Classroom Exercise Breaks and Educational Outcomes in Elementary School Students

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CLASSROOM EXERCISE BREAKS AND EDUCATIONAL OUTCOMES IN ELEMENTARY SCHOOL STUDENTS

By

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Bachelor of Science
University of Maryland, 2008

___________________________________
Submitted in Partial Fulfillment of the Requirements

For the Degree of Doctor of Philosophy in

Exercise Science

The Norman J. Arnold School of Public Health

University of South Carolina

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DEDICATION

To wiggling, dancing, and jumping children everywhere.

May you keep on moving.
ACKNOWLEDGEMENTS

Thank you to Dr. Pate who has set an example of the teacher, researcher, and leader I hope to become. I am grateful to Dr. Beets, Dr. Newman-Norlund, and Dr. Schatz for providing balance and their own individual expertise.

Many thanks to Keely Flynn for the hours of tedious video coding, Dr. Dowda for statistical guidance and Alisa Brewer for learning and sharing the exercise “moves”.

Thank you to the three girls who have inspired me since we were roaming the streets of Birdland and who always remind me to be awesome.

I will never be able to thank my family enough for everything they’ve done and instilling my love of physical activity. Thanks to my mom who put up with my “attitude” at every feis, my Dad who gave up his time to coach us unruly little girls on the soccer field, my sister who was the first person I ever knew to run five miles even if only for those miserable August tryouts, and my “little” brother, who learned all his badminton skills from me.

And the most sincere and genuine thanks to all the hearts, both big and small who participated in this study to make hearts healthier. It was the generous support of the school district, principal, teachers, and parents who made this study possible. Most importantly thank you for the smiles and honesty of the 4th and 5th graders who always remind me what this research is for.
Abstract

Previous research has shown that physical activity may have beneficial effects on cognitive performance and academic achievement in children, but the optimal type and dose are unknown. Classroom exercise breaks are one type of physical activity opportunity in schools, with the potential to reach a large number of children. The purpose of this dissertation was to describe the prevalence and characteristics of classroom exercise breaks in central South Carolina, and to determine the acute effects of classroom exercise breaks on executive functions, math performance, on-task behavior and affective responses in 9 to 12 year-old children. Additionally, the dissertation examined the dose-response relationship between 5, 10, and 20 minutes of classroom exercise and these educational outcomes. Finally, the dissertation examined whether these relationships between the duration of acute classroom exercise breaks and educational outcomes varied by student characteristics. The dissertation used multiple designs including cross-sectional surveys and an experimental design.

The first study included surveys and interviews with elementary school principals. Of the 61 reporting schools, 74 percent of principals reported practicing classroom exercise breaks, though only 8 percent had school policies requiring exercise breaks. In interviews with 14 principals, school-specific practices varied greatly. Less than half of the schools reported practicing regular, school-wide exercise breaks, while
almost all schools encouraged teachers to implement them according to teacher
discretion.

For the following three studies in this dissertation, a total of 96 4\textsuperscript{th} and 5\textsuperscript{th} grade
students participated in the Brain BITES (Better Ideas Through Exercise) intervention. A
within-subjects design was used. Students participated in each of four conditions: 10
minutes of seated classroom exercise, and 5, 10, 20 minutes of classroom exercise
breaks. All sessions were videotaped. Students completed a Trail Making Test,
operational digit recall task, and a one-minute math test before and after each
condition. Two observers coded student on-task behavior before and after the
conditions from video footage using a momentary time sampling protocol. Positive
affect during the sessions was also coded. Focus groups were conducted with students
and teachers after the intervention to discuss acceptability and feasibility of the
classroom exercise breaks. Repeated measures mixed model ANCOVAs with linear
contrasts compared the post-test scores between conditions. Interactions with student
characteristics including gender, intelligence (IQ), fitness, body mass index (BMI),
behavior, school engagement, baseline on-task behavior and physical activity
participation were examined.

The average physical activity intensity during the exercise conditions ranged
from 4.00 to 4.35 (1 is equal to lying down and 5 is equal to being very active). Math
performance improved after 10 minutes of classroom exercise breaks compared to the
sedentary condition (25.6 vs 24.4 math problems correct, \(d=0.28, p=0.03\)). On-task
behavior improved after 10 and 20 (87.6\% and 83.9\% vs 77.1\%, \(d=0.45, 0.29\),
p=.004,.056) minutes. Positive affect was higher in all three exercise conditions compared to the sedentary condition (5 minutes=46.6%, $d=1.54$; 10 minutes=45.5%, $d=1.56$; 20 minutes=36.1%, $d=1.15$; sedentary=7.8%). Students and teachers reported that the classroom exercise breaks were enjoyable to students, but teachers would only be able to implement five minutes or less in their classrooms.

Overall, this dissertation found that classroom exercise breaks are common practices in schools, though the characteristics of the practices vary on a school-to-school basis, and are acceptable to students, teachers, and principals. Ten minutes of classroom exercise breaks had the most beneficial effects on student educational outcomes including math performance, on-task behavior and positive affect. Schools should provide training, resources, and administrator support to provide classroom exercise breaks of this duration.
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CHAPTER 1

OVERALL INTRODUCTION

The majority of children do not meet recommended levels of physical activity.\(^1\) Inadequate physical activity results in multiple health consequences,\(^2\) thus increasing the physical activity of youth has become a national priority.\(^3\) Schools are a primary target for reaching large numbers of children, with over 95 percent of children attending schools.\(^4\) Unfortunately, instead of increasing physical activity opportunities, schools are reducing physical activity opportunities in response to reduced budgets and an increased focus on standardized testing.\(^5\),\(^6\) Ironically, reducing physical activity may lower the very academic achievement schools are trying to increase.

Research on the connection between physical activity and cognition has been conducted for over half a century. Large cross-sectional studies have found positive associations between physical activity,\(^7\) fitness,\(^8\),\(^9\) and physical education\(^10\) with multiple cognitive assessments and academic achievement measures. Experimental studies have also shown positive effects of acute\(^11\)-\(^14\) and regular physical activity\(^15\),\(^16\) on cognitive function and academic performance. While the evidence suggests a positive relationship between physical activity and cognition and academic achievement, there are remaining concerns about methodology and study rigor.\(^17\)-\(^20\) Even with the proliferation in the number of studies examining the connection between
physical activity and cognition in children, little is still known about the ideal duration and type of physical activity to maximize these benefits.

One way to increase physical activity throughout the school day is through classroom exercise breaks. Classroom exercise breaks are short bouts of physical activity that are integrated throughout the school day. Compared to physical education and recess, they require few additional resources and a brief amount of time, making them ideal for schools with reduced budgets and limited time in their rigidly structured curriculums. Because of these benefits, schools and teachers have begun implementing these practices. Despite the proliferation of classroom exercise breaks, little is known on how these practices are being implemented in schools as well as the effects on educational outcomes.

Few studies have examined the effects of classroom exercise breaks on student cognition or academic achievement. Three studies have looked at the effects of regular classroom exercise breaks on standardized test scores and found that scores in some subjects improved but results were inconsistent. Mahar et al. and Grieco et al. directly observed classroom behavior after an acute classroom exercise break and found that children improved or maintained on-task behavior compared to when they did not exercise. Only one study directly compared classroom exercise breaks to longer doses of physical activity. Kubesch et al. found children improved cognitive performance after 20 minutes of physical education, but not after a five minute of classroom exercise break. No previous studies have directly compared the acute cognitive effects of different durations of classroom exercise breaks.
To address the gaps in the existing literature surrounding classroom exercise breaks, this dissertation takes an epidemiological and experimental approach to better understand classroom exercise breaks in elementary schools. Little is known about the qualities of classroom exercise breaks that are being implemented in elementary schools. The purpose of Study One was to evaluate the prevalence and characteristics of existing classroom exercise breaks in elementary schools in central South Carolina. Using online surveys and phone interviews with principals, this study described what types of classroom breaks are being implemented in elementary schools, how they first started, barriers to implementation and any benefits or disadvantages of implementing these practices.

Previous studies on the effects of physical activity on cognition and academic achievement have not identified the ideal type and dose of physical activity to elicit these educational benefits. The remaining three studies in this dissertation used a within subjects, experimental design to examine multiple educational effects of classroom exercise breaks in 4th and 5th grade students and to examine the dose response relationship between 5, 10, and 20 minutes of classroom exercise breaks. This was the first study to directly compare the cognitive effects between multiple durations of classroom exercise. The purpose of Study Two was to determine the acute effects of classroom exercise breaks on executive functions and math performance and to examine the dose-response relationship between 5, 10, or 20 minutes of classroom exercise breaks and these cognitive functions. Additionally, the study examined whether the relationship between duration of acute classroom exercise breaks and cognitive
functions varied by student gender, intelligence (IQ), fitness, body mass index (BMI),
behavior, school engagement, and physical activity participation during the
intervention.

While there have been two previous studies that directly observed on-task
behavior after acute classroom exercise breaks,\textsuperscript{24,29} neither of these studies have
directly compared different durations of exercise or examined how the effects varied
based on classroom and individual characteristics. The purpose of Study Three was to
determine the acute effects of classroom exercise breaks on on-task behavior in
elementary school students and to examine the differences between 5, 10 and 20
minutes of exercise. Additionally, the effects were examined by individual classrooms
and several individual student factors including gender, intelligence quotient (IQ),
fitness, BMI, behavior, school engagement and baseline on-task behavior.

The fourth study examined the effects of a classroom exercise break on positive
affect in children. While physical activity has been shown to improve positive affect, and
enjoyment has been shown to improve educational outcomes, no studies have
objectively measured the effects of classroom exercise on positive affect. The purpose
of Study Four was to examine the affective responses, acceptability and feasibility of a
classroom exercise break intervention in elementary school students and to examine if
the effects differed between 5, 10, and 20 minutes of classroom exercise breaks. This
mixed-methods study used direct quantitative observations of positive affect and
qualitative focus groups with students and teachers to provide a holistic description of
the affective response to classroom exercise breaks.
References


CHAPTER 2

MANUSCRIPT 1: CLASSROOM EXERCISE BREAKS IN CENTRAL SOUTH CAROLINA: ‘IT’S NOT A WELL-OILED MACHINE’ BUT ‘KIDS ARE HAPPY AND PRODUCTIVE’

1 Howie EK, Beets MW, Newman-Norlund RD, Schatz JC, Pate RR. To be submitted to Teacher Education Journal of South Carolina.
Abstract

In order to comply with state physical activity policies and increase physical activity of students, schools have begun to implement classroom exercise breaks. Little is known about the characteristics of existing classroom exercise breaks. The purpose of this study was to evaluate the prevalence and characteristics of existing classroom exercise breaks in elementary schools in central South Carolina. Principals in elementary schools in central South Carolina were invited to participate in a brief online survey about classroom exercise breaks. Principals who reported classroom exercise breaks occurring in their school were invited to participate in a phone interview about the characteristics and implementation of classroom exercise breaks. Sixty-one principals responded to the online survey. Of those responding, 74 percent reported classroom exercise breaks in their school and only 8 percent reported a school-level policy requiring classroom exercise breaks. Interviews with 14 principals revealed that the characteristics of classroom exercise breaks vary widely between schools, with less than half of schools participating in regular, school-wide morning exercise breaks. Principals reported many benefits of classroom exercise breaks including improved student behavior and attention, with little resistance to or disadvantages of implementing classroom exercise breaks. Providing resources and example activities, training teachers to implement breaks, and building communities of practice may increase the prevalence of classroom exercise breaks.
Introduction

As children continue to fail to meet physical activity recommendations,\(^1\) many states have adopted policies to provide physical activity opportunities for children through schools.\(^2-4\) Many of these school-based policies have focused on physical education and recess.\(^2\) Unfortunately, faced by budget cuts and competing priorities, many school districts report reducing physical education.\(^5,6\) The Center for Education Policy reports that 68 percent of schools reported funding decreases to staff in non-core academic areas, including physical education, with another 50 percent anticipating further cuts in the 2011-2012 school year.\(^6\) While physical education and recess opportunities are being decreased, classroom exercise breaks are an alternative way to meet physical activity recommendations. Classroom exercise breaks do not require additional staff or require large amounts of time. These five to ten minute short bouts of exercise in the classroom are recommended as a tool to increase school physical activity,\(^7,8\) and many schools have begun to implement them.\(^2,9\)

South Carolina is one of the states that adopted a policy to increase physical activity in schools. In addition to requiring 90 minutes of physical education per week, South Carolina’s Student Health and Fitness Act requires 60 minutes of physical activity per week in addition to physical education.\(^10\) The physical activity time can include recess and other physical activity opportunities, including classroom exercise breaks. Principals must report their minutes of physical activity and physical education to the South Carolina Department of Education in an annual survey. This survey found that the number of schools participating in classroom exercise breaks in South Carolina has
grown over the past 5 years. Only 12 percent of responding principals reported classroom exercise breaks occurring in their schools in 2007-2008 compared to 66 percent reporting them in 2010-2011. In the most recent report, 38 percent of schools reported practicing video exercise (including aerobic videos, jazzercise, deskercise, FitKids, energizers), 35 percent reported morning exercise (including morning stretching, morning calisthenics, CORE exercise), and 66 percent reported classroom exercise led by teachers. Other than this brief survey, little additional information is known about these classroom exercise break practices in South Carolina or nationally, including the specific types of classroom exercise breaks in use, how the practices began in each school, and any benefits or disadvantages of implementing these practices.

A better understanding of these practices may help to improve and increase the implementation of classroom exercise breaks. Improving implementation through research of contextual factors that influence the process is important for school physical activity interventions. While previous studies have looked at the implementation of broad physical activity policies in other states, none have focused exclusively on classroom exercise breaks and few have used both quantitative and qualitative methods to uncover the process of implementation as well as perceived benefits and disadvantages. Mixed method approaches provide ideal inductive methods for uncovering this process. The purpose of this study was to evaluate the prevalence and characteristics of existing classroom exercise breaks in elementary schools in central South Carolina.
Methods

Study Design

This was a cross-sectional study using surveys and interviews to evaluate the practice of classroom exercise breaks in elementary schools in central South Carolina. Informed consent was obtained from school districts and participants. Complete confidentiality was maintained upon participant and school board decision. The study was approved by the University of South Carolina’s Institutional Review Board.

Participants

The study sampled public elementary schools in central South Carolina. There were 226 public elementary schools in this geographical location within 14 counties and 25 school districts. In consideration of efficiency in obtaining school district approval, districts with less than 4 schools were not included, resulting in a total sample of 192 schools, from 11 counties and 19 school districts. The demographic information for the sampled districts can be found in TABLE 2.1. Principals from all 192 schools were emailed to participate in an online survey about the prevalence of classroom exercise breaks and classroom exercise break policies. Principals who reported classroom exercise breaks in their school were invited to participate in a brief phone interview about the implementation of classroom exercise breaks.

All schools in eligible districts were categorized into four school demographic strata in order to examine variations in practices by school demographics. Stratum were based on the percentage of free-and-reduced lunch (FRL) and the percentage of students not meeting English and Math standards on 2010-2011 state assessments. The
four categories, as depicted in TABLE 2.2, included: low income/lower achieving, low income/higher achieving, high income/lower achieving, high income/higher achieving. These strata were selected based on a preliminary analysis of previously reported data from the 2010-2011 state physical activity report. A logistic model using school-level demographic and three self-reported classroom exercise break practices (video, morning exercises, and classroom exercises) from the state physical activity report was examined. There was a trend that schools with a greater percentage of FRL and more students not meeting state standardized test standards were less likely to report classroom exercise break practices.

**Measures**

*Online survey*

Principals were invited to complete a brief, five minute online survey on classroom exercise break practices in their school. All school districts were contacted for approval. Principals who did not respond after the initial email were sent a reminder approximately two-weeks later.

*Principal Interviews*

Principals who reported that classroom exercise breaks take place in their schools were invited by email to participate in a 10 minute, semi-structured phone interview. Principals who did not respond after the initial email were sent a reminder approximately one-week later.
Interview questions were constructed in advance according to Patton’s suggestions to include questions that are singular, open-ended, clear and neutral and of various types including opinion, role playing, and presupposition questions.\textsuperscript{20}

\textit{Standards of Validation}

To ensure the rigor of this qualitative study, trustworthiness as defined by Lincoln and Guba, including transferability, dependability and confirmability,\textsuperscript{21} was established through the following methods. Transferability is provided through a “thick description” of the schools included in the study, so that the results of this study may be generalized to other populations. Dependability (reliability) and confirmability (objectivity) were established through an audit trail.\textsuperscript{21} An audit trail was maintained throughout the study and included all initial correspondence with school district personnel and administrators, emails, interview notes, qualitative codes, and any written documents from schools.

\textit{Analysis}

Descriptive statistics are presented for the total group, the online survey responders and the interviewees. Results from the email surveys, including the prevalence of classroom breaks and classroom break policies are presented for all responders and by stratum. Using SAS 9.2, logistic models were used to test if the presence of classroom exercise breaks differed by school demographic strata. Detailed notes from the interviews were summarized into broad themes. Recurrent themes were then compiled across interviews.
Results

Survey Results

A total of 61 principals responded to the online survey for a response rate of 32 percent. Of those responding to the survey, 33 principals in participating districts and reporting classroom exercise breaks in their school were contacted to participate in a brief interview. Fourteen participated for a response rate of 42 percent. Principals responding to the online survey were in schools with slightly lower percentages of students receiving FRL, Poverty Indices, and students not meeting math and English standards as seen in TABLE 2.1. Of the 61 principals who responded to the online survey, 74 percent reported classroom exercise breaks in their school as seen in TABLE 2.3. Using a logistic model, the prevalence of classroom exercise breaks differed by school demographic strata ($p=.05$) with the lowest prevalence in Strata 3 (high FRL, high achieving) (54%) and the highest in Strata 1 (low FRL, high achieving) (90%). Forty-eight percent of principals reported that more than half of the classrooms in their school participate in classroom exercise breaks. Only 8 percent of principals reported a school policy requiring classroom exercise breaks. There were no differences in the percentage of classrooms that participate or the presence of a policy requiring classroom exercise breaks by school demographic strata.

Interview results

The 14 principals interviewed for this study represented 8 school districts in central South Carolina. They had lower percentages of students receiving FRL, poverty
index, and students not meeting state academic standards than all schools in the area. A summary of the themes from the interviews follows.

School Priorities

When asked what their priorities for their students were, five principals reported safety as their number one priority for students. Almost all principals reported academic achievement or learning as a priority for students. The majority of principals reported multiple priorities beyond solely academic achievement.

Description of Classroom Exercise Break Practices

Each school reported different classroom exercise break practices. Five of the schools had exercise breaks as part of their regular morning news show. Most principals emphasized that classroom breaks were up to the discretion of the teacher to, “keep it fluid, how it fits into each classroom”. As one principal stated in reference to the organization and practice of classroom breaks in her school, “It’s not a well-oiled machine.” Even schools that participated in morning exercises as a whole school also allowed teachers to decide how classroom exercise breaks were implemented during the rest of the day. Some of the resources used were OrganWise Guys, Brain Breaks, Brain Gym, CATCH, NFL Play 60, Fit with Fred, and other YouTube videos. While many schools provided resources to teachers, the most commonly reported resource was other teachers, with ideas spreading between classrooms. Of the schools with morning news show exercise breaks, some used videos, others had teacher- or student-led exercises. Most morning videos lasted 5 minutes, with a range from 3 to 7 minutes.
While all grades participated, multiple principals emphasized that movement is incorporated directly into the curriculum for the younger grades.

Initiation of Classroom Exercise Breaks

Five principals, the ones who had incorporated exercise into the school-wide morning news show, reported that classroom exercise breaks were implemented in response to South Carolina’s Student Health and Fitness Act of 2005 as a way to “get in extra minutes” of physical activity to meet the requirements. Other schools had either district or individual teachers who initiated the practices. No principal reported individually initiating classroom exercise breaks in their school. While nine principals discussed participating in breaks and/or leading by example through engaging other school physical activity opportunities, few of the principals had formal or personal physical activity experience. One principal described her participation in physical activity as, “Don’t make me breathe too hard.” Two of the principals were former physical education teachers, and admitted that their physical education background “absolutely” affects how they lead. Yet, they are cautious to not “push” physical activity. Overall there was little resistance to implementation, though some principals discussed a little initial reluctance from students describing the exercises as “hokey”. Several principals discussed that the reason for limited resistance was because teachers understood the purpose of it and the practice was not enforced or mandated. “It’s not mandatory, so if a teacher doesn’t like it, they don’t have to do it.” One principal discussed that if she did mandate it, she expected that there would be increased resistance from her teachers.
Reaction to Classroom Exercise Breaks

The primary response to how the students react was, “The kids love it.” Only two principals discussed instances where students did not enjoy classroom exercise breaks. One principal described, “[You] may get a kid who doesn’t like to do it on a particular day, but it’s usually because of another reason.” Another principal discussed how the older students in her school were not participating in the exercise. The school staff conducted a survey of the students, found that it was mostly a peer influence causing them not to participate, and had the physical education teacher meet with the older students to emphasize the health benefits and reasoning behind the practice.

Principals discussed few disadvantages of implementing classroom exercise breaks. Only one principal mentioned any potential disadvantages; “if a teacher does not have control of their classroom it could be a problem.” All principals discussed the benefits not only for student physical health, but also improved behavior, attention, focus, alertness, and “getting the energy out.” Many discussed positive effects on the as well as increasing student happiness and engagement in school and four specifically referred to benefits involving the “brain.”

Discussion

This study provides a description of classroom exercise breaks in central South Carolina. Overall, the majority of schools reported practicing some type of classroom exercise break, but the specific practices varied between schools. This variation in physical activity practices between schools is known, as school plays a large role in a
child’s physical activity levels. Less than half of the principals interviewed had structured, school-wide morning exercise breaks, and all principals emphasized individual teacher discretion in implementing classroom exercise breaks throughout the day.

The emphasis on teacher discretion is pertinent to the discussion about implementing policies to require classroom exercise breaks. While principals in this study reported that the state policy, the Student Health and Fitness Act, spurred them to increase the prevalence of these practices in their schools, very few schools reported school-level policies requiring teachers to regularly implement the exercise breaks. One principal even emphasized potential problems with adopting school-level policies, such as increased resistance from teachers. Because of this resistance, school-level policies may be inherently difficult to implement. A study of school board members found that a policy to adopt classroom exercise breaks was the policy least likely to be adopted to increase physical activity during the school day. While school policies may be an effective technique to increase school-day physical activity, other alternative approaches may also prove to be beneficial.

Training teachers on these benefits and building their skills may increase implementation without the need for additional policies. The principals in this study discussed that the reason their schools implemented classroom exercise breaks was because teachers believed in the purpose and classroom exercise breaks support best-practice teaching and school priorities. Giving teachers knowledge and skills to implement classroom exercise breaks increases their autonomy to best implement
classroom exercise breaks in their individual classroom while minimizing resistance and negative reactions to top-down policies. Teachers each have unique classrooms and need the flexibility and discretion to best implement classroom exercise for their students. Encouraging teacher autonomy is one of the goals of teacher professional development to strengthen teachers’ engagement and empowerment in all subject areas. Training and resource support to provide classroom exercise is currently not regularly provided to schools. In a previous study of school physical activity policies, less than half of administrators felt that they were adequately prepared to improve physical activity practices. In the current study, multiple principals requested training for teachers as well as resources, such as music and ideas, to help them implement classroom exercise breaks. Interventions and education agencies should find ways to provide adequate training and resources to schools to implement classroom exercise breaks. Creating a community of practice around exercise breaks is a bottom-up approach that would allow teachers to share knowledge and example activities thereby spreading effective classroom exercise break practices.

Classroom exercise breaks were viewed very positively by the principals that were interviewed. All of the principals discussed multiple benefits for students, primarily that the students enjoy them. It is obvious that principals believe in the cognitive benefits of exercise for students’ attention, behavior, learning, and engagement and are aware of the research supporting a positive connection between physical activity and academic achievement. These strong beliefs in the academic benefits of physical activity exist despite the inconsistencies remaining in the research on the association between
physical activity and academic performance.\textsuperscript{30, 31} Thus, additional research to further show the positive associations between exercise and academic achievement may not convince administrators and teachers to implement school-day physical activity; they are already convinced. Future research efforts should focus on the best types and doses of exercise to efficiently maximize the benefits of exercise in school and how to train teachers to implement these practices. These studies may have greater practical implications for educators by uncovering ways to help schools to best implement these practices.

Limitation of this study included a sampling bias and the potential for response bias. Principals who responded to the survey and participated in interviews may not have represented the entire sample of schools in central South Carolina. First, it is possible that principals in schools who practice classroom exercise breaks were more likely to respond to the survey. The prevalence of classroom exercise breaks in this study is higher than the prevalence reported by the School Health Policies national survey which reported less than half of elementary schools participating in classroom exercise breaks.\textsuperscript{2} However, that study was conducted over five years ago and evidence from South Carolina suggests that the prevalence of classroom exercise breaks has been increasing.\textsuperscript{12} In South Carolina, sixty-six percent of elementary schools reported teacher-led classroom exercise during the 2010-2011 school year, not including morning exercise breaks,\textsuperscript{12} which is closer to the estimates found in the current study.

Secondly, only principals who reported classroom exercise breaks in their school were interviewed for this study. Additional research is needed to understand the
barriers and contextual environment of schools who do not participate in classroom exercise breaks. When examining the demographics of which schools responded to the survey and the interview, schools who responded had, on average, lower percentages of students receiving free-and-reduced lunch and higher standardized test performance than the total sample. However, there was representation from almost all school districts as well as a full range of school demographic profiles for both the survey and the interviews. Ideally, a larger sample would be more representative, however, there was difficulty in obtaining school district approval to conduct research in a large number of school districts. This difficulty is not new in school-based research.\textsuperscript{32, 33} Already overwhelmed school districts have many requests for research and it can be difficult to prioritize and participate in studies. In order to best support education and children’s learning, universities and school districts should create on-going and balanced partnerships to enable research that benefits both entities.\textsuperscript{33} Hooper and Britnell propose a model for university-school partnerships for mental health research,\textsuperscript{32} and similar models are needed for all aspects of student health and learning.

Additionally, because the breaks were not objectively observed and the reports were solely self-reported, the actual practices may differ from those reported by principals. With this response bias, it is possible that due to social desirability, principals over-reported classroom exercise breaks, and the actual number of teachers implementing regular, quality classroom exercise breaks is less than reported. Objective measures of physical activity are needed to determine if students are participating in these classroom exercise breaks. Finally, the findings of this study can only be
generalized to similar schools in South Carolina and further studies are needed to see if classroom exercise breaks practices are similar in other locations and a larger sample of schools.

Many schools and principals are implementing innovative classroom exercise break practices with the hope to improve the health and learning of South Carolina’s children. Findings from this study can help to expand these effective practices across the state and set an example nationally. Schools need the support and resources from educational agencies, and the guidance from findings of additional research in order to implement high quality classroom exercise breaks.
Table 2.1: School demographics for sampled school districts

<table>
<thead>
<tr>
<th>Total Sampled</th>
<th>Online Survey Responders</th>
<th>Interview Responders</th>
</tr>
</thead>
<tbody>
<tr>
<td># Counties</td>
<td>11</td>
<td>9</td>
</tr>
<tr>
<td># School Districts</td>
<td>16</td>
<td>15</td>
</tr>
<tr>
<td># Schools</td>
<td>192</td>
<td>61</td>
</tr>
<tr>
<td>% FRL</td>
<td>59.7 (22.5)</td>
<td>53.7 (23.1)</td>
</tr>
<tr>
<td>Poverty Index(^a)</td>
<td>72.8 (22.2)</td>
<td>68.3 (22.9)</td>
</tr>
<tr>
<td>% Not meeting English Standard(^b)</td>
<td>22.5 (9.6)</td>
<td>20.9 (9.9)</td>
</tr>
<tr>
<td>% Not Meeting Math Standards(^b)</td>
<td>26.98 (12.5)</td>
<td>23.7 (11.3)</td>
</tr>
</tbody>
</table>

\(^a\)Poverty Index calculated by the SC Department of Education based on percentage of free and reduced lunch and Medicaid eligibility

\(^b\)Data from the SC Department of Education 2010-2011 Palmetto Assessment of State Standards

Table 2.2: Number of schools available in each school demographic stratum (mean % free-and-reduced lunch, % not meeting state academic standards\(^a\))

<table>
<thead>
<tr>
<th># Schools (districts represented)</th>
<th>&lt;60% Free-and-reduced Lunch</th>
<th>&gt;60% Free-and-reduced Lunch</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lower Achieving</td>
<td>46</td>
<td>45</td>
</tr>
<tr>
<td></td>
<td>(51.11, 17.45)</td>
<td>(79.38, 31.58)</td>
</tr>
<tr>
<td>Higher Achieving</td>
<td>48</td>
<td>53</td>
</tr>
<tr>
<td></td>
<td>(30.42, 11.56)</td>
<td>(76.82, 25.33)</td>
</tr>
</tbody>
</table>

\(^a\)Achievement based on percentage of students meeting 2010-2011 Palmetto Assessment of State Standards according to data from the SC Department of Education
# Table 2.3: Percentage of schools reporting classroom exercise breaks, prevalence and policies

<table>
<thead>
<tr>
<th>Response</th>
<th>Total</th>
<th>Strata 1</th>
<th>Strata 2</th>
<th>Strata 3</th>
<th>Strata 4</th>
<th>p-value&lt;sup&gt;c&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Low FRL, Low Achievement&lt;sup&gt;a&lt;/sup&gt;</td>
<td>Low FRL, Low Achievement</td>
<td>High FRL, Low Achievement</td>
<td>High FRL, Low Achievement</td>
<td></td>
</tr>
<tr>
<td></td>
<td>N&lt;sup&gt;b&lt;/sup&gt;</td>
<td>61</td>
<td>19</td>
<td>17</td>
<td>13</td>
<td>11</td>
</tr>
</tbody>
</table>

**Classroom Exercise Breaks conducted within school**

<p>| | | | | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
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<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>yes</td>
<td>73.8 (45)</td>
<td>89.5 (17)</td>
<td>76.5 (13)</td>
<td>53.8 (7)</td>
<td>63.6 (7)</td>
<td>.05</td>
</tr>
</tbody>
</table>

**Percentage of classrooms that participate (n)**

<p>| | | | | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
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<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>0-25%</td>
<td>39.3 (24)</td>
<td>26.3 (5)</td>
<td>41.2 (7)</td>
<td>61.5 (8)</td>
<td>36.4 (4)</td>
<td>.52</td>
</tr>
<tr>
<td>25-50%</td>
<td>11.5 (7)</td>
<td>21.1 (4)</td>
<td>11.8 (2)</td>
<td>0 (0)</td>
<td>9.1 (1)</td>
<td></td>
</tr>
<tr>
<td>50-75%</td>
<td>24.6 (15)</td>
<td>26.3 (5)</td>
<td>17.7 (3)</td>
<td>15.4 (2)</td>
<td>36.4 (4)</td>
<td></td>
</tr>
<tr>
<td>75-100%</td>
<td>23.0 (14)</td>
<td>26.3 (5)</td>
<td>29.4 (5)</td>
<td>23.1 (3)</td>
<td>9.1 (1)</td>
<td></td>
</tr>
<tr>
<td>Not sure</td>
<td>1(1)</td>
<td>0 (0)</td>
<td>0 (0)</td>
<td>0 (0)</td>
<td>9.1(1)</td>
<td></td>
</tr>
</tbody>
</table>

**Have policy requiring Classroom Exercise Breaks**

<p>| | | | | | | |</p>
<table>
<thead>
<tr>
<th></th>
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<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>yes</td>
<td>8.2 (5)</td>
<td>5.3 (1)</td>
<td>11.8 (2)</td>
<td>0 (0)</td>
<td>18.2 (2)</td>
<td>.48</td>
</tr>
</tbody>
</table>

FRL=% of students receiving Free-and-Reduced Lunch

<sup>a</sup>Achievement was based on the SC Department of Education 2010-2011 Palmetto Assessment of State Standards

<sup>b</sup>One school opened in 2012-2013 and did not have previous school year data available to group it into a stratum but responses are included in total

<sup>c</sup>p-value from logistic regression
References


CHAPTER 3

MANUSCRIPT 2: ACUTE EFFECTS OF CLASSROOM EXERCISE BREAKS ON EXECUTIVE FUNCTIONS AND MATH PERFORMANCE IN ELEMENTARY SCHOOL STUDENTS: A DOSE-RESPONSE


Abstract

**Background** Physical activity may be associated with improved cognitive and academic performance in children. The optimal dose of physical activity to produce these benefits is unknown. Classroom exercise breaks are a feasible, time efficient way to increase physical activity of children in schools.

**Purpose** The purpose of this study was to determine the acute effects of classroom exercise breaks on executive function and math performance in 9 to 12 year-old children and to examine the dose-response relationship between 5, 10, or 20 minutes of classroom exercise breaks compared to 10 minutes of sedentary classroom activity.

**Design** Within-subjects experimental study conducted over four weeks in the Spring of 2012.

**Setting/participants** Ninety-six 4th and 5th grade students in an elementary school in South Carolina.

**Intervention** Classroom groups were randomized to receive each of four treatments: 5, 10, or 20 minutes of a classroom exercise breaks or 10 minutes of a seated classroom lesson. The intervention included moderate-to-vigorous physical activities led by research staff.

**Main Outcome Measures** The dependent variables were executive function (Trail Making Test and Operational Digit Recall test) and math performance (One-Minute Math Worksheet). Students completed these tests immediately before and after each
condition. Post-test scores for each variable were compared between conditions using a repeated measures mixed ANCOVA model, adjusted for gender, classroom group, and the time-varying pre-test scores. Linear contrasts tested the differences between doses. Potential effect modifiers including fitness, Body Mass Index (BMI), and IQ were included as interaction terms.

**Results** Math scores were higher after 10 minutes of classroom exercise breaks compared to the sedentary condition (d=0.28, \( p=0.03 \)). Differences in effects were seen in groups when stratified by sex, IQ, fitness, BMI, behavior, and school engagement. There were no significant main effects.

**Conclusions** A 10-minute classroom exercise break modestly improved math scores in elementary school students compared to a seated classroom lesson, with no overall negative effects with any duration.

**Introduction**

Children are not meeting physical activity recommendations.\(^1\,^2\) Yet, instead of increasing opportunities for physical activity, many schools have reduced physical education and other physical activity opportunities in response to budget reductions and increased attention on standardized testing.\(^3\,^4\) Paradoxically, reducing physical activity, may decrease the academic achievement that schools are trying to improve. Recent reviews\(^5\,^8\) and cross-sectional studies have shown that physical activity,\(^9\,^{13}\) physical education,\(^14\) and fitness levels\(^15\,^{18}\) may be positively associated with the broad outcome of academic achievement, often operationalized as performance on
standardized tests. Several experimental studies have explored a possible causal relationship between acute exercise and cognition in children\textsuperscript{19-22} with overall positive support for a causal role between exercise and cognition.\textsuperscript{23}

Of the cognitive abilities shown to improve with exercise, the strongest effects have been seen in executive function.\textsuperscript{24, 25} Executive functions are “general purpose control mechanisms that modulate the operation of various cognitive subprocesses,” or higher order complex cognitive processes.\textsuperscript{26} These functions include working memory, inhibition and cognitive flexibility as unique, but related, components.\textsuperscript{26, 27} Executive function is highly predictive of academic achievement\textsuperscript{28} and can be improved through interventions.\textsuperscript{29} However, many questions remain unanswered regarding the relationships between physical activity, executive function and academic achievement, including the appropriate dose of physical activity required to produce optimal outcomes.\textsuperscript{5}

Time is a critical resource in schools and one of the most common barriers to implementing physical activity; therefore it is crucial to maximize efficiency in implementing physical activity throughout the day. Classroom exercise breaks are short bouts of physical activity that are conducted within the classroom as opposed to physical education and recess which are extended periods of physical activity. Schools have begun to implement classroom exercise breaks into their curriculum and practices, even as research continues to explore the optimal delivery, frequency, timing and duration of exercise breaks. Preliminary findings suggest that classroom exercise breaks are acceptable to teachers and may improve physical activity and cognitive outcomes.\textsuperscript{30-32}
Yet, only three studies have examined the acute cognitive effects of short exercise bouts (of approximately 10 minutes) in children, with varying effects. No previous studies have evaluated the differences in the acute cognitive effects of classroom exercise breaks of various durations in children.

Therefore, the purpose of this study was to determine the acute effects of classroom exercise breaks on executive function and math performance in 9 to 12 year-old children. Additionally, the study examined the dose-response relationship between 5, 10, or 20 minutes of classroom exercise breaks and these cognitive functions. The exercise durations were based on prior research reporting improvements in executive functions and academic performance following 10 and 20 minutes of physical activity.

Schools and teachers, however, tend to use shorter durations of 5 minutes as longer interventions may not be as practically implemented into school policy and practice. Currently, it is unknown if these shorter breaks have acute cognitive benefits. Finally, the study examined whether the relationship between duration of acute classroom exercise breaks and cognitive functions was moderated by gender, intelligence (IQ), fitness, body mass index (BMI), behavior, school engagement, and/or physical activity participation during the intervention.

Methods

Study Design

This study used a within-subjects experimental design. There were four treatment conditions: 10 minutes of sedentary classroom activity, and 5, 10 and 20
minute classroom exercise breaks. Students participated in each of the four conditions. The within-subject design was used to account for between-subject variation and increase efficiency with only a small probability of carryover between acute exercise treatments between weeks. The intervention was administered to 5 classroom groups of 47 4th graders and 49 5th graders at approximately the same day and time each week for each classroom. To reduce sequencing and account for practice effects, a balanced Latin Square design was used to randomize the four treatments at the classroom level. The unit of analysis was the student. The primary dependent variables of executive function and math performance were assessed before and after each experimental condition. This pretest-posttest design was chosen to account for daily variation in cognitive abilities within each child and to focus on the change in cognitive performance with exercise. All participants provided parental consent and student assent. This study was approved by the IRB at the University of South Carolina and the research board of the school district.

**Participants and Setting**

Participants were from four 4th grade and four 5th grade classrooms at an elementary school in South Carolina. All data was collected during the Spring of 2012. Participants ranged from 9 to 12 years-old. The overall school population was 18% black, 8% Hispanic, and 70% white; 30% of students received free-and-reduced lunch.

**Intervention**

The Brain BITES (Better Ideas Through Exercise) classroom exercise break intervention was designed to maintain moderate-to-vigorous aerobic activity for the
duration of the exercise break. Research staff led students in activities that could be performed in minimal space; physical activities included stationary marching with arm movements, and various forms of jumping and running in place. Each exercise condition began with 30 seconds of low-intensity warm-up and ended with a brief deep breathing and stretching cool-down. Activities performed were similar throughout the intervention with only the duration of activities varying. During the sedentary condition, students completed research questionnaires and the research staff delivered a brief lesson about the importance of physical activity.

The instructor had a brief planning session with the students before the intervention to select activities and music to increase buy-in and enjoyment. To encourage participation and high-intensity activity, students were instructed on how to take heart rates using their carotid or radial pulse. Students were instructed that heart healthy exercise gets their heart rates to 150 beats per minute. Heart rates were self-assessed and recorded by the students after each condition. The instructor physically participated, gave verbal cues, and offered positive descriptive encouragement, which has been shown to increase child activity. The exercise sessions were videotaped and observed for intervention fidelity.

**Measures**

Information was collected on potential confounding variables and factors that have been shown to influence the relationship between exercise and cognition. These included SES, gender, age, student engagement, attention-deficit/hyperactivity and problem behavior symptoms, IQ, BMI, daily physical activity, and
fitness.\textsuperscript{15-19, 48} Students completed a brief questionnaire to obtain age, physical activity levels, sports participation, grades on their last report card, and attitudes/motivation for academics (e.g., I enjoy school/learning).\textsuperscript{49} Parents completed a brief questionnaire to obtain socioeconomic status (household income, parent education) and the Conners’ Parent Rating Scales Revised short version, a 27 item checklist to assess attention-deficit/hyperactivity and problem behavior symptoms.

Prior to beginning the intervention, participants completed height and weight measurements and a baseline aerobic fitness assessment of the PACER test from the FITNESSGRAM testing battery administered by research staff during physical education class. The Kaufmann Brief Intelligence Test- Second Version (KBIT-2) measure of abbreviated IQ was administered to each child individually and composite IQ scores were used.

\textit{Physical Activity Intensity}

Videotapes of all four conditions were coded for intensity of physical activity using a modified System for Observing Fitness Instruction Time (SOFIT) as modified by Donnelly. Observations of participating individual children were made at consecutive 10-second intervals during the exercise or sedentary condition, not including cognitive testing. Each child’s average activity level during the 10-second interval was coded using a scale from 1 to 5 where 1 is equal to lying down and 5 is equal to being very active (e.g., running in place, jumping). Videos were viewed and coded three times for a total of 4,212 observations. To assess reliability, ten percent of the intervals were recoded
four months after the initial coding (n=424). Intervals were randomly selected in groups of 10. The percent agreement was 91.0% with a weighted kappa of 0.95.

Each video was watched three times. The video was scanned from left to right during the first viewing, right to left during the second, and from the center for the third viewing. If a participant could not be viewed (obstructed by another participant or out of the frame of view), the next participant was observed. Different participants were observed during each interval in each of the three viewings. Each participant was observed for an average of 16.8 intervals during the sedentary condition, 7.5 intervals during the 5-minute exercise break, 12.5 intervals during the 10-minute break, and 25.5 intervals during the 20-minute break. Mean physical activity intensity scores were calculated for each participant for each condition.

**Cognitive Measures**

The testing battery was assessed in pilot work to establish feasibility and acceptability. Outcome variables are operationally defined in TABLE 3.1.

**Trail Making Test**

The Trail Making Test (TMT) was selected as a theoretically and neuropsychological valid, feasible and appropriate measure of executive functions in children. TMT performance has been shown to be affected by exercise in adults.\textsuperscript{50, 51} The TMT has two parts, A and B. Part A consists of connecting numbers, while Part B involves alternating between numbers and letters. The TMT Part B has been validated as a measure of planning\textsuperscript{52} and set switching also known as cognitive flexibility.\textsuperscript{53} The TMT has reliability of 0.64 in children aged 3-6\textsuperscript{54} and 0.56 over 6 months in children 4-12
years of age.\textsuperscript{55} Two alternative forms, mirror images, were used for each testing to decrease practice effects. The test was modified to be self-timed for group administration, and a subsample of participants was observed for accuracy of self-timing. As suggested by Sanchez-Cubillo, TMT-A primarily measures visuoperceptual ability, TMTB measures working memory, and the difference between TMTB and TMTA (TMTBA) represents executive control. Therefore, TMTBA was used as a measure of executive function in the current study.\textsuperscript{53} The correlation of TMTB with TMTBA was 0.94. The TMTBA pre-tests had a one-way intraclass correlation of 0.65.

\textit{Digit Recall}

Operational digit recall is a validated measure of working memory, as part of the \textit{Working Memory Test Battery for Children}.\textsuperscript{28} To modify the task for increased validity, students were read a list of numbers, and then given 5 seconds to write them in chronological order from the lowest to highest. The digit recall score was the number of sequences the student answered correctly, adjusted for the length of the sequence. The digit recall pre-tests had an intraclass correlation of 0.63.

\textit{Timed Math Test}

To assess ecological validity and direct application to academics, a timed math test was given, similar to a previous study.\textsuperscript{56} Students completed as many grade-appropriate math problems as possible within 1 minute. The math score was the number of problems correctly answered. The pre-test math scores had an intraclass correlation of 0.95.
Analysis

Descriptive statistics were calculated for the total group and for each gender using SAS 9.2. As the cognitive tests may be prone to practice effects, the Time x Condition interaction was examined in an initial ANOVA to test for order effects. This interaction was only significant for the digit recall scores. However, when the raw scores were examined, it was noted that the scores did not improve over time, as expected from a practice effect. This lack of practice effects, coupled with the randomization to the order of conditions to counterbalance significant practice effects, allowed the primary analyses to include all classroom groups together, adjusting for group.

To test for an overall difference between all exercise conditions versus the sedentary condition, a repeated measures ANCOVA mixed model (PROC MIXED) tested the difference in post-test scores between conditions, controlling for pre-test scores. This method of analysis was chosen to account for the within subject correlation in repeated measures, the ability to use all available data, and the ability to adjust for a time-varying covariate. Models were adjusted for gender, classroom group, as well as the time-varying covariate of pre-test scores. Separate analyses were conducted for the independent variables of TMT, digit recall, and math scores.

To examine the dose-response relationship, linear contrasts tested the differences between doses of 5, 10, 20 minutes of exercise and 10 minutes of sedentary activity. Cohen’s $d$ effect sizes were estimated.

Finally, to test whether the effects differed by baseline student characteristics or by participation in the intervention, interaction terms were added to the model.
Potential effect modifiers of abbreviated IQ, fitness levels, BMI, behavior problems from the Conners’ Parent Rating Scales, and school engagement were split based on median scores. Interaction terms between the condition and the dichotomous effect modifier were added to the model in separate analyses. Significance for interactions was set at p<0.10. To test if the effects on cognitive outcomes were influenced by student exercise intensity, an interaction between condition and mean physical activity intensity was added to the model.

**Results**

A total of 96 students participated in the study. Demographics and baseline descriptive variables can be seen in TABLE 3.2. The average physical activity intensity during the exercise conditions ranged from 4.00 to 4.35 as seen in TABLE 3.3. There were no differences in intensity between exercise conditions.

**Main Effect of exercise on cognitive outcomes**

There were no significant main effects of the conditions on the dependent variables of post-test TMT (F=0.92, df=243, p=.43) or math scores (F=2.04, df=249, p=0.11). There was a significant difference between conditions for digit recall scores (F=3.35, df=249, p=0.02).

**Differences Between Doses**

The change in math scores was significantly higher after 10 minutes of exercise compared to the sedentary condition as seen in FIGURE 3.1. The estimated effect size was $d=0.28$. Collapsing the data across all exercise conditions, math scores were significantly greater than after the sedentary condition (p=0.05). There were no other
significant differences between any durations of exercise and the sedentary condition in digit recall scores or performance on the TMT as seen in FIGURE 3.1.

**Effect modification**

The third objective examined whether the results differed by gender, IQ, fitness, BMI, behavior, classroom engagement, and physical activity intensity during the intervention. Ninety-two students completed the KBIT-2, 89 students completed the FITNESSGRAM PACER test, 90 students were measured for Body Mass Index, and 73 students had parents complete the Conners’ Behavior Rating Scale at baseline. The median splits for the variables were 103 for composite IQ, 15 20-meter laps for the FITNESSGRAM PACER (the healthy fitness zone is ≥23 laps for boys and ≥7 laps for girls), a BMI of 19 (approximately 85th percentile for 10 year old boys, a Conner’s behavior score of 13 and a school engagement score of 21.

Students who had higher fitness had higher math scores across all exercise conditions, including when adjusted for gender, race, parent education and parent income (p<.001). The Spearman correlations between continuous effect modifiers can be seen in TABLE 3.4. To test whether several student characteristics influenced their responses to the exercise, interaction terms between the exercise dose with gender, IQ, fitness, BMI, behavior, school engagement, and physical activity intensity during the intervention were tested. The only overall significant interactions were between IQ and condition for math scores (p=.05, students with lower IQ had larger improvements in math scores after 10 minutes of exercise), and BMI and condition for digit recall (p=.01, students with lower BMI improved after 10 minutes). There were no associations
between an individual child’s intensity of physical activity and the cognitive outcomes (p=.73 for math scores, p=.41 for digit recall scores, p=.82 for TMT).

The results for the comparisons between the exercise doses and the sedentary condition for math scores can be seen in FIGURE 3.2. After 5 minutes of exercise, students with lower IQ (p=.04, d=-.29), lower fitness (p=.06, d=-.27) and higher BMI (p<.01, d=-.42) had lower digit recall scores compared to sedentary. After 20 minutes of classroom exercise breaks, students with higher IQ (p=.08, d=.25) and lower BMI (p<.01, d=.47) had higher digit recall scores compared to sedentary. The only significant differences in TMT scores were for students with low engagement who decreased their performance after 5 and 10 minutes of exercise compared to sedentary (40.60 and 38.54 seconds vs 28.92 respectively).

**Discussion**

This is the first study to directly compare the acute effects of varying doses of classroom exercise breaks on acute cognitive outcomes. The current study found that a 10 minute classroom exercise break modestly improved math scores in elementary school students compared to a sedentary classroom lesson, and there were no effects after 5 or 20 minutes of exercise though there was a trend towards significance after 20 minutes. These findings are largely consistent with previous research that found improvements in diverse measures of cognitive functions following 10 to 50 minutes of various types of physical activity.\(^{21, 57-60}\) Researchers have yet to see significant improvements in cognition with doses less than 10 minutes, although few studies have
examined these shorter durations. In one of the few studies to directly compare multiple doses, Kubesch et al. found improvements in cognitive performance after 20 minutes of a physical education class but no improvements after 5 minutes of a classroom exercise break.

In the current study, overall effects were seen in math scores and not in working memory or the TMT. This may have been due to the much lower reliability and higher variation in the operational recall and TMT scores compared to the math test. The reliability of TMT scores in this study was consistent with previous studies. Executive function is a difficult construct to measure due to the low reliability and task impurity. Nonetheless, executive function may be most responsive to exercise, making it an important outcome to include. To counter the modest reliability of executive function measures, this study used a within subject design and included pre-tests measures for each condition, including them as a covariate in the model. Additionally, very recent work suggests that select cognitive functions may be more sensitive to acute physical activity such as attention and inhibition than working memory.

Many hypotheses exist for the mechanisms underlying improvements in cognitive performance after acute exercise, including increased neuroelectric activity as measured through electroencephalogram, catecholamines, and brain oxygenation and cerebral blood flow during exercise. Classroom exercise breaks may also positively influence psycho-social pathways such as improving self-esteem. These mechanisms may respond differently to different doses, intensities, and types of physical activity, but
a clear dose-response pattern has not yet emerged.$^{50, 68}$ Several researchers have proposed an inverted-U hypothesis, where the maximum cognitive benefits are received with a moderate amount of physical activity and with potential declines in performance with too little or too much exercise.$^{69-72}$ The results of this study suggest that 5 minutes of classroom exercise may not be enough to elicit cognitive benefits and longer durations of 10 or 20 minutes are needed as there was a trend for 20 minutes to produce positive cognitive benefits. Further research is needed to support or refute the inverted-U hypothesis.

The findings from this study suggest that different students may react differently to classroom exercise breaks. Previous studies have shown factors such as student engagement,$^{40, 41}$ attention-deficit/hyperactivity and problem behavior symptoms,$^{42, 43}$ IQ,$^{44}$ BMI,$^{45-47}$ regular physical activity,$^{10, 12, 13, 42}$ and fitness$^{15-19, 48}$ to influence the relationship between exercise and cognition. In this study, students with lower IQ, higher fitness, higher BMI, better behavior or lower school engagement had more improvement in math scores with the classroom exercise breaks. Prescribing classroom exercise breaks for individual students, however, may be impractical in the school setting. Nonetheless, classroom tracking, or the common practice of grouping of students with similar academic abilities,$^{73}$ allows for tailored recommendations to specific classrooms. For example, a classroom of students with lower academic ability may benefit from 10 minutes of classroom exercise breaks, while a classroom of students with behavioral problems may seek alternative physical activity opportunities such as recess.
This study was a “real-world” efficacy study, implemented by research staff. This approach ensured high implementation fidelity, with high participation in moderate-to-vigorous physical activity throughout the intervention, but is not easily sustainable. Nevertheless, the intervention was designed to be easily implemented by classroom teachers using few resources and some schools have already implemented similar practices. Additionally, the classroom exercise break was delivered as a complete package of specific exercises, music, encouragement and cool down strategies. The results can only be generalized to similar classroom breaks and not all types of physical activity, as effects may differ by type or intensity of exercise such as outdoor recess or lighter intensity activity. These analyses were not adjusted for the multiple comparisons included in the effect modification analyses. These are preliminary analyses and further studies are needed to confirm the findings.

While this study did not find cognitive improvements after 5 minutes of classroom exercise breaks, 10 minutes were sufficient to elicit small improvements in math scores. Also noteworthy, there were no overall negative effects following any duration. Unfortunately, with rigid school schedules and curriculums, most exercise breaks currently being implemented in schools last less than 10 minutes. Additional training and resources may help teachers and administrators conduct 10 minute classroom exercise breaks. If conducting classroom exercise breaks for 10 minutes is not feasible, schools can implement other physical activity opportunities of similar durations to receive acute cognitive benefits.
### Table 3.1: Operational definitions of primary dependent variables

<table>
<thead>
<tr>
<th>Measure</th>
<th>Operational Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Cognitive Flexibility</strong></td>
<td>Difference between Part A and Part B (seconds)</td>
</tr>
<tr>
<td><strong>Trail Making Test</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Working Memory</strong></td>
<td>Number of correct numbers recalled; number of lists recalled in correct order</td>
</tr>
<tr>
<td><strong>Digit Recall</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Academic Achievement</strong></td>
<td>Number of math problems correct</td>
</tr>
<tr>
<td><strong>Timed Math Test</strong></td>
<td></td>
</tr>
</tbody>
</table>

### Table 3.2: Baseline descriptive variables (% or mean ± SD)

<table>
<thead>
<tr>
<th></th>
<th>Total</th>
<th>Female</th>
<th>Male</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>N</td>
<td>96</td>
<td>62</td>
<td>34</td>
<td></td>
</tr>
<tr>
<td>Age</td>
<td>10.7 ± .6</td>
<td>10.7 ± 0.6</td>
<td>10.7 ± 0.6</td>
<td>.68</td>
</tr>
<tr>
<td>% Black</td>
<td>19.8</td>
<td>19.1</td>
<td>21.2</td>
<td>.85</td>
</tr>
<tr>
<td>% White</td>
<td>68.8</td>
<td>66.7</td>
<td>72.7</td>
<td></td>
</tr>
<tr>
<td>% Income &lt;40,000</td>
<td>33.8</td>
<td>30.4</td>
<td>40.9</td>
<td>.19</td>
</tr>
<tr>
<td>Verbal IQ&lt;sup&gt;a&lt;/sup&gt;</td>
<td>98.4 ± 13.4</td>
<td>97.9 ± 14.2</td>
<td>99.2 ± 12.1</td>
<td>.64</td>
</tr>
<tr>
<td>Matrices&lt;sup&gt;a&lt;/sup&gt;</td>
<td>102.4 ± 12.0</td>
<td>102.4 ± 17.2</td>
<td>102.8 ± 11.7</td>
<td>.82</td>
</tr>
<tr>
<td>IQ&lt;sup&gt;a&lt;/sup&gt;</td>
<td>102.0 ± 15.2</td>
<td>102.4 ± 17.2</td>
<td>101.5 ± 11.4</td>
<td>.78</td>
</tr>
<tr>
<td>% A student</td>
<td>14.3</td>
<td>12.1</td>
<td>19.2</td>
<td>.45</td>
</tr>
<tr>
<td>BMI</td>
<td>19.9 ± 4.5</td>
<td>20.7 ± 4.9</td>
<td>18.4 ± 3.5</td>
<td>.02</td>
</tr>
<tr>
<td>% BMI ≥ 95&lt;sup&gt;th&lt;/sup&gt; percentile</td>
<td>21.3</td>
<td>25.4</td>
<td>8.82</td>
<td>.14</td>
</tr>
<tr>
<td>Fitness&lt;sup&gt;b&lt;/sup&gt;</td>
<td>22.1 ± 12.9</td>
<td>19.5 ± 10.5</td>
<td>26.6 ± 15.4</td>
<td>.01</td>
</tr>
<tr>
<td>Physical Activity&lt;sup&gt;c&lt;/sup&gt;</td>
<td>5.3 ± 2.0</td>
<td>5.3 ± 1.9</td>
<td>5.3 ± 2.3</td>
<td>.92</td>
</tr>
<tr>
<td>Behavior&lt;sup&gt;d&lt;/sup&gt;</td>
<td>16.2 ± 14.2</td>
<td>14.2 ± 12.7</td>
<td>20.5 ± 16.5</td>
<td>.08</td>
</tr>
<tr>
<td>School Engagement&lt;sup&gt;e&lt;/sup&gt;</td>
<td>20.8 ± 5.7</td>
<td>21.2 ± 5.4</td>
<td>19.9 ± 6.1</td>
<td>.36</td>
</tr>
</tbody>
</table>

<sup>a</sup> Standardized scores from Kaufmann Brief Intelligence Test-Second Version  
<sup>b</sup> # 15m laps completed during PACER test  
<sup>c</sup> >60 minutes per day<sup>*</sup> (days per week)  
<sup>d</sup> score >23 may suggest behavioral problems  
<sup>e</sup> range from 6 to 30, higher scores indicate higher engagement with school  

IQ, Intelligence Quotient
### Table 3.3: Average Intensity of Intervention for each condition ± SD (Coded from 1-5; MVPA ≥ 4)

<table>
<thead>
<tr>
<th></th>
<th>Sedentary</th>
<th>5 minutes</th>
<th>10 minutes</th>
<th>20 minutes</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong># Intervals Observed</strong></td>
<td>1125</td>
<td>465</td>
<td>862</td>
<td>1760</td>
</tr>
<tr>
<td><strong>Student Intensity</strong></td>
<td>2.01 ± 0.05</td>
<td>4 ± 0.43</td>
<td>4.35 ± 0.33</td>
<td>4.26 ± 0.37</td>
</tr>
<tr>
<td><strong>Instructor Intensity</strong></td>
<td>2</td>
<td>4.58</td>
<td>4.53</td>
<td>4.52</td>
</tr>
<tr>
<td><strong>% Compliance</strong></td>
<td>1.01</td>
<td>0.87</td>
<td>0.96</td>
<td>0.94</td>
</tr>
</tbody>
</table>

### Table 3.4: Spearman correlations between continuous student variables

<table>
<thead>
<tr>
<th></th>
<th>IQ</th>
<th>Fitness</th>
<th>BMI</th>
<th>Behavior</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fitness</td>
<td>.02</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>BMI</td>
<td>.08</td>
<td>-.51*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Behavior</td>
<td>-.05</td>
<td>.02</td>
<td>.02</td>
<td></td>
</tr>
<tr>
<td>Engagement</td>
<td>-.02</td>
<td>.08</td>
<td>-.06</td>
<td>-.17</td>
</tr>
</tbody>
</table>

*p<.05
<table>
<thead>
<tr>
<th></th>
<th>Sedentary</th>
<th>5 min</th>
<th>10 min</th>
<th>20 min</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>TMT</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td>37.70</td>
<td>38.14</td>
<td>40.84</td>
<td>35.87</td>
</tr>
<tr>
<td>SE</td>
<td>2.79</td>
<td>2.55</td>
<td>2.47</td>
<td>2.49</td>
</tr>
<tr>
<td>p-value</td>
<td>ref</td>
<td>0.89</td>
<td>0.34</td>
<td>0.57</td>
</tr>
<tr>
<td>ES (d)</td>
<td>ref</td>
<td>-0.02</td>
<td>0.14</td>
<td>-0.08</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>Sedentary</th>
<th>5 min</th>
<th>10 min</th>
<th>20 min</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Digit Recall</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td>17.89</td>
<td>16.77</td>
<td>18.12</td>
<td>18.63</td>
</tr>
<tr>
<td>SE</td>
<td>0.53</td>
<td>0.48</td>
<td>0.47</td>
<td>0.48</td>
</tr>
<tr>
<td>p-value</td>
<td>ref</td>
<td>0.08</td>
<td>0.72</td>
<td>0.26</td>
</tr>
<tr>
<td>ES (d)</td>
<td>ref</td>
<td>-0.25</td>
<td>0.05</td>
<td>0.16</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>Sedentary</th>
<th>5 min</th>
<th>10 min</th>
<th>20 min</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Math</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td>24.36</td>
<td>24.81</td>
<td>25.56</td>
<td>25.39</td>
</tr>
<tr>
<td>SE</td>
<td>0.51</td>
<td>0.47</td>
<td>0.46</td>
<td>0.47</td>
</tr>
<tr>
<td>p-value</td>
<td>ref</td>
<td>0.41</td>
<td>0.03</td>
<td>0.06</td>
</tr>
<tr>
<td>ES (d)</td>
<td>ref</td>
<td>0.10</td>
<td>0.28</td>
<td>0.23</td>
</tr>
</tbody>
</table>

*difference from sedentary condition at p<.05, error bars are SE. TMT, Trail Making Test, lower scores are better.

**Figure 3.1:** Performance on cognitive tasks after 10 minutes of seated classroom activity or 5, 10, 20 minutes of classroom exercise breaks.
Figure 3.2: Math scores after sedentary classroom activity or 5, 10, 20 minutes of classroom exercise breaks, stratified by baseline characteristics.
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CHAPTER 4

MANUSCRIPT 3: ACUTE CLASSROOM EXERCISE BREAKS IMPROVE ON-TASK BEHAVIOR IN 4TH AND 5TH GRADE STUDENTS: A DOSE-RESPONSE

3 Howie EK, Beets MW, Newman-Norlund RD, Schatz JC, Pate RR. To be submitted to Journal of School Health.
Abstract

**Background:** This study was the first to directly compare the acute effects of 5, 10, and 20 minutes of classroom exercise breaks on on-task behavior and to examine the variations by individuals and classrooms. **Methods:** In this within-subject experiment, 96 4th and 5th grade students, in 5 classroom groups, participated in each of four conditions: 10 minutes of sedentary classroom activity and 5, 10, 20 minutes of classroom exercise breaks led by research staff. Time-on-task was directly observed from videotapes before and after each condition. The post-test time-on-task scores were compared using a repeated measures mixed ANCOVA, adjusted for age, classroom, and the time-varying pre-test time-on-task. Comparisons between each exercise condition and sedentary were made using linear contrasts. Interactions were examined by several individual student factors including gender, intelligence quotient (IQ), fitness, Body Mass Index (BMI), behavior, school engagement and baseline on-task behavior. **Results:** Time-on-task was significantly higher after 10 minutes of classroom exercise breaks compared to sedentary (87.6% vs 77.1%, $d=0.45$, $p=.004$). Females, students with lower IQ, lower BMI and higher fitness saw greater effects than males, students with higher IQ and lower fitness. **Conclusion:** Ten minutes of classroom exercise breaks improved time-on-task behavior in children.

Many factors influence students’ performance in school and on standardized academic tests. One large influence on academic achievement is student on-task behavior and attention. Thus to improve academic achievement, many teachers and
interventions have aimed to increase on-task behavior or time-on-task.\textsuperscript{9-11} Emerging evidence suggests that one way to increase on-task behavior is through increasing physical activity opportunities during the school day.\textsuperscript{12-15} Physical activity in children has been shown to improve neuroelectric activity,\textsuperscript{16} attention and inhibitory control\textsuperscript{17} which help students to rule out distractions and focus on the task. When researchers have objectively observed on-task behavior in relation to recess, they found that students are more on-task after recess.\textsuperscript{14, 18} Attention and the ability to inhibit distracters, which both contribute to on-task behavior, have both been shown to improve after an acute bout of physical activity in children.\textsuperscript{17, 19} Additionally, an observational study found that schools where students have greater amounts of recess, teachers report better classroom behavior.\textsuperscript{20}

Unfortunately, adding physical activity to the school day can be difficult due to the competing priorities, budget concerns and lack of time reported by teachers and administrators.\textsuperscript{21-23} Classroom exercise breaks, short bouts of physical activity integrated within the school day, provide a low-budget and feasible way to increase physical activity in students. Components of Take 10!, an example classroom exercise break curricula, have been integrated into numerous interventions, and have had a generally positive effect on educational and health outcomes.\textsuperscript{24}

Few studies, however, have examined the acute effects of these short exercise bouts on on-task behavior in children. Mahar et al. observed on-task behavior before and after a classroom exercise break and found that on-task behavior increased by 8 percent after the exercise.\textsuperscript{12} Another study found that exercise breaks can help students
maintain on-task behavior. Little is known on the optimal dose of these classroom exercise breaks. Kubesch et al. found positive cognitive effects after 20 minutes of physical education but not after 5 minutes of a classroom exercise break. To our knowledge, no study has directly compared different durations of classroom exercise breaks on on-task behavior or attention.

Also unknown are the differential effects of classroom exercise breaks between classrooms and individual students. In the two studies to observe on-task behavior after classroom exercise breaks, both found that the effects were different based on student characteristics. In those studies, the beneficial effects of classroom exercise were the most beneficial in those with attention difficulties and with higher body mass index. Other individual differences in responses have not been examined. These variations in response can be lost when results are examined in unstratified groups.

The purposes of this study were to determine the acute effects of classroom exercise breaks on on-task behavior in elementary school students and to examine the differences in responses between 5, 10 and 20 minutes of exercise. Additionally, the effects were examined by individual classrooms and several individual student factors including gender, intelligence quotient (IQ), fitness, BMI, behavior, school engagement and baseline on-task behavior.

Methods

Participants

A convenience sample of a school and classrooms was selected through agreement of the principal and teachers. Participants ranged from 9 to 12 years of age
and were 4th or 5th grade students in one elementary school in central South Carolina. All students from eight participating classrooms were invited to participate. Classrooms in the school were grouped on the basis of academic abilities and interests. To efficiently administer the intervention to consenting students, some classes were combined and the intervention was delivered to five classroom groups.

**Procedures**

This study used a within-subjects experimental design with students exposed to each of four conditions: 10 minutes of sedentary classroom activity and 5, 10, 20 minutes of classroom exercise breaks. The order of conditions was randomized to each classroom group, using a Latin Square design,\textsuperscript{26, 27} to counterbalance practice effects. Time-on-task was measured before and after each condition while the students performed pencil-and-paper tasks. This pre-post design was used to account for daily variation in time-on-task. To familiarize students with the classroom exercise breaks, thus reducing novelty effects, students participated in two days of classroom exercise breaks per week. Time-on-task was only observed on one day a week. All observations were held on the same time and day of the week for each classroom group. Parent consent and student assent were obtained for all participants.
**Treatments**

The Brain BITES (Better Ideas Through Exercise) exercise break intervention was led by research staff. The exercise breaks were designed to maintain moderate-to-vigorous physical activity and to be fun and engaging for the students. Specific exercises were selected to be feasible within a small classroom setting and included marching in place with arm movements, various forms of jumping, and running in place. Exercise sessions were performed to music selected by the students in a brief planning session prior to the intervention and the instructor verbally encouraged as well as physically participated in all sessions. To further encourage participation, the instructor encouraged students to get their heart rates to 150 beats per minute. Students recorded their own self-palpated carotid or radial pulse rates immediately after each session.

Activities were similar across the four exercise conditions; only the duration of activities varied. All intervention conditions were videotaped and coded for physical activity intensity. The three exercise durations were 5, 10, and 20 minutes of classroom exercise breaks. These durations were selected because research has found acute effects in similar outcomes with 10 and 20 minutes of physical activity.\textsuperscript{12, 28} Limited evidence has shown that briefer periods of physical activity may not be sufficient to elicit acute improvements in cognitive functions,\textsuperscript{25} however, for feasibility and sustainability, briefer sessions are more likely to be implemented and integrated within busy classroom schedules.
**Instruments**

Baseline measures were administered prior to the intervention. Standardized height and weight were used to calculate Body Mass Index (BMI). Participating students completed the 15m PACER test from the FITNESSGRAM battery as an estimate of aerobic fitness. Students were individually administered the Kaufmann Brief Intelligence Test-Second Version (KBIT-2) as a measure of abbreviated IQ. Additionally, students completed a brief survey on their previous academic grades, physical activity levels, and engagement in school. Parents completed a brief survey on parent education, race and socioeconomic status. They also completed the Conners’ Parent Rating Scales Revised short edition, a 27 item checklist to assess attention-deficit/hyperactivity and problem behavior symptoms.

**Physical Activity Intensity**

To assess the fidelity of the intervention, videotapes of all four conditions were coded for intensity of physical activity using a modified System for Observing Fitness Instruction Time (SOFIT) as modified by Donnelly. Observations were made of individual children at consecutive 10-second intervals during the exercise or sedentary condition, not including cognitive testing. Their average activity level during the 10-second interval was coded using a scale from 1 to 5 where 1 is equal to lying down and 5 is equal to being very active (ex. running in place, jumping). Videos were viewed and coded three times with a different child observed for the same intervals during each viewing. Each participant was observed an average of 16.8 times during the sedentary condition, 7.5 times during the 5-minute exercise break, 12.5 times during the 10-
minute break, and 25.5 times during the 20-minute break. To assess reliability, ten percent of the intervals were recoded four months after the initial coding (n=424). Intervals were randomly selected in groups of 10. The percent agreement was 91.0% with a weighted kappa of 0.95.

*Time-on-task*

To obtain an ecologically valid measure of time-on-task, children were directly observed as consistent with previous studies. A systematic time sampling observation system was used. Multiple observation intervals of time-on-task have been used ranging from 10 seconds to 30 seconds to 1 minute. As used by Riley et al, a 15 second observation interval was selected for this study. To be able to assess time-on-task in all participants within the short testing frame, video cameras, placed in the front of the classroom were used for direct observation. Consented students were observed for time-on-task during the testing procedure. Time-on-task was determined by the direction of the student’s gaze, either at the instructor or on the testing materials. Students were observed while completing paper-and-pencil tests before and after each condition. The videos were edited so only the testing procedures, and not the treatment condition, were included and the videos were assigned random identification codes. Both observers were unaware of the time and condition of testing, remaining blinded to the condition. Each video segment was viewed three times. A student was viewed for 15 seconds and the number of off-task interruptions was tallied. Off-task behavior included direction of gaze away from the instructor or testing materials,
speaking out of turn, and excessive fidgeting. The observer cycled through all visible students in three viewings of the complete condition from left to right, right to left, and beginning in the center of the classroom. Different students were observed at each 15-second interval between the 3 viewings. If a student was not visible for at least 5 seconds during the 15-second interval (due to obstructed camera view from another student or the student was in a position where the observer could not see his or face), the observer proceeded to the next student.

Videos were watched by two observers (an observer blinded to the study aims, and the primary investigator). Both observers viewed the same students at the same time intervals. During the first round of coding, interobserver agreement was 81 percent with a kappa statistic of 0.41. While the agreement was moderate, each interval that differed between coders were examined a third time by the primary investigator to reach agreement. For the analysis, if a student was off-task at all during the 15-second interval, that interval was considered to be off-task (regardless of the total count of off-task interruptions). The percentage of intervals coded as on-task for each student during each condition was used as the dependent variable.

**Data Analysis**

Descriptive statistics were calculated for the total group and each classroom group individually using SAS 9.2. Between-group comparisons were made using ANCOVA or chi-square tests. The intraclass correlation for pre-test time-on-task scores was 0.525. Due to this variation, pre-test time-on-task scores for each condition were included in the model testing the overall effect.
A repeated measures mixed ANCOVA model tested the difference in post-test time-on-task between conditions, adjusted for classroom group and age and with pre-test time-on-task scores included as a time-varying covariate (PROC MIXED). Mixed models using maximum likelihood estimation were used to account for the time-varying covariate of pre-test time-on-task, to utilize all available data, and account for the within-subject correlation with repeated measures. To examine to differences between durations of classroom exercise breaks, linear contrasts compared post-test time-on-task for each exercise condition to the sedentary condition.

To examine the differences between classroom groups and individual student characteristics, these analyses were repeated separately for each classroom group. Interactions between potential effect modifiers were added to the model of the total group including gender, IQ, fitness, BMI, attention-deficit/hyperactivity problem behavior symptoms, and school engagement. Participants were categorized based on the median split of the potential modifiers. Students were also split into the most on-task and the least on-task students using the mean pre-test time-on-task from each of the four conditions. Mahar et al. previously used a cut-off of less than 50% on-task behavior to classify the least on-task students. In this study, only 6 participants averaged less than 50% on-task behavior, therefore, students who were on-task less than 60% of the time were considered to be the least on-task.
Results

Of the students participating in the study, 10.7% were black, 68.8% were white, and 34% had a parent income less than $40,000. There were between classroom group differences in age (as expected with multiple grade levels), verbal IQ and physical activity levels as seen in TABLE 4.1. One classroom group did not complete the entire research protocol due to technical (camera malfunction), logistical (students obstructing the camera view) and scheduling difficulties that prevented observation of on-task behavior for all four treatments. Additionally, that classroom was the only classroom who participated in the intervention at the end of the school day causing disruptions that precluded that classroom from being exposed to all of the treatments. Therefore, this classroom was excluded from the analyses.

Seventy-five students in four classroom groups were included in the analyses. The intervention was implemented with high-fidelity and an average intensity (scale from 1 to 5 where 1 is equal to lying down and 5 is equal to being very active) of 4.35 (SD 0.47), 4.37 (SD 0.32), and 4.29 (SD 0.33) for the 5, 10, and 20 minutes classroom exercise break conditions respectively. There was a significant improvement in observed on-task behavior after 10 (p<.01, d=.50) and 20 minutes (p=.056, d=.32) of exercise compared to the sedentary condition, see FIGURE 4.1A.

Classroom Analysis

Individual classroom groups displayed unique results when analyzed as separate groups as seen in FIGURE 4.1B and TABLE 4.2. Classrooms 1, 3, and 4 had higher scores
after 10 minutes of exercise, and Classroom 3 also had improvements after 5 minutes of exercise.

**Student Characteristics Analyses**

There was a significant interaction between the exercise dose and gender \((p=.0002)\). Both boys and girls improved time-on-task after 10 minutes, but boys had lower time-on-task after 5 minutes while girls had higher time-on-task. No other overall interactions were significant. The individual estimates and linear contrast comparisons can be seen for each potential modifier in FIGURE 4.2.

**Discussion**

This study was the first to directly compare the acute effects of different durations of classroom exercise breaks on on-task behavior. Classroom exercise breaks improved students’ on-task behavior after 10 minutes of exposure with a trend to increased on-task behavior after 20 minutes. Similar to the current study, two previous studies that observed time-on-task after classroom exercise breaks found positive effects in on-task behavior after 10 minutes of classroom exercise breaks.\(^\text{12, 13}\) The current study was the first to look at the effects of less than 10 minutes of classroom exercise breaks on time-on-task, and found no change in time-on-task after 5 minutes of classroom exercise. No studies have directly compared the acute effects of physical activity on on-task behavior. When examining other cognitive outcomes, Kubesch et al. found no improvement after 5 minutes of classroom activity but did find cognitive improvements after 20 minutes of a physical education class.
When the results from individual classrooms were examined separately, different classrooms displayed unique results. Three out of the four classrooms improved on-task behavior after 10 minutes of classroom exercise, one classroom had no changes in on-task behavior, and one classroom also showed improvement after 5 minutes of exercise. The differences between classrooms are not unexpected, as classrooms were tracked, or group based on academic abilities and interests. Future research is needed to confirm and understand these classroom differences. Understanding these differences may be useful in making specific recommendations for certain classes. For example, a classroom, such as Classroom 3 may be able to benefit from 5 minutes of classroom exercise breaks, while other classrooms need 10 minutes.

Only one classroom had decreased time-on-task after any of the exercise breaks, though the decrease was not statistically significant. During the post-testing of this condition, a teacher knocked over a bookshelf which caused an obvious disruption and students’ attention was diverted. This classroom variation points to the complexity of doing research in uncontrolled settings, where several factors can influence results. Many of these factors cannot be completely controlled for statistically and must be considered in the study design and interpretations of findings.

Beyond classroom variation, interesting findings emerged when the results across all classrooms were stratified by individual student characteristics. Boys were the only group who had a decrease in time-on-task after any exercise. Students with lower IQ, higher fitness, and lower BMI showed improvements in time-on-task after 10 minutes of exercise. Grieco et al. found that children with higher BMI showed greater
beneficial effects from a classroom exercise break. Of note, no differences were seen between students based on school engagement or their baseline on-task behavior.

These results did not support Mahar et al.’s findings that classroom exercise breaks had the greatest benefits in students who were most off-task. However, the current findings do suggest that on-task behavior can be improved in both the most off-task students and students with low engagement in school, who are the students with greater academic needs. More research is needed to understand how physical activity may have unique cognitive effects in different students and how regular classroom exercise breaks will affect student on-task behavior. Overall, the effects of classroom exercise breaks appear to be sensitive to multiple factors.

**Limitations**

As a “real world” efficacy study, the intervention was implemented by research staff. Implementation by research staff increased the fidelity of intervention and enabled direct comparisons between delivered doses. However, classroom exercise breaks delivered by outside staff are not sustainable for widespread implementation; teachers need to be trained to implement these practices. Future studies will be needed to examine if teachers can implement the same intensity and duration classroom exercise breaks as implemented in this study. Another limitation is the potential for subjectivity with direct observation. For this study, however, several precautions were taken to maintain objectivity in coding time-on-task including blinding observers to the study condition and using an objective and systematic protocol. While the interobserver correlations were fair, any disagreements between observers were further re-evaluated
to reach consensus. While time-on-task is not a perfect proxy for whether a student is paying attention or engaged with the lesson, it is a tangible, observable metric used by teachers in the classroom.\textsuperscript{45, 46}

\textbf{Implications for School Health}

This study has immediate practical implications for implementing classroom exercise breaks into the school day. With strict curriculums and limited time in elementary schools, administrators and teachers must be creative to integrate physical opportunities throughout the school day. A primary barrier to implementing physical activity in the classroom is teachers’ fear that students will not be able to settle back down into the lesson, as acknowledged by the teachers in this study. This study suggests that students do not become more off-task after a brief, high intensity, classroom exercise break, but rather increased their on-task behavior.

Students are suffering from the consequences of sedentary lifestyles. One out of five children show early signs of cardiovascular disease such as high blood pressure\textsuperscript{47} and one out of six children are obese.\textsuperscript{48} Less than half of children are meeting physical activity recommendations,\textsuperscript{49} despite the many health benefits of physical activity for children including improved cardiorespiratory fitness, metabolic profiles, bone health, and mental health.\textsuperscript{50} Classroom exercise breaks are one physical activity opportunity that have been shown to improve the health of children.\textsuperscript{24, 51, 52} If teachers can implement these 10 minute classroom exercise breaks, students may not only receive health benefits of classroom exercise breaks, but as this study showed, students may be more on-task to learn.
Human Subjects Approval Statement

This study was approved by the University of South Carolina Institutional Review Board and the research review board of the participating school district.
Table 4.1: Demographics by classroom group (mean (SD))

<table>
<thead>
<tr>
<th>Classroom Group</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>n</td>
<td>19</td>
<td>12</td>
<td>18</td>
<td>26</td>
<td>21</td>
<td></td>
</tr>
<tr>
<td>Gender (% female)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>.90</td>
</tr>
<tr>
<td>Age (years)</td>
<td>11.2</td>
<td>11.2</td>
<td>11.1</td>
<td>10.2</td>
<td>10.2</td>
<td>&lt;.0001</td>
</tr>
<tr>
<td>Age (years)</td>
<td>(.39)</td>
<td>(.29)</td>
<td>(.36)</td>
<td>(.34)</td>
<td>(.39)</td>
<td></td>
</tr>
<tr>
<td>Verbal IQ(^a)</td>
<td>89.3</td>
<td>105</td>
<td>99.1</td>
<td>101.5</td>
<td>98.5</td>
<td>.01</td>
</tr>
<tr>
<td>Verbal IQ(^a)</td>
<td>(10.1)</td>
<td>(7.68)</td>
<td>(14.36)</td>
<td>(14.43)</td>
<td>(13.17)</td>
<td></td>
</tr>
<tr>
<td>Matrices IQ(^a)</td>
<td>101.3</td>
<td>105.8</td>
<td>104.8</td>
<td>105</td>
<td>95.5</td>
<td>.06</td>
</tr>
<tr>
<td>Matrices IQ(^a)</td>
<td>(11.03)</td>
<td>(7.93)</td>
<td>(15.51)</td>
<td>(8.01)</td>
<td>(14.09)</td>
<td></td>
</tr>
<tr>
<td>Composite IQ(^a)</td>
<td>99.7</td>
<td>106.6</td>
<td>102.5</td>
<td>105.1</td>
<td>96.8</td>
<td>.33</td>
</tr>
<tr>
<td>Composite IQ(^a)</td>
<td>(23.96)</td>
<td>(4.52)</td>
<td>(16.22)</td>
<td>(9.16)</td>
<td>(13.08)</td>
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<tr>
<td>Fitness(^b)</td>
<td>19.8</td>
<td>23.9</td>
<td>27.5</td>
<td>21.5</td>
<td>19.1</td>
<td>.32</td>
</tr>
<tr>
<td>Fitness(^b)</td>
<td>(11.16)</td>
<td>(11.97)</td>
<td>(14.23)</td>
<td>(15.72)</td>
<td>(8.20)</td>
<td></td>
</tr>
<tr>
<td>BMI</td>
<td>18.7</td>
<td>18.6</td>
<td>20.3</td>
<td>20.9</td>
<td>20.0</td>
<td>.48</td>
</tr>
<tr>
<td>BMI</td>
<td>(3.42)</td>
<td>(2.86)</td>
<td>(3.89)</td>
<td>(6.04)</td>
<td>(4.51)</td>
<td></td>
</tr>
<tr>
<td>Physical Activity(^c)</td>
<td>4.3</td>
<td>6</td>
<td>4.8</td>
<td>5.3</td>
<td>6.3</td>
<td>.03</td>
</tr>
<tr>
<td>Physical Activity(^c)</td>
<td>(2.35)</td>
<td>(1.49)</td>
<td>(1.86)</td>
<td>(2.37)</td>
<td>(1.13)</td>
<td></td>
</tr>
<tr>
<td>Behavior(^d)</td>
<td>22.2</td>
<td>21.7</td>
<td>11.1</td>
<td>14.8</td>
<td>15.4</td>
<td>.25</td>
</tr>
<tr>
<td>Behavior(^d)</td>
<td>(14.91)</td>
<td>(11.39)</td>
<td>(8.53)</td>
<td>(14.30)</td>
<td>(17.67)</td>
<td></td>
</tr>
<tr>
<td>Engagement(^e)</td>
<td>22.1</td>
<td>19.3</td>
<td>19.3</td>
<td>22.3</td>
<td>19.7</td>
<td>.33</td>
</tr>
<tr>
<td>Engagement(^e)</td>
<td>(5.86)</td>
<td>(5.60)</td>
<td>(7.38)</td>
<td>(4.10)</td>
<td>(5.27)</td>
<td></td>
</tr>
</tbody>
</table>

\(^a\) Standardized scores from Kaufmann Brief Intelligence Test-Second Version
\(^b\) # 15m laps completed during PACER test
\(^c\) >60 minutes per day* (days per week)
\(^d\) score >23 may suggest behavioral problems
\(^e\) range from 6 to 30, higher scores indicate higher engagement with school
Table 4.2: Post-test time-on-task for each condition by classroom group* (SE)

<table>
<thead>
<tr>
<th>Classroom Group</th>
<th>Sedentary</th>
<th>5 min</th>
<th>10 min</th>
<th>20 min</th>
</tr>
</thead>
<tbody>
<tr>
<td>One</td>
<td>79.44 (4.2)</td>
<td>89.78 (4.3)</td>
<td>91.67 (4.0)</td>
<td>89.60 (3.9)</td>
</tr>
<tr>
<td>Two</td>
<td>86.61 (5.2)</td>
<td>83.38 (5.2)</td>
<td>81.53 (5.3)</td>
<td>81.96 (5.8)</td>
</tr>
<tr>
<td>Three</td>
<td>72.78 (5.0)</td>
<td>89.90 (6.5)</td>
<td>88.57 (5.6)</td>
<td>82.29 (5.3)</td>
</tr>
<tr>
<td>Four</td>
<td>71.11 (5.0)</td>
<td>56.81 (4.6)</td>
<td>88.03 (4.6)</td>
<td>79.53 (4.6)</td>
</tr>
</tbody>
</table>

*adjusted for gender and pre-test time-on-task
Figure 4.1: Observed time-on-task after 10 minutes of seated classroom activity or 5, 10, 20 minutes of classroom exercise breaks in A) Total group, B) Each classroom individually

* difference from sedentary within classroom group at p<.05
** Figure 4.2: Time-on-task after seated classroom activity or 5, 10, 20 minutes of classroom exercise breaks, stratified by baseline characteristics

** difference from sedentary condition at \( p < .10 \)

* difference from sedentary condition at \( p < .05 \)
References


CHAPTER 5

MANUSCRIPT 4: SMILES COUNT: A MIXED-METHODS ANALYSIS OF THE AFFECTIVE RESPONSE, ACCEPTABILITY AND FEASIBILITY OF A CLASSROOM EXERCISE BREAK INTERVENTION IN ELEMENTARY SCHOOLS

Howie EK, Beets MW, Newman-Norlund RD, Schatz JC, Pate RR. To be submitted to The Elementary School Journal.
Abstract

To foster successful students, educators must care for the whole child, including student physical health. Physical activity is a critical component of physical health. This mixed-methods, experimental study used quantitative observations and qualitative focus groups to examine affective responses to, along with the acceptability and feasibility of a classroom exercise break intervention in 4th- and 5th-graders (n=96). The effects were compared between various durations of classroom exercise breaks and by individual student characteristics. Videotapes of 5, 10, and 20-minute classroom exercise breaks were coded for positive affect using a momentary time sampling protocol and compared to 10 minutes of sedentary classroom activity. Students had higher positive affect during all the exercise conditions as compared to the sedentary condition. Students described multiple benefits of the classroom exercise breaks and teachers reported that students enjoyed the exercise and that there were no problems with the students settling down afterwards. Classroom exercise breaks are a feasible and enjoyable way to increase physical activity in a youth population that is increasingly sedentary.

Introduction

A whole child approach to education requires that all students be safe, engaged, supported, challenged and healthy. One critical component of student health is regular participation in physical activity. Children receive numerous health benefits from physical activity including improved cardiorespiratory fitness, body composition,
metabolic profile, muscular fitness, and bone health which ultimately decrease the risk for chronic diseases and mortality. Unfortunately, many children do not meet the guidelines for recommended levels of physical activity. In addition to the numerous physical health benefits, physical activity is also beneficial for mental health and can decrease the risk of depression and anxiety while improving self-esteem. Acute exercise has also shown to improve mood in adults and children.

Not only has physical activity been shown to improve mood, but enjoyment of physical activity may also be important for sustaining regular physical activity. Enjoyment of physical activity has consistently been shown to be related to higher levels of physical activity in children. Furthermore, children who enjoy physical activity are more likely to engage in future physical activity. Fortunately, children do enjoy exercise. Fun and enjoyment are the primary reasons that children report for participating in physical activities. Both children and teachers believe physical activity interventions should be enjoyable, and levels of enjoyment have been shown to moderate the effects of exercise interventions. Conversely, developmentally inappropriate physical activities, where children do not have fun, may have negative effects on children’s future participation in physical activity. Thus, creating enjoyable, appropriate physical activity opportunities is an essential component of public health policies designed to increase physical activity levels of youth.

The importance of children having fun during physical activity goes beyond just enjoyment. Fun and happiness may improve performance in school through associated cognitive benefits as well as increased engagement in school. Some studies have
observed that children who are happy may learn better.\textsuperscript{22, 24} Thus, it is important to provide enjoyable physical activities during school, as it can increase positive affect and may ultimately influence academic achievement outcomes. Classroom exercise breaks are one type of physical activity opportunity during the school day that requires few additional resources or large amounts of time. While many studies have researched the affective responses of adults to exercise,\textsuperscript{5} none to our knowledge have objectively quantified positive affect in response to physical activity in children.

Nonetheless, even if physical activity opportunities increase positive affect, the physical activity practices are unlikely to be implemented widely if they are not acceptable and feasible to students and teachers. Qualitative approaches provide methods to assess the acceptability and feasibility of classroom exercise breaks. The inductive approach of qualitative research helps to collect participant perspectives without imposing presupposed research hypotheses.\textsuperscript{25} When combined with quantitative measures, qualitative methods can provide a more holistic picture of the classroom exercise breaks.

**Why Positive Affect is Important in Education**

Positive affect is a pleasurable state of engagement with the environment that includes the positive emotions of happiness, joy, excitement, enthusiasm and contentment.\textsuperscript{26, 27} Positive affect and positive emotions have shown to have beneficial effects on cognitive functions. Dreisbach found that positive emotions increase the flexibility, problem solving and critical thinking in response to a novel stimulus.\textsuperscript{20} A review of the effects of positive affect on cognitive skills found that positive affect
improves creative problem solving, negotiation, and decision making. A number of theoretical models capable of explaining the effect of positive affect on cognitive function have emerged in the last few decades. Fredrickson’s Broaden-and-Build theory proposes that positive emotions expand the thought-action repertoire which allows individuals to think critically and broadly. In contrast, negative emotions narrow the thought-action repertoire and cause quick, impulsive decisions.

In addition to direct effects on cognitive processes, positive affect may also improve student school engagement. If a student enjoys school, they are more likely to engage in the classroom and be motivated to learn. Higher school engagement has been shown to predict academic achievement. A review of the effects of student engagement on academic achievement found that there is a consistent, positive association between engagement and achievement. A prospective longitudinal study followed over 300 students from kindergarten through eighth grade and found that higher positive engagement predicted higher student academic success as measured by a standardized achievement test.

As a result of these findings regarding the importance of positive affect and positive emotions to academic success, many psychologists, including school psychologists, have adopted approaches grounded in positive psychology. Positive psychology focuses on happiness and positive emotion, the opposite of deficit based psychology, as the most effective way to improve student performance. Lewis et al. found that positive affect predicts student school satisfaction and school engagement, and interventions based on positive psychology are associated with improved academic
performance.\textsuperscript{32} Barnes argues for the need for positive emotion in schools, and advocates that physical education is a key part of providing enjoyment and engagement.\textsuperscript{33} As a result of the influence of student enjoyment in school on educational outcomes, student enjoyment is often an outcome of effective teaching. Multiple state approved teacher evaluations include an evaluation of student enjoyment and engagement.\textsuperscript{34, 35} Taken together, this research highlights the need to improve positive affect in students.

\textit{The Relationship Between Exercise and Positive Affect}

There is a reciprocal relationship between physical activity and positive emotions. Not only are children who enjoy physical activity more likely to participate in physical activity, but physical activity has also shown to improve positive emotions. First, several studies have shown that individuals who enjoy exercise participate in more physical activity.\textsuperscript{8, 9} The affective response to an acute bout of exercise was measured in healthy sedentary adults, and then they reported their physical activity levels at 6 and 12 months.\textsuperscript{8} Those with greater positive affective responses to exercise reported higher levels of physical activity. These results have been replicated in children. A within-subjects study of 9 and 10 year-old children found that children had higher positive mood after 15 minutes of exercise compared to a 15 minute video.\textsuperscript{7} Similarly, adolescents who had a more positive affective response to acute exercise had higher levels of objectively measured physical activity.\textsuperscript{9}

Secondly, physical activity and exercise have shown to improve mood in adults\textsuperscript{5, 6} as well as children.\textsuperscript{7} Exercise is thought to improve mood through several plausible
physiological and psychosocial pathways including monoamines, endorphins, endocannabinoid receptors, improved self-concept, and distraction from other worries. While original research showed that exercise increased monoamines and beta-endorphins, these increases are not always associated with positive changes in mood.

The most current hypothesis for the underlying biological mechanism underlying the positive effect of exercise on mood is through endocannabinoid signaling. The importance of endocannabinoid signaling for mood and emotion was first identified in response to THC, the active ingredient in marijuana. Endocannabinoids are lipid receptors that are concentrated in areas of the brain associated with reward and emotion. Exercise increases endocannabinoids, which has been correlated to improved mood, motivation to exercise, and the phenomena known as the “runner’s high.” Increased positive affect from exercise may also occur through psychosocial factors such as self-efficacy and improved self-concept. The distraction hypothesis posits that while exercising, people do not think about other problems or issues that may be causing a negative mood. Additionally, the effects of exercise on emotions have shown to differ by individual characteristics. It is possible that students with lower fitness or higher BMI may have different affective responses to physical activity.

**Fitting Exercise into the School Day through Classroom Exercise Breaks**

Physical activity opportunities, particularly physical education and recess, are being reduced in schools due to budget concerns and increased focus on standardized testing resulting from No Child Left Behind. In a survey of principals, The Center for
Education Policy found that seven out of ten schools reported decreasing staff in non-core academic areas, including physical education, with five out of ten anticipating further cuts. Classroom exercise breaks are one way to increase the minutes of physical activity that students receive, without requiring many additional resources. Classroom exercise breaks are short bouts of physical activity (they do not interfere with rigid curriculum time), that occur in the classroom (they do not need additional gym or outdoor space), and are led by classroom teachers (there is no need for additional staff).

For these reasons, schools across the nation are implementing classroom exercise breaks. The School Health Policies survey reported that 40 percent of school districts either require or recommend classroom exercise breaks for elementary schools. The commercial market has also capitalized on this growing market and provides resources to teachers to implement classroom exercise breaks such as Brain Breaks and OrganWise Guys. Despite the policies requiring classroom exercise breaks, no previous studies have examined the acceptability and feasibility of these practices to students and teachers.

With the growing prevalence of classroom exercise breaks, there has been an emergence of studies examining the effects of classroom exercise breaks on student health and health behaviors such as physical activity. Liu et al. found improvements in Body Mass Index (BMI) after a 9 month daily classroom exercise break intervention. Similarly, a randomized control trial of 24 elementary schools found that schools that implemented daily classroom exercise breaks had improvements in student BMI after three years. Short-term studies have also found that classroom exercise breaks
increase overall physical activity.\textsuperscript{50-52} A few studies have also examined the effects of classroom exercise breaks on educational outcomes such as cognitive and academic performance and found positive effects.\textsuperscript{50, 51, 53-56} The positive effects of exercise on academics have been studied more commonly in response to overall physical activity, fitness, physical education and recess,\textsuperscript{57-60} but classroom exercise breaks may be even more critical to student academic achievement. Exercise within the classroom, which occurs directly within the school day and learning environment, may be more likely to affect students’ disposition and learning. No prior studies have thoroughly examined the affective response to classroom exercise breaks.

\textit{Research Questions}

This mixed methods study used quantitative observations and qualitative interviews to examine the affective responses to, along with the acceptability and feasibility of a classroom exercise break intervention in elementary school students. This study answered four research questions. 1) Do classroom exercise breaks influence positive affect in elementary school students? 2) Do the effects differ by the duration of the classroom exercise break? 3) Do the effects differ by individual student characteristics? 4) Are classroom exercise breaks acceptable to students and teachers? For the purposes of this study, acceptability is operationally defined as the willingness to participate in or conduct voluntary classroom exercise breaks in the future.
Methods

Study Design

This study was a mixed-methods experimental study of a classroom exercise break intervention. This study used a within-subjects experimental design. Students participated in each of four treatment conditions: 10 minutes of sedentary classroom activity, and 5, 10 and 20 minute exercise breaks. Quantitative observations of positive affect were coded from video footage of all four conditions. Qualitative information was obtained through teacher and student focus groups after the intervention was completed.

Participants

Participants were from four 4th grade and four 5th grade classrooms from an elementary school in South Carolina. Four 4th grade and four 5th grade teachers participated in the focus groups after the intervention was completed. Student participants ranged from 9 to 12 years of age. The total school population was 18% black, 8% Hispanic, and 70% white with 30 percent receiving free-and-reduced lunch. The demographics of the sample can be seen in TABLE 5.1.

Intervention

The Brain BITES (Better Ideas Through Exercise) intervention was designed to be implemented within the classroom setting. The exercise breaks were led by research staff, set to music, and attempted to engage all children in moderate-to-vigorous physical activity. Activities included jumping, hopping, marching, and running in place.
The instructor physically participated and gave positive encouragement to the students. To encourage higher intensity activity, children were taught to take their own carotid or radial pulses, with the goal of obtaining 150 beats per minute during exercise. The intervention was videotaped for intervention fidelity and to objectively code positive affect.

To assess the fidelity of the intervention, videotapes of all four conditions were coded for intensity of physical activity using a modified System for Observing Fitness Instruction Time (SOFIT)\textsuperscript{61} modified by Donnelly. Observations were made of individual children at consecutive 10-second intervals during the exercise or sedentary condition. Their average activity level during the 10-second interval was coded using a scale from 1 to 5 where 1 is equal to lying down and 5 is equal to being very active (ex. running in place, jumping). Videos were viewed and coded three times with a different child observed for the same intervals during each viewing. The average intensity of each condition was 2.01 (SD 0.05) during the sedentary condition, 4.00 (SD 0.43) during the 5 minute exercise condition, 4.35 (SD 0.33) during the 10 minute exercise condition and 4.26 (SD 0.37) during the 20 minute exercise condition.

\textit{Measures}

Students completed several measures at baseline, including height and weight to calculate BMI, the 15m PACER test from the FITNESSGRAM battery to estimate aerobic fitness, and the Kaufmann Brief Intelligence Test-Second Version as a measure of abbreviated IQ.

\textit{Direct Observation}
To quantitatively measure positive affect, the videotapes of the classroom physical activity intervention were objectively analyzed. Previous studies have utilized videotape footage to analyze affect.\textsuperscript{62, 63} Several objective systems have been used to code facial expressions for affect.\textsuperscript{63, 64} As affect and emotion has not been previously coded in physical activity settings, a modified version based on the Specific Affect Coding System\textsuperscript{64} and the System for Observing Children’s Activity and Relationships during Play (SOCARP) was used.\textsuperscript{65}

The observer was trained using previous footage of child classroom physical activity. Only consented students were analyzed. Videos were viewed and coded three times. The observer scanned through all visible students in three viewings of the complete condition from left to right, right to left, and beginning in the center of the classroom. Different students were observed at each 10-second interval between the three viewings. If a student was not visible for at least five seconds during the 10-second interval (due to being obstructed from the camera by another student or leaving the frame of view), the observer proceeded to the next student. The observer watched the selected student for a 10-second interval and coded whether or not they displayed positive affect. Positive affect is a broad disposition\textsuperscript{26}, differing from specific emotions, and involves some subjective analysis. Signs of positive affect included smiling and positive verbal response (i.e. “This is fun” or “I like this”). A total of 4260 observations were made with 1122 (mean 16.7 per student) during the sedentary condition, 471 (mean 7.5 per student) during the 5 minutes, 876 (mean 12.3 per student) during the 10 minutes, and 1791 (mean 26.3 per student) during the 20 minutes. Retest reliability was
tested in ten percent (n=420) of the coded intervals four months after the initial coding. The intervals were randomly selected in groups of 10. The overall percent agreement was 95.7 percent with a kappa of 0.91. The primary child-level outcome variable was the percentage of intervals coded for positive affect for each condition.

*Student Focus Groups*

Focus groups were held with consenting, participating students within one week of the completion of the classroom exercise break intervention. The focus groups assessed acceptability and reactions to the intervention to inform future practices. Focus groups were conducted with the participating classroom groups (total number of students per classroom ranged from 12 to 26), for a total of 5 groups. Facilitative questions included general opinions, how they felt afterwards, and how they would change it. The discussion were recorded and transcribed.

*Teacher Focus Groups*

The 4<sup>th</sup> and 5<sup>th</sup> grade teachers participated in focus groups at the end of the 5-week intervention period to gather information on the implementation, feasibility, perceived benefits and overall impressions of the intervention. Two focus groups were conducted, one with the 4, 4<sup>th</sup> grade teachers and one with the 4, 5<sup>th</sup> grade teachers. Focus groups were recorded and transcribed.

*Analysis*

Descriptive statistics were calculated for the total group and separately for each gender using SAS 9.2. Positive affect was approximately normally distributed. To answer Research Question 1, a repeated measures mixed ANCOVA model tested the difference
in positive affect between conditions, adjusted for classroom group and age using PROC MIXED. To examine the differences between durations of classroom exercise breaks for Research Question 2, linear contrasts compared positive affect for each exercise condition to the sedentary condition. Cohen’s $d$ effect sizes were calculated for each condition compared to sedentary. A minute-by-minute analysis of the time course of positive affect was also conducted over the duration of the activities. The mean positive affect was calculated for each minute, and then graphically compared across the four conditions. To examine the interactions between gender, fitness and BMI, for Research Question 3, these analyses were repeated with interaction terms. Participants were categorized based on the median split of the potential modifiers.

Research Question 4 was answered through analysis of focus group transcripts. Transcriptions from student focus groups and teacher interviews were coded for emerging themes. In vivo codes were created during open coding using the constant comparative method. Codes were then grouped into final emergent themes using constant comparative analysis. To ensure the rigor of this qualitative study, validity as defined by Lincoln and Guba was established through triangulation of the data. The credibility of the theory, referred to as validity in quantitative studies, was strengthened through triangulation including multiple sources (students, teachers) and multiple methods (direct observations, surveys, interviews).

Results

1) Do classroom exercise breaks affect positive affect in elementary school students?
There was a significant main effect of the conditions on positive affect (F=60.47, df=178;).

2) Do the effects differ by time and duration of the classroom exercise break?

All three exercise durations improved positive affect (5 minutes=46.6%, \(d=1.54\); 10 minutes=45.5%, \(d=1.56\); 20 minutes=36.1%, \(d=1.15\)) as compared to the sedentary condition (7.8%). When positive affect was visually examined in relation to time during the intervention, positive affect began to decrease after 5 minutes, and leveled out at 30 percent (compared to 8% during the sedentary condition) as seen in FIGURE 5.1.

3) Do the effects differ by individual student characteristics?

When results were stratified by gender, fitness level, IQ and BMI, all exercise conditions still had higher positive affect than during the sedentary condition. During 5 and 10 minutes of classroom exercise breaks, females had higher positive affect than males (53.6% vs. 37.0%, \(p=0.01\); 50.7% vs. 39.8%, \(p=0.07\)) as seen in FIGURE 5.2. During 5 minutes of exercise, children with lower fitness had higher positive affect than those with higher fitness (53.0% vs. 41.3%, \(p=0.05\)). There were no other differences between IQ or BMI levels.

4) Are classroom exercise breaks acceptable to students and teachers?

The students and teachers found the study approach acceptable. The students and teachers reported they believed the classroom exercise breaks had multiple benefits for the students. The following themes emerged from the interviews and focus groups.
The students discussed three primary benefits of the classroom exercise breaks, the physical benefits of the exercise, the effects on the cognitive and academic tests afterwards, and their enjoyment of the breaks. The students thought that it was a “fun way of exercising”, “it’s good for the body”, and that it was a “good workout”. The students reported enjoyment of the classroom exercise breaks including that they were “fun” and “awesome.” “I really like the exercise’s cause it’s fun.” “It’s fun and it’s a cool way of exercising.” The students felt that they were more focused and awake afterwards. Their responses varied by the length of the classroom exercise break. Many students reported that the 5 minute break was too short. Some liked the 20 minutes the best while others preferred the 10 minutes. Some students reported that the tests were more difficult afterwards because they were tired. One student stated, “It depends on which one, cause sometimes I did better after exercise, for certain things, but sometimes I didn’t.” One 4th grade student summed up his experience, “What do you think of Brain BITES? It’s the best thing ever. What do you like best about it? The exercising, everything. Why do you like the exercise? Because it helps me, FOCUS.”

The teachers reported that the most positive aspects of the classroom exercise breaks were that the students looked forward to them and enjoyed them and that they did not see any problems with the students settling down afterwards. The teachers also noted that the students seemed to think it helped. For example, a teacher described how one student began doing the exercises on her own in the middle of standardized testing, and multiple teachers used a modified version of the exercise break during the state testing. Despite seeing the benefits, teachers were honest about the difficulty of
fitting classroom exercise breaks into their daily routine with the emphasis on standardized testing, standards and structured curriculums. They felt that they have little time during the day to integrate these practices. As one teacher put it,

The only way you’re going to get teachers to do it, is to make it part of the program. Cause you’re going to have some teachers that will say yeah let’s do it, and most of them are gonna say, yeah I don’t have time.

If the teachers were to implement classroom exercise breaks, the teachers reported that they would only be able to get in 5 minutes in the morning, perhaps as part of the morning news show.

Discussion

This was the first study to quantify the affective response to acute classroom exercise breaks. This study found that children respond positively to classroom exercise breaks. Directly observed positive affect was higher during all classroom exercise breaks than during the sedentary control condition. Multiple sources were triangulated and all showed that the children enjoyed the classroom exercise breaks.

All durations of classroom exercise breaks improved positive affect equally. When positive affect was examined over the time course of the classroom exercise break, positive affect did begin to decrease between 5 and 10 minutes. However, positive affect plateaued at a level still much higher compared to the sedentary condition. Research suggests that there may be an ideal duration and intensity of exercise to elicit positive affective responses. Benjamin et al. found that positive affect decreased in children during a graded exercise test as intensity and duration
increased. Early research on the dose-relationship between exercise intensity and affect proposed that higher intensities produce negative affect responses following an inverted-U pattern. More recent work proposes an alternative and more complex dose-response model where moderate intensity activity elucidates positive affect among most people, while individual characteristics determine if an individual responds positively or negatively to higher intensity exercise. When the students in the current study were asked about their responses to the different durations, they responded inconsistently. While some students said they preferred the 5, and 10 minutes, the majority said they liked the 20 minutes. Two students said they did not like any of the durations. Thus, while positive affect did begin to decline as the duration increased, the overall positive findings show that these durations and intensities of classroom exercise breaks produce positive affect in the majority of children. Schools and teachers can implement these durations without causing negative responses in students.

Previous research in adults has shown that positive responses to exercise may differ based individual characteristics such as baseline self-efficacy or frontal cortical activity. In the current study, students responded to the classroom exercise breaks similarly regardless of IQ and BMI. The only differences between students found in this study were that females showed higher positive affect than males and students with lower fitness had higher positive affect during 5 minutes of exercise compared to students with higher fitness. Importantly, all groups had significantly higher positive affect during exercise than during the sedentary condition. This homogeneity in responses shows that even students with lower fitness or higher BMI enjoyed
participating in these higher intensity classroom exercise breaks. As all children improved positive affect in response to the intervention, classroom exercise breaks appear to provide an appropriate physical activity opportunity for all students.

Despite the improved positive affect during all the durations of classroom exercise breaks and the children’s slight preference towards the longer breaks, teachers discussed the ability to only implement exercise breaks of less than 5 minutes in duration. Teachers suggested that the best options would be to include exercise in the morning news shows, but this would require support from the principal. Teachers in this study cited the strict curriculums and limited time as large barriers to implementing longer breaks, consistent with previous reports from teachers and administrators about the competing priorities in schools creating barriers to increasing physical activity. 69-71 This reluctance to include physical activity in favor of academic time is despite research that physical activity may improve cognitive performance and academic achievement in students. 58, 59 The increase in positive affect found in this study may even be a mediating factor in the improved cognitive function by broadening and building cognitive processes. 26 Tomporowski et al. suggest that changes in core affect during exercise improve cognitive performance. 72 Yet other evidence suggests that the mechanisms underlying improvements in affect after exercise are separate form those improving cognitive performance. 73 Regardless of the mechanism, Diamond suggests that positive emotional development is critical for the development of executive functions and other cognitive processes. 74 As she eloquently states, If we want the best academic outcomes, the most efficient and cost-effective route to achieve that is, counter intuitively, not to narrowly focus on academics, but to
also address children’s social, emotional, and physical development. Similarly, the best and most efficient route to physical health is through also addressing emotional, social, and cognitive wellness. Emotional wellness, similarly, depends critically on social, cognitive, and physical wellness.\(^{74(p780)}\)

Future studies are needed to examine if the increase in positive affect during exercise improves children’s enjoyment and engagement in school. Additionally, exercise can be incorporated into academic lessons so as not to take away time from curricular instruction.

One of the limitations of this study was the third person observation of positive affect. Outward displays of positive affect may not be genuinely indicative of happier children as children may be enjoying the activity but not smiling, or smiling and not enjoying the activity. However, outward displays of positive emotion are what teachers observe and use to interpret if the students enjoy the activity. Future studies can assess student perceptions of positive affect through self-reported questionnaires such Profile of Mood States\(^{75}\) or the Minimood specifically for children.\(^{76}\) Nonetheless, the findings from these objective observations were confirmed by student focus groups, where the students reported their positive experiences during the classroom exercise breaks. While the focus groups were not conducted by an independent evaluator, questions were designed to elicit both positive and negative responses to the intervention. The triangulation of multiple sources and multiple methods minimized the limitations from a single measure and created a holistic picture of the affective response and acceptability of classroom exercise breaks.

It is important to note that these effects are the results of the entire classroom exercise break experience, including the brief warm-up and cool down, music, and social
interaction and not solely physical activity. However, the sedentary condition was an attention control with research staff and also included social interaction. Regardless of the single mechanism for increased positive affect, if children are having fun while participating in classroom exercise breaks and being physically active, teachers may be more likely to provide additional opportunities to be physically active.

Overall, students and teachers responded positively to the classroom exercise breaks. Classroom exercise breaks have shown to be an acceptable practice to increase physical activity and positive affect during the school day. Some scholars argue that happiness itself is a goal of education, and classroom exercise breaks are one tool to make children happy. Unfortunately, the teachers expressed reserve in implementing regular classroom exercise breaks in their classrooms. Top-down policies may be needed to ensure children participate in daily classroom exercise breaks and incorporate physical activity into instructional time as a way to provide for the education of the whole child.
Table 5.1: Baseline descriptive variables (% or mean ± SD)

<table>
<thead>
<tr>
<th></th>
<th>Total</th>
<th>Female</th>
<th>Male</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>N</td>
<td>96</td>
<td>62</td>
<td>34</td>
<td></td>
</tr>
<tr>
<td>Age</td>
<td>10.7 ± .6</td>
<td>10.7 ± 0.6</td>
<td>10.7 ± 0.6</td>
<td>.68</td>
</tr>
<tr>
<td>% Black</td>
<td>19.8</td>
<td>19.1</td>
<td>21.2</td>
<td>.85</td>
</tr>
<tr>
<td>% White</td>
<td>68.8</td>
<td>66.7</td>
<td>72.7</td>
<td></td>
</tr>
<tr>
<td>% Income &lt;40,000</td>
<td>33.8</td>
<td>30.4</td>
<td>40.9</td>
<td>.19</td>
</tr>
<tr>
<td>Verbal IQ(^a)</td>
<td>98.4 ± 13.4</td>
<td>97.9 ± 14.2</td>
<td>99.2 ± 12.1</td>
<td>.64</td>
</tr>
<tr>
<td>Matrices(^a)</td>
<td>102.4 ± 12.0</td>
<td>102.4 ± 17.2</td>
<td>102.8 ± 11.7</td>
<td>.82</td>
</tr>
<tr>
<td>IQ(^a)</td>
<td>102.0 ± 15.2</td>
<td>102.4 ± 17.2</td>
<td>101.5 ± 11.4</td>
<td>.78</td>
</tr>
<tr>
<td>% A student</td>
<td>14.3</td>
<td>12.1</td>
<td>19.2</td>
<td>.45</td>
</tr>
<tr>
<td>BMI</td>
<td>19.9 ± 4.5</td>
<td>20.7 ± 4.9</td>
<td>18.4 ± 3.5</td>
<td>.02</td>
</tr>
<tr>
<td>% BMI ≥ 95(^{th}) percentile</td>
<td>21.3</td>
<td>25.4</td>
<td>8.82</td>
<td>.14</td>
</tr>
<tr>
<td>Fitness(^b)</td>
<td>22.1 ± 12.9</td>
<td>19.5 ± 10.5</td>
<td>26.6 ± 15.4</td>
<td>.01</td>
</tr>
<tr>
<td>Physical Activity(^c)</td>
<td>5.3 ± 2.0</td>
<td>5.3 ± 1.9</td>
<td>5.3 ± 2.3</td>
<td>.92</td>
</tr>
<tr>
<td>Behavior(^d)</td>
<td>16.2 ± 14.2</td>
<td>14.2 ± 12.7</td>
<td>20.5 ± 16.5</td>
<td>.08</td>
</tr>
<tr>
<td>School Engagement(^e)</td>
<td>20.8 ± 5.7</td>
<td>21.2 ± 5.4</td>
<td>19.9 ± 6.1</td>
<td>.36</td>
</tr>
</tbody>
</table>

\(^a\) Standardized scores from Kaufmann Brief Intelligence Test-Second Version
\(^b\) # 15m laps completed during PACER test
\(^c\) >60 minutes per day* (days per week)
\(^d\) score >23 may suggest behavioral problems
\(^e\) range from 6 to 30, higher scores indicate higher engagement with school
Figure 5.1: Percent of positive affect observed by minute
**Figure 5.2**: Positive student affect after seated classroom activity or 5, 10, 20 minutes of classroom exercise breaks, stratified by baseline characteristics

*between group differences at p<.10
** between group differences at p<.05
References


CHAPTER 6

OVERALL DISCUSSION

Significance

Many children do not participate in adequate levels of physical activity,\(^1\) and regrettably, schools provide few opportunities for children to be physically active.\(^1\) Recent legislation has increased the focus on standardized testing in schools in the United States. No Child Left Behind requires that states must develop, implement, and improve upon standardized assessments in elementary and secondary education in order to receive federal funding. As a result of the increased focus on standardized testing, schedules have become less flexible and school resources are more limited. One way to increase physical activity within tight schedules and limited resources is through classroom exercise breaks. Several schools report these practices already, yet little is known about the prevalence and characteristics of classroom exercise breaks in elementary schools.

Schools are reducing physical activity despite previous research that has shown that physical activity may improve cognitive function and academic achievement in adults,\(^2,\(^3\) as well as children.\(^4,\(^5\) In contrast to the plethora of recent studies finding positive correlations between fitness and academic achievement,\(^5-13\) there have been fewer experimental studies of the acute and long term effects of physical activity on
various educational outcomes.\textsuperscript{14-17} The ideal dose and type of exercise to elicit positive cognitive benefits is still unknown.

**Purpose**

The purpose of Study One of this dissertation was to determine the prevalence and characteristics of classroom exercise breaks in elementary schools in central South Carolina. The purpose of Study Two was to describe the acute effects of classroom exercise breaks on cognitive functions including executive function and academic performance of elementary school students. Study Three described the acute effects of classroom exercise breaks on on-task behavior of elementary school students. Finally, the purpose of Study Four was to determine student affective responses to, as well as the acceptability and feasibility of classroom exercise breaks.

**Design and Methods**

Two study designs were used in this dissertation. Study One used cross-sectional surveys and interviews of elementary school principals. Principals in central South Carolina were invited to complete a brief online survey about the prevalence of classroom exercise breaks. Fourteen principals were then interviewed by phone about the characteristics and implementation of classroom exercise breaks in their schools.

Studies Two, Three, and Four used a within-subjects experimental design. A total of 96 4\textsuperscript{th} and 5\textsuperscript{th} grade students in one elementary school in South Carolina participated in the Brain BITES (Better Ideas Through ExerciSe) intervention. Students participated in each of four conditions: 10 minutes of sedentary classroom activity and 5, 10, and 20 minutes of classroom exercise breaks. Students completed the Trail Making Test, an
operational recall test, and a one-minute math test before and after each condition. Students were also videotaped and observed for on-task behavior during the cognitive testing. Videotapes of the exercise were coded for physical activity levels and positive affect. Focus groups were conducted with the students and teachers after the intervention. The cognitive scores, on-task behavior, and positive affect were compared between conditions using repeated measures mixed model ANCOVAs adjusted for age, classroom group, and time-varying pre-test scores where applicable. Interactions were tested between the exercise doses and potential effect modifiers of gender, IQ, fitness, BMI, parent rated behavior, school engagement, baseline on-task behavior and intensity during the intervention.

**Major Findings**

Study One found that classroom exercise breaks were prevalent in 74 percent of responding elementary schools in central South Carolina. Few schools, however, had policies requiring teachers to conduct classroom exercise breaks. Individual school practices varied, and included school wide morning exercises, commercially available videos and activity examples, and unique teacher-developed activities. All exercise breaks last approximately 5 minutes or less. Principals cited numerous benefits of the breaks including improved student behavior, attention, and health.

Study Two found that math performance increased after 10 minutes of classroom exercise breaks compared to the sedentary condition. There were no decreases in performance on the other cognitive tasks. Students with lower IQ, higher
fitness, higher BMI, better behavior and lower school engagement had greater improvement in their math scores.

Study Three found that students had higher on-task behavior after 10 and 20 minutes of classroom exercise breaks compared to the sedentary condition. The results varied for individual classrooms, with no classrooms having decreased on-task behavior after any of the exercise conditions. Students with lower IQ, higher fitness, and lower BMI had the greatest improvements in on-task behavior. Boys decreased on-task behavior after 5 minutes of exercise, but had higher on-task behavior after 10 minutes of exercise compared to sedentary.

Study Four found that students had significantly higher positive affect during 5, 10, and 20 minutes of classroom exercise breaks compared to the seated classroom activity. Females had higher positive affect responses, and students with lower fitness had greater improvements in positive affect during 5 minutes of classroom exercise. There were no differences in the positive affect responses between student IQ or BMI.

Overall, this dissertation found that classroom exercise breaks are highly prevalent in central South Carolina, yet most of the breaks last 5 minutes or less. This may be problematic as 10-minute classroom exercise breaks were the only duration to improve math performance, on-task behavior, and positive affect. Ten to 20 minutes of acute exercise has previously shown to improve cognitive functions\textsuperscript{14} and on-task behavior in children.\textsuperscript{18, 19} While this was the first study to directly compare different durations of classroom exercise breaks, Kubesch et al. also did not find improvements after 5 minutes of classroom exercise on cognitive outcomes compared to 20 minutes of
The findings from this dissertation confirm previous findings that longer durations have been more effective than shorter durations on various educational outcomes.\textsuperscript{16, 21-24}

**Limitations**

There were several limitations of this dissertation. A limitation of Study One was the potential for reporting bias by principals. There is a chance that the non-responders were less likely to participate in classroom exercise breaks. Additionally, due to social desirability, principals are likely to over-report practicing classroom exercise breaks. These are concerns with all surveys. However, this was a preliminary study to get an overview of practices. Further studies with direct observation of practices are needed to get a reliable and objective description of what schools are practicing.

Studies Two, Three and Four were “real world” efficacy studies. The classroom exercise breaks were implemented by research staff. The research staff ensured high fidelity of the intervention and control over the dose delivered, but classroom exercise breaks implemented by outside staff cannot be easily sustained in a school. This dissertation only examined the acute effects of classroom exercise breaks. It is possible that regular implementation would decrease novelty and lead to additional physiological and psychological effects that would influence the students’ responses in educational outcomes to classroom exercise breaks.

**Practical Implications**

Policymakers and administrators should recognize the need to provide training and resources for teachers to implement 10-minute classroom activity breaks. Training
may include professional development workshops where teachers learn the importance and benefits of physical activity and how to conduct high quality classroom exercise breaks. Resources could include high quality and student–friendly exercise videos as well as example activities. One large resource for supplying and generating ideas for classroom exercise breaks is other teachers who are already implementing these practices. Educational agencies can provide opportunities for in-person and online idea-sharing including professional development workshops or web-based social networks.

To ensure widespread implementation of these practices, administrators may need to implement top-down policies requiring teachers to implement classroom exercise breaks. However, successful examples of implementation emphasize the importance of integrating physical activity into school-wide standard best-practices at the teacher-level. Both bottom-up and top-down efforts may be needed for successful implementation. If teachers cannot implement 10-minute classroom exercise breaks, schools may need to find other physical activity opportunities of this duration to receive the benefits such as outdoor recess integrated throughout the school day or daily physical education. They may also be able to integrate physical activity with academic content. While 10-minute classroom exercise breaks had the most acute benefits in the current studies, teachers should not be discouraged from conducting shorter exercise breaks as there were no detrimental effects on executive functions, math performance, on-task behavior or affect.
Considerations for Future Research

The findings from this dissertation elicit additional research questions for future studies. To verify the reported practices of principals in Study One, direct observation or other objective measures of duration and student physical activity levels are needed. If the actual duration and intensity of existing classroom breaks are not satisfactory, efforts should focus on improving the quality of these current practices.

This dissertation was the first to directly compare the acute effects of various durations of classroom exercise breaks on educational outcomes. Future studies are needed to examine the dose response of various durations over the long term and to examine the relationships among these variables. The routinization and reduced novelty of regular classroom exercise breaks may have different physiological and psychological responses, thus leading to different educational as well as health effects. For example, regular, five-minute classroom exercise breaks may have positive effects on educational outcomes when implemented multiple times per day.

Further research is needed to explore the individual and classroom variations in the effects of classroom exercise breaks on cognitive and academic performance. If the differential effects from this dissertation are confirmed, it may be possible to tailor classroom exercise break recommendations for different students or classrooms. For example, some classrooms may benefit from high intensity 10 minute breaks while others receive greater benefits from lighter intensity or shorter duration breaks.

This dissertation was implemented by research staff, and future studies will need to explore how teachers can effectively and efficiently be trained to implement these
practices. As the principals in Study One reported, the best source of ideas and encouragement is fellow teachers. Communities-of-practice for school physical activity need to be established to disseminate these practices.

**Conclusion**

Classroom exercise breaks of 10 minutes had the most beneficial effects on student math performance, on-task behavior and positive affect. There were no beneficial effects on any of the educational outcomes after 5 minutes, however, there were no detrimental effects on any of the outcomes after any of the durations. Most classroom exercise breaks being currently implemented in schools are shorter than 10 minutes. Future efforts are needed to train teachers to implement exercise breaks of this duration or to find other physical activity opportunities of equal duration. Schools may need to adopt policies requiring longer classroom exercise breaks.
References


CHAPTER 7

PROPOSAL

Introduction

In order to meet the academic achievement goals set by No Child Left Behind, many schools have decreased or eliminated planned physical activity opportunities. The removal of these opportunities has potentially detrimental consequences for children’s physical, mental and social wellbeing. These negative health outcomes could have adverse effects on the very academic achievement goals that schools were originally attempting to meet.

Researchers have investigated the link between academic achievement and physical activity, with promising initial results. Cross-sectional studies have demonstrated positive correlations between academic achievement and fitness, physical activity and physical education, though it is not possible to draw causal inferences. Some experimental studies have reported significant improvements in cognitive functioning resulting from exercise interventions. Executive function, the component of cognitive functions that includes the ability to plan, organize, prioritize, and quickly shift between activities, seems to be particularly sensitive to physical activity. Taken together, these data suggest that the current strategy of cutting
physical activity in favor of academics may be counterproductive, due to the importance of executive function in academic outcomes.\textsuperscript{12, 13}

This dissertation focuses on the cognitive effects of a specific type of physical activity: short bouts of exercise integrated into the classroom. The optimal dose of classroom exercise breaks is unknown. While the majority of prior research has focused on the effects of exercise of longer durations (20 to 30 minutes), some schools have begun implementing breaks of shorter duration. These high intensity exercise breaks may deliver a dose of physical activity more efficiently than traditional recess\textsuperscript{14, 15} and physical education.\textsuperscript{16, 17} Preliminary findings suggest classroom exercise breaks are acceptable to teachers and may improve cognitive outcomes.\textsuperscript{18} Additionally, short breaks are a fun, cost effective and easy to implement option for increasing physical activity levels in school-aged children. While, little is known about factors influencing the implementation of these exercise breaks in schools,\textsuperscript{19} a better understanding of such barriers and facilitators will increase the probability that future exercise programs are successful.

Aims and Hypotheses

\textit{Aim 1: Determine the prevalence and characteristics of classroom exercise breaks in elementary schools in Central South Carolina.}

\textit{Objective 1a:} Determine the prevalence of classroom exercise breaks in elementary schools in Central South Carolina.

\textit{Hypothesis 1a:} The prevalence of classroom exercise breaks will be 75 percent.
Objective 1b: Describe the characteristics of classroom exercise breaks in elementary schools in Central South Carolina.

Hypothesis 1b: The majority of classroom exercise breaks will be led by classroom teachers, be integrated into academic lessons, and will be short duration.

Objective 1c: Determine characteristics influencing the implementation of classroom exercise breaks in elementary schools in Central South Carolina.

Hypothesis 1c: Elementary schools implementing classroom exercise breaks will have fewer barriers and more facilitators than schools not implementing classroom exercise breaks.

Aim 2: Describe the acute effects of classroom exercise breaks on cognitive functions including executive function and academic performance of elementary school students.

Objective 2a: Determine the acute effects of classroom exercise breaks on cognitive functions including executive function and academic performance.

Hypothesis 2a: Acute classroom exercise breaks will have a positive effect on cognitive functions.

Objective 2b: Describe the dose-response relationship between duration of classroom exercise breaks and post exercise cognitive functions.

Hypothesis 2b: Acute classroom exercise breaks of 5, 10, and 20 minutes will have progressively more positive effects on cognitive functions.
**Objective 2c:** Identify whether the acute effects of classroom exercise on cognitive functions are modified by baseline levels of general intelligence, parent-rated behavior, fitness, or Body Mass Index.

**Hypothesis 2c:** Students with lower general intelligence, poorer behavior, lower fitness and higher body mass index will have more positive responses in cognitive functions to classroom exercise breaks.

**Aim 3:** Describe the acute effects of classroom exercise breaks on attention of elementary school students.

**Objective 2a:** Determine the acute effects of classroom exercise breaks on attention.

**Hypothesis 2a:** Acute classroom exercise breaks will have a positive effect on attention.

**Objective 2b:** Describe the dose-response relationship between duration of classroom exercise breaks and post exercise attention.

**Hypothesis 2b:** Acute classroom exercise breaks of 5, 10, and 20 minutes will have progressively more positive effects on attention.

**Objective 2c:** Identify whether the acute effects of classroom exercise on attention are modified by baseline levels of general intelligence, parent-rated behavior, fitness, or Body Mass Index.

**Hypothesis 2c:** Students with lower general intelligence, poorer behavior, lower fitness and higher body mass index will have more positive responses in attention to classroom exercise breaks.
**Aim 4: Determine student affective responses to classroom exercise breaks.**

*Objective 3a: Compare student affective responses to classroom exercise breaks with the response to a sedentary classroom activity.*

*Hypothesis 3a: Students will have a more positive affective response during classroom exercise breaks than during a sedentary classroom activity.*

*Objective 3b: Describe the dose-response relationship between durations of classroom exercise breaks and student affective response.*

*Hypothesis 3b: Acute classroom exercise breaks of 5, 10, and 20 minutes will have non-linear effects on student affective responses.*

*Objective 3c: Describe student and teacher subjective responses to classroom exercise breaks.*

*Hypothesis 3c: Student and teachers will report positive subjective responses to classroom exercise breaks.*

**Significance of the Proposed Study**

This project has immediate practical implications. The media has highlighted schools incorporating classroom exercise breaks into the school day. Yet no research studies have examined the prevalence and characteristics of these increasingly common practices, including the optimal duration of classroom exercise breaks. Once the proposed aims are achieved, schools can potentially implement efficient physical activity breaks and schedule physical activity throughout the day to not only improve student health but also maximize learning and academic achievement. Time is a critical
resource in schools and one of the most common barriers to implementing physical activity; therefore it is crucial to maximize efficiency in implementing physical activity breaks throughout the day. Thus, it is important to discern what dose is necessary for positive outcomes. Future research that builds on this preliminary work could inform administrators on how to best allocate time for physical activity. If the relationship between exercise and executive function is scientifically validated, and the optimal exercise protocol is determined, classroom exercise breaks will be a legitimate tool for increasing children’s physical activity, and possibly improving classroom learning. Understanding the barriers and facilitators for implementing these practices can help other schools implement classroom exercise breaks.

Limitations

During the intervention, children may not participate in moderate to vigorous physical activity for the entire duration. The instructor will encourage and give support, and offer other activity type options. At no time will the participants be forced to exercise, and noncompliance will be noted. All results will be analyzed using intent to treat analysis with additional sensitivity analyses.

Due to the short window for testing, a limited testing battery was selected. Ideally, administering more tests would include a more comprehensive assessment of executive function. However, the simple and short battery provides a broad assessment of critical educational outcomes.

A limitation to testing executive function is the potential for practice effects. To limit practice effects, the testing is spread over four weeks, and classrooms are
randomized to the order of conditions. It is expected that the effect of exercise will be
greater than the practice effects. Other results are possible, however, as this is an
exploratory study. If no change is seen, this may be evidence that 20 minutes of exercise
is not sufficient to elicit cognitive changes seen in previous studies, there was a failure of
the cognitive battery to detect these changes, or practice effects obfuscated any
intervention effects. It is also possible that a decrement in cognitive function and/or
attention may occur due to hyperarousal from exercise.

The complex stratified sampling to obtain a representative sample for Study One
may result in a non-representative sample of schools participating in interviews and
observations due to selection bias. Though the schools will be selected randomly,
schools willing to participate may have different classroom exercise breaks than schools
refusing participation. In interviews, it is possible that the participant will give socially
desirable answers. This will present a bias favoring the classroom exercise breaks.
During observations, because of outsider observers, it is possible the teachers may
change their behavior so that it is not representative of regular classroom practices.

Review of Literature

Definitions

There are multiple goals of education. The Thoughtful Classroom Teacher
Effectiveness Framework, used in New York, New Jersey, and Michigan suggests that
successful learners are engaged and enjoy learning. Students are energetic and
enthusiastic, display effort, enjoy themselves in the classroom, express their own
interests and ideas, are on-task and motivated, stretch their minds with different forms of thinking. Therefore, several educational outcomes will be examined including academic achievement, cognitive functions, executive function and affect, all operationalized as unique constructs. While several organizations have differing, specific definitions of academic achievement (i.e. scores on a particular state achievement test), academic achievement will be broadly defined as the quality and quantity of a student’s work. Cognition encompasses a wide array of mental processes including, but not limited to attention, executive functions, and perception.

Executive function includes the ability to plan, organize, prioritize, and quickly shift between activities based on the inter-related skills of response inhibition, working memory, and set shifting.\(^{21, 22}\)

Affect is consciously accessible feelings that can be separated from a specific circumstance: a part of emotions.\(^{23}\) Affect is experienced broadly on a continuum ranging from positive to negative.

Classroom exercise breaks are short bouts of exercise integrated into the classroom. Exercise is physical activity performed to improve fitness, while physical activity is any body movement that raises energy expenditure above resting.\(^{24}\) Moderate-to-vigorous physical activity (MVPA) has been shown to have the greatest health benefits and is defined in youth as greater than 4 METS.\(^{25}\)

Implementation is putting policy into action or turning policy into practice.\(^{26}\) Interventions and policies that have been enacted are not directly translated into outcomes; they must be implemented.
Physical Activity and Children’s Health

The Surgeon General’s Report on Physical Activity and Health described the strong association between physical activity and heart disease, stroke, hypertension, cancer, diabetes, obesity and many other diseases and conditions.27 These negative health consequences do not affect just adults, but children as well. The World Health Organization cites physical activity as essential for muscle and bone development, cardiovascular health, coordination, maintenance of a healthy body weight, as well as social and psychological benefits in children.28

America’s children and youth have a poor health profile. Fitness has decreased in developed countries, with the greatest decline in the United States.29 According to National Health and Nutrition Examination Survey, 7.5 million or 33.6 percent of adolescents have low cardiorespiratory fitness.30 Of all elementary students in California, only 45 to 48 percent of students passed at least one of the tests of muscular strength and endurance.31 In a sample of 375 7 to 9 year old children in Kansas, 5 percent had metabolic syndrome, 37 percent had high blood pressure, 18 percent had high triglycerides, and half had at least one symptom of metabolic syndrome.32 Seventeen percent of children and adolescents from 2 to 19 are overweight or obese.33 In addition to increased adiposity, the timing of the adiposity rebound has become earlier,34 and an early adiposity rebound may lead to increased adiposity later in life.35 The adiposity rebound is when BMI begins to increase between the ages of 4 to 6, after reaching its lowest point.
Physical activity has been shown to improve cardiorespiratory fitness by 5 to 20 percent, increase muscular strength, improve metabolic health, improve bone health, decrease rates of adiposity, and may relate to a later adiposity rebound. Physical activity also improves self-esteem and reduces depression in children and youth. Thus it is recommended that children between the ages of 6 and 17 participate in at least 60 minutes a day of physical activity including muscle and bone strengthening activities on three days per week.

**Physical Activity Prevalence in Children**

Physical inactivity is one of the greatest public health concerns of the 21st century. America is in an obesity and physical activity crisis, and the problem is not just in adults. According to the National Youth Risk Behavior Surveillance System, in 2009, only 18.4 percent of high school students were active at the recommended levels of 60 minutes every day and only 37 percent were active 5 days of the week. Girls are much less active than boys with only 11.4 percent of girls meeting the recommendations as compared to 24.8 percent of boys. In addition, black males and females are less active than their white counterparts with 10 percent of black females meeting recommendations and 24.4 percent of black males. And physical activity decreases with increasing age; 21.3 percent of ninth graders met recommended levels compared to only 15.3 percent of twelfth graders. In children aged six to eleven, 46 percent meet recommended guidelines as measured directly by accelerometry.

South Carolina is one of the least active states in the nation. Only 17.1 percent of high school students were active for at least 60 minutes a day in the past seven days.
Accurate physical activity prevalence data for elementary age children is unavailable. Physical activity begins to decline starting at age nine throughout young adulthood.\textsuperscript{46, 47} Instilling the importance of physical activity in children is important.

**Physical Activity Interventions in Children**

Fortunately, physical activity is a modifiable behavior, and several approaches have been taken to increase physical activity. In 2002, the Task Force for Community Preventive Services reviewed and evaluated the effectiveness of multiple approaches to increasing physical activity.\textsuperscript{48} They found evidence in support of informational campaigns (point of decision prompts and community-wide campaigns), environmental and policy approaches, and behavioral and social interventions (such as school-based physical education).

**Afterschool**

The afterschool setting has been intervened upon in attempt to increase overall physical activity. In a meta-analysis of 11 afterschool interventions, Beets et al. found a positive effect of .44 for increasing physical activity.\textsuperscript{49} In another review of nine afterschool physical activity interventions, Atkin et al. found three of the nine studies reported positive changes in physical activity.\textsuperscript{50} Intervention approaches have ranged from fitness-based interventions\textsuperscript{51} to multi-sport programs.\textsuperscript{52} There have been mixed results in afterschool interventions. The Girls Health Enrichment Multi-site Studies (GEMS) included four site-specific interventions to decrease obesity and increase physical activity in young African American girls. Each site was individually tailored for the local population. Two of the programs were successful: a parent and child group
meeting in Tennessee and community dance classes in California. These two interventions are now being conducted as full-sized randomized control trials.\textsuperscript{53}

\textit{Home and Community}

Perhaps the most difficult setting to reach has been the home and family setting. Interventions in this setting have included family group meetings with pedometers\textsuperscript{54} and preschool children with parent pairs.\textsuperscript{55} Other types of interventions have included community-based and media campaigns. A wide-scale media campaign VERB, also had successful results. VERB was a national social marketing and branding campaign conducted by the CDC to increase physical activity levels in “tweens” aging from nine to thirteen. After four years, a dose response relationship was found between media exposure and physical activity levels.\textsuperscript{56} Unfortunately, funding ran out and the campaign had to be discontinued.

Current environmental level interventions are identifying the determinants of and ways to promote active commuting to school in children. As part of the 2005 Safe, Accountable, Flexible, Efficient Transportation Equity Act, the Safe Routes to School program includes funding for infrastructure to promote active commuting to school, including sidewalks and bicycle lanes.\textsuperscript{57}

\textit{Policy}

One way to establish physical activity practices, such as classroom exercise breaks, are by creating policies. Policy interventions, whether at the federal, state or school level also offer promise for increasing physical activity. The Centers for Disease Control\textsuperscript{58} and National Physical Activity Plan\textsuperscript{59} advocate for physical activity programs in
schools. Policies are a guide to discretionary action\textsuperscript{60} and can range from federal legislation to policies implemented by school boards or school administrators. One sector that has received a large focus of physical activity policy is the school setting. A review of school health policies found that 70 percent of schools nationwide have adopted policies to follow national physical education guidelines.\textsuperscript{61} In South Carolina, the Student Health and Fitness Act of 2005 (SHFA) requires minimum physical education and physical activity minutes in elementary schools across the state. The SHFA requires 150 minutes of physical education and physical activity combined, with 90 minutes of physical activity.

The Exercise is Medicine campaign is trying to influence healthcare policy to incorporate physical activity as a compensated vital sign that is assessed at each doctors’ visit and prescribed. For example, a child may wear an accelerometer to track physical activity levels, and then if levels are inadequate, the family may be referred to an exercise specialist. The consultation and future exercise sessions would be compensated through health insurance. Individual primary care interventions have been implemented in pediatric settings with limited success.\textsuperscript{62}

Evidence shows that despite increased policy efforts, there are many gaps in the process of translating these school-based policies into positive outcomes. Nanney et al. reviewed school nutrition and physical activity policy adoption and found that only 38 percent of the 148 physical activity policy objectives selected by Nanney et al. were adopted by state governments, showing the limited reach of these policies.\textsuperscript{63}
In addition to traditional school-based, community, environmental and policy interventions, there are innovative strategies being used. In Arkansas, school-wide reports of Body Mass Index are being sent home with each child\textsuperscript{64}, and rapidly developing technological advances, such as cell phone activity monitors, are being piloted for physical activity promotion.

\textit{Physical Activity in Schools}

School settings offer a large potential to increase physical activity and several interventions have successfully increased physical activity in this population. Over 95 percent of children, over 50 million children, between the ages of 5 and 17 attend school.\textsuperscript{65} Because children are required to attend school, schools have the potential to increase physical activity in a large percentage of the population through recess, physical activity in the classroom and physical education. The American Heart Association described the essential role that schools should play in establishing physical activity promoting policies and practices.\textsuperscript{66} School day physical activity accounts for at least 70 percent of children’s MVPA.\textsuperscript{67} Schools also play a critical role in helping children to meet physical activity guidelines.\textsuperscript{68} In a time when family backgrounds and home environments are shown to be critical to health behaviors, school based interventions may provide an equal opportunity for all children. School-based interventions affect physical activity similarly across family backgrounds.\textsuperscript{69}

Despite specific objectives in Healthy People 2010 to increase physical education requirements and participation,\textsuperscript{70} and only 56 percent of children report having physical education at least once a week.\textsuperscript{44} The School Health Policies and Programs Study
surveyed schools nationwide and found the percentage of schools requiring physical education ranged from 20 percent of schools in eleventh and twelfth grades to 60 percent in elementary school grades.\textsuperscript{71} While physical education is not the only opportunity for physical activity, it is the most publicized and has had the largest advocacy efforts. Only 11 percent of states and 57 percent of local districts require recess in elementary school.

The school setting has been one of the most common settings for youth physical activity interventions. Several reviews have been conducted of school-based physical activity interventions. In a meta-analysis of 8 studies, Katz et al. found reductions in body weight with combined physical activity and nutritional interventions but no reduction with physical activity interventions alone.\textsuperscript{72} However, Durant critiqued the review citing small effects, limited reliability, and emphasized the need to employ novel strategies in new school based interventions.\textsuperscript{73} A recent review of 26 school-based studies concluded that there was no evidence of negative effects and some evidence of positive effects from school-based interventions and recommended the continued promotion of physical activity in this setting.\textsuperscript{74} School based interventions had positive outcomes on the duration of physical activity while in school, cholesterol and fitness, but did not improve blood pressure, or body mass index. There has been large heterogeneity among school-based intervention studies, so further research is needed.

The Child and Adolescent Trial for Cardiovascular Health (CATCH) is one of the most popular school-wide interventions, and its curriculums are currently being disseminated. CATCH was a multi-center intervention in third graders to reduce
cardiovascular risk factors. It consisted of 30 minutes of physical education three times per week and goals to decrease the intake of fat and sodium in school food. After two and a half years, there were no significant changes in overall cardiovascular profile, but moderate to vigorous physical activity increased during physical education classes.\textsuperscript{75}

Comprehensive interventions, such as CATCH, including physical education, recess, and education components, have had varied results. In 3\textsuperscript{rd} and 4\textsuperscript{th} graders in North Carolina, the only significant findings after the 8-week Cardiovascular Health in Children intervention were increased physical activity knowledge and self-reported physical activity.\textsuperscript{76} Action Schools! BC in Canada increased daily step counts in 9 to 11 year-old boys but not girls.\textsuperscript{77} In 15 elementary schools in Switzerland, a multi-component intervention increased physical activity and fitness and decreased adiposity.\textsuperscript{78}

While there have been a large number of school-based interventions, many have been of weak methodology. In concurrence with the Task Force for Community Preventive Services’ recommendations, physical activity interventions should continue to be implemented in schools, because they have the potential to affect a large number of children. It is necessary to continue to test the efficacy and effectiveness of innovative school-based interventions. In addition to providing students knowledge, they should teach skills to children to improve self efficacy and increase lifelong physical activity as well as include efforts to increase parental support. Due to these issues, there is a need to test different approaches beyond broad school-wide interventions.\textsuperscript{79}

Physical Education
Despite recommendations, few schools provide mandatory daily physical education. The National Association for Sport and Physical Education as well as new school health guidelines from the Centers for Disease Control recommend 30 minutes of daily PE for elementary students and 45 minutes for secondary school students.\(^5\) While 69.3 percent of elementary schools require physical education, only 3.8 percent of elementary schools provide daily physical education.\(^7\)

These organizations and agencies also distinguish the need for quality physical education. Physical education does not necessarily include physical activity; “Education for a physically active lifestyle does not always involve participation in vigorous activity” (p. 484).\(^8\) Teachers may have students waiting in lines, or standing and doing drills, which are not opportunities for physical activity. One study involving timed observations of physical education classes found that only 9 percent of class time involved moderate-to-vigorous physical activity\(^1\) while another found 3\(^{rd}\) graders to participate in MVPA 36.2 percent of their 30 minute physical education class.\(^1\)

Physical education interventions have been shown to increase MVPA during physical education class, but have thus far not shown increases in physical activity out of school or over the long term.\(^8\) Even physical education classes with at least 50 percent of class time in MVPA make a small contribution to meeting physical activity guidelines. For example, Sports, Play and Active Recreation for Kids (SPARK) provided 40 minutes of MVPA in physical education per week, which is 13 percent of the total recommended level of physical activity.\(^8\)
The now highly marketed physical education intervention, SPARK, was a physical activity intervention for fourth-graders in California schools. It consisted of 30 minutes of physical education three times per week as well as weekly classroom lessons on self-management. After two years of implementation, students in SPARK schools spent twice as much time in moderate to vigorous physical activity than control schools (40.2 and 17.8 minutes respectively) but there were limited fitness gains seen only in girls. Move it Groove it, a physical education intervention in Australia, non-significantly increased MVPA by 4.5 percent or less than one minute per physical education class. This intervention included project teams, teacher training and resources, and small equipment grants. The Middle School Physical Activity and Nutrition (M-SPAN) intervention provided staff development for middle school physical education teachers to increase MVPA in existing curriculums. M-SPAN increased the percentage of time in MVPA from 48 percent to 52 percent, which was a non-significant increase compared to control schools.

**Recess**

School recess has been found to be the most active opportunity throughout the school day and is also important for children’s emotional and social development. Only 11.8 percent of schools require recess and 25.5 percent recommend regular recess. Even when children get out to the playground, actual physical activity levels at recess are often lower than expected and girls are less active than boys at recess. Thus recess only makes up 15 to 20 percent of school day MVPA, but may contribute more for the least active children.
Recess interventions have attempted to increase physical activity levels on the playground. Providing markings and play equipment did not increase physical activity levels of preschoolers who only engaged in MVPA for 11 percent of recess. Small pilot studies in elementary schools including staff training, activity zones and portable equipment have shown small increases in recess activity measured through accelerometers and pedometers. Some recess interventions have shown null or negative effects on physical activity. Stellino et al. tested multiple recess interventions for elementary school students including a circuit course, obstacle course and Frisbee games. They found these activities decreased children's MVPA.

**Classroom Exercise Breaks**

Many school districts report cutting physical education in response to No Child Left Behind (NCLB). The Center for Education Policy reports that 68 percent of schools report funding decreases to staff in non-core academic areas, including physical education, with another 50 percent anticipating further cuts the 2011-2012 school year. Physical activity and physical education often come secondary to primary subjects that are tested in standardized tests. Evidence from Arkansas suggests that NCLB has increased overweight and physical inactivity in children. An alternative way to meet physical activity recommendations with limited time and resources for intensive physical education and recess are classroom exercise breaks. These five to ten minute sessions integrate short bouts of exercise in the classroom and are recommended as a tool to increase school physical activity.
The School Health Policies and Programs study found 43.6 percent of elementary schools self-reported including physical activity breaks outside of physical education and recess.\textsuperscript{71} In adults, research has shown that bouts as short as 10 minutes confer health benefits, with little research on bouts shorter than 10 minutes.\textsuperscript{99} Using cross-sectional NHANES data, Mark and Janssen found that bouts of physical activity predicted decreased adiposity, independent of the volume of physical activity in youth.\textsuperscript{100} Liu et al.’s Happy 10 program incorporated at least one 10 minute exercise break in first through fifth grade classrooms and found an improvement in BMI after a school year.\textsuperscript{101} The sessions were of moderate to vigorous intensity with 25 to 35.1 kcals per session. In another study, schools that implemented at least 75 minutes per week of short exercise breaks had less of an increase in BMI compared to controls and schools that did not implement at least 75 minutes.\textsuperscript{102}

A review of exercise breaks found that school-based exercise breaks increased physical activity, though most physical activity measures were self-report.\textsuperscript{103} Some of the studies included in the review reported positive changes in fitness or determinants, but there was little evidence of changes in BMI. Objective pedometers have shown classroom exercise breaks to increase physical activity.\textsuperscript{89, 104}

In South Carolina, the Student Health and Fitness Act requires 90 minutes of physical activity beyond physical education. The physical activity time can include recess and other physical activity opportunities including exercise breaks. The Department of Education annually collects information from district representatives on opportunities for physical education and physical activity in kindergarten through 5\textsuperscript{th} grade and
compiles the information annually as the *Report for the Implementation of Physical Education and Physical Activity Minutes for Students in Grades Kindergarten through Five as Required by the Students Health and Fitness Act of 2005*. The design of the survey used for evaluation report of SHFA is closed response, with “yes/no”, “check all that apply”.

In the most recent report, 38 percent of schools reported practicing video exercise (including aerobic videos, jazzercise, deskercise, FitKids, energizers), 35 percent reported morning exercise (including morning stretching, morning calisthenics, CORE exercise), and 66 percent reported classroom exercise led by teachers. While these practices have increased since 2007-2008, they have decreased from the previous two years; See TABLE 7.1.

**Physical Activity Implementation**

Despite the large number of physical activity interventions, few studies have collected in-depth information on the process of implementation. There has been slightly more research on physical activity policy implementation particularly in the school setting. Although there are many definitions of implementation, implementation is operationally defined as putting policy into action or turning policy into practice.

With the proliferation of state level physical activity policies, researchers have attempted to analyze these policies in several states. Researchers in Colorado and North Carolina have taken preliminary steps to assess the policy implementation process through interviews and surveys of district representatives. Belansky et al. conducted interviews with key informants in elementary schools in Colorado to assess the success
of Colorado State Bill 05-81, a wellness policy bill passed in 2005. These interviews uncovered details about the implementation process, including barriers to implementation such as academic pressures, inadequate resources, lack of knowledge, and lack of enforcement. These are similar to the top barriers reported to implementing the Student Health and Fitness Act in South Carolina which included scheduling issues and funding.

In North Carolina, Evenson, Ballard, Lee, and Ammerman distributed online surveys to district representatives in evaluation of the state’s 2005 Healthy Active Children Policy. Several school-level strategies, positive benefits and barriers (lack of time and academic pressures) were reported, though the authors noted that district responders were not representing individual schools. Kelder et al. used both surveys and direct observation and found that while school and physical education teachers reported physical activity minutes at or above required levels, students reported levels well below these requirements. There was no evaluation of the implementation process.

Brownson et al. stress the need to better understand the real-world factors that influence the implementation at the school level. Qualitative approaches provide appropriate methods for uncovering this process. Despite the usefulness of qualitative research to understand the process of policy implementation by school administrators, few qualitative studies have been conducted. In his argument for increased qualitative and ethnographic research in education policy analysis, Odden emphasized
the importance of going beyond assessing whether a program is implemented, but assessing the quality of implementation as well.\textsuperscript{112}

Currently, physical activity implementation analysis has been primarily limited to quantitative evaluation which has produced limited information on the process of implementation. Qualitative assessments can also capture the contextual elements that are crucial to success or failure of an intervention. For example, there is not a culture of physical activity promotion in schools which is a primary barrier to increasing school physical activity. As one superintendent explained, “What we continue to hear is ‘No Child Left Behind.’ I haven’t heard ‘Don’t leave fat kids behind.’ It’s about keeping kids academically fit. That’s foremost on our minds.”\textsuperscript{107(p S155)} Physical activity policy research needs more research using quantitative and qualitative study designs.\textsuperscript{26}

The design of the survey used for evaluation report of South Carolina’s SHFA is closed response, with “yes/no” and “check all that apply” responses and reporting of minutes of opportunity by classroom.\textsuperscript{105} Qualitative interviews, such as focus groups directly with implementers (teachers), would provide a more detailed account of implementation.

Most physical activity implementation research has focused on reports from district-level administrators. Self-reports from district-level administrators are not accurate sources for implementation evaluation. First, self-report is not consistently reliable. For example, one school reported 375 minutes of physical activity and 300 minutes of physical education per week.\textsuperscript{105} Such a total would constitute two hours a day of physical activity time during each school day; such an extreme outlier can be
assumed not to reflect the actual practice in the school. In addition, in the 2010-2011 data from the PEPA report, 17 schools had discrepancies between the two or more administrators reporting school level data. Secondly, district administrators do not accurately represent local school-level implementation and school-level personnel often do not represent individual classrooms.\textsuperscript{108} There is large within district variation in implementation of state level education policies.\textsuperscript{113} Local educators are more likely to accurately report local implementation.

**Physical Activity and Educational Outcomes**

Large cross-sectional studies have shown that physical activity,\textsuperscript{114-122} physical education\textsuperscript{6} and fitness levels\textsuperscript{3, 4, 31, 123-127} are associated with the broad outcome of academic achievement, often performance on standardized tests. Some cross-sectional studies have examined more specific cognitive outcomes.\textsuperscript{10, 128-130} Longitudinally, fitness has shown to be predictive of academics over time.\textsuperscript{131} More specifically, several studies have attempted to uncover the causal relationship between acute exercise and cognition in children\textsuperscript{10, 132-134} with overall positive effects.\textsuperscript{135} Fewer longitudinal experimental designs have assessed the effects of chronic exercise on cognition in children. Davis et al. has found that a 9 month aerobic afterschool program increased planning skills, achievement, and fMRI activity.\textsuperscript{8, 136} Kamijo et al. demonstrated that a similar afterschool intervention improved working memory and event-related potentials using electroencephalography.\textsuperscript{9} In adults, a recent meta-analysis of randomized control trials did find a consistent positive effect of physical activity on cognition.\textsuperscript{137} A review of
the acute effects of exercise on cognition found that exercise may improve response speed, response accuracy, complex thinking and problem solving.\textsuperscript{138}

Specifically, effectiveness studies have examined various types of school day physical activity and cognitive or academic outcomes. Acute physical activity exposure has ranged from stretching,\textsuperscript{139} to outdoor recess,\textsuperscript{140} to physical education classes\textsuperscript{141-144} and inclusive long-term interventions.\textsuperscript{145-150} There have been varied outcomes used as well ranging from attention\textsuperscript{140, 142} to math scores.\textsuperscript{144, 151} Recently, there have been effectiveness studies examining classroom physical activity and various outcomes. See TABLE 7.2.

Only three studies have examined the acute effects of these short exercise bouts in children. Mahar et al. examined time-on-task after 10 minutes of integrated physical activity and found a positive effect.\textsuperscript{152} Kubesch et al. examined cognitive performance on the flanker and dots tasks and found no improvement after 5 minutes of classroom physical activity.\textsuperscript{141} Grieco et al. found that an integrated classroom exercise intervention improved time-on-task.\textsuperscript{153} Three other primary studies have examined chronic effects of teacher implemented classroom exercise. Donnelly et al.,\textsuperscript{102} Katz et al.,\textsuperscript{154} and Reed\textsuperscript{155} all examined the effects of regularly implemented classroom physical activity and found positive effects on academic achievement. Reed et al. also found positive improvements in fluid intelligence.\textsuperscript{155} Additionally, components of Take 10! have been integrated into numerous interventions, and in a review, have had a generally positive effect on educational and health outcomes.\textsuperscript{156}
These studies have had varied outcomes and limited process evaluations. Donnelly et al.,\textsuperscript{102} had the most extensive process evaluation on the fidelity of implementation,\textsuperscript{157} while other studies ranged from no monitoring to single random site visits. Without complete monitoring of the intervention, it is impossible to quantify the dose needed to elicit positive outcomes in these effectiveness trials. The dose of physical activity has also ranged from 90 minutes per week in 10 minute bouts to a total of 10 to 15 minutes per day integrated with classroom lessons.

Basch argues that current physical activity interventions in schools are not designed for the best educational outcomes.\textsuperscript{158} Diamond recommends that to best improve executive functions, interventions should be fun, involve student interests, vigorous activity, and involve social interaction.\textsuperscript{159}

\textit{Mechanisms}

The mechanism for improved cognition and academics is still unknown with many controversial findings. One hypothesized model of mediators is shown in FIGURE 7.1. Exercise influences the whole body system and may have multiple points of influence.\textsuperscript{160} Concurrent research has identified plausible evidence of the underlying biological mechanisms for chronic adaptations, namely increases in Brain-Derived Neurotrophic Factor (BDNF) and increased hippocampal neurogenesis,\textsuperscript{161} which support these mental improvements. After three days of aerobic exercise in animal models, BDNF modulated synapsin I and synatophysin, docking proteins needed for synaptic transmission.\textsuperscript{162} In humans, Ferris et al. found that serum BDNF increases with high intensity exercise, but these changes were not correlated with cognitive function.
scores. However, Ferreira found that exercise may induce hippocampal plasticity independent of BDNF, and in rats, there may be differential effects in adults and adolescents. The type of exercise may influence BDNF response. Pereira et al. showed an increase in cerebral blood volume in the dentate gyrus with exercise, indicative of neurogenesis. Cross-sectional associations have been found between fitness, hippocampal volume, and relational memory performance. In a small number of children, Davis et al. found increased prefrontal and decreased posterior parietal activation following a year long aerobic exercise program. The prefrontal region is important for executive control and higher thinking tasks while the posterior parietal is involved in planned actions.

Improvements in cognitive function following acute exercise have been related to increased neuroelectric activity. Yanagisawa et al. found increased activity of the left dorsolateral prefrontal cortex during a Stroop test in human adults. The dorsolateral prefrontal cortex is important for working memory and organizing other executive functions. In children, Hillman et al. found increased P3 amplitude indicative of increased attentional allocation following 20 minutes of walking. Another theory is that exercise increases arousal through the release of catecholamines which improves cognitive processes. However most of this research has been correlational, limiting causal inferences. McMorriss did not find that catecholamines, including serotonin and endorphins, were directly related to cognitive performance during exercise, but there is a more complex correlational relationship. Another hypothesis is the increased oxygenation in the brain from increased cerebral blood flow from exercise improves
cognitive metabolism and performance. A review of 21 studies using near-infrared spectroscopy found acute exercise increased oxygen in the brain.\textsuperscript{173}

**Executive Functions**

Of the cognitive abilities shown to improve exercise or fitness, the strongest effects have been seen in executive function.\textsuperscript{11} Exercise studies in children have confirmed these improvements in executive function.\textsuperscript{10} Executive function, as defined by Mikaye, are “general purpose control mechanisms that modulate the operation of various cognitive subprocesses,”\textsuperscript{22(50)} or higher order complex cognitive process including working memory, inhibition and cognitive flexibility as unique, but related, components of executive function.\textsuperscript{174} Executive function has been researched extensively in relation to learning disabilities, including ADHD, in clinical populations,\textsuperscript{175} and have shown to be highly predictive of academic achievement with early assessments of executive functions predicting later academic success.\textsuperscript{176} Executive function is also a successful target of interventions.\textsuperscript{177}

**Attention**

Attention has also been shown to be highly predictive of academic achievement and learning in school.\textsuperscript{178} Based on Luria’s model, attention is the first functional unit of mental processes, upon which higher order functions, such as planning and executive functions are built.\textsuperscript{179} Specifically, selective attention depends on the ability to inhibit distracters,\textsuperscript{179} which may relate to the inhibitory component of executive function. Attention has been shown to improve with exercise,\textsuperscript{10, 152, 153} and the effects may be the
most beneficial in those with attention difficulties\textsuperscript{152} and with higher body mass index.\textsuperscript{153}

\textit{Affect}

Some scholars argue that happiness itself is a goal of education.\textsuperscript{180} Having fun is related to positive school engagement. One component of school engagement is emotional engagement, or how much the student enjoys being at school.\textsuperscript{181} If a student has fun at school, they are more likely to engage in the classroom\textsuperscript{182} and be motivated to learn.\textsuperscript{183} A longitudinal study of students found that higher school engagement predicted academic achievement.\textsuperscript{181, 184} Research has found that students who find school boring and not fun have lower achievement.\textsuperscript{181} Positive affect also has been shown to improve creative thinking and problem solving.\textsuperscript{185} Fredrickson proposed a Broaden and Build theory by which positive affect and positive emotions expand the individual’s thought-action repertoire and personal resources.\textsuperscript{23} Through multiple experiments, Dreisbach found that positive affect modulates cognitive control in changing situations and helps a person to become more cognitively flexible.\textsuperscript{186}

Fun is also important in increasing physical activities. Fun is the primary reason children report for participating in physical activities\textsuperscript{187}; children consider physical activity to be fun.\textsuperscript{188} Diamond also suggests that positive emotional development is critical for executive function and cognitive development.\textsuperscript{159} Barnes et al. argue for the need for smiles and positive emotion in schools with a curriculum including physical education.\textsuperscript{189}
Summary

Previous studies examining the relationship between these educational outcomes, particularly cognition, and physical activity have produced inconsistent results, partly due to weak methodology. Measures chosen to assess executive function have ranged in their psychological validity and field studies have had poor physical activity fidelity measures. A review by Etnier et al. found that of 128 different measures used to study cognitive processes and exercise, only 10 have been identified as common neuropsychological measures of executive function. Gioia raised the issue of ecological validity in executive function measurements. Many measures lack verisimilitude (how testing demands and conditions reflect actual demands) and veridicality (does the test predict everyday functioning), as most cognitive tests are highly specific tasks administered in controlled laboratory settings. The results of these tests are more difficult to directly apply to school outcomes. Recent work by Chaddock and colleagues used a complex real-life, multi-tasking situation (street crossing) and found higher fit children were better able to successfully cross the street, independent of differences in physical performance. As a result of problems with methodology, the optimal duration of exercise breaks throughout the day is unknown and the case to convince policy makers of the value of physical activity for children in schools is not optimized.

The purpose of this dissertation is to examine multiple educational outcomes of classroom physical activity breaks. The overarching goal of this research is to inform administrators and policy makers of the multiple benefits of physical activity beyond
health, in order to propose and enact school physical activity policies. This dissertation will include a description of current classroom exercise break practices and an objective examination of the cognitive and academic dose response to classroom activity breaks and subjective, affective responses of students, teachers and administrators to implementation of these breaks. I hypothesize that classroom exercise breaks will have positive effects on cognitive, academic, and affective outcomes.

**Theoretical Framework**

This dissertation is framed by multiple theoretical frameworks from education and health promotion. Including movement in the school day is consistent with multiple educational theories including the whole child perspective, multiple intelligences theory, and meta-volition theory.

**Educational Theories**

Both the multiple intelligences and whole child theories are similar educational theories that emphasize multiple components of learning beyond typical cognitive and content based intelligence. Movement is critical for kinesthetic learners and Gardner argues for multi-modal instruction for all students.\(^{193}\) Gardner describes multiple intelligences including linguistic, logical-mathematical, intrapersonal. Naturalistic, spatial, musical, interpersonal intelligences may also be reached through classroom exercise breaks through incorporation of musical songs, movement around the classroom, and social interactions. Diamond, a developmental cognitive neuroscientist, insists on the inclusion of physical play for the development of the whole child.\(^{159}\) She clearly articulates,
If we want the best academic outcomes, the most efficient and cost-effective route to achieve that is, counter intuitively, not to narrowly focus on academics, but to also address children's social, emotional, and physical development. Similarly, the best and most efficient route to physical health is through also addressing emotional, social, and cognitive wellness. Emotional wellness, similarly, depends critically on social, cognitive, and physical wellness.\(^{(p780)}\)

Interventions using a whole child approach address academic, emotional and social factors influencing youth.\(^{(194)}\) This method of education has been challenged by needs to meet standards from No Child Left Behind. Schools have focused more on academic achievement through teaching subjects explicitly included on state tests, often at the expense of the whole child.

**Meta-Volition Theory**

Classroom exercise breaks as an intervention are supported by the meta-volition model. Yancey’s meta-volition theory incorporates elements of the social ecologic model to explain the success of institutionalized exercise break practices.\(^{(195)}\) Key concepts in the meta-volition model include compulsory, ubiquitous and institutionalized physical activity that is culturally adapted, fun, and socially supported. In this dynamic theoretical framework, incorporating brief exercise breaks into organizational routine affects multiple levels of the social ecological model including interpersonal and environmental levels of behavior change. See FIGURE 7.2 for a descriptive figure of the meta-volition model. The social ecological model as applied to physical activity includes multiple levels influencing behavior including interpersonal, environmental and policy.\(^{(196)}\) Classroom exercise breaks are policy-based and employ the social environment to increase physical activity. The fun approach also relies on social interactions and personal motivation.
In this model, action is initiated through an enthusiastic leader and a behavioral catalyst; exercise breaks serve as the behavioral catalyst and a principal or teacher may be the enthusiastic leader. Next, the process is automated as it becomes regular practice. A viral marketing phase follows, where students and teachers began to talk of the classroom exercise break practices and the perceived benefits. Eventually, these practices will be spread to other schools and larger educational agencies. This dissertation will consist of the beginning of the process by examining how educational leaders influenced the implementation process.

**Study One Methods**

**Purpose**

The purpose of this study is to evaluate the prevalence and characteristics of existing classroom exercise breaks in Central South Carolina. If classroom exercise breaks are of low prevalence and quality, improving these classroom exercise breaks may become the target of future physical activity interventions.

**Aim 1: Determine the prevalence and characteristics of classroom exercise breaks in elementary schools in Central South Carolina.**

*Objective 1a:* Determine the prevalence of classroom exercise breaks in elementary schools in Central South Carolina.

*Hypothesis 1a: The prevalence of classroom exercise breaks will be 75 percent.*

*Objective 1b:* Describe the characteristics of classroom exercise breaks in elementary schools in Central South Carolina.
Hypothesis 1b: The majority of classroom exercise breaks will be led by classroom teachers, be integrated into academic lessons, and will be of short duration.

Objective 1c: Determine characteristics influencing the implementation of classroom exercise breaks in elementary schools in Central South Carolina.

Hypothesis 1c: Elementary schools implementing classroom exercise breaks will have fewer barriers and more facilitators than schools not implementing classroom exercise breaks.

Study Design

This is a cross-sectional study with surveys and interviews to evaluate the practice of classroom exercise breaks in Central South Carolina.

Methods

Participants

The sample will include a representative sample of public elementary schools in the Central Midlands of South Carolina. There are 226 public elementary schools in this geographical location within 14 counties and 25 school districts. Districts with less than 4 schools will not be included, resulting in 192 schools, from 11 counties and 19 school districts. The demographic information for the sampled districts can be found in TABLE 7.3.

A stratified random sample of schools will be drawn and invited to take part in the study. All schools in eligible districts will be categorized into four stratum. Stratum will be based on the percentage of free and reduced lunch and the percentage of students not meeting English and Math standards and state assessments. The four
categories, as depicted in TABLE 7.4, will include: low income/lower performing, low income/higher performing, high income/lower performing, high income/higher performing. To examine the potential influence of these factors on exercise break practices, a logistic model with 2010-2011 school level demographic and three self-reported classroom exercise break practices (video, morning exercises, and classroom exercises) was run. There was a trend for schools with a greater percentage of free and reduced lunch and more students not meeting state standardized test standards were less likely to report these practices and schools.

Principals or physical activity coordinators will be emailed for a brief 5 minute survey on classroom exercise break practices in their school. After one week, principals that have not replied will be sent a follow-up email. Two weeks following the second email, if 20 schools from each stratum have not replied or a total of 90 schools, remaining principals will be called by the primary investigator. Following the phone call, principals who have still not replied will not be included in the study. If a school declines to participate, a replacement will be selected from the same stratum. Of the schools reporting classroom exercise breaks, 10 schools from each stratum will be selected for direct observations and a longer in-depth interview. If the schools do not consent to participating, another school from that stratum will be selected. The districts will be contacted for approval before contacting school principals and one classroom teacher from each school for in-depth interviews. In-depth interviews will include questions to determine the specific practices in each school and facilitators and barriers to those
practices. If the intended number of interviews or schools implementing classroom exercise practices is not reached, additional school districts will be contacted.

**Measures**

**Email survey**

Principals or physical activity coordinators from all schools in identified school districts within Central South Carolina will be contacted through email. The brief survey will be conducted with the principal or physical activity coordinator where contact information is available, unless the principal refers the researcher to a more knowledgeable administrator (Vice Principal, PE director, etc). See Appendix for email questions.

**Principal Interviews**

Ten schools who report participating in classroom exercise breaks from each stratum will be randomly selected to participate in in-depth interviews and direct observations. In-depth interviews will be scheduled at participant convenience and will be conducted at the participant’s chosen location (most likely their school or by phone) for approximately one hour by the primary investigator. If available, the administrator who played a role in implementing the classroom exercise breaks will be interviewed. Interviews will be digitally recorded using a digital voice recorder (Olympus America, Pennsylvania). Interview questions were constructed in advance according to Patton’s suggestions to include questions that are singular, open-ended, clear and neutral and of various types including opinion, role playing, and presupposition questions. See Appendix B for a list of guiding initial questions.
Classroom Teacher Interviews

Principals or physical activity coordinators will identify and provide contact information for one classroom teacher at their school who practices classroom exercise breaks. The teacher will be contacted for an interview at their convenience. If they do not agree to participate, the principal or physical activity coordinator will provide an alternative teacher to contact. The interview will be conducted by the primary investigator and will include questions describing their classroom exercise break practices, perceived benefits to their classroom, and barriers and facilitators to implementing these practices. Sample interview questions can be found in the Appendix. A total of 40 classroom teachers will be interviewed.

Standards of Validation

A primary concern of many critics of qualitative research is a lack of rigor. Qualitative studies have differing ontological and epistemological views than quantitative research making the standards of external validity, internal validity, reliability and objectivity not relevant to qualitative research conducted with a post positivist, social constructivist view. There are equivalent criteria by which qualitative studies are held. To ensure the rigor of this qualitative study, trustworthiness as defined by Lincoln and Guba, including credibility, transferability dependability and confirmability, will be established through the following methods.

The credibility of the theory, referred to as validity in quantitative studies, will be strengthened through triangulation including multiple sources (administrators, teachers) and multiple methods (surveys, interviews). Various sources will help to
eliminate single source bias. Triangulation will serve as confirmation in addition to providing a holistic portrayal of the process of implementation.\textsuperscript{198}

Transferability in qualitative research is the approximation of external validity. However, according to social constructivist theory and the specificity of grounded theory to the empirical data, the same theory may not be applicable to other samples. To be able to extrapolate the findings of a qualitative study, the details of the population must be provided through “thick description” so that readers can determine whether the theory would apply to another population. The selection process and a description of the schools included in the study will be provided.

Dependability (reliability) and confirmability (objectivity) will be established through an audit trail.\textsuperscript{199} An audit trail will be maintained throughout the study and will consist of all initial correspondence with school district personnel and administrators, emails, interview transcripts and recordings, in vivo codes and coding schemas, and written documents from schools.

\textit{Confidentiality and Ethics}

Written informed consent will be obtained from school districts and participants. Complete confidentiality will be maintained upon participant and school board discretion. Participants will have the option of retaining school identity for potential use in media relations to portray their schools as positive examples of physical activity. If participants waive this confidentiality, stories and notes will be returned and reviewed by participants before distributing any information.
All interview transcripts and observation forms will be stored in a locked, secure location. Digital files will be on a password protected computer in a locked location. Unless specific consent from principals and schools districts waives confidentiality, no participant names will be used. Participant ID numbers will be assigned and only the primary investigator will have access to the linked names and participant IDs.

**Sample Size**

As this is primarily a descriptive study, the sample size was selected based on generalizability, feasibility and ability to estimate the prevalence of classroom exercise break practices. A standard deviation of 29 was obtained from reported classroom exercise breaks from the previous four years. Using a cross-sectional, one group power analysis, 90 schools are needed to detect a prevalence of 75 with a range from 69 to 81. A total of 90 schools will be contacted for brief interviews. To obtain a representative sample, at least 20 schools will be selected from each stratum.

Interviews will continue until theoretical saturation occurs, or no new theoretical constructs emerge and further data collection is redundant. Creswell estimates approximately 20 to 30 interviews are needed.\(^{200}\) In-depth interviews will be conducted with principals and classroom teachers at 40 schools.

**Analysis**

Analysis of interview transcripts will be facilitated using NVivo 9 (QSR International) by the primary investigator. The computer software will be used as a tool and does not replace the skill and analysis of the investigator.\(^{197}\) Objective 1a will be answered through descriptive statistics of the 80 brief surveys. Objective 1b will be
addressed through descriptive statistics and qualitative analysis of the 90 brief surveys and 40 in-depth interviews with principals and classroom teachers. Objective 1c will be answered through descriptive statistics and qualitative analysis of school demographic factors and the 40 in-depth interviews with principals and teachers. Logistic regression will test the group differences in presence of the classroom breaks between the school demographic sub-groups.

**Study Two Methods**

**Purpose**

The purpose of this study is to determine if brief classroom exercise breaks of varying durations result in improvements in acute cognitive function and to examine the dose-response relationship. The proposed study will use valid and reliable measures of cognitive function that are easily administered in a classroom setting and sensitive to change in a non-clinical population to measure the effects of these interventions in 9 to 12 year-old children.

*Aim 2: Describe the acute effects of classroom exercise breaks on cognitive functions including executive function and academic performance of elementary school students.*

*Objective 2a:* Determine the acute effects of classroom exercise breaks on cognitive functions including executive function and academic performance.

*Hypothesis 2a: Acute classroom exercise breaks will have a positive effect on cognitive functions.*
**Objective 2b:** Describe the dose-response relationship between duration of classroom exercise breaks and post exercise cognitive functions.

*Hypothesis 2b:* Acute classroom exercise breaks of 5, 10, and 20 minutes will have progressively more positive effects on cognitive functions.

**Objective 2c:** Identify whether the acute effects of classroom exercise on cognitive functions are modified by baseline levels of general intelligence, parent-rated behavior, fitness, or Body Mass Index.

*Hypothesis 2c:* Students with lower general intelligence, poorer behavior, lower fitness and higher body mass index will have more positive responses in cognitive functions to classroom exercise breaks.

**Study Design**

This study will use a within-subjects, crossover experimental design. There will be four treatment conditions: 10 minutes of seated classroom activity, and 5, 10 and 20 minute exercise breaks. All participants will participate in each of the four conditions. The crossover design was used to account for between-subject variation and to increase efficiency, with little carryover of acute exercise treatments. To administer the intervention and testing in groups, randomization to the order of conditions will occur at the classroom level. To reduce sequencing effects, a balanced Latin Square design will be used to randomize the four treatments. See TABLE 7.5. Randomization will control for practice effects, with all classrooms receiving all conditions. The classroom setting, as opposed to a controlled laboratory setting, was chosen to improve external validity and to better facilitate research to practice applications.
The primary outcomes are cognitive functions operationally defined as executive functions and a math task. Executive function for this study is defined as the mental skills needed to perform complex planning tasks and composed of working memory, flexibility and inhibition as defined by Diamond. The primary outcomes will be assessed pre and post each condition, and the differences will be compared between conditions. This pretest-posttest design was chosen to account for daily variation in cognitive abilities within each child and to focus on the change in executive function and math performance with exercise.

**Methods**

*Participants*

Participants will be recruited from four 4th grade and four 5th grade classrooms from elementary schools in South Carolina. A convenience sample will be selected through agreement of the principal and teachers. Participants will range from 9 to 12 years of age. This age was selected for multiple reasons. The students are able to read to provide assent as well as complete reading tasks, the chosen outcome assessments have been validated for this age population, and executive functions are not as developmentally volatile in this age group as in younger ages. Parents will be asked to provide informed consent and children to provide assent prior to participation, including permission to video tape intervention and testing sessions.

*Intervention*

The Brain BITES (Better Ideas Through Exercise) exercise break intervention will be designed to be fun and feasible in a classroom setting. It will also be designed to
maintain moderate-to-vigorously aerobic activity for the entire duration of the exercise break. The sessions will be led by an exercise science graduate student with previous experience implementing similar breaks in a classroom setting. Activities will be context specific. The instructor will have a brief planning session with the students before the exercise to select activities to increase buy-in and enjoyment during initial baseline testing. Students will be asked about their current interests and favorite music. Activities will be compiled from Take 10!, Physical Activity Across the Curriculum, and instructor field experience. Example activities include prompted dancing, “marathon running”, and active classroom “Adventures” (for example climbing over the mountain, running through the desert, etc.). As some children will have difficulty maintaining longer durations of vigorous activity, body weight activities with less cardiovascular demand will be included intermittently to maintain intensity without reaching exhaustion. Activities will be similar throughout the intervention; only the duration of activities will vary.

The exercise durations were selected based on previous studies. Research has found effects in executive function and academics with 20 minutes of walking at a moderate intensity. Mahar et al. has found relevant outcomes with 10 minutes of similar aerobic physical activity breaks. Schools and teachers have also used shorter durations of 5 minute as longer interventions may not be practically implemented into school policy and practice. Kubesch et al. found no effects on cognitive outcomes after 5 minutes of physical activity. It is unknown if these shorter duration breaks have acute cognitive benefits.
During baseline assessment, students will be instructed on how to take heart rates using their carotid or radial pulse. To encourage participation, students will be instructed that heart healthy exercise gets their heart rates to 150. Heart rates will be self-assessed after all exercise breaks, including the practice sessions, and recorded. Fidelity of the intervention will be monitored by heart rate. The instructor will physically participate, give verbal cues, and offer positive descriptive encouragement, which has been shown to increase child activity. The exercise session will be video-taped and observed for intervention fidelity. The research lab has previous experience objectively observing physical activity levels.

**Measures**

Information will be collected on potential confounding variables and factors that have been shown to influence the relationship between exercise and cognition. Potential confounders include SES, gender, age, student engagement, attention-deficit/hyperactivity and problem behavior symptoms, IQ, BMI, regular physical activity, and fitness. Students will complete a brief questionnaire to obtain age, physical activity levels, sports participation, attitudes/motivation for academics (ex, I enjoy school/learning), Parents will complete a brief questionnaire to obtain socioeconomic status (household income, eligibility for free or reduced lunch), children’s academic history (ex, Is your child an A, B, C student? Has he/she ever had behavior problems?) and the Conners’ Parent Rating Scales Revised short version, a 27 item checklist to assess attention-deficit/hyperactivity and problem behavior symptoms.
During the week of baseline testing, anthropometric and IQ measurements will be taken individually for each participant. Standardized measures of students’ height and weight will be used to calculate BMI. The group of participants will complete a baseline aerobic fitness assessment of the PACER test from the FITNESSGRAM testing battery as well as the Kaufmann Brief Intelligence Test- Second Version (KBIT-2) measure of abbreviated IQ. The administration of the KBIT-2 assessment will be by staff trained by a clinical psychologist and the results of the assessment will not be interpreted or shared with parents as a valid clinical assessment.

**Physical Activity**

Videotapes of the intervention will be coded for intensity of physical activity using a modified System for Observing Fitness Instruction Time (SOFIT) (Donnelly, unpublished). Assuming 10 participating students per classroom, each video segment will be viewed three times by the primary investigator. Each viewing, three or four students will be selected. A student will be observed for 10 seconds, and observations will be recorded for 10 seconds. With 35 minutes of intervention per student and 10 students per classroom, each student will be observed for 35 intervals for a total of 2,800 intervals.

**Cognitive Measures**

A test battery was developed to assess the primary outcome of executive function. As mentioned, previous studies of exercise and cognition have been limited by their cognitive measures.\(^{190}\) Inherent difficulties exist in measuring executive function, including task-impurity, low test-retest reliability and lack of construct validity in adults\(^{22}\)
Executive function is used most during novel tasks, therefore limiting repeatability of assessments. It is difficult to isolate executive function skills due to questions of task-impurity and the complex tasks which utilize executive function also rely on several other mental processes such as attention. Etnier suggests using a combination of measures to assess the construct. In addition, executive function assessments in controlled environments are limited in external validity, as executive function is most used in uncontrolled situations (real world distractions, changes in environments, etc).

The testing battery has been assessed in pilot work to establish reliability, feasibility and acceptability. Objective measures were chosen as opposed to teacher rating scales to eliminate potential biases from teacher relationships with the children. The tests will be administered to the entire classroom simultaneously. While this may introduce additional confounding variables, Manly suggested that often measures of executive function are tested in settings that are too controlled and have no applicability to real world settings, such as a noisy classroom. It is these uncontrolled settings where executive function may be most utilized. While there is a potential for confounding cognitive demands (i.e. interference between children), this resembles the practical settings where task performance is required. Since executive functions highly influence other cognitive processes, it would be impossible to clearly isolate them in any setting. Previous measures to assess executive function have been lengthy and staff intensive (one-on-one interviews). Methods need to validly assess executive functions in
classroom setting reliably while minimizing disruption to class time through the assessment of multiple subjects simultaneously.

Total administration time will not exceed 15 minutes. The tasks are kid-friendly and easily administered. The tests and measured constructs have been connected to academic achievement. While most executive function tasks are validated through frontal lobe lesions, limiting application to non-clinical populations, these tests have shown variation in the general population. Outcome variables are operationally defined in TABLE 7.6.

**Trail Making Test**

The Trail Making Test (TMT) was carefully selected as a theoretically and neuropsychological valid, feasible and appropriate measure of executive function in children. The TMT has been shown to be sensitive to acute exercise in adults. A recent review of randomized control trials by Smith et al. found the largest cognitive effects in response to physical activity intervention in the Trail Making Test Part B. Developed in 1944 as part of the Army Individual Test Battery, it has consistently been used as a neuropsychological test to evaluate frontal lobe injuries, including in children. The TMT Part B has been validated as a measure of planning and set switching or cognitive flexibility. Functional MRIs have confirmed the frontal involvement in completing Part B of the TMT. Dikmen et al. showed the test-retest reliability of 0.79 for Part A and 0.89 for part B in over 300 adults. The TMT has also shown to be reliable in children with 0.64 in children aged 3-6 and 0.56 over 6 months in children 4-12 years of age. Administration time is less than 5 minutes. Alternative forms will be
used for each testing to decrease practice effects and maintain novelty which places stronger executive demands.\textsuperscript{22}

The test will be self-timed, reducing the time burden on classroom teachers from individual testing. A sub-sample will be timed by researchers to confirm the validity of self-timed measures. Students will be given the trail making task and an individual stopwatch. Upon instruction, they will start their own stopwatch, complete the test, stop the stopwatch, and record the time on the test. The final score will be composed of the time to take the test and an error score. As suggested by Sanchez-Cubillo,\textsuperscript{212} a ratio of TMTA to TMTB will be used as a measure of executive function.

\textit{Digit Recall}

Digit recall is a validated measure of working memory as part of the \textit{Working Memory Test Battery for Children}.\textsuperscript{176} In pilot testing of a group-administered testing session, children did not complete the task as intended. To modify the task for increased validity, students will be read a list of numbers, and then given 5 seconds to write them in chronological order from lowest to highest. This will maintain the integrity of recalling and cognitively manipulating number sequences, but discourage task diversion.

\textit{Timed Math Test}

To assess ecological validity and application to academics, a timed math test will be given, similar to previous studies.\textsuperscript{217} A math worksheet appropriate for the specific age-group will be used. Children will be given the worksheet face down. On instructor instruction, they will turn over the paper and begin, completing as many problems as possible within 1 minute. When instructor says “STOP”, all participants must stop
working and put pencils down. The score will be the number of problems correctly answered.

Procedures

At the initial visit, the study will be described and children whose parents have consented will complete written assent. Assenting participants will complete height and weight measures, the PACER test, and the Kaufmann Brief Intelligence Test - Second Version within the first week. The study will occur over five weeks, with one week for baseline testing and one week for each exercise condition. Classrooms will be randomized to the order of conditions and all students will participate in all four conditions. To help reduce novelty effects and allow the participants to practice, the participants will receive one day of the exercise or sedentary condition prior to cognitive testing. Four classes will participate in testing in the morning and four classes will participate in the afternoon. All cognitive assessments will be held on the same time and day of the week to account for day-to-day variation. The pretest will be given after 5 minutes of seated classroom activity. Posttest cognitive testing will occur after heart rate returns to 10% resting or an average of 5 minutes post exercise.$^{10}$

The control condition will have similar procedures. Measures will take place before and after 10 minutes of seated classroom activity such as academic worksheets, puzzles, or coloring. Students will be required to remain seated. The timeline is seen in TABLE 7.7.

Sample Size
G*Power 3.1.3 was used to calculate power for a repeated measures, within-between interaction design. Using a crossover, within-subject design, a sample size of 80 with 4 groups would have the power to detect an effect size of 0.15 between four conditions with an alpha of .05. This is based on reliability of 0.56 on the TMTB over 6 months in children. With 8 classrooms, it is underpowered to detect small effects if analyzed at the classroom level. However, it will be possible in this exploratory study to examine variation between classrooms and find effect sizes to be used in future studies.

Analysis

To test for a sequencing effect, an initial ANOVA with a time and treatment interaction will be run. If this interaction term is significant, the four sequences of treatments will be analyzed separately. Post-test differences executive function and timed math test will be compared between the four conditions. Using SAS 9.2, a repeated measures analysis of covariance to account for within-subject correlations, with pre-test scores included as a time varying covariate, will be used. Separate analyses will be used with independent variables of Trail Making Test change scores, Digit Recall change scores and math change score. Basic models will be adjusted for SES, baseline executive function scores, and mean physical activity coded from SOFIT video observation. Linear contrasts will be used to test the differences between all three exercise conditions and doses of 5, 10, 20 minutes of exercise as compared to 10 minutes of sedentary activity. To examine Objective 2c, potential continuous effect modifiers will be dichotomized using a median split and included as an interaction term. Interactions will an alpha of less than 0.1 will be considered significant. The potential
effect modifiers to be examined include sex, abbreviated IQ, attention disorder symptoms, fitness levels, and BMI, and engagement in school.

**Study Three Methods**

**Purpose**

The purpose of this study is to determine if brief classroom exercise breaks of varying durations result in improvements in acute attention and to examine the dose-response relationship in 9 to 12 year-old children.

**Aim 2: Describe the acute effects of classroom exercise breaks on on-task behavior of elementary school students.**

**Objective 2a:** Determine the acute effects of classroom exercise breaks on on-task behavior.

*Hypothesis 2a: Acute classroom exercise breaks will have a positive effect on on-task behavior.*

**Objective 2b:** Describe the dose-response relationship between duration of classroom exercise breaks and post exercise on-task behavior.

*Hypothesis 2b: Acute classroom exercise breaks of 5, 10, and 20 minutes will have progressively more positive effects on on-task behavior.*

**Objective 2c:** Identify whether the acute effects of classroom exercise on on-task behavior are modified by baseline levels of general intelligence, parent-rated behavior, fitness, or Body Mass Index.
Hypothesis 2c: Students with lower general intelligence, poorer behavior, lower fitness and higher body mass index will have more positive responses in on-task behavior to classroom exercise breaks.

**Study Design**

This study will use a within-subjects, crossover experimental design. There will be four treatment conditions: 10 minutes of seated classroom activity, and 5, 10 and 20 minute exercise breaks. All participants will participate in each of the four conditions. The crossover design was used to account for between-subject variation and to increase efficiency, with little carryover of acute exercise treatments. To administer the intervention and testing in groups, randomization to the order of conditions will occur at the classroom level. To reduce sequencing effects, a balanced Latin Square design will be used to randomize the four treatments similar to Study Two. Randomization will control for practice effects, with all classrooms receiving all conditions. The classroom setting, as opposed to a controlled laboratory setting, was chosen to improve external validity and to better facilitate research to practice applications.

The primary outcome is on-task behavior as measured by observed time-on-task. Attention is defined as the ability to selectively focus and inhibit distracters. The primary outcome will be assessed pre and post each condition, and the differences will be compared between conditions. This pretest-posttest design was chosen to account for daily variation in cognitive abilities within each child and to focus on the *change* in on-task behavior with exercise.
Methods

Participants

Participants will be the same as those in Study Two, and will be recruited from four 4th grade and four 5th grade classrooms from elementary schools in South Carolina. A convenience sample will be selected through agreement of the principal and teachers. Participants will range from 9 to 12 years of age. developmentally volatile in this age group as in younger ages. Parents will be asked to provide informed consent and children to provide assent prior to participation, including permission to video tape intervention and testing sessions.

Intervention

The Brain BITES (Better Ideas Through Exercise) exercise break intervention will be designed to be fun and feasible in a classroom setting and will be the same intervention as used in Study Two.

Measures

Information will be collected the same as in Study Two on potential confounding variables and factors that have been shown to influence the relationship between exercise and cognition.

Physical Activity

Videotapes of the intervention will be coded for intensity of physical activity using a modified System for Observing Fitness Instruction Time (SOFIT) as in Study Two (Donnelly, unpublished).
Attention

To obtain an ecologically valid measure of attention, direct observation of the children during testing will be used similar to previous studies.\textsuperscript{152, 219} To establish intra-rater reliability and be able to assess attention in all participants within the short testing frame, video cameras, placed in the front of the classroom will be used for direct observation. A systematic time sampling observation system will be used. Attention will be determined by the direction of the student’s gaze, either at the instructor or on the testing materials.\textsuperscript{219}

Consented students will be observed for time-off-task during the testing procedure. The videos will be edited so only the testing procedures are included and the observer remains blinded to the condition. As a measure of overall classroom testing efficiency, the duration of testing administration was recorded from the time the instructor said “Go” to begin the TMT test to “Stop” to signal the end of the math test. To make comparisons to previous studies, observations will be made through similar sampling procedures as in-person observations. Each video segment will be viewed three times. The videos will be assigned random codes so both observers will be unaware of the time and condition of testing. Student will be viewed for 15 seconds and the number of off-task interruptions will be tallied. Off-task behavior will include direction of gaze away from instructor or testing materials, speaking out of turn, and excessive fidgeting. The observer will cycle through all visible students in three viewings of the complete condition from left to right, right to left, and beginning in the center of the classroom. Different students will be observed at each 15-second interval between
the 3 viewings. If a student is not visible for at least 5 seconds during the 15-second
interval, the observer will proceed to the next student. Videos will be watched by two
observers (an observer blinded to the study aims, and the primary investigator). Videos
will have a time stamp. Both observers will observer the same students at the same
time stamps. Intervals that differ between coders will be examined a third time by the
primary investigator. Only consented students will be analyzed.

Procedures

At the initial visit, the study will be described and children whose parents have
consented will complete written assent. Assenting participants will complete height and
weight measures, the PACER test, and the Kaufmann Brief Intelligence Test- Second
Version within the first week. The study will occur over five weeks, with one week for
baseline testing and one week for each exercise condition. Classrooms will be
randomized to the order of conditions and all students will participate in all four
conditions. To help reduce novelty effects and allow the participants to practice, the
participants will receive one day of the exercise or sedentary condition prior to cognitive
testing. Four classes will participate in testing in the morning and four classes will
participate in the afternoon. All observations will be held on the same time and day of
the week to account for day-to-day variation.

The control condition will have similar procedures. Measures will take place
before and after 10 minutes of seated classroom activity such as academic worksheets,
puzzles, or coloring. Students will be required to remain seated.
Analysis

Group/grade/sex differences were tested using ANOVA and Chi-square tests. To test for a sequencing effect, an initial ANOVA with a time and treatment interaction will be run. If this interaction term is significant, the four sequences of treatments will be analyzed separately. Pre to post differences in on-task behavior will be compared between the four conditions.

Using SAS 9.2, a repeated measures analysis of covariance to account for within-subject correlations will compare post-test on-task behavior between exercise conditions and the sedentary condition. Basic models will be adjusted for classroom group, age, and time-varying pre-test on-task behavior. The overall F-statistic will be used answer Objective 2a. To answer Objective 2b, linear contrasts will be used to test the differences between doses of 5, 10, 20 minutes of exercise and 20 minutes of sedentary activity. To examine Objective 2c, potential effect modifiers will be examined through stratified analysis, including sex, abbreviated IQ, attention disorder symptoms, fitness levels, and BMI.

Study Four Methods

Purpose

The purpose of this study is to examine the affect of children during classroom exercise breaks and their subjective response to the practice. The practice is less likely to be implemented if it is not enjoyable to students.
Aim 4: Determine student affective responses to classroom exercise breaks.

Objective 4a: Compare student affective responses to classroom exercise breaks with the response to a sedentary classroom activity.

Hypothesis 4a: Students will have a more positive affective response during classroom exercise breaks than during a sedentary classroom activity.

Objective 4b: Describe the dose-response relationship between durations of classroom exercise breaks and student affective response.

Hypothesis 4b: Acute classroom exercise breaks of 5, 10, and 20 minutes will have non-linear effects on student affective responses.

Objective 4c: Describe student and teacher subjective responses to classroom exercise breaks.

Hypothesis 4c: Student and teachers will report positive subjective responses to classroom exercise breaks.

Study Design

This study will use a within-subjects, crossover experimental design. This study will use the same participants and intervention from Study Two. The classrooms will be randomized to the order of conditions. Quantitative data will include objectively coded positive affect during the intervention conditions, student focus groups and teacher interviews.

Methods

Participants
This study will use the same participating schools as Study Two. Teachers of participating classrooms will also be included.

**Measures**

**Direct Observation**

To quantitatively measure positive affect, the video tapes of the classroom physical activity intervention from Study Two will be analyzed. Several objective systems have been used to code facial expressions for affect. As affect and emotion has not been previously coded in physical activity settings, a modified version based on the Specific Affect Coding System\(^{220}\) and the System for Observing Children’s Activity and Relationships during Play (SOCARP) will be used.\(^{221}\) Previous studies have utilized videotape footage to analyze affect.\(^{222, 223}\) The sampling procedure will be consistent with the observation system used for attention in Study Three.

Positive affect is a broad disposition,\(^{23}\) differing from specific emotions, and will involve some subjective analysis. Signs of positive affect will include smiling and positive verbal response. Observers will be trained using previous footage of child classroom physical activity. Videos will be watched by two observers (an observer blinded to the study aims, and the primary investigator). Videos will have a time stamp. Only consented students will be analyzed. Assuming 10 participating students per classroom, each video segment will be viewed three times by the primary investigator. A student will be observed for 10 seconds, and observations will be recorded. With 55 minutes of intervention per student and 10 students per classroom, each student will be observed
for 55 intervals for a total of 4,400 intervals. The primary outcome variable will be the percentage of intervals coded for positive affect.

**Focus Groups**

Focus groups will be held with consenting, participating students within one week of the completion of the classroom exercise break intervention. The focus groups will assess acceptability and reactions to the intervention to inform future studies. Sample questions are included in Appendix C. Groups will be 10 to 20 students and the time and location will be determined by the teacher. Discussions will take no longer than 30 minutes and will be recorded.

**Interviews**

Each classroom teacher and school principal will complete an in-depth interview at the end of the 5-week intervention period to gather information on the implementation, feasibility, perceived benefits and overall impressions of the intervention. Sample interview questions are included in Appendix C. Interviews will be recorded and will include discussion of the feasibility and acceptability of classroom exercise breaks.

**Standards of Validation**

The same standards of validation used in Study One will be applied.

**Sample Size**

Using a crossover, within-subject design, a sample size of 80 would have the power to detect an effect size in percentage of positive affect between the two conditions of 0.15 with an alpha of .05. With 8 classrooms, it is underpowered to detect
small effects if analyzed at the classroom level. However, it will be possible in this exploratory study to examine variation between classrooms and find effect sizes to be used in future studies. There will be 8 focus groups, which is compatible with health-education research and 8 teacher interviews.

**Analysis**

To examine Objective 4a, descriptive statistics of the frequency and type of positive affects during intervention and control conditions will be reported from video observation. The directly observed positive affect codes will be averaged for each condition and compared using a repeated measures analysis of covariance adjusted for classroom group and gender. To answer Objective 4b, linear contrasts will be used to test the differences in positive affect between doses of 5, 10, 20 minutes of exercise and 10 minutes of sedentary activity. To answer Objective 4b, analysis of focus group and interview transcripts will be examined for emergent themes. The emergent themes will be integrated with the positive affect data to depict an overall description of the affective response to classroom physical activity breaks. This combination of qualitative and quantitative research maximizes the strength of the study. To ensure the rigor of this qualitative method, dependability (reliability) and confirmability (objectivity) will be established through an audit trail. The findings of the study will be shared with participating teachers and school administrators.
**Table 7.1:** Percentage of submitting South Carolina schools reporting exercise break practices over 4 years

<table>
<thead>
<tr>
<th>Type of Exercise</th>
<th>2007-08</th>
<th>2008-09</th>
<th>2009-10</th>
<th>2010-11</th>
</tr>
</thead>
<tbody>
<tr>
<td>Video</td>
<td>23</td>
<td>52</td>
<td>57</td>
<td>38</td>
</tr>
<tr>
<td>Morning</td>
<td>16</td>
<td>n/a</td>
<td>40</td>
<td>35</td>
</tr>
<tr>
<td>Classroom</td>
<td>12</td>
<td>64</td>
<td>76</td>
<td>66</td>
</tr>
</tbody>
</table>

Percent of Schools reporting

|         | 91      | 92      | 71      | 66      |
Table 7.2: Summary of studies examining classroom exercise interventions and educational outcomes

<table>
<thead>
<tr>
<th>Study Design</th>
<th>Participants</th>
<th>Intervention</th>
<th>Outcome Measure</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Chronic Effects</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Donnelly et al., 2009&lt;sup&gt;179&lt;/sup&gt;</td>
<td>Cluster randomized controlled trial</td>
<td>1,527 2&lt;sup&gt;nd&lt;/sup&gt; and 3&lt;sup&gt;rd&lt;/sup&gt; graders</td>
<td>Teacher led, integrated academic, 90 minutes per week in 10 min bouts, 3 years</td>
<td>Wechsler Individual Achievement Test-2&lt;sup&gt;nd&lt;/sup&gt; Edition (academic achievement)</td>
</tr>
<tr>
<td>Physical Activity Across the Curriculum</td>
<td>24 schools</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Katz et al., 2010&lt;sup&gt;155&lt;/sup&gt;</td>
<td>Randomized-group design</td>
<td>403 2&lt;sup&gt;nd&lt;/sup&gt; graders 403 3&lt;sup&gt;rd&lt;/sup&gt; graders 408 4&lt;sup&gt;th&lt;/sup&gt; graders</td>
<td>Teacher led, non-academic, approximately 30 minutes daily, approximately 8 months</td>
<td>Missouri Academic Performance (MAP), Independence School District progress reports, classroom behavior</td>
</tr>
<tr>
<td>Activity Bursts in the Classroom for Fitness</td>
<td>5 schools</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reed et al., 2010&lt;sup&gt;236&lt;/sup&gt;</td>
<td>Randomized-group design</td>
<td>155, 3&lt;sup&gt;rd&lt;/sup&gt; graders</td>
<td>Teacher led, integrated academics, 30 minutes per day, 3 days, 3 days per week, approximately 3 months</td>
<td>Standard Progressive Matrices (Fluid intelligence); Palmetto Achievement Challenge Tests (academic achievement)</td>
</tr>
<tr>
<td><strong>Acute Effects</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Grieco et al., 2009&lt;sup&gt;177&lt;/sup&gt;</td>
<td>2x2x3 repeated-measures factorial design</td>
<td>97, 3&lt;sup&gt;rd&lt;/sup&gt; graders 9 classes</td>
<td>Teacher led, integrated academic, 10-15 minutes</td>
<td>Pre and post direct observation of on-task behavior using momentary time sampling</td>
</tr>
<tr>
<td>Texas I-CAN</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Kubesch et al., 2009&lt;sup&gt;166&lt;/sup&gt;</td>
<td>Randomized within-subject cross-over</td>
<td>81, 7&lt;sup&gt;th&lt;/sup&gt; graders</td>
<td>Teacher led, non-academic, 5 minutes</td>
<td>Pre and post computerized Flanker and Dots tasks (executive functions)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mahar et al., 2006&lt;sup&gt;188&lt;/sup&gt;</td>
<td>Multiple-baseline across classrooms, repeated measures design</td>
<td>62, 3&lt;sup&gt;rd&lt;/sup&gt; graders 25, 4&lt;sup&gt;th&lt;/sup&gt; graders 4 classes</td>
<td>Teacher led, integrated academic, 10 minute activities</td>
<td>Pre and post direct observation of on-task behavior using momentary time sampling</td>
</tr>
<tr>
<td></td>
<td># Schools</td>
<td>% FRL</td>
<td>Income</td>
<td>Poverty Index</td>
</tr>
<tr>
<td>-------</td>
<td>-----------</td>
<td>-------</td>
<td>---------</td>
<td>---------------</td>
</tr>
<tr>
<td>Aiken</td>
<td>20</td>
<td>56.3%</td>
<td>$44,296</td>
<td>77.3%</td>
</tr>
<tr>
<td>Edgefield</td>
<td>4</td>
<td>58.3%</td>
<td>$44,391</td>
<td>78.5%</td>
</tr>
<tr>
<td>Fairfield</td>
<td>4</td>
<td>78.6%</td>
<td>$32,120</td>
<td>95.7%</td>
</tr>
<tr>
<td>Kershaw</td>
<td>11</td>
<td>54.4%</td>
<td>$45,035</td>
<td>77.4%</td>
</tr>
<tr>
<td>Lancaster</td>
<td>9</td>
<td>54.3%</td>
<td>$38,590</td>
<td>75.0%</td>
</tr>
<tr>
<td>Lexington 1</td>
<td>15</td>
<td>35.5%</td>
<td>$60,061</td>
<td>53.5%</td>
</tr>
<tr>
<td>Lexington 2</td>
<td>5</td>
<td>58.5%</td>
<td>$41,521</td>
<td>81.3%</td>
</tr>
<tr>
<td>Lexington 5</td>
<td>12</td>
<td>30.5%</td>
<td>$66,101</td>
<td>49.1%</td>
</tr>
<tr>
<td>Newberry</td>
<td>8</td>
<td>63.5%</td>
<td>$41,080</td>
<td>77.6%</td>
</tr>
<tr>
<td>Orangeburg 3</td>
<td>4</td>
<td>78.7%</td>
<td>$29,335</td>
<td>97.1%</td>
</tr>
<tr>
<td>Orangeburg 5</td>
<td>8</td>
<td>75.5%</td>
<td>$31,593</td>
<td>96.0%</td>
</tr>
<tr>
<td>Richland 1</td>
<td>29</td>
<td>65.2%</td>
<td>$38,098</td>
<td>86.4%</td>
</tr>
<tr>
<td>Richland 2</td>
<td>18</td>
<td>40.8%</td>
<td>$59,328</td>
<td>60.7%</td>
</tr>
<tr>
<td>Sumter 17</td>
<td>15</td>
<td>64.3%</td>
<td>$37,219</td>
<td>83.6%</td>
</tr>
<tr>
<td>Sumter 2</td>
<td>15</td>
<td>73.6%</td>
<td>$38,070</td>
<td>89.4%</td>
</tr>
<tr>
<td>York 1</td>
<td>5</td>
<td>58.2%</td>
<td>$41,294</td>
<td>74.2%</td>
</tr>
<tr>
<td>York 2</td>
<td>6</td>
<td>32.3%</td>
<td>$57,754</td>
<td>51.0%</td>
</tr>
<tr>
<td>York 3</td>
<td>16</td>
<td>52.6%</td>
<td>$47,175</td>
<td>70.3%</td>
</tr>
<tr>
<td>York 4</td>
<td>7</td>
<td>20.2%</td>
<td>$70,978</td>
<td>28.9%</td>
</tr>
<tr>
<td>South Carolina</td>
<td>578</td>
<td>63.5%</td>
<td>$38,916</td>
<td>75.6%</td>
</tr>
<tr>
<td>United States</td>
<td>42.9</td>
<td>50,046</td>
<td>12.3%</td>
<td>87.4%</td>
</tr>
</tbody>
</table>

**Study Sample**

<table>
<thead>
<tr>
<th># Schools</th>
<th>% FRL</th>
<th>Income</th>
<th>Poverty Index</th>
<th>Race (% Black)</th>
<th>Pop Density (per sq mile)</th>
<th>Rural-Urban Code</th>
<th>% Not Meeting English</th>
<th>% Not Meeting Math</th>
</tr>
</thead>
<tbody>
<tr>
<td>192</td>
<td>55.3%</td>
<td>$45,475</td>
<td>72.9%</td>
<td>33.3%</td>
<td>353.2%</td>
<td>2.4</td>
<td>22.6%</td>
<td>27.1%</td>
</tr>
</tbody>
</table>

*a* Poverty Index calculated by the SC Department of Education based on percentage of free and reduced lunch and Medicaid eligibility

*b* Based on 2003 Rural-Urban Continuum Codes

*c* Data from the SC Department of Education 2010-2011 Palmetto Assessment of State Standards
Table 7.4: Number of schools available in each stratum (mean %FRL, % not meeting standards)

<table>
<thead>
<tr>
<th># Schools (districts represented)</th>
<th>&lt;60% FRL</th>
<th>&gt;60% FRL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lower Performing</td>
<td>46</td>
<td>45</td>
</tr>
<tr>
<td></td>
<td>(51.11, 17.45)</td>
<td>(79.38, 31.58)</td>
</tr>
<tr>
<td>Higher Performing</td>
<td>48</td>
<td>53</td>
</tr>
<tr>
<td></td>
<td>(30.42, 11.56)</td>
<td>(76.82, 25.33)</td>
</tr>
</tbody>
</table>

Table 7.5: Randomization of intervention conditions*

<table>
<thead>
<tr>
<th>Classroom Group</th>
<th>Week 1</th>
<th>Week 2</th>
<th>Week 3</th>
<th>Week 4</th>
<th>Week 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Baseline</td>
<td>A</td>
<td>B</td>
<td>C</td>
<td>D</td>
</tr>
<tr>
<td>2</td>
<td>Baseline</td>
<td>B</td>
<td>D</td>
<td>A</td>
<td>C</td>
</tr>
<tr>
<td>3</td>
<td>Baseline</td>
<td>C</td>
<td>A</td>
<td>D</td>
<td>B</td>
</tr>
<tr>
<td>4</td>
<td>Baseline</td>
<td>D</td>
<td>C</td>
<td>B</td>
<td>A</td>
</tr>
<tr>
<td>5</td>
<td>Baseline</td>
<td>B</td>
<td>D</td>
<td>A</td>
<td>C</td>
</tr>
</tbody>
</table>

*Condition A - 10 minutes in classroom seated activity (reading, coloring, worksheets)
Condition B - 5 minutes staff facilitated exercise break daily
Condition C - 10 minutes staff facilitated exercise break daily
Condition D - 20 minutes staff facilitated exercise break daily
Table 7.6: Operational definitions of outcome variables for Study Two

<table>
<thead>
<tr>
<th>Measure</th>
<th>Operational Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Cognitive Flexibility</strong></td>
<td>Trail Making Test Difference between Part A and Part B (seconds)</td>
</tr>
<tr>
<td><strong>Working Memory</strong></td>
<td>Digit Recall Number of correct numbers recalled; number of lists recalled in correct order</td>
</tr>
<tr>
<td><strong>Academic Achievement</strong></td>
<td>Timed Math Test Number of math problems correct</td>
</tr>
<tr>
<td>---------</td>
<td>---</td>
</tr>
<tr>
<td>Classroom 4&lt;sup&gt;th&lt;/sup&gt;-1</td>
<td>Classroom Info Session</td>
</tr>
<tr>
<td>Classroom 4&lt;sup&gt;th&lt;/sup&gt;-2</td>
<td>Consent to parents</td>
</tr>
<tr>
<td>Classroom 5&lt;sup&gt;th&lt;/sup&gt;-3</td>
<td>Parent questionnaire and Conners</td>
</tr>
<tr>
<td>Classroom 5&lt;sup&gt;th&lt;/sup&gt;-4</td>
<td></td>
</tr>
<tr>
<td>School 2</td>
<td></td>
</tr>
<tr>
<td>Classroom 4&lt;sup&gt;th&lt;/sup&gt;-5</td>
<td>Consent to parents</td>
</tr>
<tr>
<td>Classroom 4&lt;sup&gt;th&lt;/sup&gt;-6</td>
<td>Parent questionnaire and Conners</td>
</tr>
<tr>
<td>Classroom 5&lt;sup&gt;th&lt;/sup&gt;-7</td>
<td></td>
</tr>
<tr>
<td>Classroom 5&lt;sup&gt;th&lt;/sup&gt;-8</td>
<td></td>
</tr>
</tbody>
</table>
Figure 7.1: Proposed model of mediators and moderators on academic achievement from Tomporowski (2011)
Figure 7.2: Meta-Volition model from Yancey (2009)
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APPENDIX A
CHANGES TO PROPOSAL

Study One

It was originally proposed to interview 40 principals and 40 classroom teachers, 10 from each strata. However, school district approval provided a major barrier to accessing principals. Therefore, 14 interviews were completed with principals. Saturation was reached and the responders did not differ largely from the sampled population on key school demographic variables. Interview participants had slightly lower percentage of students receiving free-and-reduced lunch and not meeting English and Math standards.
APPENDIX B
STUDY ONE SURVEY AND INTERVIEW QUESTIONS

Interview Questions for Principals

Brief Survey (email)

Classroom exercise breaks are short bouts of exercise integrated into the classroom (this does not include recess or physical education).

1. To your knowledge, do teachers in your school conduct classroom exercise breaks?

2. In your school, approximately what percentage of teachers conducts classroom exercise breaks?

3. If your school conducts in classroom exercise breaks, what grades participate in classroom exercise breaks?

4. Does your school have a policy requiring teachers to conduct classroom exercise breaks? If yes, briefly describe.

In-Depth Semi-structured Interviews

Principals

1. Do you have a school policy (formal or informal) requiring exercise breaks? What is the policy?
2. How long has your school practiced these exercise breaks?

3. How did classroom exercise breaks start in your school?

4. Was there any resistance to implementation?

5. What was the reaction from teachers? Parents? Students?

6. What benefits or disadvantages do you perceive from exercise breaks for students? Teachers?

7. What are your top priorities for your students?

8. What is your physical activity experience?

9. Do you have any additional thoughts or comments on classroom exercise breaks in elementary schools?

10. We are learning about physical activity opportunities, and your school is a great example. Would it be possible to speak with one of your classroom teachers who conducts classroom exercise breaks?

Classroom Teachers

1. How often do you have exercise breaks in the classroom? When do you usually have them?

2. What types of activities do you do? Do you lead them (or video)?

3. How long do they typically last?

4. How do the children behave before and after the practices?

5. Why do you practice these exercise breaks?
6. If you were going to try to convince another teacher to begin these practices, what would you tell them?

7. Do you have any additional thoughts or comments on classroom exercise breaks in elementary schools?
APPENDIX C
STUDY FOUR FOCUS GROUP QUESTIONS

Student Focus Group Sample Questions

1. What did you think of the Brain BITES?
2. Which was your favorite week?
3. Did you feel different afterwards?
4. What was your favorite part?
5. Would you like to keep doing Brain BITES?
6. How would you change it?

Teacher Questions

1. Do you or have you implemented similar practices in your classroom? If yes, please describe.
2. What do you think of the Brain BITES intervention?
3. What were your students’ reactions to the exercise?
4. What was the difference in the students on days we did Brain BITES?
5. Did you notice a difference between weeks?
6. Would you be willing to implement this intervention? For how long of a duration? If yes, why? If no, why not?
7. What support would you need to implement Brain BITES?
8. What is your physical activity experience?