull et al., 2008). St. Clair-Thompson and Gathercole's study also used this test measure to examine EF skill separability in elementary students but did not publish reliability. Our results revealed excellent reliability, which aligns

with Hull et al.'s findings (Hull et al., 2008). In the end, we chose this assessment because it measured switch cost, an important construct, but it also fit well into normal class day activities.

Our use of the Plus Minus Task was different from St. Clair and Gathercole's study in that we gave this assessment as a pre and post-test around a physical activity treatment while they used a one-time assessment. We sought to investigate how two different time doses of physical activity affected a student's shifting compared to no physical activity. Although different aims, we used the same participants and viewed it as an excellent opportunity to compare results.

In following the same calculation as St. Clair-Thompson and Gathercole's study to arrive at a student's switch cost, our results appeared very different (St Clair-Thompson & Gathercole, 2006). The instructions are to average the additional and subtraction tests' scores and subtract the total correct on the alternating test. In following these steps, they show a mean switch cost of 11.51. We assume this means a favorable switch cost of 11.5, but it was difficult to determine from the article's description and tables (St Clair-Thompson & Gathercole, 2006). We found very different results with our pre-test switch cost scores to be negative, ranging from -4.1 to -0.5 and our post-test scores ranging from -3.0 to -0.9. When we calculated the total switch cost after physical activity, we found a range of -2.4 to 3.3. There is a large discrepancy in results between the two studies making an interpretation as to why difficult. Future studies will have to help clarify our results by administering the Plus Minus Task assessment and then calculate the switch cost difference using the same procedure as St. Clair-Thompson and Gathercole and our study.

Feasibility and Acceptability of Classroom Physical Activity Breaks

The second aim of our study was to determine the acceptability and feasibility of CPAB. Students and teachers are key stakeholders, and we found that both students and teachers were

accepting of having physical activity breaks in the classroom but teachers realistically implementing these regularly were questionable. Teachers and students held very different ideas and views on these exercise breaks.

Students found these short activity breaks to be enjoyable, made them feel more awake and alert for future learning while looked forward to school on days they had CPAB. Encouraging students to be more physically active during the school day is needed to meet daily activity goals, and finding activities that students enjoy increases the likelihood of participation (Allender et al., 2006; Bragg et al., 2009; De Bourdeaudhuij et al., 2005). Additionally, students found these breaks beneficial to their learning environment. These findings are supported by other studies exploring the feasibility of CPAB (Calella et al., 2020; Masini et al., 2020). The last result of students looking forward to school on CPAB was encouraging as this promotes greater school engagement while likely reducing absences and leading to academic success (Abbott-Chapman et al., 2014).

Teachers in our study were also supportive of physical activity breaks but wanted more researched-based information on the classroom impact before they would regularly implement for longer than a quick break. References to quick breaks show that these teachers were more supportive of 5-minute CPAB, and only with additional research would they look to implement activity breaks of 10 minutes or more. They also share that breaks would only be included if their schedules allowed and if students could exhibit self-control. While supportive, the veteran teachers seemed more set in their teaching methods and beliefs, which may play a more significant role in regular implementation even with more research data.

One benefit that was acknowledged was the ease of use Go Noodle provided. Many classrooms are equipped with computers and projectors, making a web-based product relatively

easy to implement. All teachers shared this observation, and this was a significant selling feature for use in the future. Other websites similar to Go Noodle exist, providing multiple options while requiring little preparation for teachers. Other CPAB is not as easy to implement, requiring teachers to learning movements before leading their class, while others require teachers to combine movements with an academic lesson (Donnelly et al., 2017; Hill et al., 2010; Howie et al., 2014, 2015). These types of interventions add to the workload of teachers, making them less likely to implement.

The future of classroom-based physical activity implementation hinges on overcoming barriers. Teachers in this study cited time, classroom behavior, and interference in daily activities as their barriers. These concerns are similar to other studies, but it may be that these hesitations are more about challenging currently held teaching beliefs and methods (Calella et al., 2020; Dinkel et al., 2017; Masini et al., 2020; Turner et al., 2019). Teachers with more experience may not be as open to making changes to their teaching ways as students in university teacher education programs. Preservice teachers are more malleable in their educational beliefs, still building confidence ineffective instructional methods, and seeking to apply their understanding of theory through numerous learning avenues. Previous studies found positive results when preservice teachers were trained in movement integration. These included participants having a more positive attitude toward CPAB, exhibited greater confidence level in how to implement activity breaks, felted empowerment towards implementation, held few perceived barriers toward implementation, and were more likely to implement CPAB in their classroom (Goh et al., 2013; C. Webster, 2011; C. Webster et al., 2010; C. A. Webster et al., 2013). Receiving training and opportunity under the guidance of a university education program allows preservice teachers the

environment to learn and grow in their abilities just as they do for all other areas of their education preparation (Allsopp et al., 2006).

This study found that students and teachers are accepting of classroom physical activity breaks. Feasibly implementing activity breaks still has obstacles, but training preservice teachers may pave the way for broader and more supportive implementation. Preservice teachers who have movement integration training as an undergrad were shown to hold greater confidence and a stronger belief in the benefits that students receive due to regular CPAB (Linker & Woods, 2018).

Teachers in the study mentioned time, classroom behavior, and interfering with the day's activities as why they struggle seeing themselves incorporating these breaks regularly or for longer than a quick break. These teachers may be more established in their educational beliefs and teaching methods, making it more difficult to change behaviors. Preservice teachers, on the other hand, are youth in their educational beliefs, still building confidence in affective instructional methods, and seeking to apply their understanding of theory through numerous learning environments. Previous studies found that after preservice teachers receive movement integration training, they demonstrated a positive attitude towards CPAB, exhibited greater confidence implementing activity breaks, held few perceived barriers towards CPAB, felt empowered, and were more likely to implement CPAB in their classroom (Goh et al., 2013, 2013; C. Webster et al., 2010; C. A. Webster et al., 2013). While under the supervision of a university education program, training provides preservice teachers an environment to learn and grow in their movement integration abilities. Linker and Woods found that after a movement integration course, all preservice teachers in their study said they would integrate CPAB into their classroom while feeling the planning is easy (Linker & Woods, 2018). Future studies

should explore if movement integration coursework during teacher education programs can overcome commonly cited teacher barriers in hopes of more effective teacher implementation of CPAB.

Executive Function: Shifting

We found that 5 minutes of physical activity was not enough to bring about a significant switch cost difference compared to no physical activity, with students performing worse in their switching ability. After 10 minutes of physical activity, students performed better when compared to 5 minutes of physical activity. While no significant difference was observed when comparing 10 minutes of physical activity to no physical activity, students did not perform worse. Students found the break enjoyable and expressed that they were more awake and alert for learning, but it did not translate into being about to move back and forth between activities.

Most of the previous research found that at least 10 minutes of moderate to vigorous physical activity was necessary to bring about positive results in students (Egger et al., 2019; A. L. Fedewa et al., 2018; Hill et al., 2010; Howie et al., 2014; Szabo-Reed et al., 2017). A few studies found positive improvements with less than 5 minutes of physical activity but only in on-task behavior (Citation Ma 2014, 2015, and Raney 2017). While other studies have explored more extended periods, we determined that 20 minutes of physical activity was not realistic for classroom implementation and focused on 5 and 10 minutes of activity. Only one other study compared physical activity effects across more than one-time dose-finding improvements in on-task behavior and math fluency after 10 and 20 minutes (Howie et al., 2015).

The executive function of shifting has largely been ignored in previous CPAB research. Only Egger et al. have recently explored this essential EF skill and found that elementary students shifting ability improved after a 20-week CPAB intervention (Egger et al., 2019). This

finding is an important result because students regularly move from one activity to another throughout their day without the benefit of physical activity breaks. After all, teachers are worried about time and do not want to disrupt the day's activities. The ability for students to engage and disengage between activities plays an essential role in their academic pursuits.

EF skills play an important role in student learning, but so far, CPAB has found limited success in enhancing working memory, inhibition, and shifting skills. So far, only Schmidt et al. and Egger et al. have observed positive inhibition and shifting results, respectively (Egger et al., 2019; Schmidt et al., 2016). On-task behavior seems to benefit the most from CPAB (Howie et al., 2014; Mavilidi et al., 2020a; Raney et al., 2017; Szabo-Reed et al., 2017; A. Watson et al., 2017).

A downside to this research is that many of the assessments used to test EF skills are time-consuming, making school collections a challenge. Additionally, the COVID-19 pandemic has made in-school collections difficult.

This study found that the Plus Minus Task is a reliable assessment tool for measuring shifting in elementary students aged 10-12. We also discovered that 5 and 10 minutes of physical activity did not elicit a positive effect on student shifting abilities.

Future studies should consider an extended intervention across multiple times, such as 10 and 15 minutes, and have more testing to determine what time length benefits begin to show up for students. Additionally, using at least two assessments measure will help provide richer and more accurate results.

Generalizability

Finding avenues and opportunities for students to increase their physical activity during school are positive steps towards encouraging students to be more active. These activity breaks

can be used at all ages and grade levels. Students enjoy and look forward to school on CPAB days, which helps to build school engagement. Even short periods of physical activity help students meet daily recommended activity guidelines.

CPAB is easy to implement into the classroom setting for all grade levels and requires no training to begin using. Websites like Go Noodle limit the planning time for teachers, and there are a wide variety of video types and lengths available. Technology within the school building has made access and projection a regular part of today's classroom.

Limitations

This study had three main limitations. First, our sample size was small, which likely impacted our results when comparing switch costs across both time lengths. Additionally, only three teachers shared their views, and even though their opinions reflect many past study findings, it is always beneficial to have a more extensive sample feedback. Secondly, this assessment's low-stakes nature of the Plus Minus Task could have contributed to the student's approach to testing. Since students did not receive credit or a grade for their participation, it could be suggested that students may not have put forth their best effort. With a small sample size, one or two students' poor effort could significantly affect the whole and reduce the likelihood of a significant positive result. Third, the determination that CPABs did not positively impact a student's switch cost may have been due to the short exposure time to CPAB and the aerobic-only activities. Switching may require a more prolonged and more regular exposure to CPAB along with a high level of physical activity that is cognitively engaging.

Implications and Future Research

Implementing classroom physical activity breaks into the regular school day is a positive step to increasing students' physical activity during the school day. Interventions such as this

encourage an active lifestyle and can assist in combating the harmful effects of inactivity. While being more physically active is a positive health benefit, determining a positive academic relationship will hopefully encourage teachers and schools toward implementation. Additionally, establishing the amount of time needed to achieve cognitive, behavioral, and academic benefits would be essential for teacher planning and implementation.

Future research should explore middle and high school-aged students to see how regular physical activity breaks impact older students. Studies should target EF skills and academic subjects similar to what has been studied in elementary students. Longitudinal study designs comparing regular daily CPAB and no physical activity throughout middle and high school can determine the effect physical activity has on a student's learning. Multiple assessments for each of the EF skills and standardized achievement tests can be used to assess the full impact of regular physical activity breaks on student achievement.

Chapter 7 - Conclusions

This study found that students are supportive of CPAB and feel they are beneficial to their learning environment. We also determined that the Plus Minus Task was a reliable assessment tool to use with school-aged students to measure the executive function skill of switching. Finally, while we did not find that acute physical activity positively affected students' switching abilities, research should continue to investigate the impact classroom physical activity has on students' learning environment. CPAB provides students an enjoyable way to receive more physical activity during the school day while feeling more awake and on-task for future learning.

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Appendices

Appendix A: Modified Borg RPE Scale for Kids:

RPE Scale for Kids

RPE stands for **Relative Perceived Exertion**. Relative Perceived Exertion means, "How hard do I feel I am exercising?" It is a tool you use to tell others how your body is feeling when you exercise. Kids who exercise in numbers 4-7 are getting moderate to vigorous exercise. That means your body is getting the right amount to be healthy! You should get 60 minutes of exercise in this range every day.

My Number...	My Face...	This what I may be thinking...	This is what my body may be doing...
1		This exercise is the same as resting.	I am getting ready to exercise, but I don't feel different yet.
2		This exercise isn't hard.	I am getting a little hot. I can still talk normally.
3		I am just beginning to feel like I am exercising.	I am feeling like my body is warming up.
4		I am starting to feel like I am exercising. I feel good!	I can almost talk in a regular voice, but it is getting harder!
5		This exercise is a good workout! I am really working hard.	My cheeks are getting pink. I am getting a little sweaty.

My Number...	My Face...	This what I may be thinking...	This is what my body may be doing...
6		I am exercising more than I thought. It is getting hard to do.	I feel like talking is getting harder – I have to stop sometimes for air.
7		This is pretty hard. I can exercise a little bit longer, then I'll stop.	I am getting really sweaty. My body is hot!
8		This exercise is really hard, but I'm not ready to quit.	I can talk a little, but not too much.
9		I need a break from this very, very hard exercise!	My face looks red. I feel like I need to stop.
10		I'm exercising too much! My body is making me stop now!	My heart is beating very fast and strong. I can't talk.

Appendix B: Pre-Study Parent/Guardian Questionnaire

Questions: Demographic Information

1. Name: first name, last initial, and relationship
2. What is the highest degree or level of school you have completed? (If you're currently enrolled in school, please indicate the highest degree you have *received.*)
    a. Some High school
    b. High School degree or equivalent
    c. Some college, no degree
    d. Associates degree (e.g. AA, AS)
    e. Bachelor's degree (e.g. BA, BS)
    f. Master's degree (e.g. MA, MS, Med)
    g. Doctorate degree (e.g. PhD, EdD)
3. Total household income (combined income)?
    a. Less than $20,000
    b. $20,000 - $44,999
    c. $45,000 - $139,999
    d. $140,000 - $149,999
    e. $150,000 - $199,999
    f. $200,000+
    g. Prefer not to answer
4. Please provide your child's first name, last initial, grade, and age.
5. Please provide your child's approximate height and weight.
6. Parents will also complete a C-PAQ.

Appendix C: Post-Study Focus Group Questions

Student Questions

1. In one word, describe CPABs.
2. How did you feel after CPABs?
3. Did you have a favorite length? Why?
4. How would you describe GoNoodle?
5. Did you have a favorite activity from GoNoodle?
6. Would you like to CPABs every week? Why or why not?
7. Would you change anything about the CPABs?

Teachers/Administrators Questions

1. What were your impressions of the CPABs?
2. Were these CPABs different than what you expected?
3. What were your observations from the last two weeks?
4. Can you see yourself implementing CPABs in your classroom? Why or why not?
5. Does the GoNoodle website make CPABs implementation easier? Why or why not?
6. Did you see any benefits in your classroom following CPABs?
7. If CPABs allowed students to be more attentive, able to move from activity to activity more easily, perform better academically while improving positive behaviors, would you find a way to implement CPABs into your classroom? Why or why not?
8. What were your overall all impressions of the CPABs?
9. What might you change/adjust?

Appendix D: Post-Study Questionnaires and Focus Group Interview Questions

Student Questionnaire

1. Did you enjoy the classroom physical activity breaks?

   Yes Not Sure No

2. Did you like the GoNoodle videos?

   Yes Not Sure No

3. Did you look forward to school on the days you had classroom activity breaks?

   Yes Not Sure No

4. How did you feel after the activity breaks?

   More awake and alert
   The same as before the activity break
   Tired, more sleepy

5. Describe your schoolwork after the activity breaks?

   I was more focus on my schoolwork
   I could not tell a difference
   I could not focus on my schoolwork

6. Would you like to have classroom activity breaks every week?

   Yes
   Maybe
   No

Teacher Questionnaire

1. Which describes your attitude related to classroom physical activity breaks prior to the event?

   I was excited to give them a try
   I was indifferent about them
   I was dreading the idea of them

2. After activity breaks, students were …

   More attentive
   No different

Less attentive

3. Describe students' overall reactions to the activity breaks.

   They enjoyed them.
   They were neutral towards them.
   They did not enjoy them.

4. Describe your students' academic focus following the physical activity break.

   Students appeared more focused after the activity break.
   There was no discernable difference in their focus.
   Students appeared less focused after the activity break.

5. On activity break days, students appeared more excited about coming to school.

   Agree
   No difference
   Disagree

6. How likely are you to implement classroom activity breaks in the future?

   Likely
   Uncertain
   Unlikely

Appendix E: IRB Approval

UNIVERSITY OF ARKANSAS

To:	Mark Bjornsen
From:	Douglas J Adams, Chair IRB Expedited Review
Date:	12/17/2020
Action:	**Expedited Approval**
Action Date:	12/09/2020
Protocol #:	2009281306A001
Study Title:	Classroom Physical Activity Breaks and Academic Achievement in Elementary Students
Expiration Date:	09/26/2021
Last Approval Date:	12/09/2020

The above-referenced protocol has been approved following expedited review by the IRB Committee that oversees research with human subjects.

If the research involves collaboration with another institution then the research cannot commence until the Committee receives written notification of approval from the collaborating institution's IRB.

It is the Principal Investigator's responsibility to obtain review and continued approval before the expiration date.

Protocols are approved for a maximum period of one year. You may not continue any research activity beyond the expiration date without Committee approval. Please submit continuation requests early enough to allow sufficient time for review. Failure to receive approval for continuation before the expiration date will result in the automatic suspension of the approval of this protocol. Information collected following suspension is unapproved research and cannot be reported or published as research data. If you do not wish continued approval, please notify the Committee of the study closure.

Adverse Events: Any serious or unexpected adverse event must be reported to the IRB Committee within 48 hours. All other adverse events should be reported within 10 working days.

Amendments: If you wish to change any aspect of this study, such as the procedures, the consent forms, study personnel, or number of participants, please submit an amendment to the IRB. All changes must be approved by the IRB Committee before they can be initiated.

You must maintain a research file for at least 3 years after completion of the study. This file should include all correspondence with the IRB Committee, original signed consent forms, and study data.

cc: Erin K Hickey, Investigator