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Feasibility and Efficacy of a Recess-Based Combined Fitness Intervention on Cognition and Academic Performance in Elementary School Children

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Feasibility and Efficacy of a Recess-Based Combined Fitness Intervention on Cognition and Academic Performance in Elementary School Children

A Dissertation Proposal Presented

by

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DEDICATION

This dissertation project is dedicated to my husband and sons. They have been my sources of inspiration and my chief supporters throughout my doctoral graduate program.

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ABSTRACT

FEASIBILITY AND EFFICACY OF A RECESS-BASED COMBINED FITNESS INTERVENTION ON COGNITION AND ACADEMIC PERFORMANCE IN ELEMENTARY SCHOOL CHILDREN

MAY 2019

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Youth physical activity and fitness have been reported to influence cognition and academic related outcomes. Despite the potential benefits of muscular fitness, few intervention studies have examined the impact of an intervention that has incorporated both cardiorespiratory and muscular fitness training on cognition and academic performance in children. Previous studies have mainly been implemented either during the school day or immediately after-school. Although recess may be an ideal time to promote physical activity because it does not compete with other academic demands, it has been an understudied setting. Therefore, the purpose of this dissertation project was to examine the feasibility, acceptability, and the preliminary efficacy of a 3-month recess-based combined fitness (i.e., cardiorespiratory and muscular fitness) program on cognition and academic performance in elementary school-age children. Two elementary schools were randomly assigned to either the combined fitness intervention or control group. The intervention was implemented during recess for 15 minutes/weekday for 13 weeks while the control group continued participating in their regular recess sessions.

Process evaluation data (feasibility and acceptability) were collected throughout the intervention. Executive functions, classroom behavior, fitness, and physical activity were collected at baseline and 3-months. Process evaluation data showed that the program achieved high intervention session intensity dosage (mean percentage of maximal heart rate = 58.0±5.8%), number of implemented sessions (88%), and percentage of sessions implemented as planned (78% of sessions). However, intervention session intensity dosage based on accelerometry (% of time spent in moderate-to-vigorous activity: 41.7±14.5%) and participation (19.4% attendance rate) were lower than expected. Moderate-to-vigorous physical activity during recess sessions was significantly higher in the intervention group, compared to the control group (intervention group = 41.7±2.1%; control = 30.4±0.2, $P<0.001$). No other significant changes were observed in cognition, classroom behavior, total day physical activity, or fitness outcomes. This project provided some preliminary evidence that a recess-based combined fitness intervention is feasible and acceptable, and can promote moderate-to-vigorous physical activity during school recess. However, certain factors (e.g., methods to improve attendance to enhance the dosage received) should be targeted to refine and improve the intervention to determine if it can impact academic and cognitive outcomes.

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CHAPTER 1

INTRODUCTION

The Current State and Impact of Academic Performance and Cognition

Poor academic performance and low fitness levels in young children (i.e., preadolescent children) are both prevalent concerns that can be addressed with physical activity interventions. According to the 2013 National Assessment of Educational Progress (NAEP) Nations Report Card, 58% and 65% of fourth graders were below the proficient levels in mathematics and reading, respectively (1). Although the NAEP has reported a trend of improved academic progress since 1990 in the U.S., poor academic performance remains a major concern. Academic performance plays an important role in youth development and future opportunities (1). Students that exhibit higher levels of academic performance are more likely to earn college degrees and have greater access to employment opportunities (1). Factors that influence academic performance include socioeconomic status, education environment, parental involvement, physical fitness, and physical activity, among others (2, 3).

Cognition refers to the collection of mental processes that allow an individual the ability to interact with the environment (e.g., perception, pattern recognition, attention, concept formation and reasoning, and intelligence) (4). Cognitive processes that are highly involved in the control of behavior are executive functions (i.e., selective attention, interference suppression, response inhibition, task switching, working memory, and task-set representation) (5). Executive functions are considered important for academic achievement, learning, and activities of daily living (6-9). This is because executive functions allow our minds the ability to plan, coordinate, and focus (e.g., ignore a distraction, inhibit an inappropriate response, shift our mind set and attention from one task to another, and integrate these processes together) (10). As these processes play a significant role in learning and problem solving, cognitive processes are also positively associated with current academic performance levels in children, and can be used to predict future academic performance (6, 7, 9). These abilities provide the foundations for academic skills and daily behaviors. Executive functions in children can be influenced by both internal (e.g., neural anatomy and genetics) and environmental (e.g., low fitness, poor nutrition, economic hardship, abuse or neglect from caregivers, and exposure to violence in the home or community) factors (11, 12).

Children's Physical Activity and Fitness Relationships with Cognition and Academic Performance

Fitness levels (i.e., cardiorespiratory fitness, muscular fitness, flexibility, and body composition) are also an increased concern among U.S. children (13, 14). Low fitness levels in children have been directly related to their low levels of physical activity, which have been associated with various adverse health outcomes, such as lower cardiovascular and muscular health, lower bone mineral density, and increased depressive symptoms (15). Optimal fitness helps reduce health risk profiles in children and similar to physical activity, also tracks into adulthood (16, 17).

Physical fitness and physical activity have been linked to cognition and academic performance in children (2). Review papers have reported that higher levels of fitness are associated with better executive functioning, academic achievement, and academic behaviors (2, 4, 18-25). Researchers have indicated that the relationship pathway between physical activity and academic performance may be mediated by physical fitness (with the most attention given to cardiorespiratory fitness), health factors (e.g., obesity), and psychological and social variables (e.g., self-esteem and self-efficacy) (4). However, although experimental research has emerged examining the effects of physical activity interventions on cognition and academic performance in children, most have only assessed aerobic fitness and health factors as mediators (2, 24, 26).

Schools are a common setting utilized in experimental intervention studies targeting health related behaviors and academic performance-related outcomes as they provide access to a large number of children for a substantial amount of time (13). Many of the studies that have examined school-based physical activity interventions in elementary school-age children have observed positive effects on cognition (i.e., executive functions) and academic achievement (2). However, there are (at least) two gaps (i.e., limited research on the role of muscular fitness and school recess-based programming) that are noted in the literature regarding the design of such interventions that will be addressed in the proposed project.

Youth physical activity interventions designed to improve cognition and academic performance outcomes have primarily targeted cardiorespiratory fitness and therefore, focused on aerobic training modalities (2, 24). However, current physical activity guidelines for children recommend muscular fitness activities in addition to aerobic activities because they promote additional health and performance benefits (e.g., muscular strength, motor skills, bone mineral density, balance, and coordination) compared to aerobic fitness alone (15). Muscular fitness programs also typically involve more complex movements than traditional aerobic programs, which often utilize basic locomotive movements (27). Complex movements (e.g., activities that require more coordination than walking and running) may have additional or independent benefits on some aspects of cognition such as improvements in inhibition and standardized academic testing scores (28, 29). Such movements are thought to be more cognitively demanding and require more mental effort than rhythmic and repetitive movements often utilized in cardiorespiratory training programs (10, 11, 30), which has been proposed to offer further neurophysiological benefits (31). Furthermore, cross-sectional studies have reported positive associations between cognition and academic achievement with muscular fitness (29, 32). Despite the potential impact of muscular fitness, currently only two intervention studies have examined the impact of a program that emphasized both cardiorespiratory and muscular fitness on cognition or academic performance (33, 34).

Although previous studies examining physical activity and academic performance have mainly been implemented either during the school day (specifically during classroom time) or immediately after-school (2, 14, 23, 35-37), these intervention settings pose some limitations. For example, after-school programs may not be accessible to all students due to transportation concerns, parent work schedules, and scheduling conflicts with other extracurricular activities. Therefore, to increase accessibility and exposure to more students, it could be argued that physical activity and fitness interventions designed to impact cognitive and academic outcomes should be implemented during the school day. However, physical activity interventions designed for the classroom setting are often in competition with other academic demands, such as time constraints and pressure to meet learning standards and improve students' standardized test scores (13). It is possible that the school day, specifically during academic classroom time, may not be the most viable setting in which to intervene.

Consequently, non-academic classroom time such as school recess may be an ideal time to promote physical activity and fitness. Furthermore, during preliminary meetings with the school administrative staff to discuss this dissertation project, school recess was strongly identified as the setting with the greatest need to enhance physical activity. The greatest concern regarding school recess was observed reductions in physical activity during colder weather and indoor recess (the designated recess setting during inclement or very cold weather). For example, it was consistently reported (anecdotally) that during indoor recess, sedentary behaviors of students increase due to small classroom space and increased use of media (such as electronic tablets). Researchers that have reported on physical activity levels during school recess have corroborated these concerns (38-40). Children tend to be more active during warmer weather months and in outdoor settings, compared to indoor settings. However, to date, school recess time has been a relatively understudied setting in relation to youth fitness and cognitive outcomes.

A typical recess session consists of unstructured free playtime designed to enable children to interact socially with each other (13). Accordingly, most educational organizations often promote providing children with opportunities to engage in unstructured play activities. However, some researchers have reported that providing structured physical activities during the recess period may be beneficial in increasing the physical activity levels of elementary school-age children (13). In a review of recess-based interventions that have targeted physical activity by Ickes et al. (41), most studies reported improvements in physical activity. Furthermore, although studies that have examined fitness outcomes (supported mediators of academic-related outcomes) from recess interventions is limited, in two studies that targeted youth fitness, researchers reported improvements in muscular endurance (42, 43), cardiorespiratory fitness (42), and flexibility (43). However, only a small number of recess intervention studies have examined the impact of recess on academic performance or behavior related outcomes (i.e., on-task time and concentration) (44-46). Currently, only one recess-based study has examined areas of cognition (reporting improvements in inhibition and working memory) (33). Unfortunately, the impact of a school recess-based physical activity intervention on overall executive function and academic achievement has yet to be examined.

An important component in reporting the impact of health behavior interventions includes an assessment of a program's implementation. Both the internal and external validity of a study can be impacted by the degree of intervention fidelity and therefore should be evaluated by collecting information on various process evaluation variables (47, 48). Process evaluation analyses can also provide information on the feasibility and acceptability of a program. In order to better inform the state of the evidence on the impact of physical activity interventions on academic performance-related outcomes, process evaluation measures should be examined and reported (24). Unfortunately, most experimental studies to date that have examined the impact of physical activity and fitness on cognition and academic performance have not presented process evaluation outcome data.

Although researchers have provided initial support that improvements in fitness and academic-related outcomes could be elicited by providing structured physical activity opportunities during the school recess setting, there is paucity in the literature regarding recess interventions designed to enhance fitness and other academic performance related outcomes. Furthermore, an analysis of process evaluation measures will provide valuable information to refine future recess-based interventions and assess the effectiveness and sustainability of this type of program in larger studies. Therefore, the purpose of this study was to evaluate the feasibility, acceptability, and preliminary efficacy of a 3-month recess-based combined fitness intervention (i.e., an intervention that integrated cardiorespiratory and muscular fitness modalities) on cognition and academic performance in elementary school-age children, compared to a control condition. As there appears to be substantial support for working memory and inhibition (2), these two executive function areas were assessed as our cognitive outcomes. Academic performance was assessed in two categories: academic achievement (a common measure in the previous literature) (2) and academic behaviors (specifically on-task time behavior which has been shown to improve immediately after acute activity sessions) (49).

Research Aims and Hypotheses

Aim 1: Examine the feasibility (recruitment, retention, and fidelity) and acceptability (participation and level of intervention enjoyment) of a 3-month recess-based combined fitness intervention in elementary school-age children. We set our process evaluation measure goals based on reviewed literature and previous studies conducted in our laboratory.

H_{1a}: For feasibility (recruitment and retention), we hypothesized that the study recruitment (n=50) and retention goals (75% at 3-month data collection) would be met. Recruitment goals were based on a power calculation for inhibition (accounting for anticipated attrition) and retention goals were based off of previous elementary school studies (50, 51). Attrition levels below 75% would decrease our sample size and therefore reduce power anticipated results.

H_{1b}: For fidelity, we hypothesized that participants would demonstrate high adherence (i.e., participants would maintain an average intensity level of moderate-to-vigorous physical activity for at least 50% of each intervention session and the majority of participants would participate in at least half of each session) and the intervention leaders would demonstrate high compliance and integrity (i.e., at least 90% of the sessions would be implemented, at least 90% of the intervention sessions would be implemented as planned, and leaders would provide encouragement in at least 90% of the sessions). Although it would be ideal for participants to spend 100% of each intervention session in moderate-to-vigorous physical activity (i.e., all 15 minutes), fidelity reports from previous studies in our laboratory indicate that 50% (i.e., 7.5 minutes of each session) is a realistic goal to account for varying levels of participation, instructional time, and group management. Further, we anticipate that changes in fitness will mediate improvements in academic related outcomes and therefore, participation in less than at least 50% of moderate-to-vigorous intensity physical activity is not likely to elicit improvements in fitness (52).

H_{1c}: For acceptability, we hypothesized that the intervention children would demonstrate high participation rates at the recess intervention sessions, a high degree of enjoyment of the lesson plans, and satisfaction with the overall program, as assessed with daily attendance and participation reports and a post-intervention participant survey.

Aim 2: Evaluate the preliminary efficacy of a 3-month recess-based combined fitness intervention on cognition and academic performance in elementary school-age children.

H_{2a}: We hypothesized that compared to the control group, children randomized to the combined fitness intervention would show greater improvements in cognition, specifically inhibition/attention and working memory, as assessed by flanker and list sorting tasks, respectively.

H_{2b}: We hypothesized that compared to the control group, children randomized to the combined fitness intervention would have greater improvements in academic performance related variables, specifically on-task behavior and academic achievement as assessed by direct observation and mathematics and reading scores, respectively.

Aim 3: Evaluate the preliminary efficacy of a 3-month recess-based combined fitness intervention on health-related fitness in elementary school-age children.

H_{3a}: We hypothesized that children randomized to the combined fitness intervention would have greater improvements in cardiorespiratory fitness compared to the control arm as assessed by the PACER test.

H_{3b}: We hypothesized that children randomized to the combined fitness intervention would have greater improvements in muscular fitness compared to the control arm as assessed by a muscular fitness battery.

Summary of Significance and Innovation

Due to the positive relationship between muscular fitness and working memory, it is possible that muscular fitness could impact cognition and academic performance. Despite this potential impact, training modalities targeting muscular fitness have rarely been examined, and are rarely used regularly in school-based physical activity programs. The majority of previous studies examining physical activity and academic performance have been implemented as classroom breaks, active learning lessons, enhanced physical education, or after-school programs and have not utilized the recess period (a setting that will not compete with academic demands). This study addressed these two gaps in the current physical activity and academic performance literature and allowed us to learn more about this complex relationship by examining a different fitness modality. The significance of this study is that the findings allowed us to examine an understudied modality regarding youth academic performance that also contributes to the overall health and fitness of children. We evaluated the potential benefits of enhancing physical activity opportunities during recess with the goal of improving health-related fitness components. The study also allowed us to explore additional strategies that can assist with a meaningful outcome, academic performance, and simultaneously provided an additional school-based avenue for targeting fitness and physical activity in children.

The studied research questions were novel in that we addressed some important research limitations that will help fill more than one gap in our knowledge about using physical activity to mediate changes in cognition and academic performance. The process evaluation measures provided us with valuable information for refinement of the recess-based intervention used in this study so that future research can further assess the efficacy and sustainability of this type of program.

CHAPTER 2

REVIEW OF LITERATURE

Overview

Over the past few decades, several scientific reviews have been published examining the relationships between physical activity, physical fitness, cognitive health, and academic performance in children (2, 4, 18, 21-23, 25, 26, 53-55). Recently, the American College of Sports Medicine (ACSM) published a position stand on the state of the evidence of physical activity, fitness, cognition, and academic achievement in elementary school aged children (2). The authors concluded that there are positive associations among physical activity, fitness, cognition, and academic achievement and there is no evidence that physical activity negatively impacts cognitive and academic performance. However, the findings among experimental studies are still inconsistent and many areas need further exploration to better understand the effects of physical activity and fitness on cognition and academic achievement. Further research areas that were highlighted in the ACSM position stand include investigating what physical activity prescription (e.g., the type, dose, and timing of physical activity) and what strategies (i.e., how to translate the laboratory findings into school and community settings) are most effective for these outcomes (2). This proposal will address some key gaps in the current literature by examining the feasibility and preliminary efficacy of a combined fitness (i.e., a physical activity program targeting both cardiorespiratory and muscular fitness), school recess-based intervention on cognition and academic performance in elementary school-age children.

This review of the literature is divided into six sections. The first section covers academic performance and its relationship to cognition. The second section discusses methods used to assess cognition and academic performance in children. The third section discusses physical activity and fitness, followed by a discussion of common fitness and physical activity assessment methods in section four. The fourth section addresses the relationship between physical activity, fitness, and cognition. The fifth section covers the relationships between physical activity, fitness, and academic performance. The last section describes limitations in the scientific literature that were addressed in this project. For the purposes of this review of the literature, academic performance is used as a global term that encompasses academic achievement (e.g., standardized test scores and grades), academic behaviors (e.g., classroom on-task behavior, attention, and attendance rate), and academic beliefs and attitudes (e.g., feelings and perceptions about self and school). Cognition refers to mental processes (e.g., executive functions), brain function (e.g. neural activity), and brain anatomy.

Academic Performance and Cognition in U.S. Children

Academic performance plays an important role in youth development and future opportunities. Students that exhibit higher levels of academic performance are more likely to earn college degrees and have greater access to employment opportunities (56). According to the 2013 National Assessment of Educational Progress (NAEP) Nations Report Card, 58% and 65% of fourth graders were below the proficient levels in mathematics and reading, respectively (16). Although the NAEP has reported a trend of improved academic progress since 1990 in the United States, poor academic performance is still a major concern (1). Factors that influence academic performance include socioeconomic status, education environment, parental involvement, cognition, and physical activity and fitness, among others (2, 3). The research in our laboratory focuses on conducting youth physical interventions and examining their effects on health and behavior outcomes. Therefore, this proposal will focus on physical activity and fitness as potential influencers and mediators to cognition and academic performance.

Cognition is the collection of mental processes (e.g., perception, pattern recognition, attention, concept formation and reasoning, and intelligence) that allow an individual the ability to interact with the environment (4). Cognitive processes that are highly involved in the control of behavior and goal-directed actions are executive functions (i.e., selective attention, interference suppression, response inhibition, task switching, working memory, and task-set representation) (10). Executive functions are considered important for academic achievement, learning, and activities of daily living because these functions provides the brain the ability to plan, coordinate, and focus (6-9). In other words, they serve as the command center for ignoring a distraction, inhibiting an inappropriate response, shifting a mind set and attention from one task to another, and coordinating these processes together. These abilities provide the foundations for academic skills and daily behaviors. Therefore, these cognitive processes correlate with current academic levels in children and can be used to predict future academic performance (6-9). In a sample of 570 young children (ages 5-7 years) correlations between executive functions (measured with the Cognitive Assessment System) and academic achievement (measured with Woodcock-Johnson Tests of Achievement) ranged between 0.25 and 0.55, with the strongest correlations reported between complex executive functions and dictation, applied problems, and quantitative concepts (10). In the same study, the correlation between executive functions and academic achievement in children ages 8 to 17 (n = 816) ranged from 0.28 to 0.50, with the strongest relationships reported in the same achievement categories at the younger group. In another study by St. Clair-Thompson et al. (9), 11 year old children (n = 51) completed a series of executive function tasks and a scholastic attainment test. Working memory correlations were 0.62 ($P < 0.01$) and 0.45 ($P < 0.01$) with English and mathematics scores, respectively. Inhibition (i.e., the ability to suppress a response) correlations were 0.31 ($P < 0.05$), 0.36 ($P < 0.05$), and 0.34 ($P < 0.05$) for English, mathematics, and science scores, respectively.

Children's executive functions can be influenced by both internal factors (e.g., neural anatomy and genetics) and environmental factors (e.g., low fitness, poor nutrition, economic hardship, abuse or neglect from caregivers, and exposure to violence in the home or community) (11, 12). Specifically, lower levels of executive performance have been correlated with the aforementioned environmental factors at various stages in childhood.

Assessments of Academic Performance and Cognition

Physical activity researchers have used a variety of tools and assessments to measure both academic performance and cognition. An understanding of the differences among these measurements is important in the interpretation of results from studies. The diverse range of tools used across studies (in addition to physical activity and fitness methodology) can make interpretation of findings challenging.

Assessments of Academic Performance

As previously mentioned, academic performance measurements have often been classified into three categories: academic achievement, academic behaviors, and academic attitudes and beliefs. Physical activity researchers have used state standardized test scores (57-59), national or clinical standardized tests scores (e.g., the Wechsler Intelligence Scale and the Woodcock Johnson Tests of Achievement) (34, 60-64), and school grades or grade point averages as measures of academic achievement (57). Although clinical tests provide a more comprehensive assessment of a student's academic performance and progress, including some clinical diagnoses, the outcomes provided in these tests may be outside the focus of most physical activity researchers and can be time consuming to conduct. State standardized tests provide a convenient measure with readily available data, but are typically conducted only once per year so study designs and assessment time points may be less flexible with this assessment. Other measures that do not add to assessment time demands and may be more easily available to researchers are school grades, grade point averages, and academic assessment reports.

In the area of academic behaviors, assessments of concentration and attention have included momentary time sampling (65), the Behavioral Observation of Students in Schools (BOSS) tool (66), and the d2 test of attention (i.e., a standardized paper and pencil test completed by children that instructs them to cross out any letter "d" with two marks around it) (67). Although there does not appear to be a consensus or a gold standard for academic behaviors in relation to physical activity research, direct observation methods such as the BOSS tool place less burden on the participants (68).

Measures of academic attitudes and beliefs have been varied and consisted of self-report surveys to assess self-concept (69-72) and school anticipation (73), interviews to assess school value, self-esteem and resiliency (74) and school connectedness (i.e., school adjustment and social competence) (75), and an aptitude test that included an emotional indicator domain (76). Academic attitudes have been studied limitedly in elementary school age children, as many of these tools have been validated in older youth populations.

Assessments of Cognitive Function

In youth physical activity and fitness studies, cognition has sometimes been studied comprehensively with assessment batteries such as the Cognitive Assessment System (61, 77) and the Cambridge Neuropsychological Test Battery (CANTAB) (14). Similar to the clinical assessments measuring academic achievement, although these batteries provide more overall information about a child's cognition, the assessment time requirement is greater. Therefore, when researchers are interested in specific executive functions, they may opt to include specific tasks or tests that are less time intensive. Common measures of specific executive functions that have been utilized in youth physical activity and fitness studies are flanker tests (inhibitory control and attention) (5), Stroop tests (inhibitory and interference control) (78-80), the Visual Memory Span test or letter digit span task (working memory) (32, 79-83), the Trail-making test (cognitive flexibility) (79, 80), the Tower of London test (planning) (79), the odd-ball task (processing speed) (84), and the Attention Network Test (14).

In addition to providing information about brain structure, functional magnetic resonance imaging (fMRI) has been used as a proxy of neural activity to assess blood flow to areas of the brain involved with executive functions (i.e., the prefrontal, parietal, striatal, and hippocampal regions) (5). More recently, electroencephalography (EEG) recordings have been used to measure neuroelectrical activity during physical activity (22). Event-related potentials (ERPs) are recordings of neural activity from EEG sensors that are linked to the occurrence of an event (e.g., a stimulus or response) (5, 84). The P3 (P300 or P3b) is a component of the ERP that has been helpful in teasing out various processes involved in a stimulus response (22). P3 amplitude and latency are neuroelectrical indices of some executive functions (84).

Physical Activity and Fitness in Children

Evidence-based data from studies in school-age children have provided strong support that physical activity can improve musculoskeletal health, components of cardiovascular health, motor proficiency, mental health outcomes, and adiposity (85-87). The latter is significant because between 2011 and 2012, 31.8% of American youth were classified as overweight or obese, and the childhood prevalence of obesity did not decrease between 2003-2004 and 2013-2014 (88). Successful obesity prevention and treatment programs during childhood could reduce the likelihood of developing cardiovascular disease in adulthood (89). Furthermore, according to a longitudinal study by Telama et al. (90), high levels of physical activity in childhood are predictive of healthy physical activity levels in adulthood (i.e., meeting the recommended physical activity guidelines), which indicates that activity in youth may have a long-term impact.

In addition to assisting with excessive weight gain, there is strong evidence that physical activity during childhood improves cardiorespiratory fitness, muscular fitness, bone health, and cardio-metabolic health (i.e., reduces risk of high blood cholesterol, high blood pressure, and type 2 diabetes) and moderate evidence that regular physical activity can reduce symptoms of depression (15).

While physical activity can be used to describe any bodily movements that result in energy expenditure, fitness is defined as a set of attributes that are considered health-related (i.e., cardiorespiratory, muscular strength, muscular endurance, flexibility, and body composition) or skill-related (i.e., balance, speed, agility, coordination, reaction time, and power) (91). Optimal fitness helps to reduce health risk profiles in children and similar to physical activity, also tracks into adulthood (17, 92). In addition to the benefits derived from regular physical activity, children with higher levels of health- and skill-related fitness are also less likely to have excess central adiposity and poor cardio-metabolic health profiles and more likely to have greater bone mineral density, motor skill performance, and potentially athletic performance (16, 27, 93).

Due to the health and physical function benefits derived from physical activity and fitness, governing bodies and organizations have published various physical activity guidelines and fitness training recommendations for children (15, 94, 95). The 2008 Physical Activity Guidelines for Americans recommend that children and adolescents should participate in at least 60 minutes of moderate to vigorous physical activity on each day of the week, with at least three days per week including muscle-strengthening and bone-strengthening activities (15). Children who meet these physical activity guidelines are likely to demonstrate adequate health-related fitness levels, but additional physical activity (including more vigorous physical activity) is recommended for improvements in the skill-related components of fitness (96).

In the United States, the National Health and Nutrition Examination Survey [NHANES] has tracked physical activity levels among youth and used Fitnessgram assessments to measure fitness levels (97). For each assessment, children who score above a threshold depending on standardized norms for their age and gender are considered to be in the “healthy fitness zone” and those not meeting the threshold are sometimes categorized as either not meeting the “healthy fitness zone” or having low fitness levels (98). Despite national recommendations, many American children are not receiving adequate daily physical activity and have low fitness levels. The 2003-2008 NHANES data indicated that only 42% of American children ages 6 to 11 were meeting the national recommendations for daily physical activity (99). Compounding the concern of many youth not meeting the physical activity guidelines is the pattern of decreasing levels of physical activity in children as they age (99). Furthermore, temporal trends indicate that physical activity in youth also appears to decrease over time (100) and between 2003 and 2004, children ages 6 to 11 spent approximately 42% of their day in sedentary behavior (99). Although surveillance data is not available for their younger counterparts, in 2012 only 42% of American 12 to 15 year olds had adequate levels of cardiorespiratory fitness (97). This was a decrease from just over 52% in 1999-2000. In fact, in the 2014 United States Report Card on Physical Activity for Children and Youth, a grade of “D” was assigned for health-related fitness, indicating that only 21-40% of American youth are meeting the recommended benchmarks (16). Although cardiorespiratory fitness was the primarily indicator in the Report Card for health-related fitness, the NHANES National Youth Fitness Survey of 2012 reported that only 51.7% of 6 to 15 year old children met the health fitness zone for pull-ups (a measurement of muscular fitness) (101).

Assessment of Physical Activity

There are three categories of physical activity measurement techniques utilized in youth research and program design: primary (i.e., direct observations, doubly labeled water, and indirect calorimetry), secondary (i.e., heart rate, pedometers, and accelerometers) and subjective (i.e., self-report, interviews, proxy-reports, and diaries) (102). Primary techniques are considered criterion standards, but secondary techniques can provide objective measurements of physical activity that are sometimes more feasible to utilize in field-based (i.e., school) research with larger populations. The use of accelerometers has increased in field-based youth physical activity studies because they provide an objective measurement of physical activity behaviors, are typically acceptable to participants, are generally reliable and robust, and some monitors will provide information about body posture (103). Accelerometer cut-points have been established based on regression equations that allow the prediction of time spent in various intensities of physical activity (104-106).

Assessment of Fitness

Cardiorespiratory fitness is most accurately measured in children in laboratory settings using a maximal oxygen consumption protocol (e.g., graded treadmill tests or graded cycle ergometer tests) (95). However, maximal oxygen consumption can also be estimated using field-based tests such as the one mile walk/run test, step tests, and shuttle runs (95). Although not as accurate as maximal protocols, field-based tests may be more feasible and practical for assessing children, particularly when measurements need to be assessed within the elementary school environment. Standardized fitness test batteries (e.g., Fitnessgram and Eurofit) have been developed to assess all five components of health-related fitness and have been implemented for assessing progress in both physical education classes and research studies (98, 107). The Fitnessgram test battery includes assessment options for cardiorespiratory fitness (i.e., the progressive aerobic cardiovascular endurance run [PACER], the one-mile run, and the walk test), body composition (i.e., skinfold measurements, body mass index, and bioelectrical impedance), muscular fitness (i.e., the curl-up, trunk lift, 90 degree push-up, modified pull-up, pull-up, and flexed arm hang tests), and flexibility (i.e., the back-saver sit and reach and shoulder stretch tests) (98). The Eurofit battery includes anthropometric tests (body composition), the sit-and-reach test (flexibility), the handgrip, sit-up, and bent arm hang (muscular fitness), the 20 meter endurance shuttle run (cardiorespiratory endurance), as well as some measures for skill-related components of fitness (107).

Relationships of Physical Activity, Fitness, and Cognition

Earlier studies initially conducted in adults, reported that among cognitive functions, executive functions appear to be impacted by physical activity and fitness (4, 26). Based on these findings, an aerobic fitness and executive function hypothesis was developed (2, 4, 25, 108). Recently, this hypothesis was extended to children. This hypothesis describes a mechanistic pathway between cardiorespiratory fitness and executive functions, which is illustrated in the shaded portion of Figure 1 (page 43). Laboratory study findings suggest that physiological adaptations that occur in the brain from cardiorespiratory training (both structural and functional) potentially alter some executive functions, which in turn mediate changes in academic achievement, behaviors, and attitudes (23, 25). Physiological changes that have been observed from a combination of human and animal exercise training studies include increased cerebral capillary growth, blood flow, and oxygenation; increased production of neurotropins and nerve cells of the hippocampus; increased neurotransmitter levels and brain tissue volume; up regulations of brain-derived neurotropic factors; increased development of nerve connections; and therefore increased density of the neural network (23, 54, 109, 110). These adaptations may result in changes in brain tissue volume, such as increases in hippocampal volume (i.e., via neurogenesis), which in turn may enhance the brain's ability for learning and memory. It has also been proposed that physical activity and exercise may elicit some direct benefits on executive functions in the absence of those physiological changes influenced by cardiorespiratory endurance. Cognitive demands that are inherent in certain complex motor skills may elicit greater activation of the prefrontal cortex and enhance hippocampal and cerebral volume (4, 11). Participation in physical activity games that are cognitively challenging (e.g., a game that require use of certain executive functions) has been suggested to promote transfer and adaptation to the executive function skills engaged (11).

Pediatric cognition studies examining executive functions have grown exponentially over the past two decades and afforded researchers with some foundational information on the influence of physical activity and fitness. Cross-sectional studies have provided information about the correlations between physical activity, fitness, and cognition. A positive association was observed in two studies that examined objectively measured physical activity with cognition (79, 111), but no association was reported in another (112). Among the studies with significant correlations, one reported a positive association between objectively measured moderate-to-vigorous physical activity and inhibition and attention in Finnish fifth and sixth graders (n = 224) (111). In a study conducted by van der Niet et al. (79) in 8 to 12-year-old Dutch children (n = 80), volume of objectively measured physical activity was positively correlated with planning, and sedentary behavior was inversely associated with inhibition. The lack of consistent findings between these two and the study by Pindus et al. (112) could be related to differences in cognitive measures and the diversity in tested covariates.

Although some studies observed null findings (113, 114), the majority have reported positive associations between fitness and cognitive measures (77, 78, 82-84, 115-123). Among these studies, cardiorespiratory fitness was used to define overall fitness and assessed with the Fitnessgram PACER test (78, 83, 84, 116, 117) or a graded exercise test (61, 82, 113, 118-123). For example, Buck et al. (78) found that aerobic fitness (measured via the Fitnessgram PACER test) was positively associated with all three conditions of the Stroop test (an indicator of inhibition and reaction time) in 74 children (ages 7 to 12 years). Using a graded treadmill test to determine maximal oxygen uptake in 7 to 11 year old children (n = 170), Davis et al. (77) observed positive associations between cognition measured from the Cognitive Assessment System and cardiorespiratory fitness. Studies collectively demonstrated that gender, pubertal age, socioeconomic status, body composition, body mass index (BMI), age/grade, and IQ are potential confounders in the physical activity, fitness, and cognition relationships. For example, socioeconomic status is both inversely related to children's level of school-day physical activity and academic achievement scores (124, 125). Two longitudinal studies demonstrated that fitness was predictive of future cognitive health (118, 126).

In acute bout studies, researchers have used protocols of a single physical activity session to inspect if changes occur in cognition. The majority of acute bout studies that were conducted in laboratory settings indicate that a single session of physical activity can result in positive cognitive changes (127-131), with only a limited number of studies reporting inconclusive results (132, 133). In a study by Hillman et al. (130), 9 year old children (n = 20) demonstrated an improvement in response accuracy (along with a larger P3 amplitude) after 20 minutes of walking on a treadmill. In another report, Best et al. (127) examined a 60 minute session of physically active video games (versus traditional sedentary video games) in 33 children (ages 6 to 10 years) and observed improved interference scores. Acute physical activity studies completed in school settings have demonstrated more consistent support for cognitive health benefits (67, 134-136).

A smaller number of physical activity intervention studies with cognitive outcomes have been conducted in children, including quasi-experimental designs (14, 28, 33, 128, 137) and three randomized controlled trials (77, 138-144). The three randomized control studies resulted in several publications (Table 1). Most results from the intervention studies have shown improvements in at least one cognitive function (i.e., inhibition, working memory, and/or cognitive flexibility). Sample sizes ranged from 18 (144) to 470 (137) participants and study lengths varied from 8 weeks (128) to 9 months (a complete school year) (137, 138, 140, 141, 145). The majority of physical activity training studies that examined cognitive outcomes were conducted as after-school community programs (77, 138-145). Among the other school-based settings, the majority were integrated into physical education programs (14, 28, 128, 137) and only one was conducted during school recess (33). All of the studies described in Table 1 utilized mainly aerobic activities for the intervention training modality with the exception of van der Niet et al. (33). The study by van der Niet et al. used a combination of cardiorespiratory and muscular fitness exercises. A small number of studies also described the selected intervention activities as cognitively challenging (28, 33, 128, 138). Cognitively challenging activities (e.g., object control and manipulation or more complex locomotor skills) are movements or exercises that require greater coordination and use of executive functions than traditionally prescribed cardiorespiratory activities (e.g. walking and running) that are more rhythmic and repetitive in nature (28, 33).

Relationships of Physical Activity, Fitness and Academic Performance

The modified version of Tomporowski et al.'s model in Figure 1 (page 43) also illustrates the potential pathways and relationships between physical activity and exercise and academic performance (4). Potential mediators in this pathway are physical fitness (i.e., muscular fitness and flexibility, in addition to cardiorespiratory fitness), health factors (i.e., obesity, sleep, and fatigue), and psychological and social variables (i.e., self-esteem, self-efficacy, and self-worth). Correlational studies have reported inverse relationships between BMI percentile and academic achievement and between sleep quality and volume with mental functioning (4). In addition, there is some evidence that greater levels of self-perception (i.e., self-concept and self-esteem) are associated with higher levels of academic performance (4). Age, socioeconomic status, and gender are suggested moderators. For example, academic performance often improves with age, but some studies have demonstrated disparities when it comes to socioeconomic status. A review by Tomoporowski et al. (4) of the effect of physical activity interventions on mental functions reported that children from lower income families may exhibit lower baseline levels of academic performance and therefore, may be more likely to be higher responders to an intervention. However, it should be noted that disparities in academic performance among lower income children have been related to a lack of academic resources and educational tool accessibility often associated with their school systems (146).

Academic Achievement

The majority of studies looking at academic performance outcomes have used measures of academic achievement (i.e., standardized academic test scores and school or subject-specific grades). Most studies with cross-sectional designs have reported positive associations between at least one component of fitness, (typically cardiorespiratory fitness) and academic achievement (29, 61, 83, 147-161). These studies used the Fitnessgram or Eurofit test batteries, an 800-meter run, or graded exercise tests to assess fitness. Longitudinal studies that have also assessed fitness with Fitnessgram tests observed consistent positive associations with academic achievement (158, 162, 163). When physical activity was examined, mixed results were observed in cross-sectional studies with some strong positive associations (164, 165), some positive associations with select academic subjects (166-169), two null findings (170, 171), and one study that reported a slight negative association (172). The heterogeneity of the findings reported in cross-sectional studies could be related to the variability in study design factors. Some of the design factors noted in these studies include items such as differences in age, locations of the study samples, outcome measurement tools, and in particular, methods used to assess physical activity. Objective measurements of physical activity were used in half of the studies (164, 166, 168, 171). Among the studies that assessed physical activity objectively, all used accelerometers as the measurement tool and most reported positive relationships between physical activity and at least some or all of the academic outcome variables of interest (e.g., state and clinical standardized exams) (164, 166, 168). Researchers have also examined the association between physical education programs on academic achievement with observational studies (generally positive associations) (173-175) and enhanced or additional physical education interventions (mixed results) (134, 176-181).

Experimental studies exploring physical activity interventions have also reported mixed results. A summary of experimental physical activity studies that focused on academic performance are listed in Table 2. Some interventions elicited clear improvements (59, 60, 62, 182), some reported selective benefits (58, 63, 64), and some observed no significant improvements in academic outcomes (34, 57, 60, 77, 139, 183-185). Study sample sizes ranged from 15 (57) to 4,588 (59) and the intervention lengths ranged from 3 months (60) to 6 years (183). Many studies reported improvements in mathematics achievement as a result of physical activity interventions (57-59, 61, 63), while some also observed benefits in reading performance (57, 63). In addition to mathematics and reading achievement, Donnelly et al. (62) found positive effects in writing and spelling. Among these chronic physical activity intervention studies, two also reported positive impacts on academic behaviors (i.e., attention and on-task behavior) (63, 182).

Academic Behaviors

Studies that have examined the role of physical activity on academic behaviors have focused on concentration or attention and have mostly examined acute bouts of physical activity. Study protocols have included assessing behavior before and after active lessons in the classroom (65, 67, 186), cross-over designs (130, 187, 188), and randomizing groups to different physical activity conditions (44, 189, 190). Findings have been generally positive, with some effect modification reported for children with greater initial off-task behavior (i.e., those that exhibited greater off-task behavior at the onset demonstrated greater benefits) (186) and lower socioeconomic status (i.e., children from lower income families experienced greater benefits) (190).

Academic Beliefs and Attitudes

Literature examining the role of fitness and physical activity on academic beliefs and outcomes, such as self-esteem, perceptions of academic competence, and attitudes toward school has mainly been limited to middle and high school samples (69-71, 73, 74, 76). Some of the measures from these studies would be hard to translate to elementary children, due to their younger age and maturity and the lack of validated tools to assess certain variables. Among studies that have been conducted in elementary school, researchers have reported either positive (75) or no association (72, 191) between physical activity and academic beliefs or attitudes. Pellegrini et al. (75) reported that during the first year of elementary school, student (n = 44) participation in a variety of playground games (including chase and ball games) predicted social competence (in boys) and school adjustment (in boys and girls). Bluechardt et al. (191) reported no significant changes in social competence in elementary school children (n = 45) after a 10-week extracurricular physical activity intervention consisting of a 90 minutes supervised physical activity sessions. Similarly, in another intervention study that examined the effects of 12-week running program in 9 to 11 year olds (n = 154), no benefits were detected for perceived self-concept (72).

Limitations in the Current Literature

Although physical activity research on the cognition and academic performance of children has become more prevalent, this area is still in the infancy stage and many questions have yet to be addressed. Due to the variability in study designs, outcome measures, and physical activity modalities in the current literature, it is challenging to draw conclusions. In review papers that have examined the role of fitness on cognitive and academic outcomes, authors have consistently suggested the future directions outlined in Table 3 (2, 23, 24, 53, 54). The following sections provide justification for three suggested future research focuses that were addressed in this dissertation project: a) the influence of muscular fitness on cognition and academic performance; b) the timing and setting of the physical activity intervention; and c) the inclusion of process evaluation measures.

Muscular Fitness and Academic-Related Outcomes

Current physical activity guidelines recommend muscular fitness activities in addition to cardiorespiratory activities for children because they can improve motor skills, motor ability, body composition, and bone mineral density, reduce insulin resistance and metabolic risk factors, and provide some psychological benefits (27, 93, 94, 192-196). Youth physical activity interventions designed to improve cognition and academic performance outcomes have primarily targeted cardiorespiratory fitness and therefore focused on cardiorespiratory fitness training modalities (2, 24). One recent cross-sectional study reported a positive association in a sample of 70 children (ages 7-9 years) between muscular fitness and working memory and mathematics performance (32). In an experimental study, children (ages 8-12 years, n = 112) participating in an intervention that incorporated both aerobic and muscular fitness activities demonstrated greater improvements in inhibition and verbal working memory, compared to a control group (33). Interestingly, the findings from both of these studies were independent of cardiorespiratory fitness (32, 33). Muscular fitness exercises typically involve more complex movements than traditional aerobic modalities, which often utilize basic locomotive movements (27). Complex movements (e.g., activities that require more coordination than walking and running) may have additional or independent benefits on some aspects of cognition such as inhibition (28, 29). Despite the potential impact of muscular fitness, few intervention studies have examined the impact of an intervention that stressed both cardiorespiratory and muscular fitness training on cognition or academic performance.

Timing of the Physical Activity Intervention

One review of physical activity interventions in children concluded that school-based settings are the most effective for improvements in health-related outcomes (197). Given that in the Fall of 2017, 35.6 million children between preschool and grade 8 (ages 4 to 13 years) were projected to attend schools in the United States, schools provide ideal settings to target youth behaviors (198). The emergence of the school comprehensive health program model has facilitated a surge of school-based physical activity and fitness research studies (199). School components that have been targeted and have shown promise in positive physical activity behavior include physical education, recess, the academic classroom, school transportation, and the before- and after-school periods (13, 35, 85, 200-208).

Although many of the previous studies examining physical activity and academic and cognitive measures have been implemented during the school day (28, 33, 34, 57, 59, 62, 63, 128, 137, 209) or after-school programs (60, 77, 138-145, 182), these setting can pose some challenges. After-school programs may face transportation barriers (e.g., if the program is not located at the child's school as with many of the after-school programs listed in Tables 1 and 2). Children participating in after-school programs may not experience the academic behavior and cognitive benefits that have been demonstrated with acute bouts of activity. Specifically, trials that have studied acute bouts of physical activity have reported some beneficial effects on academic behaviors (e.g., attention and on-task time) within the first two hours immediately following the physical activity session (65, 210). Therefore, it is possible that physical activity and fitness interventions designed to impact academic behaviors and cognitive outcomes should be implemented during the school day. However, programs integrated into classroom time often compete with other academic demands. Teachers and school administrators are faced with time constraints and pressure to meet learning standards and improve the standardized test scores of their students (211). Therefore, non-academic school-day time such as school recess may be an ideal setting to target the fitness, cognition, and academic performance of children as it does not take away from academic time and provides an acute activity break that may influence the students' afternoon classroom behavior and cognitive functions.

The benefits of a physical activity program integrated into school recess on fitness and academic-performance outcomes has been understudied. Of the limited studies that have examined recess-based physical activity interventions on academic performance-related outcomes, the findings have been generally positive (13). In one observational study that examined the relationship between receiving school recess and group classroom behavior of third grade students (n = 15,305), researchers reported that recess frequency was positively associated with teacher reported student classroom behavior (212). A longitudinal study examining whether participating in playground games influenced attitudes toward school reported that first grade children (n = 77) that engaged in more games during recess were more likely to have a greater perception of school (both genders) and social competence (in boys only) (75). Pellegrini et al. (46) reported that general classroom attention was better in elementary school children after 30 minutes of outdoor recess. Jarrett et al. (45) found that recess breaks enhanced on-task time in students (n = 43). Collectively, these studies have primarily focused on academic behavior measures of academic performance.

Only two experimental studies with school recess as the setting have examined cognitive outcomes (33, 44). In a sample of second to fourth graders, a physically active recess versus a sedentary school break resulted in improved classroom concentration (as measured by the Woodcock-Johnson Test of Concentration) in the fourth graders (44). In an eight-week combined fitness intervention integrated during school recess twice per week in 53 elementary school age children, van der Niet et al. (33) observed improvements in working memory and inhibition in the intervention group, compared to a control group.

The paucity of recess intervention studies on fitness and academic performance related outcomes may be influenced by the traditional message from educational organizations that promote recess as a time for unstructured, free play (13). Unstructured recess provides children with a period to self-select the activities of participation (213). On the other hand, some schools offer structured recess programs where students participate in teacher-selected activities. Structured recess opportunities and programs that integrate physical activity may be more beneficial than the traditional recess paradigm (13). A number of studies examining structured physical activity recess interventions have reported improvements in youth physical activity and other psychological-social factors (13). In two separate studies by Eather et al., the researchers examined the impact of a multi-component physical activity program (Fit4Fun) on fitness performance in Australian elementary school age children (42, 43). The multi-component program used in both studies included eight 60-minute health and physical activity lessons, a break-time (i.e., recess) program, and a home-fitness program that was implemented over 8 weeks. The first study was an 8-week pilot study that examined feasibility and efficacy of the Fit4Fun intervention in 49 elementary school children and observed significant improvements in the treatment group for the sit-up, sit-and-reach, and wall-sit tests (43). The second study included a sample of 118 children and assessed the health-related fitness variables after a 6-month follow-up period as well. Significant effects of the program remained 6 months after the intervention ended for cardiorespiratory fitness, sit-up performance, and sit-and-reach performance (42).

The Eather et al. studies (42, 43) demonstrated that incorporating structured physical activity into recess could be beneficial in improving children's fitness levels. As discussed in section five of this chapter ("Relationships of Physical Activity, Fitness, and Cognition"), fitness levels are an important mediator in the relationship between physical activity and executive functions/academic performance (Figure 1, page 43)). Furthermore, academic performance outcomes such as academic achievement, attitudes, and beliefs have not yet been examined sufficiently in recess studies. Therefore, a school recess study using a structured fitness intervention adds to the current literature.

Process Evaluation Measures

Implementation consists of how well an intervention program is conducted during a trial period (47). Assessing a program's implementation is an important component in reporting the impact of health behavior interventions because 1) the degree of implementation can impact both internal and external validity of a study; 2) the theoretical model used in the intervention design can be evaluated; 3) the level of feasibility and acceptability of a program can be assessed; and 4) problems or concerns that could ultimately impact outcomes can be identified early (47, 48). Implementation can be considered through a variety of process evaluation variables. Such process evaluation measures can and should include fidelity (how well the program followed the implementation plan), dosage (how much of the program plan was delivered), quality (the strength of the intervention delivery), participant responsiveness (the degree to which the intervention held the attention and interest of the participants), control/comparison conditions monitoring (the tracking of the attention and services provided to each treatment group), program reach (the attendance and participation rates of the participants) and adaptation (modifications made to the original intervention implementation plan) (47). Physical activity intervention studies examining academic performance should report these types of measures to fully inform the state of the evidence on the benefits of certain program designs and dosages (24). Unfortunately, most experimental studies to date that have examined the impact of physical activity on academic performance have not reported process evaluation outcome data. Among the randomized controlled trials discussed earlier (i.e., the 3 year Physical Activity Across the Curriculum intervention study), one article was published that included process evaluation after the first year of the study (214). The authors noted the importance of measuring and analyzing this data as it was "instrumental in identifying successes and challenges faced by teachers when trying to modify existing academic lessons to incorporate physical activity" (214). An analysis of process evaluation measures will provide valuable information to refine future recess-based interventions and assess the effectiveness and sustainability of this type of program in larger studies.

Summary

Although physical activity research on cognition and academic performance in children has become more prevalent, this area is still in the infancy stage and many questions have yet to be addressed. Due to the variability in study designs, outcome measures, and physical activity modalities in the current literature, it is challenging to draw conclusions. In review papers, researchers have suggested consistent future directions and the proposed study will address some key gaps in the current physical activity and academic performance literature. In addition, findings from this dissertation project provide us with more insight about this complex relationship by examining a different fitness modality and the feasibility and acceptability of a recess-based combined fitness intervention.

Table 1. Experimental physical activity intervention studies assessing cognition.

Authors (Year)	Sample; Setting	Intervention (Length; Design)	Measure of Cognition	Results
Chaddock-Heyman et al. (2013) (138)	N=32 (7-9 year olds); After-school community-based program	9 months; Fitness intervention (70 minutes of MVPA) daily on school days (mainly aerobic activities)	Structural MRI and fMRI	Intervention enhanced specific areas of prefrontal cortex function involved in cognitive control
Chang et al. (2013) (128)	N=26 (kindergartners); During school program	8 weeks; Two 35 minute sessions per week of low- or moderate-intensity soccer (cognitively challenging aerobic activity)	ERPs and modified Eriksen Flanker Test (inhibition)	Regardless of intensity, exercise results in shorter reaction times & higher response accuracy
Crova et al. (2014) (28)	N=70 (9-10 year olds); PE school-based program	6 months; One 2-hour tennis session (cognitively-challenging aerobic activity)	Random number generation task (inhibition and working memory)	Better inhibition in higher-fit children (also modified by weight status)
Davis et al. (2007) (139)	N=94 (overweight 7 to 11 year olds); Community-based after-school program	15 weeks; Low- (20 minutes/day) or high-dose (40 minutes/day) of daily aerobic exercise	CAS (executive functions)	High-dose group had higher planning scores than control group (p=0.03)
Davis et al. (2011) (61)	N=171 (overweight 7 to 11 year olds); Community-based after-school program	15 weeks; Low- (20 minutes/day) or high-dose (40 minutes/day) of daily aerobic exercise	CAS and fMRI (sub-study)	Intent to treat analysis revealed dose-response benefits of aerobic exercise on executive function
Drollette et al. (2017) (215)	N=308; (7 to 9 year olds); After-school community-based program	9 months; Fitness intervention (70 minutes of MVPA) daily on school days (mainly aerobic activities)	Flanker task and ERP recording	Intervention group had greater improvements in fitness and response accuracy (with ERN amplitude stability from pre- to post-test)
Fisher et al. (2011) (14)	N=64 (second graders); PE	10 weeks; One additional PE	CANTAB, ANT, and CAS	Intervention group had greater scores

	school-based program	session per week (mostly aerobic)		for CANTAB Spatial Span and Spatial Working Memory Errors and ANT Accuracy
Hillman et al. (2014) (140)	N=221 (7 to 9 year olds); After-school community-based program	9 months; Fitness intervention (70 minutes of MVPA) daily on school days (mainly aerobic activities)	Modified flank task (attentional inhibition) and color-shape switch task (cognitive flexibility)	Intervention lead to better improvements in inhibition and cognitive flexibility
Kamijo et al. (2011) (141)	N=43 (7 to 9 year olds); After-school community-based program	9 months; Fitness intervention (70 minutes of MVPA) daily on school days (mainly aerobic activities)	Modified Sternberg task (working memory) and ERPs	Intervention lead to improved Sternberg task performance
Krafft et al. (2014) (144)	N=18 (sedentary and mostly African American 8 to 11 year olds); After-school community-based program	8 months; Daily 40 minutes of aerobic activity	Tractography (white matter integrity), CAS, and Behavioral Rating Inventory of Executive Function	Increased white matter integrity in intervention group associated with improved scores of attention and teacher-rated executive function
Krafft et al. (2014) (142)	N=43 (unfit 8 to 11 year olds); After-school community-based program	8 months; Daily 40 minutes of aerobic activity	fMRI, antisaccade task (inhibition of glance) and flanker task (attentional inhibition)	Intervention decreased activation in brain areas supporting antisaccade performance and increased activation supporting flanker performance
Krafft et al. (2014) (143)	N=22 (sedentary and overweight 8 to 11 year olds); After-school community-based program	8 months; Daily 40 minutes of aerobic activity	Resting state fMRI	Intervention participants demonstrated support that exercise may enhance brain development
Reed et al. (2013) (137)	N= 470 (African Americans in 2nd – 8th grade); PE school-based program	9 months; Daily PE (45 minutes of mainly aerobic activity, with emphasis on	Standard Progressive Matrices Test (fluid intelligence) and Perceptual	Intervention participants had greater improvements on

		fundamental skills)	Speed Test (perceptual speed)	8 of 26 cognitive measures
van der Niet et al. (2016) (33)	N=105 (8 to 12 year olds): Recess-based school program	22 weeks; Intervention group received cognitively challenging aerobic and muscular fitness exercises twice per week for 30 minutes	Stroop test (inhibition), Visual Memory Span Test and Digit Span test (working memory), Trailmaking test (cognitive flexibility), and Tower of London (planning)	The intervention group improved Stroop test and Digit Span test (without significant improvements in any fitness measures)

Table 2. Experimental physical activity intervention studies assessing academic performance.

Authors (Year)	Sample; Setting	Intervention (Length; Design)	Measure of Academic Performance	Results
Adsiz et al. (2012) (182)	N=60 (4th and 5th graders); After-school program	12 weeks; Sports participation program with supervised trainer on 3 days per week	Bourdon Attention Test (academic behavior)	Physically active children had higher levels of attention than sedentary group
Ahamed et al. (2007) (34)	N=287 (4th and 5th graders); School-based program	16 months; Daily physical activity (aerobic and muscular fitness) integrated into six "action zones"	Canadian Achievement Test (academic achievement)	Physical activity increased in intervention schools by 47 minutes/week, but not significant differences between groups in outcome
Bugge et al. (2018) (183)	N=1,888 (K through 4th graders); Physical education school-based program	2 to 6 years; 90-minute of physical education (two sessions/week) vs. 270 minutes/week six sessions/week)	Danish National Test System – Danish and mathematics (academic achievement)	No increases or decreases in performance due to intervention
Chaya et al. (2012) (60)	N=200 (7 to 9 year olds); After-school, school-based program	3 months; Daily physical activity (modality unclear) or yoga for 45 minutes	Indian adaptation of Wechsler Intelligence Scale (academic behaviors and achievement)	No significant differences between activity groups; Yoga was as effective as general physical activity
Davis et al. (2011) (61)	N=171 (overweight 7 to 11 year olds); Community-based after-school program	15 weeks; Low- (20 minutes/day) or high-dose (40 minutes/day) of daily aerobic exercise	Woodcock-Johnson Test of Achievement II (academic achievement)	Dose-response benefits of exercise on mathematics achievement
Donnelly et al. (2009) (62)	N=1,527 children and 24 schools (2nd and 3rd graders); Classroom school-based program	3 years; 90 minutes of weekly, mainly aerobic physical activity integrated into academic lessons	Wechsler Individual Achievement Test II (academic achievement)	Intervention schools had significantly greater changes in academic achievement scores (reading, math, spelling, and writing)

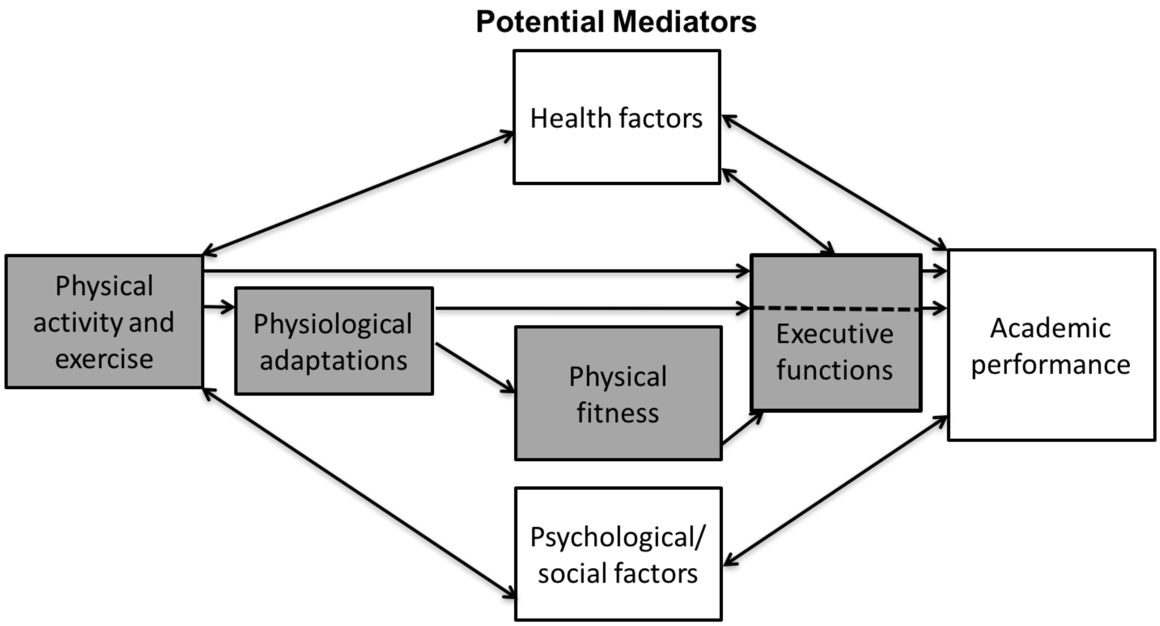
Donnelly et al. (2017) (184)	N=584 children in 17 schools (2nd and 3rd graders); Classroom school-based program	3 years; Target of 100 minutes weekly, mainly aerobic physical activity integrated into academic lessons	Wechsler Individual Achievement Test III (academic achievement)	Intervention did not improve or diminish academic achievement
Erwin et al. (2012) (57)	N=15 (3rd graders); Classroom, school-based program	20 weeks: Daily 20-minute physical activity breaks related to math and reading content	Standardized test scores, reading and math fluency, and grades (academic achievement)	Short bouts of physical activity increase reading fluency and math scores
Gao et al. (2013) (58)	N=208 (3rd through 5th grade Latino children); School-based program	9 months; 30 minutes of daily aerobic dance activity three days per week	Utah standardized test math and reading scores (academic achievement)	Math scores were significantly greater in intervention group
Hollar et al. (2010) (59)	N=4,588 (elementary school children); School-based program	2 years; Increased physical activity opportunities provided during school day (along with other health education)	Florida Comprehensive Achievement Test (academic achievement)	Intervention group had higher math scores
Mullender et al. (2015) (63)	N=228 (2nd and 3rd graders); Classroom, school-based program	9 months; Two 1- to 15 minute physically active classroom lessons (frequency not clear)	Tempo-Test-Rekenen, 1-Minute Test, and On Task Behavior (academic achievement and behavior)	Intervention lessons increased on-task behavior and post-math and reading scores were higher
Reed et al. (2010) (64)	N=155 (3rd graders); Classroom, school-based program	3 months; Teachers integrated physical activity into core curricula 30 minutes/day for 3 days/week	Palmetto Achievement Challenge Tests (academic achievement)	Intervention group had higher, but non-significant, scores on English/language arts and math/science
Szabo-Reed et al. (2017) (189)	N=584 children in 17 schools (2nd and 3rd graders); Classroom school-based program	3 years; Target of 100 minutes weekly, mainly aerobic physical activity integrated into academic lessons	Time-on-task via direct observation (academic behavior)	Intervention students participated in more MVPA, percent of time in MVPA was positively associated with time-on-task

Table 3. Recommended future research directions and considerations to validate the benefits of physical activity and fitness on children's cognitive health and academic performance.

Recommendations & Considerations for Future Research:
1. Investigate the frequency, mode, intensity, and duration of physical activity that provide the greatest benefits*
2. Additional RCT designs implemented during the school day to determine what intervention design and physical activity setting is efficacious*
3. Address health and academic disparities and mental disorders through physical activity interventions
4. Publication of more process evaluation measures from intervention studies*
5. Assessment of more academic related attitudes and behaviors
6. Focus on learning as an outcome
7. Identification of critical periods in development (i.e., a stage in maturation in which the development of the nervous system and cognition is especially sensitive to environmental stimuli)
8. Use of reliable and valid measures of physical activity and academic achievement*

*Future research recommended areas that will be incorporated into this research proposal.

Figure 1. Suggested pathways between physical activity and academic performance.



CHAPTER 3

METHODS

Study Overview

This dissertation project used a two-arm randomized controlled design to assess the feasibility, acceptability, and preliminary efficacy of a 3-month recess-based combined fitness intervention on cognition and academic performance in elementary school children. The Strong Minds with Aerobic and Resistance Training during Recess (SMART Recess) pilot study was held from December of 2017 through December of 2018 (Figure 2, page 76). The study was conducted in third and fourth graders of two elementary schools within the Amherst-Pelham Regional Public Schools (ARPS) district and was implemented during the school recess periods. For this pilot study, randomization took place at the school level with one school assigned to the intervention and the other school assigned to the control condition. Participants were recruited in the winter of 2017. Parents completed informed consent (Appendix 1) and parental permission forms (Appendix 2), student participants completed an assent form (Appendix 3), and school staff completed an informed consent (Appendix 4). Process evaluation measures were assessed daily, weekly, biweekly, and post-intervention (depending on the measure). Physical measures (i.e., height and weight), physical activity, measurements of cognition, academic performance, fitness, and covariates of interest were assessed at baseline (weeks 1-3) and post-intervention (weeks 17-18). Physical activity was also assessed at midpoint (weeks 10-11). The intervention school received a combined fitness intervention (i.e., an intervention that incorporated a combination of cardiorespiratory and muscular fitness activities) for 3 months (weeks 3-18) between February and May of

2018. The control group was asked to continue their usual in-school activities and received the intervention after data collection was concluded (fall of 2018).

Schools and Participants

School Selection and Demographics

Two ARPS schools (Fort River Elementary School and Crocker Farm Elementary School) agreed to participate in this study. During the 2015-2016 academic year, there was a total of 422 students attending Crocker Farm Elementary School and 366 students attending Fort River Elementary School (grades kindergarten through 6). Additional characteristics of the schools' demographics are displayed in Table 4. This study enrolled students in grades three and four at both schools. During the start of the 2016-2017 academic year, there were 53 third graders and 58 fourth graders at Crocker Farm Elementary School and 43 third graders and 45 fourth graders at Fort River Elementary School. Among the total student body, 43% and 44% were eligible for free or reduced-price lunch for Crocker Farm and Fort River, respectively and both schools had similar racial distributions. Daily recess sessions at both schools were organized by grade level and were approximately 30 minutes in duration.

School Randomization

The schools served as the unit of randomization. One school was randomized to the treatment intervention and the other school was randomized to the control condition. The intervention school received a 3-month combined fitness program during the first half of daily school recess periods. The control school followed their usual practice of unstructured free play during school recess during the data collection period. In the fall of 2018 (after data collection was completed) the control school was given the intervention program; however, no data was collected.

Participant Recruitment

Students from third and fourth grades were included in this project due to the strength of the evidence in the literature regarding the benefits of cardiorespiratory fitness on executive control observed in this age group (2). Within each school, all third and fourth grade children participated in their school's assigned treatment group (i.e., intervention or control condition). However due to the assessment protocol, students were individually recruited to take part in the data collection portion of this study. Flyers about the study were distributed through each classroom (Appendix 5). Students interested in enrolling in the study had their parent or guardian complete the bottom portion of the flyer to share their contact information so we could email them a link to our online interest from. If an email address was not provided, a printed copy of the interest form was sent home with the student via their classroom.

At the start of the recruitment phase, members of the research team set up meetings with the third and fourth grade teachers at each school to explain the study, describe how students could enroll in the study, and answer any questions they had about the study. Next, the research team visited each classroom to provide students with a brief information session, show them the tools that would be used for measurements (e.g., an accelerometer), and answer questions. Research staff also attended school and ARPS Parent Guardian Organization (PGO) sponsored events to promote the study. In addition, electronic media (i.e., the laboratory's website, Facebook, and PGO blogs and email newsletters) was used to disseminate information about the study. These recruitment methods have been used successfully in some of our previous studies (216-218).

Participant Inclusion and Exclusion Criteria

Participants were eligible to participate in the study if they were in third or fourth grade at one of the participating schools at the time of recruitment. These grades were selected for ease of comparison to the literature, as most preadolescent physical activity and cognition studies have been conducted in 7 to 9 year old children. Participants were excluded from specific analyses if they were unable to participate in assessments or the intervention program due to physical limitations, unable to wear the activity or heart rate monitors (i.e., for physical activity or fidelity analyses), had an individual education plan (IEP) or diagnosed cognitive or academic disability such as attention-deficit hyperactivity disorder or autism spectrum disorder (i.e., for cognitive outcome analyses), or were unable to successfully complete the practice trials for inhibition/attention and working memory.

Experimental Intervention

Intervention Development

The proposed combined fitness intervention was developed using youth physical activity and exercise training guidelines and recommendations from the American College of Sports Medicine, the National Strength and Conditioning Association, and the 2014 International Consensus on Youth Resistance Training (27, 94, 95). Recently, researchers have demonstrated increasing support for children's training programs that incorporate mixed modalities (i.e., programs that incorporate a variety of movements that target more than one component of fitness) (219). Such programs combine general and specific physical activities in order to target both health- and skill-related components of fitness. Faigenbaum and colleagues (193, 195, 220) refer to this as integrative neuromuscular training and have successfully implemented this type of programming into school physical education sessions and after-school programs. In addition to integrating all fitness components, the use of high-intensity training paradigms has also been increasingly researched in youth populations. Such studies have demonstrated that this type of training (alternating high and moderate-to-low intensity activities for short bursts) can be a time efficient and effective option to increase various fitness measures (i.e., cardiorespiratory endurance, muscular endurance, flexibility, balance, and power) in children, and is similar to children's natural movement and play patterns (221, 222). Therefore, the intervention combined modalities to target various fitness components. In addition, because the secondary aim of the study was to examine the effect of our intervention on cognitive and academic outcomes during school recess, a setting which has limited time, we also incorporated high-intensity interval training.

Combined Fitness Intervention

The combined fitness intervention (Appendix 6) incorporated cardiorespiratory endurance, muscular endurance and strength, balance, and coordination components using elastic resistance bands, medicine balls, body weight, and fundamental motor movements. Intervention sessions were integrated into the first 15 minutes of recess periods on five days (Monday through Friday) per week for 3 months and were led by trained researchers that served as intervention leaders. The third and fourth grades at the intervention school had separate recess times and therefore, there was a potential of approximately 60 students per recess session that could participant in the intervention. We aimed for a ratio of one intervention leader to 10 students. Depending on the number of participants during each recess session, students were sometimes placed in smaller groups. Providing the intervention session for only 15 minutes allowed students to still have a half of each session for free playtime (i.e., 15 minutes) with the goal of maximizing participation and minimizing attrition rates. Specific research staff members were designated to lead intervention sessions with the assistance of school teachers and staff that supervised recess periods. All intervention sessions began with a short (1 to 2 minute) icebreaker activity to foster camaraderie and provide a dynamic warm-up. The participants were then introduced to one new muscle-strengthening movement. The main component of the session was a group activity or inclusive game. A sample session plan is shown in Table 5. Session plans were created for both outdoor and indoor recess settings. To encourage attendance in the intervention sessions, we provided incentive prizes (e.g., collective toe tokens) for participation.

Control Condition

Due to the possibility that offering an alternative or active control program could also impact cognition and academic performance outcomes, a traditional, inactive control condition was used for this study (223). The control school followed their regular recess practice of offering unstructured and supervised free play. At the conclusion of data collection, the control school received the intervention protocol and material. However, no data was collected during this period.

Measurements

Trained data collectors obtained all measurements and outcome assessments that are listed in Tables 6 and 7. All data was collected at the participating schools. The primary outcome measures consisted of process and fidelity assessments at scheduled intervals (Table 6) throughout the SMART Recess pilot study. All secondary outcome and covariate measures were assessed at baseline, mid-point (week 7), and during the last week of the intervention (week 18; Table 7). We elected to assess the secondary variables of interest during the last week of the intervention because we were interested in examining the preliminary efficacy of the program. Table 8 illustrates the format of data collection, how often data was collected via that format, and by whom (i.e., participant, research staff, teacher/school staff, or parent).

Aim 1 Outcome Measures: Process Evaluation Measures

Process evaluation measures were collected through a variety of questionnaires that were completed by research assistants, participants, parents, and teachers or school staff (Table 6). One research assistant (not involved in the delivery of the intervention) observed each intervention session and completed the various process evaluation forms identified in Table 8.

Fidelity (Intervention Adherence, Compliance, Integrity)

To determine how well the implemented intervention sessions matched the originally intended program, fidelity measures were assessed daily by research staff using questionnaires. Intervention intensity adherence was assessed on one randomly selected day per week using heart rate monitors and qualitative observation. One intent of the intervention was to maximize moderate to vigorous physical activity (at least 50% of the time) during each session. Once a week (on a randomly selected day), a random subsample of 8 to 10 participants wore Polar A370 wrist monitors to track heart rate during the intervention session (Polar Electro Inc., Lake Success, NY). Although the accuracy of wrist-worn monitors is more varied than chest sensors compared to electrocardiogram measurements, the Polar A370 wrist device takes less time to place on participants and provides feedback on intensity levels (224-228). Given the short time period we had during recess to implement the intervention session and provide participants with free play time, and that the monitor feedback may have assisted with motivation to stay within the target intensity zone, we opted to use wrist monitors (rather than chest monitors) as a measurement tool for fidelity. In addition, one research assistant observed each intervention session and completed the SMART Recess Implementation Form (Appendix 7), which included questions (questions #5, 6, 10, and 12 shown in Table 9) that were used to assess fidelity measures. The first part of the SMART Recess Implementation Form was completed during each intervention session. The second part was completed within 20 minutes of the end of the intervention period, between recess sessions. In addition, on the same day that heart rate monitors were worn, physical activity was assessed objectively with accelerometry during the whole recess period among the same subsample of participants (n = 5 to 10). A GTX3+ accelerometer (Actigraph, LLC, Pensacola, FL), programmed to store data in 15-second epochs, was worn by each participant on his or her right hip during the recess session. The Evenson et al. (105) activity count thresholds for children were used to categorize the accelerometer counts into continuous variables of percent recess time spent in sedentary, light, moderate, and vigorous intensity physical activity.

Dosage

How much of the original intervention program plan was delivered was assessed with questions on the SMART Recess Implementation Form completed daily by a research staff member during each intervention session (questions #1, 3, and 12 in Table 9). Intervention start and stop times and participant attendance was recorded.

Quality

To determine if all intervention components were delivered clearly and correctly, research staff completed the SMART Recess Implementation Form after each intervention session (question #11 in Table 9).

Acceptability

We assessed the students and school staff/teacher enjoyment and satisfaction with the intervention. Information regarding student enjoyment and satisfaction was collected from items on the SMART Recess Implementation Form completed by a research staff member after each intervention session (question #7 in Table 9) and the “Student Post-

Intervention Survey" that was completed by the participants via an online survey administered on an iPad tablet at the conclusion of the intervention (Appendix 8). School staff completed the "School Post-Intervention Survey" (Appendix 9) at the end of the study through an online survey that was emailed to them.

Program Reach

Participation rates (i.e., individual student attendance) at the intervention sessions were recorded in the SMART Recess Implementation Form (question #2 in Table 9).

Adaptation

Monitoring adaptations that were made to the original intervention was important so we could understand what the true exposure (and exercise dosage) was in the final study. To assess what changes were made to the original intervention session plans, a research staff member responded to questions and recorded notes on the SMART Recess Implementation Form after each intervention session (questions #13 and 14 in Table 9).

Monitoring of Control Group

A qualitative observation was conducted by one research staff member once a week at the control school to monitor the recess practices (on the same day that the intervention school sub-sample of participants wore the heart rate monitors and accelerometers). The research staff member completed the Control School Monitoring form (Appendix 10) during each direct observation session to record the physical activity practices that took place to provide a more meaningful and informed comparison at the conclusion of the study. Physical activity of the control group was also assessed once a week during the full recess period following the accelerometry methods described in the fidelity section (on the same day that heart rate monitors and accelerometers were worn in the intervention group).

Aim 2 and Aim 3 Measures Overview

Cognition, academic performance, physical fitness, and covariate measures (i.e., demographic variables and physical activity) were assessed through a variety of questionnaires and instruments that were completed by research staff, participants, and parents (Table 8). Most of the variables for study aims 2 and 3 were collected over three visits during the baseline data collection period and three visits during the post-data collection period (Figure 2). All assessment visits were conducted during the participants' regularly scheduled recess periods. However, the visits were staggered and at baseline were completed as participants enrolled in the study (i.e., not all enrolled students were measured each day). At each time point, the first visit was conducted individually and the second and third visits were conducted in small groups (n = 8 to 10). During the first assessment visit, physical measures were taken by a research assistant and recorded on the Physical and Fitness Data Sheet (Appendix 11). This visit concluded with the completion of the cognitive measures and accelerometer placement. At visit two, the accelerometers were collected and the muscular fitness assessment was conducted. Cardiorespiratory fitness was assessed at the third visit. Parents were asked to complete the Demographic Data Questionnaire (Appendix 12) online as soon as informed consent (for the parent role in the study) and parent permission (for the child's role in the study) forms were signed. Paper copies were provided to parents that did not provide an email address.

Aim 2 Measures: Cognition and Academic Performance

Cognition

Measures of cognition were assessed with tests from the National Institutes of Health (NIH) Toolbox® for Assessment of Neurological and Behavioral Function (229). The NIH Toolbox® was developed by 15 Institutes, Centers, and Offices at NIH to provide accessible and consistent measures to neuroscience researchers. Cognition is one of the four domains assessed by the NIH Toolbox®, which offers seven instruments for individuals ages 3 to 85 years. In 2013, Weintraub et al. (230) published validity and reliability data for the cognitive battery of the NIH Toolbox from a sample of 476 participants, ages 3 to 85. Reliability of the Flanker Inhibitory Control and Attention Test in children ages 3 to 15 (n = 52) was reported as an intra-class correlation of 0.95 (95% CI = 0.92 to 0.97). The convergent validity of this test in a larger sample (n = 312) was r = -0.48 (when compared to a "gold standard" criterion measure – the Wechsler Intelligence Scale for Children, 4th edition). For the List Sorting Working Memory Test, among 66 children, ages 3 to 15 years the intra-class correlation was 0.87 (95% CI = 0.80 to 0.92). The convergent validity of this test when also compared to the Weschler Intelligence Scale for Children was 0.58 (n = 350; age = 8 to 85 year). An account was set up for each study participant with his or her study ID and demographic information. One research assistant administered each cognitive assessment to participants. A script was provided in the NIH Toolbox's Administrator's Manual for each instrument, which was displayed on the iPad and read by the research assistant to the participant.

Inhibition and Attention

The executive functions of inhibition and attention were assessed using the NIH Toolbox® Flanker Inhibitory Control and Attention Test Ages 3-7 version 2.0 (for children under the age of 8) or the NIH Toolbox® Flanker Inhibitory Control and Attention Test Ages 8-11 version 2.0 (for children 8 years old or older) (229). For the flanker test, participants were required to pay attention to a specific target stimulus and inhibit non-target flanking stimuli. The stimulus (indicated by an audio recording of "middle") was an arrow that was flanked by two additional arrows on each side. The participant was given two response options on the bottom of the screen. They were asked to touch the arrow that matched the direction of the middle arrow in the center of the screen that was surrounded by the flanking arrows (Figure 3, page 77). This test included two types of trials, congruent (i.e., the middle arrow pointed in the same direction as the flanking arrows) and incongruent (i.e., the middle arrow pointed in the opposite direction of the flanking arrows), which were intermixed and equiprobable within the test. There were four practice trials and participants had to get at least three out of four of those trials correct to advance to the test trials. Participants were given two more sets of four practice trials to advance (with the same cutoff). The test included one block of 20 trials for all participants.

Two scores were calculated for the flanker test and then combined – an accuracy score and a reaction time score. The accuracy score could range from 0 to 5 and was determined by the following formula: accuracy score = 0.125 x the number of correct responses. The maximum score was 40. A reaction time score was only calculated if participants earned an accuracy score of at least 4. The reaction time score could also range from 0 to 5. Because reaction time data tend to be positively skewed, the NIH toolbox application applied a log (Base 10) transformation to each participant's median reaction time score. The reaction time score was calculated using the formula below (RT = median reaction time; 500 = minimum reaction time in ms; 3,000 = maximum reaction time ms).

$$\text{Reaction Time Score} = 5 - \left(5 * \left[\frac{\log RT - \log(500)}{\log(3000) - \log(500)}\right]\right)$$

Working Memory

Working memory was assessed using the NIH Toolbox List Sorting Working Memory Test Age 7+ version 2.0 (229). This test required a wireless keyboard, along with the iPad. Sets of food or animal pictures were visually and orally presented to the participants. Participants were required to place these sets in order of smallest to biggest. Two conditions were included for the presented sets: 1-List and 2-List. The 1-List condition requested that participants place the presented set of food items or a set of animal items in order from smallest to largest. The 2-List condition presented participants with both animal and food pictures. Participants were instructed to order the food first from smallest to largest, and then the animals from smallest to largest. Two practice items were presented per condition at the start of the task. If the participant did not correctly complete a practice item, the test trials were not administered. The participant gave his or her response orally for each item. Before moving on to the next item, the research assistant pressed "1" on the keyboard if the participant's response was correct or "0" if incorrect." A correct response was recorded if the participant named "all of the stimuli in the correct order without any intrusions." The administrator referred to the NIH Toolbox List Sorting Working Memory Test Examiner Answer Sheet to score each item on the keyboard. The application included several embedded rules that could result in automatic discontinuation of the task based on the number of incorrect responses a participant made. The scores for the List Sorting Working Memory Test could range from 0 to 26 and were the sum of the correctly recalled and sequenced items from the 1-List and 2-List conditions.

Mathematics and Reading Achievement and Fluency

Academic achievement was assessed from the Amherst-Pelham Regional School district's AIMSWeb (NCS Pearson Inc.) testing results, an academic assessment program that the school system utilizes to assess students' achievement and fluency in mathematics and reading (percentage or number correct in each subject area and standardized grade-level percentile ranking). These academic progress reports were completed by school teachers and staff in January and June of 2018. School principals agreed to release data from these reports for participants with parental permission forms with academic release consent. The primary investigator requested these data at baseline and at post-intervention from reading and mathematics school personnel. Data was received for both time points at the intervention school for both academic subjects and for mathematics only at the control school.

Classroom Behavior

On- and off-task behavior was measured by direct observation using the Behavioral Observation of Students in Schools (BOSS) software (Pearson BOSS^{TM}, San Antonio, TX). In a sample of 196 normally developing children and children with attention deficit hyper-activity disorder, DuPaul et al. (231) reported kappa values of 0.93 to 0.98 for inter-rater reliability of the BOSS measurement tool. The BOSS software was accessed through an application on an iPad. Participants were observed for 10 minutes on two separate days within 90 minutes following their scheduled recess sessions. Research staff members were assigned to observe one participant at a time (and therefore, each research staff member could observe up to 9 students in the 90-minute post-intervention session period). The 90-minute post-intervention period was selected because in a review of acute physical activity bout studies by Tomporowski et al. (49), benefits on classroom behavior were reported to range from 60 to 120 minutes after the activity session. Student behavior was assessed in 15-second intervals and recorded directly into the BOSS iPad application. Student engagement (i.e., on-task behavior) was recorded using momentary time-sampling (i.e., the behavior that was present immediately at the start of the interval was recorded, regardless of whether that behavior continued throughout the interval) (68). Active engagement was recorded when the participant was actively attending to his or her assigned work and passive engagement was recorded if the participant was passively attending to the assigned work (232). Off-task behavior was recorded using partial-interval recording (i.e., any behavior that occurred during the interval was recorded, even if that behavior was not present for the entire duration of the interval) (68). Off-task behavior was recorded for any behavior not directly associated with the assigned academic work. Off-task behaviors were classified as off-task motor for any occurrence of motor activity, off-task verbal for audible verbalizations, and off-task passive for periods when a participant was passively not involved in the academic activity for at least three consecutive seconds (232). A list of criteria for each coding option is provided in Table 10. Data from the two observations at each time point (baseline and post) were averaged to provide the following variables (expressed as a percent of time): active engaged time, passive engaged time, off-task motor, off-task verbal, and off-task passive. On each day of observation, at least two randomly selected students were double-coded by a senior research assistant and a regular research assistant. Inter-rater reliability was determined and reported from this data.

Aim 3 Measures: Health-Related Fitness

Cardiorespiratory Fitness

Cardiorespiratory fitness was estimated using the Fitnessgram PACER test (98). The PACER test has been validated to estimate maximal oxygen consumption (98). A study by Morrow et al. (233) assessed the inter-rater reliability of physical education teacher and expert administrators (n = 23) in 1,010 elementary school students. Teacher/teacher reliability was reported to have 82% agreement (modified kappa = 0.64, $P < 0.001$) and expert/expert reliability had 96% agreement (modified kappa = 0.92, $P < 0.001$). The PACER is a multistage 20-meter shuttle run that requires the participants to run as long as they can while the pace gets faster each minute. Two lines were measured 20 meters apart and marked with cones. The Fitnessgram audio application was used for this assessment. Participants placed their feet behind the starting line on the "ready" signal given from a research assistant. The research assistant then began the audio recording. At the word “start”, participants were asked to run to the other cone before the first beep sounds. At the sound of the second beep, participants turned around and ran back to the first line. Participants had to wait for the beep before they began each run. A triple beep indicated the end of a minute and notified the participants that the pace would increase. Participants continued running back and forth from the start to the end line until the end of the PACER, or until they had two misses (i.e., they were not able to reach the second line before the beep sounded). Research assistants crossed off lap numbers on the Physical and Fitness Data Sheet. The total score was the number of laps completed before the second miss. Scores were also dichotomously categorized as meeting the healthy fitness zone or not from Fitnessgram standardized norms based on age and gender (98).

Muscular Fitness

To assess muscular fitness, we included a full-body series of resistance exercises appropriate for the pediatric population (including a front squat, push-up, lunge, bent-over row, shoulder press, calf-raise, and curl-up) that has been used in a recent cognition study by Kao et al. (32). For each exercise using the correct form, participants were asked to complete as many repetitions as possible in 30 seconds with either a self-selected medicine ball or body weight. A strength index score was calculated for each exercise that took the medicine ball weight, body weight, and repetition number into account (i.e., strength index = [body weight + medicine ball]/number of repetitions).

Covariate and Moderator Measures

Physical Measures

Physical measures included weight and height measured at baseline. Weight was measured using an electronic, portable scale (Scaletronix 5125 Model, White Plains, NY). The participant was asked to remove his or her shoes and any excess clothing. He or she was instructed to stand on the taped "X" mark on the scale and weight was recorded to the nearest tenth of a kg. A portable stadiometer (Shorr Height Measuring Board, Olney, MD) was used to measure height. With shoes removed, the participant stood with his or her back and heels against the board, with feet together, and head placed neutrally so the lower level of the orbit is parallel to the floor. Height was recorded to the nearest tenth of a cm. Weight and height were measured at least twice and were measured in an alternating order (i.e., weight measurement #1, height measurement #1, weight measurement #2, height measurement #2). A third measurement was taken if the difference between the first two readings was greater than 0.3 kg for weight and/or 0.5 cm for height. Average weight and height was used to calculate body mass index (BMI). BMI percentiles were then calculated based on birth date, measurement date, and BMI (2).

Physical Activity

Physical activity was assessed objectively with accelerometry. At each measurement time point, a GTX3+ accelerometer, programmed to store data in 15-second epochs, was worn by each participant on his or her right hip for seven consecutive days. Non-wear time was classified using a modified (i.e., at least 30 minutes of consecutive zeros) Choi et al. algorithm (234). The Evenson et al. (105) activity count thresholds for children were used to categorize daily accelerometer counts into continuous variables of percent time spent in sedentary, light, moderate, and vigorous intensity physical activity.

Demographic Measures

Parents and guardians completed an online Demographic Data Questionnaire (Appendix G) at baseline to collect information on race and ethnicity, presence of an education/learning disability, parental income, parental education, parental height and weight, and child handedness. If a parent or guardian was unable to complete this questionnaire online, a printed copy was made available to them.

Statistical Analyses

Sample Size and Power Calculation

All statistical analyses were completed in Stata (Stata 15.1, College Station, TX), with α levels set at $P < 0.05$. Previously published youth intervention studies have reported a small to moderate effect size on changes in cognition and academic performance (2). The primary aim of this study was to determine if we could recruit and retain a sample of elementary school students, and if the intervention was acceptable to the participants. However, for our secondary aim a power calculation was run in Stata to estimate the sample size needed to detect a meaningful change in one of our cognitive outcomes (inhibition/attention). Using an analysis of covariance (ANCOVA) model, assuming a 0.80 correlation between baseline and post-scores, a sample size of 46 children will gave us 95% confidence and 80% power to detect a moderate effect size

(Cohen's d = 0.5) in inhibition/attention. Based on attrition rates from previous school-based studies conducted in our laboratory, we anticipated a 10% loss to follow-up, so we planned to recruit 50 participants (25 per school) (216).

Descriptive Statistics

Descriptive statistics were calculated for variables for the overall sample and between the two groups. To assess for differences between the groups at baseline two sample t-tests were used for continuous variables and chi square tests were used for categorical variables.

Aims and Hypotheses

Aim 1: Examine the feasibility (recruitment, retention, and fidelity) and acceptability (participation and level of intervention enjoyment) of a 3-month recess-based combined fitness intervention in elementary school-age children.

H_{1a}: For feasibility (recruitment and retention), we hypothesized that the study recruitment (n=50) and retention goals (75% at 3-month data collection) would be met.

H_{1b}: For fidelity, we hypothesized that the average intensity level of participants would reach moderate-to-vigorous physical activity thresholds for at least 50% of the intervention sessions and at least 75% of the intervention sessions would be implemented as planned.

H_{1c}: For acceptability, we hypothesized that the intervention children would demonstrate high participation rates at the recess intervention sessions, a high degree of enjoyment of the lesson plans, and satisfaction with the overall program, as assessed with daily attendance and participation reports and a post-intervention participant survey.

Analysis for H_{1a}, H_{1b} and H_{1c}: Descriptive statistics were calculated for outcomes relating to Aim 1 (process evaluation measurements). Means and standard deviations were calculated for continuous variables, frequency distributions were calculated for categorical variables. For qualitative variables, representative quotations were presented.

Aim 2: Evaluate the preliminary efficacy of a 3-month recess-based combined fitness intervention on cognition and academic performance in elementary school-age children.

H_{2a}: We hypothesized that children randomized to the combined fitness intervention would have greater improvements in cognition, specifically inhibition/attention and working memory, compared to the control arm as assessed by Flanker and list sorting tasks, respectively.

H_{2b}: We hypothesized that children randomized to the combined fitness intervention would have greater improvements in academic performance related variables, specifically on-task behavior and academic achievement compared to the control arm as assessed by direct observation and mathematics and reading scores, respectively.

Analysis for H_{2a} and H_{2b}: To assess Aim 2, the relative benefits of the combined fitness intervention (intervention group versus control) with respect to change over time in cognition (inhibition/attention and working memory) and academic performance (mathematics and reading achievement scores, classroom behavior, and school engagement) were assessed with ANCOVA models adjusted for baseline scores and potentially other covariates (i.e., age, gender, BMI percentile, race, parental income, and parental education). Covariates that were significantly different between groups at baseline or were strongly correlated with the outcome variable were entered in the models.

Aim 3: Evaluate the preliminary efficacy of a 3-month recess-based combined fitness intervention on health-related fitness in elementary school-age children.

H_{3a}: We hypothesized that children randomized to the combined fitness intervention would have greater improvements in cardiorespiratory fitness compared to the control arm as assessed by the PACER test.

H_{3b}: We hypothesized that children randomized to the combined fitness intervention would have greater improvements in muscular fitness compared to the control arm as assessed by a muscular fitness battery.

Analysis for H_{3a} and H_{3b}: To assess Aim 3, the relative benefits of the combined fitness intervention (intervention group vs. control) with respect to change over time in cardiorespiratory fitness (completed PACER laps) and muscular fitness (strength index score) were assessed with ANCOVA models adjusted for baseline scores and potentially other covariates (i.e., age, gender, BMI percentile, race, and parental income). Covariates that were significantly different between groups at baseline or were strongly correlated with the outcome variable were entered in the models.

Anticipated Outcomes

We anticipated that process evaluation data would demonstrate support that a combined fitness intervention was a feasible and acceptable program that could be successfully implemented in a school-based recess setting. We also expected to see greater improvements in measures of cognition and academic performance in the combined fitness intervention, compared to the control group. If the aims of the proposed study were achieved, it would provide us with information on the feasibility of a recess-based combined fitness program on cognition and academic performance and would help identify additional strategies that can be implemented by schools to assist with improving academic performance in children.

Table 4. Demographic characteristics of the two participating elementary schools.

Demographic Variable	Crocker Farm Elementary	Fort River Elementary
Race		
Caucasian	45%	50%
Hispanic	22%	23%
Asian	16%	13%
African American	9%	8%
American Indian/Alaskan	0%	1%
2 or More Races	8%	5%
Gender		
Male	52%	48%
Female	48%	52%

Table 5. Sample session plan for the combined fitness intervention.

Component	**Length**	**Combined Fitness Intervention**
Icebreaker/ Warm-Up	2 min.	*Ice-breaker Activity:* An activity (e.g., I Like Relay game) that included dynamic movements such as giant steps, Jumping Jacks, and inch worm walks.
Interval Segment	2 min.	*Movement of the Day:* A new muscle-strengthening movement was demonstrated by intervention leaders and practiced by the students.
Group Activity	11 min.	*Fitness Bingo:* Students were split into small groups and each group received a Bingo game card. Each box on the card will had a number (for repetitions) and a movement. A Bingo game was played with the students completing the repetitions and movement on each space.

Table 6. Description of primary aim variables and measurement time points.

Variable	Description	Daily	Weekly	Post-intervention
Fidelity	Intervention adherence, compliance, integrity	X	X	X
Dosage	How much of the original program is delivered	X		
Quality	Clear and correct delivery of intervention	X		
Acceptability	Participants' enjoyment and satisfaction of intervention			
Program Reach	Attendance and participation	X		
Adaptation	Changes made to the original intervention plan	X		
Monitoring of Comparison Group	Nature and services received by control school		X	X

Table 7. Description of secondary aim variables and covariates and measurement time points.

Category	Variable(s)	Base-line	Mid-point	Post
	Academic Outcomes			
Executive Functions	• inhibition/attention • working memory	X		X
Achievement	• mathematics achievement and fluency • reading achievement and fluency	X		X
Behavior	• classroom off-task time	X		X
	Covariates/Moderators			
Physical Measures	• height • weight • BMI percentile	X		X
Demographic Measures	• age • gender • race • ethnicity • education/learning disability • parental income • parental education • parental height and weight • child handedness	X		
Physical Activity	• percent time in moderate physical activity • percent time in vigorous physical activity	X	X	X
Health-Related Fitness	• cardiorespiratory fitness • muscular fitness	X		X

Table 8. List and timeline of data collection methods and forms.

Data Collection Form/Program and Method	Variable(s)	Completed By	Measurement Time Point
Physical & Fitness Data Form (printed form)	• height • weight • BMI percentile • cardiorespiratory fitness • muscular fitness • shoulder flexibility • low back/hamstring	RA	B, M, P
Psychological/Social Surveys Form (Qualtrics survey on iPad)	• school engagement • self-esteem • scholastic self-competence • physical activity self-efficacy • physical activity enjoyment	S	B, P
Demographic Data (Online Qualtrics survey)	• age • gender • race • ethnicity • education/learning disability • parental income • parental education • parental height and weight • child handedness	PA	B
SMART Recess Implementation Form (printed form)	• fidelity • dosage • quality • program reach • adaptation	RA	D
Monitoring of Comparison Group Form	• control group services/activities	RA	W
BOSS System (iPad application)	• classroom off-task time	RA	B, P
NIH Toolbox (iPad application)	• inhibition/attention • working memory	RA	B, P
Accelerometers	• percent time in moderate physical activity • percent time in vigorous physical activity	S	W, B, M, P
Heart rate monitors	• fidelity/adherence - percent time in moderate and vigorous physical activity	S	W

Student Post-Survey (Qualtrics survey on iPad)	• acceptability	S	P
School Post-Survey (Online Qualtrics survey)	• acceptability	T	P

Key: P=parent of participant; RA=research assistant; S=student participant; T=teacher/school staff; B=baseline, M=mid-point, P=post-intervention; D=daily; W=weekly

Table 9. Questions that will be included in the SMART Recess Implementation Form.

PART I: *These items are to be recorded during each intervention session.*

1. Among those with consent/assent, record participants that are in attendance. (Dosage)
2. How many students participated in the intervention session? (Program Reach)
3. Record start and end time of intervention session. (Dosage)
4. Were heart rate monitors or accelerometers used today? If yes, record participant IDs and corresponding monitor #s. (Adherence)

PART II: *These items are to be recorded within 20 minutes after the end of an intervention session.*

Yes or No:

5. Did at least 50% of the students participate? If no, why? (Reach)
6. Did the majority of students participate in at least half of the intervention session? If not, approximately how many minutes did the majority of the students participate in? (Fidelity)
7. Did the majority of the students seem to enjoy the intervention session? (Acceptability)
8. Did the intervention session appear to hold the interest/attention of the majority of the students participating? (Participant Responsiveness) If not, explain.
9. Did the intervention leader(s) provide encouragement during the intervention session? (Fidelity)
10. Was the intervention session implemented as intended? If no, why not? (Fidelity)
11. Did the intervention leader implement the intervention session clearly and correctly? (Quality)
12. Did the intervention leader implement all the planned session components? If no, which components were not implemented and why? (Fidelity & Dosage)
13. Were modifications/adaptations made from the original intervention session plan? If yes, what modifications were made? (Adaptation)
14. Did the intervention leaders recommend modifications or changes for the future? If yes, explain. (Adaptation)

Table 10. Criteria for recording behaviors with the BOSS system.

Behaviors	Criteria	
	Should be scored if:	Should not be scored if:
Active engaged time	• Writing • Reading aloud • Raising a hand • Talking to the teacher about the assigned material • Talking to a peer about the assigned material • Looking up a word in a dictionary	• Talking about nonacademic material (verbal off task) • Walking to the worksheet bin (motor off task) • Calling out (verbal off task) unless it is considered an appropriate response style for the classroom) • Aimlessly flipping the pages of a book (motor off task) • Engaging in any other form of off-task behavior
Passive engaged time	• Listening to a lecture • Looking at an academic worksheet • Silently reading assigned material • Looking at the blackboard during teacher instruction • Listening to a peer respond to a question	• Aimlessly looking around the classroom (passive off task) • Silently reading unassigned material (passive off task) • Engaging in any other form of off task behavior
Off-task motor	• Engaging in any out-of-seat behavior • Aimlessly flipping the pages of a book • Manipulating objects not related to the academic task • Physically touching another student when not related to an academic task • Bending or reaching • Drawing or writing not related to academic task • Fidgeting in seat	• Passing paper to a student as instructed by the teacher • Coloring on an assigned worksheet as instructed • Laughing at a joke told by another student (off-task verbal) • Swinging feet or fidgeting while working on assigned material
Off-task verbal	• Making any audible sound, such whistling, humming, forced burping • Talking to another student about an assigned academic task when such talk is prohibited by the teacher • Making unauthorized comments • Calling out answers to academic problems when the teacher has not specifically asked for an answer or permitted such behavior	• Laughing at a joke told by the teacher • Talking to another student about the assigned academic work during a cooperative learning group • Calling out the answer to a problem when the teacher has permitted such behavior during instruction
Off-task passive	• Sitting quietly in an unassigned activity • Looking around the room • Staring out the window • Passively listening to other students talk about issues unrelated to the assigned academic activity	• Quietly reading an assigned book • Passively listening to other students talk about the assigned work in a cooperative learning group

Figure 2. The overall study timeline including measurement time points.

Teacher meetings to explain study	Participant recruitment	Baseline data collection	Combined fitness intervention (15 weeks)	Post-data collection	Control group receives intervention
December 2017	December 2017 – January 2018	January 2018 (Weeks 1-3)	February – May 2018 (Weeks 4-18)	May 2018 (Weeks 17-18)	September-December 2018

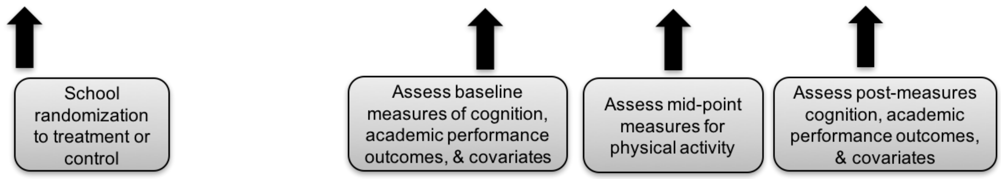
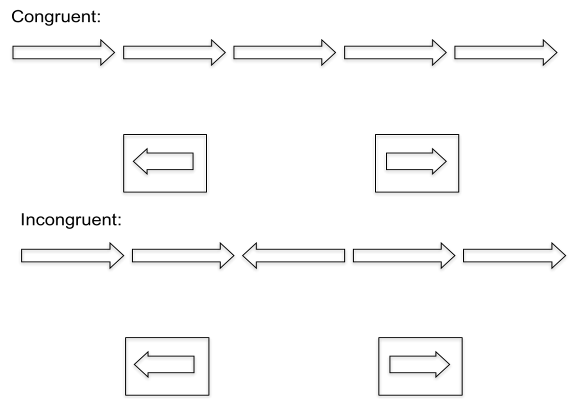


Figure 3. Examples of congruent and incongruent Flanker test items.



Note: For both tasks, an audio recording asked the participants which of the bottom squares matches the direction of the middle arrow above.

CHAPTER 4

MANUSCRIPTS

Study 1: Implementation Evaluation of a Recess-Based Fitness Intervention in Elementary School Children: A Randomized Controlled Pilot Study

Abstract

Most studies that have examined the impact of fitness on academic-related outcomes have not reported process evaluation outcome data. The purpose of this study was to describe the process evaluation measures of a pilot study designed to examine the feasibility and acceptability of a combined fitness intervention (CFI) in elementary school students. **METHODS:** Two schools were randomized to either a 3-month CFI or control condition (CON). The CFI was implemented during recess for 15 minutes/weekday. Process evaluation measures were recorded daily (research staff questionnaire), weekly (accelerometer and heart rate monitors), and post-intervention (participant and school-staff questionnaire). **RESULTS:** High levels were observed for intensity dosage during the CFI sessions based on heart rate (mean percentage of maximal heart rate: 58.0 ± 5.8%), level of implementation (88% of sessions), and percentage of sessions implemented as planned (78% of sessions). However, intensity dosage during the intervention sessions based on accelerometry (% of time spent in moderate-to-vigorous activity: 41.7 ± 14.5%) and participation (19.4% attendance rate) were lower than expected. **CONCLUSION:** This study provided some preliminary evidence that a CFI is feasible and acceptable during school recess. However,

certain factors (e.g., methods to improve attendance to enhance the dosage received) should be targeted to refine and improve the CFI.

Introduction

Low levels of fitness and physical activity (PA) in children have been associated with various adverse health outcomes, such as lower cardiovascular and muscular health and increased depressive symptoms (52). Despite these relationships, most U.S. children are not physically fit, with recent surveillance data indicating that only 21- 40% are meeting the recommended benchmarks for fitness and PA (92, 101). This is unfortunate as both fitness and PA have been linked to brain health, including cognition and academic performance in children (2). For example, higher levels of fitness have been associated with better executive functioning, academic achievement, and academic behaviors (2, 19, 24). In addition, a review by Tomporowski et al. (4) reported that fitness (with the most attention given to cardiorespiratory fitness) may mediate the relationship between PA and academic performance. More recent reviews have acknowledged the emergence of experimental research examining the effects of PA interventions on cognition and academic performance in children (2, 24). Although activities that enhance muscular fitness are recommended for children, and some reports have noted positive associations between cognition and academic achievement with muscular fitness, most studies have only targeted aerobic fitness (15, 29, 32). Few studies have examined the impact of intervention programs that emphasized both cardiorespiratory and muscular fitness on cognition or academic performance (33, 34).

Previous studies examining PA and academic performance have mainly been implemented either during the school day (specifically during classroom time) or immediately after-school (2, 14, 23, 35-37); however, these intervention settings pose some limitations. For example, after-school programs may not be accessible to all students due to transportation concerns and scheduling conflicts with other extracurricular activities. To increase accessibility and exposure to more students, it could be argued that PA and fitness interventions designed to impact cognitive and academic outcomes should be implemented during the school day. However, PA interventions offered during classroom time are often in competition with other demands, such as academic lessons and preparing for standardized testing (13). Consequently, non-academic classroom time such as school recess may be an ideal time to promote PA, fitness, and related variables. Therefore, the Strong Minds with Aerobic and Resistance Training during Recess (SMART Recess) pilot intervention was designed as a school recess program that targeted both cardiorespiratory and muscular fitness.

Assessing a program's implementation is an important component in reporting the impact of health behavior interventions. The degree of implementation can impact both the internal and external validity of a study and can be evaluated by collecting information on various process evaluation variables (47, 48). Examining process evaluation measures can also provide information on the feasibility and acceptability of a program and identify problems or concerns early on that could ultimately impact the study outcomes. PA intervention studies examining academic performance-related outcomes should report process evaluation measures to fully inform the state of the evidence on the benefits of certain program designs (24). Unfortunately, most experimental studies to date that have examined the impact of PA and fitness on cognition and academic performance have not reported process evaluation outcome data.

An analysis of process evaluation measures will provide valuable information to refine future recess-based interventions and assess the effectiveness and sustainability of this type of program in larger studies. Therefore, the purpose of this paper is to describe the process evaluation measures of a pilot study designed to examine the feasibility (recruitment, retention, and fidelity) and acceptability (participation and level of intervention enjoyment) of the SMART Recess intervention in elementary school-age children.

Method

Study Overview

This study used a two-arm randomized controlled trial design to assess the feasibility and acceptability of a 3-month recess-based combined fitness intervention in elementary school children. The study was conducted in third and fourth graders of two elementary schools and was implemented during recess periods. Parents completed informed consent and parental permission forms, school staff completed an informed consent, and student participants completed an assent form. The study protocol was approved by the University of Massachusetts Amherst Institutional Review Board.

Schools and Participants

Two schools within the same district in Western Massachusetts agreed to participate in this study. The schools had similar curricula, student enrollment, and student demographics. Daily recess sessions at both schools were organized by grade level and were 30 minutes in duration. Randomization took place at the school level, with one school assigned to the intervention and the other school assigned to the control condition. Within each school, all third and fourth grade children participated in their school's assigned condition. However, students were individually recruited to take part in the assessment portion of this study. Participants were eligible to participate in the assessment portion of this study if they were in third or fourth grade at one of the participating schools at the time of recruitment. Participants were excluded from analyses if they were unable to participate in the assessment (e.g., unable to wear an activity monitor) or the intervention protocol.

Intervention

The SMART Recess intervention combined modalities to target various fitness components and was developed using youth PA and exercise training guidelines and recommendations (94, 95). The intervention incorporated cardiorespiratory endurance, muscular endurance and strength, balance, and coordination components using elastic resistance bands, medicine balls, body weight, and fundamental motor movements. The intervention was divided into five blocks (two to three weeks per block) to allow for a progression in the muscular strengthening movements. Intervention sessions were integrated into the first 15 minutes of recess periods on five weekdays per week for three months. Intervention sessions were led by trained researchers that served as intervention leaders, with a target ratio of one intervention leader to 10 students. Depending on the number of participants during each recess session, students were sometimes placed in smaller groups. All intervention sessions began with a short (1 to 2 minute) icebreaker activity to foster camaraderie and provide a dynamic warm-up (Table 11). The participants were then introduced to one new muscle-strengthening movement. The main component of each session was a group activity or inclusive game. Session plans were created for both outdoor and indoor recess settings. To encourage attendance in the intervention sessions, incentive prizes (e.g., collective toe tokens) were provided for participation.

Measurements

At baseline, height and weight were measured during recess sessions and used to calculate body mass index percentile (235). Demographic information was collected via an online questionnaire completed by the participants' parents. Process evaluation measures were collected through a variety of questionnaires that were completed by research assistants, participants, parents, and teachers or school staff (Table 12). One research assistant (not involved in the delivery of the intervention) observed each intervention session and completed the process evaluation forms. At the intervention school, recess sessions were observed daily and a semi-structured questionnaire was completed by the research assistant. Information regarding fidelity (how well the implemented intervention sessions matched the originally designed program), intervention session dosage (how many intervention sessions were implemented and how much of the original intervention program was delivered), intensity dosage (intensity of PA during intervention sessions), quality (if all intervention components were delivered clearly and correctly), acceptability (participant enjoyment and satisfaction with the intervention), program reach (participation rates), and adaptation (changes that were made to the original intervention plans) were recorded on the questionnaire. We set our process evaluation measure goals based on reviewed literature and previous studies conducted in our laboratory.

On a randomly selected day per week, a random subsample of intervention participants (n = 6 to 8) wore Polar A370 wrist monitors (Polar Electro Inc., Lake Success, NY) and GT3X+ accelerometers (Actigraph, LLC, Pensacola, FL) to assess their heart rate and PA during recess sessions, respectively. Accelerometers were programmed to store data in 15-second epochs and were worn on the right hip. Although data was reduced for all intensity categories of physical activity, we focused our attention on the moderate to vigorous PA because it is has the strongest association with health benefits (52) and is recommended in the national guidelines (236). Participants' percent time spent in moderate to vigorous PA was determined using the Evenson et al. (105) activity count thresholds for children. Additional fidelity measures (i.e., compliance and adherence to the program), as well as quality and adaptation variables, were assessed on the daily observation questionnaire. Acceptability measures were collected from program evaluation surveys completed by intervention school students and staff at the completion of the intervention. In addition, once a week (on the same day that the intervention school was observed), a research assistant observed the recess session at the control school and completed a questionnaire to monitor the recess practices. PA of the control group was also assessed once a week (during the recess period) using accelerometry in a randomly assessed sub-sample (n = 5 to 10 participants).

Analyses

Descriptive statistics were calculated for variables for the overall sample, between the two groups, and for process evaluation outcomes. Means and standard deviations were calculated for continuous variables, and frequency distributions were calculated for categorical variables. For qualitative variables, representative quotations were presented. All statistical analyses were completed in Stata (Stata 15.1, College Station, TX), with α levels set at $P < 0.05$.

Results

Feasibility (Recruitment, Retention, and Fidelity)

A total of 91 and 116 third and fourth grade students, respectively, attended the intervention and the control school, and were eligible to participate in the SMART Recess study. Of this sample, initial parental consent and permission was received for 56 students (intervention, n = 27; control, n = 29). In the control group, two students did not complete the assent document and another student had traveled out of the area before the start of baseline measurements. The baseline sample size was 53 participants (intervention, n = 27; control, n = 26). Overall reach (enrolled participants out of eligible students) was 29.7% and 22.4% in the intervention and control schools, respectively. In the intervention school, two participants were not present for post-intervention measurements (illness, n = 1; travel, n = 1). In the control school, after baseline data collection six participants withdrew from the study because they did not wish to give up future recess time for the assessments. Therefore, the final overall retention level was

92.6% (n = 25) and 76.9% (n = 20) for the intervention and the control schools, respectively. Descriptive characteristics of the study sample are presented in Table 13.

Excluding the anticipated days that school would not be in session (i.e., scheduled school breaks and staff development days), intervention sessions were implemented 88% of the time (i.e., 44 of a potential 50 days). Of the total intervention sessions (n = 44), two sessions were held indoors due to rain and the remaining sessions were held outdoors. The average intervention session length was 14.7 ± 4.6 minutes (ranging from 8 to 26 minutes). The intervention duration exceeded the planned 15 minutes 56.6% of the time in third grade and 58.2% of the time in fourth grade. During the entire 30-minute recess session, according to accelerometer data the average percent of time spent in moderate-to-vigorous PA at the intervention school was 41.7 ± 14.5% (or 9.5 ± 4.2 minutes), whereas at the control school it was 30.4 ± 14.8% (or 8.6 ± 5.3 minutes). During the intervention portion of recess sessions, the average percent of time spent in moderate-to-vigorous PA was 44.8 ± 19.3% (i.e., 5.7 ± 2.8 minutes) in the intervention school. According to observation data, during this same time frame (intervention time) at the control school, the majority of control school students engaged in light PA during recess sessions. The average heart rate of participants during the intervention sessions was 122.5 ± 12.2 beats per minute (bpm) and the average percentage of maximal heart rate was 58.0 ± 5.8%.

A summary of study process evaluation outcome variables is presented in Table 14 (page 99). The intervention was delivered as intended (n = 78.9% of sessions), including all the planned components (n = 76.1% of sessions). In addition, a significant portion of the intervention sessions were delivered clearly and correctly with adequate levels of intervention leader encouragement. Adaptations and modifications were integrated into approximately one-third of the sessions by intervention leaders. At the control school, 93.3% of the observed recess sessions consisted of unstructured activity. One observed indoor recess session at the control school utilized a combination of structured and unstructured activity.

Intervention Acceptability (Participation, Enjoyment, and Feedback)

At the intervention school, the average number of students in attendance per intervention session was approximately 5 and 11 among all third and fourth grade students, respectively. Although 89% of all students participated in at least one intervention session, the average attendance rate was below 50% for both participants enrolled in the study and all students. The average intervention school attendance rate was 19.4% for study participants and 30.1% for all students (ranging from 0 to 95.6% in both categories). Participation was higher among third graders compared to fourth graders in both study participants (mean students/session: 6.1 ± 3.1 vs. 3.1 ± 2.7) and all students (13.1 ± 4.4 vs. 8.6 ± 3.7). According to research assistant responses on the daily questionnaire regarding student enjoyment (Table 14, page 99), the majority of students appeared to enjoy the intervention sessions and the activities seemed to hold their interest. Based on student verbal feedback and assessment of individual sessions, intervention leaders recommended future modifications to approximately one third of the sessions.

Student and school staff responses to the post-intervention survey are outlined in Table 15 (page 100). Most students reported that they were likely to continue participating in the program if it were offered and would participate in the activities if they were offered in a different school setting (e.g., as classroom breaks or before school). Regarding satisfaction with the SMART Recess program, students were generally satisfied with most components. Although none responded, "extremely dissatisfied", just over 10% of the participants indicated that they were slightly dissatisfied with the timing of the intervention sessions, duration of the program, and facilitation by the intervention leaders. Despite these criticisms, intervention leaders were described by one student as "*kind and encouraging*". Completion of the assessments were described as "*easy to do*" by another student. Feedback concerning the intervention session length varied, with several reporting satisfaction with the daily length, some preferring to extend the length (i.e., "*longer than 15 minutes – the whole recess"),* and others expressing a concern that the length sometimes exceeded the planned 15 minutes (i.e., *"we should have more time for recess"*). Favorite games and activities varied among student participants. Some students indicated that while they were bored with some games, they would do the program again. Teachers and school staff expressed general satisfaction with various components of the SMART Recess program and measurements of the study. Responses provided affirmative support for continuation of the SMART Recess program such as, *"I think it was great to have an organized movement-related option for students to participate in. Along with that, the interaction between college students and third graders is highly valuable!"* Another response provided similar support with additional future recommendations regarding programming focus, *"I'd love to see the program become a permanent fixture and include attention to* *interpersonal relations to be sure the kids are able to participate and not focus on any type of competition."*

Discussion

The purpose of this paper was to provide a process evaluation of the SMART Recess pilot study in elementary school-age children. Recruitment (26%; 53 participants out of 207 eligible students) and retention goals (75% of 53 participants) were met, although some parents expressed frustration with the paperwork required to enroll their children into the study. Originally, 68 families expressed interest, but 12 did not complete all the necessary forms for study enrollment. Participant attrition was greater at the control school compared to the treatment school, which could be related to offering a traditional control condition (i.e., schools were not matched for attention). This type of control design was selected because an "active" control condition (e.g., offering an alternative program for the control school) could possibly impact the cognitive outcomes in the study. An active control condition is sometimes considered the preferred option to reduce loss to follow-up (237). However, because more time was spent with participants at the treatment school in our study, this probably contributed to the higher attrition rate in the control school. A greater loss to follow-up has also been reported by some studies examining fitness interventions in children with non-attention matched control groups (61, 140).

Some fidelity measures, such as implementation rate, implementing sessions as planned, and average PA intensity during sessions, successfully reached our pilot study goals. First, our planned intervention implementation percentage target (75%) was met.

As expected, the remaining sessions (12% of scheduled sessions) were missed due to school cancellation related to inclement weather (n = 3), field trips (n = 1), or University conflicts for the research staff (n = 2). Second, more than 75% of the time, the intervention was led as planned and all components of the sessions were delivered. However, occasionally some of the activities (e.g., Capture the Flag and some tag games) would get more competitive than intended, resulting in some arguments among students that impacted the activity portion of intervention sessions (i.e., more time was spent on group management rather than group activity). During these sessions, the activity was either ended early (if most of the session had already been completed) or was changed to a different activity, which in part contributed to the reported 25% of intervention sessions not implementing all of the planned components. Forton et al. (238) also noted that conflict resolution was sometimes a concern and that teachers recommended that future intervention leaders receive training in behavior management when describing the implementation of the Playworks curriculum (a structured, game-based recess and classroom program in 17 schools). Third, although intensity measured via accelerometers during the intervention session [41.7% of the average time was spent in moderate to vigorous physical activity (MVPA)] fell short of our goal of 50%, the participants' mean heart rate was greater than 55% of their estimated maximal heart rates. This indicates that on average the intervention participants were obtaining at least moderate intensity activity. Our mean beats per minute of 122.5 ± 12.2 was lower than the FITKids trial average heart rate of 137 ± 8.8 beats per minute (140). The focus of their program was aerobic activity and the length of the daily sessions in the FITKids trial was also longer (i.e., 2 hours with a goal of 70 minutes of intermittent MVPA) and therefore, their participants received a greater dosage from the intervention.

Despite effectively meeting the daily PA intensity goal, the overall intervention dose did not meet the expected level. The lower than expected intervention dosage was mainly due to participant attendance. With the average attendance rate of just under 20% for study participants, the overall exposure to the intervention was well below the typical attendance rate described in other fitness and cognition intervention studies of over 80% (33, 139, 140). In the current study, students had the option to participate in the intervention or other unstructured activities (provided through the school) each day during recess. It is likely that providing participants with an option could have contributed to the low participation rate (versus requiring all students to participate as in other school recess studies). However, as this was a pilot study, an agreement was made with the participating schools to make it an optional program. In a recent report by Donnelly et al. describing the findings of their 3-year Physical Activity Across the Curriculum intervention study (i.e., PA integrated into academic lesson plans), the authors also indicated challenges with the actual exposure versus planned exposure (184). The intended dose of PA was an accumulation of 150 minutes per week, but lessons were only delivered for about 55 minutes per week. Authors indicated that their planned exposure was not met because the teachers in the study did not comply with the intervention delivery, whereas in the current study, the planned exposure was not met because students chose not to participate in the intervention every day that it was offered.

One of the initial barriers related to overall participation was recruiting students to join the program during recess sessions. This again may be largely due to students having a choice of what activities to partake in during school recess. Recess is one of the few (if only) times during the otherwise structured school day that children have opportunities for free play and self-selected activities (13, 213). Therefore, offering an optional structured program competes with free play and other unstructured opportunities. This may be why most school-based PA studies with academic-related outcomes have elected to use other settings (2, 37). Our program also occasionally competed with alternative options offered during recess (i.e., computer technology club, talent show rehearsals, and student meetings).

At the beginning of the study, research staff asked students directly if they would like to join the intervention activities, but this protocol was not effective. However, once the daily activities or games began, students watching from the side or initially partaking in other activities started to join in. This unplanned participation pattern sometimes posed as a challenge to track the number of students participating in each session. As mentioned, the overall participation rate of the students enrolled in the study was lower than the students not enrolled in the study. Based on informal verbal feedback from teachers and students, some of the students that were most interested in enrolling in the study were unable to obtain parental permission and consent. Furthermore, there were some students that enrolled because they were excited more about the measurements than the actual program and some that did not enroll because they were not interested in completing measurements (but did want to participate in the intervention). Consequently, some of the students that were most compliant and enthusiastic with the intervention (i.e., had attendance rates of over 60%) were not enrolled in the study and therefore, we did not have measures on them to track the efficacy of the intervention.

Another obstacle faced was completion of study measures during school recess. This was arguably the greatest contributor to participant attrition as students expressed refusal to complete many measures during their recess period, particularly at the post-intervention time point. Some students said "*no*" as soon as they were approached and explained that they had other plans (e.g., a basketball, lacrosse, kickball, or tag game), but expressed they would complete the measures after recess if that were an option. The use of collective toe tokens was helpful at first, but general enthusiasm for this incentive prize decreased with time. Collecting the measures during recess was initially planned 1) to have consistent timing of the cognitive measures, 2) to avoid interrupting classroom time, and 3) to reduce participant burden (i.e., if before or after school appointments were requested). However, future studies offering a program during recess should discuss other potential measurement periods with the school collaborators. There was also a greater rate of measurement refusals at the control school. In addition to reasons stated above, this again could also be related to having a non-attention matched control condition, whereas anecdotally the research staff developed stronger relationships with the intervention students and it was therefore easier to recruit them for measures. It is hard to determine if this barrier was experienced by other recess studies as most either did not report when the measures were collected (42) or they were assessed at different times (i.e., at the beginning of the school day or during physical education) (33, 43, 239, 240).

Despite these difficulties, research assistant responses on the daily intervention questionnaire and student and school staff responses on the post-intervention survey regarding enjoyment and acceptability were generally positive. Most of the participants completed at least half of the intervention activities during all sessions, which provides additional support that the activities were able to hold the interest of the students. Similar to the current study, other studies have shown that recess-based structured PA programs that are designed to meet student needs are acceptable and well-received. For example, in a 9-week quasi-experimental study examining the effects of a structured recess intervention on PA in third grade students (n = 43), Howe et al. (240) reported positive responses from teachers regarding children's enjoyment. Furthermore, teacher responses also indicated satisfaction that the Howe et al. program addressed additional skills (e.g., social and teamwork skills) with the students. In our pilot study, open-ended responses on the school staff post-intervention survey, as well as verbal feedback, expressed appreciation that social skills and inclusion were integrated into the program and that the intervention provided more students with a comfortable opportunity to participate in recess activities, as well as be more active.

Some limitations of our pilot study regarding the evaluation of its implementation should be addressed. First, although some verbal feedback was recorded on daily implementation sheets, we could formally collect immediate feedback from students throughout the intervention (rather than just at post) in the future. Some of the immediate feedback that we received (i.e., during or immediately after individual recess sessions) was more specific and informative than the brief, overall responses that were received from students in the post-intervention questionnaire. Second, the teacher response rate to the post-intervention survey was low (percentage = 50%) and could potentially be addressed by providing an incentive or collecting the responses in person (rather than emailing a survey link). Third, due to staffing limitations, only one research assistant completed the intervention implementation form each day. Two data collectors would have enabled us to determine inter-rater agreement between observers for the process evaluation questions that we used to ensure reliability of these measures. Finally, the research assistants completing observations at both schools were not blinded to the treatment conditions. Although this could contribute to potential bias in the responses to the daily observation form (particularly in the open-ended responses), the research team completed a thorough training in each of the measurement protocols. There were also some strengths of our implementation evaluation. Objective measurements were used to assess heart rate and PA fidelity measures and observations of the intervention sessions were conducted daily. The process evaluation data collected in this study can also serve as valuable information to make improvements to the intervention program and inform future studies.

The accumulation of the process evaluation information examined in this paper is important to inform future work by addressing concerns and suggested modifications of the original program plan. This evaluation demonstrated that recruitment and retention goals were successfully met and some aspects of fidelity were good (i.e., average PA intensity during sessions, implementation rate, and implementing sessions as planned), while other factors need improvement (i.e., the intervention exposure due to overall low participation rates in most enrolled participants). Furthermore, the acceptability was satisfactory regarding the SMART Recess program, but less than ideal for other study components (i.e., namely participation in study measures during recess periods). Future studies may want to examine the SMART Recess program implemented as a mandatory recess program and conduct measurements during another school setting if possible.

Table 11. SMART Recess session components.

Length	Component
2 minutes	*Ice-breaker Activity:* Each session began with a warm-up activity (e.g., I Like Relay game) that included dynamic movements such as giant steps, Jumping Jacks, and side shuffles.
2 minutes	*Movement of the Day:* Each day new muscle-strengthening movement (e.g., body weight squat, elastic band chest press, and medicine ball torso twist) was demonstrated by intervention leaders and practiced by the students.
11 minutes	*Group Game/Activity:* The majority of each session was comprised of a group activity or inclusive game that integrated movements that students had already been exposed to in the intervention program up to that point. Example: Fitness Bingo. (Students were split into small groups and each group received a Bingo game card. Each box on the card will had a number and a movement. A Bingo game was played with the students completing the repetitions and movement on each space.)

Table 12. List of variables, data collection methods, and timing of process evaluation measures.

Variable(s)	Data Collection Form/Program and Method	Completed By	Measurement Time Point
• Fidelity • Dosage • Quality • Program reach • Adaptation	SMART Recess Implementation Form (during and after observation)	Research Assistant	Daily
• Control group services/activities	Monitoring of Control Group Form	Research Assistant	Weekly
• Percent time in moderate physical activity • Percent time in vigorous physical activity	Accelerometers	Student Participant	Weekly, Baseline, Mid-point, Post-Intervention
• Fidelity/adherence - percent time in moderate and vigorous physical activity	Heart rate monitors	Student Participant	Weekly
• Acceptability	Student Post-Survey (Qualtrics survey on iPad)	Student Participant	Post-Intervention
• Acceptability	School Post-Survey (Online Qualtrics survey)	Teachers/School Staff	Post-Intervention

Table 13. Baseline characteristics of the overall study sample (n=53).

Variable	All Participants (n= 53)
Age (years)	9.1 ± 0.7
Sex (% male)	54.7%
BMI percentile	62.2 ± 29.7
BMI category	
Healthy weight	66.0%
Underweight	4.0 %
Overweight	20.0%
Obese	10.0%
Race	
Caucasian	51.1%
Hispanic/Latino	27.6%
Asian	14.9%
Black/African American	6.4%
Annual Household Income	
$0 - $19,999	11.4%
$20,000-$39,999	11.4%
$40,000-$59,999	8.6%
$60,000 or more	68.6%
Diagnosed developmental disorder (% yes)	10.5%
Individualized education plan (% yes)	15.8%

Values are represented as mean ± SD or %

Table 14. Research assistant responses to the daily intervention implementation form.

Implementation Question	"Yes" Response (%)	"No" Response (%)
Feasibility		
Was the intervention implemented today?	70.5	29.5
Among students in study, did at least half participate?	29.8	70.2
Among all students, did at least half participate?	16.2	83.8
Was the intervention session delivered as planned?	78.0	22.0
Was the intervention session delivered clearly and correctly?	98.8	1.2
Were all planned components implemented?	76.1	23.9
Were modifications/adaptations implemented?	36.4	63.6
Did intervention leaders provide encouragement?	100.0	0
Acceptability		
Did the majority of the students participate in at least half of the session?	100.0	0
Did the majority of students appear to enjoy the session?	97.8	2.2
Did the intervention session appear to hold the interest of the majority?	95.4	4.6
Did intervention leaders recommend modifications/adaptations for the future?	33.7	66.3

Table 15. Responses to the post-intervention survey.

Question:	Responder:	Response (%):				
		EL	SL	L	SU	EU
If offered by your school, how likely would you be to continue participating in the recess activities that were included in our program?	Students	50	25	25	0	0
	Teachers	N/A	N/A	N/A	N/A	N/A
How likely would you be interested in participating in these activities during other times/settings during the school day?	Students	50	10	15%	10%	15%
	Teachers	N/A	N/A	N/A	N/A	N/A
How satisfied are you each of the following components of the SMART Recess pilot study?		ES	SS	N	SD	ED
Timing of the sessions	Students	44.5	33.3	11.1	11.1	0
	Teachers	100	0	0	0	0
Length of the sessions	Students	36.8	47.4	5.3	10.5	0
	Teachers	100	0	0	0	0
Duration of the program	Students	55.6	27.8	5.6	11.0	0
	Teachers	100	0	0	0	0
Content of the sessions	Students	50.0	33.3	11.1	5.6	0
	Teachers	100	0	0	0	0
Leadership of the sessions	Students	66.7	16.7	5.6	11.0	0
	Teachers	100	0	0	0	0
Initial meeting with teachers	Students	N/A	N/A	N/A	N/A	N/A
	Teachers	100	0	0	0	0
Initial meeting with students	Students	58.8	23.5	17.7	0	0
	Teachers	100	0	0	0	0

Communication	Students	N/A	N/A	N/A	N/A	N/A
	Teachers	100	0	0	0	0

Note: Students (n = 20); Teachers = school teachers and staff (n = 2); EL = extremely likely; SL = slightly likely, L = likely; SU = slightly unlikely; EU = extremely unlikely; ES = extremely satisfied; SS = slightly satisfied; N = neither satisfied or unsatisfied; SD = slightly dissatisfied; ED = extremely dissatisfied

Study 2: Effect of a Recess-Based Intervention on Cognition, Physical Activity, and Fitness in Elementary School Children: A Randomized Controlled Pilot Study

Abstract

Despite the potential benefits of both cardiorespiratory and muscular fitness, few intervention studies have examined the impact of an intervention that incorporates both fitness components on cognition and classroom behavior in children during recess. **PURPOSE:** To evaluate the efficacy of a combined fitness recess intervention (INT; consisting of both aerobic and muscular fitness activities) on cognition, classroom behaviors, fitness, and moderate to vigorous physical activity (MVPA) in children. **METHODS:** Schools (n = 2 schools; n = 54 participants) were randomized to either the INT or control group. The intervention was implemented during recess for 15 minutes/weekday for 3 months. The control group continued participating in their regular recess sessions. Baseline and post-intervention measures included a flanker test, list sorting test, classroom behavior observation, 20-meter shuttle run, muscular fitness battery, and accelerometry. ANCOVA models were used to assess the effect of the intervention. An independent samples *t* test was used to compare the average percentage of time spent in MVPA during recess between schools. **RESULTS:** MVPA during recess sessions was significantly higher in the intervention group (41.7 ± 2.1% of recess time), compared to the control group (30.4 ± 0.2, $P < 0.001$). No other significant differences were observed. **CONCLUSION:** This study demonstrated some preliminary support that a combined fitness program can increase MVPA during recess. Future research is warranted to determine if the INT can impact academic or cognitive outcomes.

Introduction

Academic performance plays an important role in youth development and future opportunities (1). However, although the National Assessment of Educational Progress Nations Report Card has reported a trend of improved academic progress since 1990 in the U.S., poor academic performance remains a major concern (16). Executive control (often referred to as executive function or cognitive control) refer to the intentional component of environmental interaction, and are processes that support the mind's ability to plan, coordinate, and focus in the service of deliberate action (6, 7, 9). Executive functions (e.g., inhibition, attention, and working memory) have been shown to underlie, in part, academic performance as they play a significant role in learning and problem solving (6, 7, 9). Related to executive control, classroom behavior is another component of academic performance and includes an array of behaviors (e.g., on- and off-task behaviors, planning, attendance, and organization) that can influence a student's performance and learning at school (37). In children, physical activity and fitness levels have been associated with executive control and classroom behaviors, and some physical activity and fitness intervention studies have demonstrated improvements in these academic related outcomes (2).

Schools are a common setting utilized in intervention studies targeting health related behaviors and cognitive outcomes as they provide access to a large number of children (13). Such studies have primarily targeted cardiorespiratory fitness and therefore, focused on aerobic training modalities (2, 24). However, in addition to aerobic activities, the current physical activity guidelines include the promotion of muscular strengthening activities (e.g., climbing on playground equipment or performing resistance training movements with body weight or strength equipment) because of added benefits on the health and physical performance of children (236). There has been some preliminary evidence of a connection between muscular fitness and academic-related outcomes in elementary school-age children (33, 115). One recent cross-sectional study in children (ages 7-9 years, n = 70) reported a positive association between muscular fitness and working memory and mathematics performance (32). In an experimental study, children (ages 8-12 years, n = 112) participating in an intervention that incorporated both aerobic and muscular fitness activities demonstrated greater improvements in inhibition and verbal working memory, compared to a control group (33). Despite the potential beneficial influence of muscular fitness, few intervention studies have examined the impact of an intervention that incorporated both cardiorespiratory and muscular fitness training on cognition and classroom behavior in elementary-age children.

Previous studies examining physical activity and academic-related measures have been implemented either during the school-day or after-school hours. These settings can pose some challenges, such as competition with other academic demands during classroom time or transportation barriers related to after-school programming compliance (2, 37, 211). Consequently, non-academic school-day time such as school recess may be an ideal setting to target physical activity behaviors that promote fitness of children as it does not take away from academic time. Currently, limited studies have examined the impact of recess-based interventions that incorporate both aerobic and muscular fitness on academic outcomes (37). Therefore, the purpose of this randomized controlled pilot study was to evaluate the efficacy of a 3-month recess-based combined fitness intervention (consisting of both aerobic and muscular fitness activities) on executive control (i.e., inhibition and working memory) and classroom behaviors (i.e., engaged and off-task behaviors) in elementary school-age children. The effect of this intervention on fitness and physical activity was also examined.

Methods

Schools and Participants

This pilot study consisted of a two-arm cluster randomized controlled trial involving two elementary schools from Western Massachusetts that were randomized (at the school level) to either the intervention or control condition. The schools had similar academic curricula, student enrollment, and student demographics (i.e., race/ethnicity and percent of students that were eligible for free or reduce lunch) and offered daily 30-minute recess sessions. Students in third and fourth grades at both schools were recruited to participate in this pilot study through flyer distributions in their classrooms, classroom visits by the research staff, and electronic media advertisements. Although all students in the participating grades were invited to participate in the Strong Minds with Aerobic and Resistance Training during Recess (SMART Recess) program, only students with completed enrollment forms (i.e., parental consent) participated in data collection. Participants were excluded from specific analyses if they were unable to participate in assessments or the intervention program due to physical limitations, unable to wear the activity or heart rate monitors, had an individual education plan (IEP) or diagnosed cognitive or academic disability (e.g., attention-deficit hyperactivity disorder or autism spectrum disorder), or were unable to successfully complete the practice trials in the cognition measures. To enroll in the study, informed consent and parent permission forms were completed by the parents or guardians and assent forms were completed by the students.

Procedures

The SMART Recess program (Table 16, page 122) was implemented for five days per week for three months. It was designed following youth exercise guidelines and recommendations and integrated various modalities (i.e., aerobic movements and muscle-strengthening body weight, elastic resistance bands, and medicine ball movements) to target both cardiorespiratory and muscular fitness (27, 94, 95). The intervention was led by trained research staff (intervention leaders) and offered daily during the first 15 minutes of recess. Sessions began with a 1 to 2-minute dynamic warm-up, followed by a 2-minute introduction of a new muscle-strengthening movement of the day. The intervention was divided into five blocks (approximately 3 weeks per block) that allowed for a progression of the muscle-strengthening movements (beginning with mostly body weight movements in Block 1 and progressing to more compound movements in Block 5). The largest segment of each session consisted of a group game or activity (offered for 11 minutes), which integrated aerobic and muscle-strengthening movements that had already been introduced up to that point. Activities were available for both outdoor and indoor recess (i.e., in the event of inclement weather). All third and fourth grade students at the intervention school were encouraged to participate in the SMART Recess sessions and were awarded an incentive prize (i.e., collective toe tokens) for attendance. During the study period, the control school followed their regular recess practices (i.e., supervised free play). An inactive control condition (i.e., continue with standard practice, rather than offer an alternate program) was chosen due to the likelihood of an active control program also exerting an influence on cognitive outcomes (223). The SMART Recess intervention program was offered to the control school at the end of all data collection.

Instrumentation

At baseline (i.e., 3-week period prior to the intervention) demographic information was obtained from parents via an online questionnaire. Participants' height and weight were measured to calculate body mass index percentiles. Executive functions, classroom behavior, fitness, and physical activity were assessed at baseline and post-intervention. These variables were collected over three visits during the baseline data collection period and three visits at post-intervention. All assessment visits were conducted during the participants' regularly scheduled recess periods, with the exception of classroom behavior which was conducted post-recess. At each time point, the first visit was conducted individually and the second and third visits were conducted in small groups (n = 8 to 10). During the first assessment visit, physical measures were taken by a research assistant and accelerometers were placed on participants. This visit concluded with the completion of the cognitive measures. Muscular fitness assessment was conducted during the second visit and cardiorespiratory fitness was assessed at the third visit.

Measures of executive control were assessed with the National Institutes of Health (NIH) Toolbox® for Assessment of Neurological and Behavioral Function (229) on an iPad (version 11.1, Cupertino, CA). Inhibition and attention were assessed using the Flanker Inhibitory Control and Attention Test Ages 8-11 version 2.0 and working memory was assessed using the List Sorting Working Memory Test Age 7+ version 2.0 (229). One research assistant administered each cognitive assessment to participants. A standardized script was displayed on the iPad for each test and read by the research assistant to the participant. In 2013, Weintraub et al. (230) published validity and reliability data for the pediatric cognitive battery of the NIH Toolbox® (ages 3 to 15 years). Reliability of the flanker test in children (n = 52) was reported as an intra-class correlation of 0.95 (95% CI = 0.92 to 0.97). The convergent validity of this test in a larger sample (n = 312 participants, ages 8 to 85 years) was r = -0.48 (when compared to a "gold standard" criterion measures – 4th editions of the Wechsler Intelligence Scale for Children and the Wechsler Adult Intelligent Scale). For the working memory test (n = 66 participants) the intra-class correlation was 0.87 (95% CI = 0.80 to 0.92). The convergent validity of this test (n = 350 participants, ages 8 to 85 years) was 0.58, when compared to the same criterion scales used for the flanker test.

For the flanker test, participants were required to pay attention to a specific target stimulus and inhibit non-target flanking stimuli. The stimulus (indicated by an audio recording of "middle") was an arrow that was flanked by two additional arrows on each side. Two response options were shown on the bottom of the screen. Each participant was asked to touch the arrow that matched the direction of the middle arrow in the center of the screen that was surrounded by the flanking arrows. This test included two types of trials: congruent (i.e., the middle arrow pointed in the same direction as the flanking arrows) and incongruent (i.e., the middle arrow pointed in the opposite direction of the flanking arrows), which were intermixed and equiprobable within the test. There were four practice trials and the test included one block of 20 trials. Two scores were calculated for the flanker test (an accuracy score and a reaction time score). The maximum number of correct responses was 40. The accuracy score could range from 0 to 5 and was determined by the following formula: accuracy score = 0.125 x the number of correct responses. A reaction time score was only calculated if participants earned an accuracy score of at least 4. The reaction time score could also range from 0 to 5.

Working memory was assessed using the NIH Toolbox List Sorting Working Memory Test Age 7+ version 2.0 (229). Sets of food or animal pictures were visually and orally presented to the participants. Participants were required to place these sets in order of smallest to biggest. Two conditions were included for the presented sets: 1-List and 2-List. The 1-List condition requested that participants place the presented set of food items or a set of animal items in order from smallest to largest. The 2-List condition presented participants with both animal and food pictures. Two practice items were presented per condition at the start of the task. Participants were instructed to first sort the food (smallest to largest) followed by the animals (smallest to largest). The participant gave their response orally for each item and the research assistant recorded if the response was correct or incorrect. The scores could range from 0 to 26 and were the sum of the correctly recalled and sequenced items from the 1-List and 2-List conditions.

Classroom behavior was measured by direct observation using the Behavioral Observation of Students in Schools (BOSS) software (Pearson BOSS™, San Antonio, TX). Participants were observed for 10 minutes on two separate days within 90 minutes following their scheduled recess sessions. Student behavior was assessed in 15-second intervals and recorded directly into the BOSS iPad application. Student engagement (i.e., active or passive on-task behavior) was recorded using momentary time-sampling (68). Off-task behaviors (i.e., motor, verbal, or passive) were recorded using partial-interval recording (68). Off-task behavior was recorded for any behavior not directly associated with the assigned academic work. Data from the two observations at each time point (baseline and post) were averaged to provide the following variables (expressed as a percent of time of observed intervals): active engaged time, passive engaged time, off-task motor, off-task verbal, and off-task passive. On each day of observation, at least two randomly selected students were double-coded by a senior research assistant and a regular research assistant to assess inter-rater reliability. In a sample of 196 normally developing children and children with attention deficit hyper-activity disorder, DuPaul et al. (231) reported kappa values of 0.93 to 0.98 for inter-rater reliability of the BOSS measurement tool.

Cardiorespiratory fitness was assessed using the Fitnessgram Progressive Aerobic Cardiovascular Endurance Run (PACER) test (98). In the PACER, participants continued running back and forth between cones placed 20 meters apart until they had two misses (i.e., they were not able to reach the second line before the beep sounded). The total score was the number of laps completed before the second miss. The PACER test has been validated to estimate maximal oxygen consumption and a study by Morrow et al. assessed the inter-rater reliability of physical education teacher and expert administrators ($n = 23$) in 1,010 elementary school students (98, 233). Teacher/teacher reliability was reported to have 82% agreement (modified kappa = 0.64, $P < 0.001$) and expert/expert reliability had 96% agreement (modified kappa = 0.92, $P < 0.001$). To assess muscular fitness, we included a full-body series of resistance exercises appropriate for the pediatric population (including a front squat, push-up, lunge, bent-over row, shoulder press, calf-raise, and curl-up) that has been used in a recent cognition study by Kao et al. (32). For each exercise, participants were asked to complete as many repetitions (with correct form) as possible in 30 seconds with either a self-selected medicine ball or body weight. A strength index score was calculated for each exercise that took the medicine ball weight, body weight, and repetition number into account [i.e., strength index = (body weight + medicine ball)/number of repetitions].

Physical activity was assessed objectively with accelerometry. At each measurement time point, a GTX3+ accelerometer, programmed to store data in 15-second epochs, was worn by each participant on his or her right hip for seven consecutive days. Non-wear time was classified using a modified Choi et al. algorithm of at least 30 minutes of consecutive zeros (234). ActiLife software (version 6.13.3, Pensacola, FL) was used to analyze the accelerometer data and the Evenson et al. (105) activity count thresholds for children were used to categorize daily accelerometer counts into continuous variables of percent time spent in sedentary, light, moderate, and vigorous intensity physical activity.

Implementation measures (i.e. feasibility, acceptability, and fidelity) are reported elsewhere. Briefly however, research assistants responded to questions on a daily implementation for to assess to assess components of fidelity and acceptability. Also, fidelity (dosage) was measured once a week (i.e., a subsample of participants wore accelerometers and heart rate monitors during recess to assess their physical activity intensity). Additional acceptability measures from a post-intervention survey was completed by participants and school staff.

Data Analysis

Overall sample and between group descriptive statistics were calculated. Baseline between group differences were assessed with independent samples *t* tests (continuous variables) or chi square tests (categorical variables). To assess the relative benefits of the SMART Recess program (intervention group vs. control) with respect to change over time in executive control (inhibition/attention and working memory scores), classroom behavior (percent of observed intervals for engaged and off-task behaviors), fitness (PACER and muscular fitness scores), and physical activity (percent time spent in moderate to vigorous physical activity), we used ANCOVA models adjusted for baseline scores and age. Other covariates that were significantly correlated with the outcome variable were entered in the models. To compare the mean percentage of time spent in moderate to vigorous physical activity during recess, an independent samples *t* test was used. To assess inter-rater reliability of the BOSS observations, the average percent agreement of double coded observations was calculated. Alpha level was set at $P < 0.05$ and analyses were completed in Stata (Stata 15.1, College Station, TX).

Results

Consent and assent documents were completed in 54 participants (intervention, n = 27; control, n = 27). In the intervention school, two students were lost to follow-up during post-intervention measurements (one due to travel and the other due to illness).

Seven participants were lost to follow-up at the control school prior to post-measures (one due to travel with the remaining due to loss of interest in study participation). Therefore, the overall study sample size was 53 (intervention, n = 27; control, n = 26). Baseline demographic variables are presented for enrolled participants in Table 17 (page 123). Significant baseline differences were observed in age and percentage with a diagnosed disorder. Four students in the intervention school had diagnosed disorders (Autism, n = 2; ADHD, n = 1, and neurological dysfunction due to Lyme's disease, n = 1), whereas no students in the control school had reported disorders. At baseline, control school participants had significantly higher inhibition scores compared to the intervention school participants (7.8 ± 0.2 versus 6.9 ± 0.2; $P = 0.001$). A significant difference in racial categories was also observed between the two schools. No other significant baseline differences were observed. Although most missing executive control data at post-test (n = 12 for inhibition and n = 17 for working memory) was due to refusal, some data were not collected due to extended school absences of participants due to illness (n = 1), travel (n = 1), or iPad malfunction (n = 2).

Due to diagnosed developmental disorders or the presence of an IEP (intervention, n = 5; control, n = 1), six participants were excluded from the executive control analyses. Adjusted post-intervention means and ANCOVA results are presented in Table 18 (page 124). All ANCOVA models were adjusted for baseline scores and age. Inhibition models were also adjusted for BMI percentile, cardiorespiratory fitness was also adjusted for sex, and physical activity was further adjusted for sex and BMI percentile. Overall, there were no significant differences in adjusted mean post-intervention scores between schools for either executive control variables (i.e., inhibition/attention and working memory). Between group differences in post-intervention adjusted mean inhibition and working memory scores was 0.08 ± 0.26 [F(1,26) = 0.11, P = 0.74, ω^2_p = -0.03] and 1.06 ± 1.11 [F(1,19) = 0.92, P = 0.35, ω^2_p = -0.004], respectively.

Forty-three students were observed for classroom behavior. Although most students were observed twice, due to time limitations and student absences some were only observed once (intervention, baseline n = 4, post n = 5; control, post n = 3). Among the double-coded observations, the average percent agreement was 57. In both groups, participants had a decrease in percent of observed intervals in engaged behaviors from baseline to post, a decrease in percent of observed intervals in motor-off task and passive off-task behaviors, and an increase in percent of observed intervals in verbal off-task behavior. However, there were no significant group by visit interactions in any classroom behavior outcomes.

A total of 22 participants [baseline, n = 13 (intervention, n = 9; control, n = 4); post, n = 9 (intervention, n = 5; control, n = 4)] did not complete all of the movements included in the muscular fitness battery, so an average was calculated based on the movements completed. The control group had slightly higher mean scores at post-intervention compared to the intervention group in both PACER and muscular fitness scores, but neither of these differences were significant. No significant between group difference was observed in total daily moderate to vigorous physical activity.

Among the intervention participants, the attendance rate was 19.4% (ranging from 0 to 95.6%). The average percent time spent in moderate-to-vigorous physical activity during recess sessions was significantly higher in the intervention group (41.7 ± 2.1%), compared to the control group (30.4 ± 0.2, $P < 0.001$). Responses in the post-intervention survey indicated that although the intervention was enjoyed by the students, they did not favor giving up recess time to complete the study measurements.

Discussion

Despite the potential impact on cognition and academic performance, training modalities targeting muscular fitness have rarely been examined in children, and are seldom used regularly in school-based physical activity programs. The majority of previous studies examining physical activity and academic performance have been implemented as classroom breaks, active learning lessons, enhanced physical education, or after-school programs and have not utilized the recess period. The purpose of this study was to evaluate the initial efficacy of a combined fitness intervention offered during elementary school recess on academic and fitness outcomes. In the present study, although the intervention school participants increased their percent of time spent in moderate to vigorous physical activity during the recess intervention, we did not observe significant effects of the SMART Recess intervention on academic-related, fitness, or total day physical activity outcomes. Although some process evaluation measures demonstrated that the SMART intervention was acceptable and enjoyed by the students, other measures (i.e., the low attendance rate in particular) indicated that there was a major concern with compliance (i.e., attendance) of the intended intervention dose, which obscured our ability to investigate the effects of the physical activity intervention on cognitive and academic outcomes.

Previous fitness interventions that have observed positive effects on academic related outcomes have generally reported strong compliance among the participants or limited the analysis to students with adequate attendance (2). Therefore, we strongly speculate that the low attendance rate in the present study contributed to the lack of significant intervention benefits. Although the physical activity intensity during intervention sessions was potentially sufficient to elicit changes in fitness, physical activity intensity was only measured in a subsample of participants. The subsample of participants that agreed to wear the monitors each week consisted of the students that participated more regularly (average attendance rate of 40.3%) and may not be representative of the intensity and exposure of all participants. Furthermore, the majority of the students enrolled in the study did not regularly participate in the intervention and the overall attendance rate was under 40%. Therefore, most of the study participants were not exposed to the intended intervention dose. In a 2011 review of physical activity and fitness interventions among youth, Kriemler et al. (241) suggested that compliance is one of the most critical factors in the effort to improve cardiorespiratory fitness through school-based programs, and therefore programs that are mandatory are more likely to report significant improvements.

In addition to compliance issues, other factors may have also contributed to our null findings. First, there was the possibility of potential misclassification of classroom behaviors due to our low agreement between observers compared to other research studies. For example, in a classroom observation study in children also using the BOSS tool, Du Paul et al. (231) reported an inter-rater reliability range of 91.5 to 99.2%, compared with the 57% agreement among our observers. Second, the level of missing data in our control group at post-intervention (due to loss to follow-up and measurement refusal) is a concern. The high amount of missing data may be related to our decision not to offer an attention matched or alternative intervention for the control school, as researchers were able to spend more time with intervention participants and potentially develop stronger interpersonal connections with those students. Although we selected a traditional control condition because alternative programs could also potentially impact cognition, some researchers have reported a greater loss to follow-up with control groups that are not matched for attention (237).

Among experimental studies, few have used recess as the setting to examine cognitive outcomes (33). In one study that was similar to ours, van der Niet (33) examined the effects of a combined fitness intervention during school recess twice per week for 8 weeks in elementary school age children (n = 105, aged 8 to 12 years). In contrast to the control group, their intervention elicited improvements in working memory and inhibition (without a significant improvement in fitness measures) in the intervention group. Compared to the current pilot study, the study by van der Niet had better compliance with the intervention protocol as only participants that attended at least 80% of the sessions (n = 47 out of 53, or 88.7% compliance rate) were included in the analysis. It is not clear if the van der Niet intervention was mandatory (i.e., all students enrolled in that school were required to participate in the program), which would have contributed to their intervention compliance. Also, their study took place in the Netherlands, where in addition to the two extra weekly physical activity sessions that were implemented during recess periods, students also received two physical education sessions per week as part of the regular academic curriculum. Therefore, their students may have received a greater exposure to school-based physical activity which could have contributed to their positive findings.

Of the limited studies that have examined recess-based physical activity interventions on classroom behavior, the findings have been generally positive (13). In one observational study that examined the relationship between receiving school recess and classroom behavior of third grade students (n = 15,305), researchers reported that recess frequency was positively associated with teacher reported student classroom behavior (212). Pellegrini et al. (46) reported that general classroom attention was better in elementary school children after 30 minutes of outdoor recess and Jarrett et al. (45) found that recess breaks enhanced on-task time in students (n = 43). These studies were comparing the inclusion of recess versus no recess, whereas the current study examined traditional recess (i.e., unstructured free play) versus a structured program. It is possible that in the current pilot study because the participants in both schools were already physically active during recess at baseline, the increase in intensity derived from the intervention may not have been sufficient to alter behavior outcomes. Intensity of physical activity during recess was not formally collected in the two previous studies which makes it challenging to compare the dosage of physical activity to the intensity level observed in our study.

A few other experimental studies have also examined the effect of physical activity programs offered during recess on classroom behavior. Among these, some have utilized the Playworks intervention. Playworks (a game-based curriculum) is a comparable intervention to SMART Recess in that it also offered structured recess activities in the form of inclusive games. In one cluster-randomized controlled trial (n =

25 schools), the Playworks program was implemented during recess over one school year in the treatment schools and researchers observed improvements in classroom behavior (i.e., attention), compared to the control schools (242). However, classroom behavior was reported by teachers and therefore the data may have been prone to reporter bias. Beyler et al. (239) also reported that teacher reported physical activity significantly increased among students randomized to the Playworks program during recess compared to control students. However, accelerometer data (more objective data than proxy report by teachers) worn by the students (n = 1,537 fourth and fifth graders) demonstrated smaller effects. In the Playworks studies, it appears that all students were exposed to the program and participated regularly), which may explain the differences in their findings (i.e., significant effects on classroom behavior) relative to the current study.

A strength of our pilot study is the inclusion of an objective measurement of physical activity both during the intervention and outside of the intervention sessions. Many previous interventions studies did not measure physical activity outside of their intervention program, so it is possible that outside factors (e.g., participation in youth sports or other physical activities at home) contributed to effects on academic related outcomes (2). Also, process evaluation data indicated that the SMART Recess program was acceptable and enjoyed by students who did participate. However, there are some important limitations to note. First, in addition to the intervention exposure concern already discussed, there was a concern with missing data at post-intervention (i.e., inhibition/attention, working memory, and muscular fitness), mainly due to refusal to complete measurements during recess periods. Second, our classroom observation inter-rater agreement was lower than what has been reported by other researchers. Therefore, it is possible that some behaviors in our pilot study were misclassified. Additional training of research staff in future studies may be needed to increase our inter-rater reliability for this measurement tool. Finally, although we mostly used validated tools for measurements, many of these were tested in controlled settings. We conducted our measures in a field setting (an uncontrolled environment with competing stimuli and variable weather conditions) where validity and reliability may have been impacted (241). Future research into the validity and reliability of these instruments in field settings is warranted.

Implications for School Health

This pilot study demonstrated some preliminary support that offering a structured fitness program is feasible and can increase percent time spent in moderate to vigorous physical activity during recess. However, to more accurately assess if this type of fitness program would benefit cognition, classroom behavior, total day physical activity, and fitness, the overall exposure would need to increase. Future research is still warranted to determine if a combined fitness program can impact such outcomes if fidelity (specifically dosage) is higher. To do this, schools may want to consider offering it to all students or implementing it during a time that does not take away from free play (e.g., before-school or during a transition time in the school day). Schools that are concerned with student physical activity levels, (e.g., due to less recess space, student motivation, or activity resources) may benefit from the physical activity opportunities and inclusive activities of the SMART Recess program.

Human Subjects Approval Statement

The University of Massachusetts Amherst Institutional Review Board approved all protocols followed in this study (protocol ID: 2017-4260).

Table 16. Example of a weekly SMART Recess session plan.

WEEK 6 (BLOCK 2)					
	Monday	Tuesday	Wednesday	Thursday	Friday
Warm-Up: Three movements (e.g., full arm circles, straight leg kicks, and jumping Jacks) and were selected and performed for two rounds each (i.e., 3 rounds of about 20 seconds each for a total of 2 minutes).					
Movement of the Day: Students practiced at least one 30-second round of the new movement after it was demonstrated and explained (2 minutes).					
Strength Movement	V sit tucks	Band/ball upright row	Ball squat	Band high back row	Side Bear Crawl
Group Activity: 11 minutes					
Activity/Game	Strength Tag (O) or Simon Says (I)	Roll the Dice (O and I)	Builders and Bulldozers (O) or Telephone (I)	Drop the Cookie (O) or Heads Up (I)	Participant Choice

Abbreviations: O = outdoor recess; I = indoor recess

Table 17. Baseline demographic characteristics of participants in the two schools.

Variable	Intervention School (n = 27)	Control School (n = 26)	*P*-value
Age (years)	8.8 ± 0.1	9.4 ± 0.1	0.0002*
Sex (% male)	66.7%	42.3%	0.08
BMI percentile	60.6 ± 6.0	64.0 ± 6.0	0.69
BMI category			
Healthy weight	66.7%	65.2%	0.99
Underweight	3.7%	4.4%	
Overweight/Obese	29.6%	30.4%	
Race			
Caucasian	63.0%	35.0%	0.03*
Asian	18.5%	10.0%	
Latino/Hispanic	11.1%	50.0%	
Black/African American	7.4%	5.0%	
Annual Household Income			
$0 - $19,999	11.1%	11.8%	0.30
$20,000-$39,999	11.1%	11.8%	
$40,000-$59,999	0%	17.6%	
$60,000 or more	77.8%	58.8%	
Diagnosed developmental disorder (% yes)	22.2%	0%	0.03*
Individualized education plan (% yes)	27.8%	5.0%	0.06

Note: Values are expressed as Mean ± SD or %. Between group differences were analyzed with independent samples *t* tests for continuous variables and chi square tests for categorical variables.
*$P < 0.05$

Table 18. Baseline means and adjusted post-intervention means from ANCOVA models.

	Intervention School		Control School		*P*-value
	Baseline	Adjusted Post	Baseline	Adjusted Post	
Executive Functions					
Inhibition/attention (score)	6.9 ± 0.9	7.7 ± 0.1	7.9 ± 0.7	7.6 ± 0.2	0.74
Working memory (score)	14.8 ± 2.8	16.8 ± 0.6	15.6 ± 2.5	15.8 ± 0.9	0.35
Classroom Behavior					
Active engaged (%)	35.1 ± 19.1	26.8 ± 4.3	33.9 ± 20.0	27.6 ± 5.6	0.92
Passive engaged (%)	35.6 ± 19.6	43.2 ± 4.1	21.2 ± 20.1	47.6 ± 5.4	0.55
Motor off task (%)	20.3 ± 18.4	25.0 ± 3.5	24.2 ± 11.6	19.7 ± 4.5	0.40
Verbal off task (%)	13.4 ± 12.1	11.3 ± 2.5	16.3 ± 9.3	16.6 ± 3.2	0.24
Passive off task (%)	9.3 ± 5.3	14.0 ± 2.4	12.7 ± 11.7	9.7 ± 3.1	0.33
Fitness					
PACER (completed laps)	19.7 ± 13.3	9.2 ± 1.9	12.9 ± 3.9	13.9 ± 2.2	0.15
Muscular fitness (score)	15.7 ± 3.1	19.1 ± 1.1	16.6 ± 5.2	22.1 ± 1.7	0.17
Physical Activity					
Total day time spent in MVPA (%)	6.4 ± 2.8	6.7 ± 2.8	6.1 ± 2.6	6.3 ± 1.1	0.62

Note: Values are presented as means ± standard deviation (baseline) or standard error (adjusted post). Post means are adjusted for baseline and age (working memory, all classroom behavior variables, and muscular fitness), baseline, age and BMI percentile (inhibition), baseline, age, and sex (PACER), or baseline, age, sex, and BMI percentile (MVPA).

Abbreviations: PACER = progressive aerobic cardiovascular endurance run; MVPA = moderate-to-vigorous physical activity

CHAPTER 5

CONCLUSION

Summary of Results

The purpose of this dissertation project was to evaluate the feasibility, acceptability, and preliminary efficacy of a 3-month recess-based combined fitness intervention on cognition and academic performance in elementary school-age children, compared to a control condition. The primary research aim (examining the feasibility and acceptability of the SMART Recess intervention) provided some preliminary supportive evidence for the program and some study design aspects. Recruitment, retention, and some fidelity goals were met. Adherence was adequate during the intervention sessions based on heart rate data (average maximal heart rate: 58.0 ± 5.8%). The level of implementation (88% of sessions), percentage of sessions implemented as planned (78% of sessions), and level of intervention leader encouragement (100% of sessions) were high. However, other fidelity outcomes did not meet the hypothesized targets. Adherence during the intervention sessions based on accelerometer data (% of session time spent in moderate-to-vigorous activity: 41.7 ± 14.5%) and actual total intervention dosage (physical activity received, 19.4% attendance rate) were lower than expected. The variability in acceptability outcomes demonstrated both positive support for the intervention (i.e., high degree of student enjoyment and teacher and student satisfaction) and areas that need improvement (i.e., attendance and participation rates in both intervention sessions and measurements).

The secondary aims of the project involved the examination of the preliminary efficacy of the SMART Recess intervention on academic outcomes, fitness, and physical activity. The SMART Recess intervention did not impact inhibition/attention, working memory, classroom behaviors, cardiorespiratory fitness, muscular fitness, or moderate to vigorous physical activity. We were unable to examine the effect of the intervention on academic achievement due to challenges comparing the academic progress reports provided by the treatment and control schools. Although we did eventually receive progress reports from both schools for mathematics at both measurement time points, the scores that were provided were presented differently and therefore, were not comparable between the two schools. More specifically, the intervention school provided raw and adjusted scores for various mathematic progress report measures, but the control group provided just the percentile scores. The control school also did not provide progress report data for reading.

Significance

This project served as a preliminary investigation to determine if a recess-based combined fitness intervention was feasible and acceptable to elementary school students and to examine the preliminary efficacy on improving aspects of their cognition, classroom behavior, fitness, and physical activity. Our findings provided some support for the feasibility and acceptability of recess as a potential setting for a fitness program and the SMART Recess intervention. However, although students enjoyed the program, the low overall participation rates resulted in a lower received dose of cardiorespiratory and muscular fitness than designed. Furthermore, we faced challenges in completing measurements during the recess period (i.e., competition with alternative recess activities and conducting measures in an uncontrolled environment with competing stimuli). These factors contributed to our inability to accurately assess the efficacy of the program on our secondary outcomes. Important “lessons learned” (i.e., unexpected study limitations and barriers) were gained from the completion of this project that can inform future research and are highlighted in the following section; however, the implementation issues obscured our ability to determine the relationship between a recess-delivered physical activity intervention on cognitive and academic outcomes.

Challenges and Limitations

There were some study challenges and limitations of this dissertation project that should be noted. The first two challenges were related to research team training. An unexpected challenge that was identified early on in the project was the need for further training of the research staff on the intervention implementation. Specifically, it became apparent that the research team needed further training on how to perform and teach the fitness movements to elementary school-age children. Although this concern could be remedied with utilizing volunteers already experienced in fitness instruction to lead the program, acknowledging this barrier was important as it suggested that sustainability of the intervention in its current state may be limited if it is not easy to implement. The study's primary investigator intervened early to lead and then assist with many of the intervention sessions during the first three weeks of the study. This "train the trainer" model appeared to work well and is recommended for the training of future SMART Recess leaders. Second, our inter-rater reliability of the classroom observations was not strong (57%). Other studies that have used this tool to assess classroom behavior have reported greater percentages of agreement between observers. Although classroom observers were trained specifically for this data collection category in our project, additional time (i.e., more practice trials), as well as experience coding real-life classrooms (i.e., rather than videos) may be needed to improve the consistency of coding between researchers. One method used by other pediatric researchers is to practice observations in the real school setting until an a priori agreement percentage is met among observers.

Some limitations and challenges of this project related specifically to data collection and measurement conditions during the recess period. One major barrier that was identified was the challenge to acquire students' agreement to complete the measures during the recess period. Process evaluation data indicated that many of the students expressed that they did not object to completing the measurements, but that they did not want to give up recess time to do so. Another limitation was that the research staff that served as data collectors were not blinded to the treatment assignments, which could have created a potential bias during data collection, particularly in the responses to the subjective semi-structured questions of the daily implementation form. Given that process evaluation measures were collected during the intervention sessions, blinding of the data collectors would not have been feasible. However, the data collectors were not involved in the implementation of the intervention and were provided with detailed training to attempt to reduce any potential bias and enhance objective responses. Another possible limitation is that all of our secondary outcome measurements were assessed in the field, in uncontrolled environments. For example, cognition measures were often conducted seated on the floor in school hallways or in general outside spaces at recess with children playing nearby. Although we tried to reduce distractions, we cannot rule out that competing stimuli and variability in testing settings could have impacted the secondary outcome measures. Given these two concerns with the recess period, it may be warranted for future studies to collaborate with the school administrators and teachers to find a time, such as during the start of the school day, to conduct study assessments.

Other limitations of the project relate to participation. First, the post-intervention response rate from the teachers was low. Although the feedback was positive, it is possible that other third and fourth grade school teachers and staff (i.e., those that did not complete the post-intervention survey) may have had other perceptions or feedback to share about the program that would be useful to us. In the future, researchers may want to seek their opinions sooner (e.g., at midpoint) and/or in person. Second, although most students participated in the program at one point during the study, the lack of consistent attendance was a concern and as mentioned before, contributed strongly to the dosage received (specifically the frequency). One possible modification to address this is to offer the program two or three days per week, rather than daily, so that regular recess free play (where students can choose what activities they like play) is provided on some days. This way we are not competing with free play every day.

Future Directions

The intervention implementation and process evaluation measures analyzed in this project provided us with valuable information for future research. In addition to potential future directions discussed above, other considerations may be warranted.

Before continuing to examine the preliminary efficacy of a combined fitness intervention (revised based on data from this project) in a recess setting, it may be practical for researchers to examine the combined fitness intervention in an alternate school- or community-based setting. These settings have demonstrated sufficient attendance and participation in previous studies and therefore, if the intervention dosage is higher we could potentially examine the efficacy of the SMART Recess program on academic related outcomes. Researchers could also compare a cardiorespiratory fitness, a combined fitness program, and a control condition to tease out if there is a similar or added benefit of adding muscular fitness to a youth program on cognitive and academic outcomes, in any school-based setting. These next steps, in addition to the data obtained from this project, can be used to refine the SMART Recess intervention so future research can continue to assess the effectiveness and sustainability of this program.

Conclusion

This project examined novel research questions by addressing a few important research limitations about the relationships between physical activity and academic-related outcomes. We evaluated the potential benefits of enhancing physical activity and fitness opportunities during recess with the goal of improving academic and health-related fitness components. The findings from the implementation evaluation will allow us to make important adjustments to the SMART Recess program and inform future research or school programming. The project provided preliminary evidence regarding the feasibility and acceptability of the SMART Recess intervention from many implementation and process evaluation measures. However, other factors relating to implementation (e.g., methods to improve attendance to enhance the dosage received) should be targeted and studied so we can more effectively examine the efficacy of a recess-based combined fitness program on academic related outcomes.

APPENDIX 1

PARENT INFORMED CONSENT

University of Massachusetts Amherst

PARENT INFORMED CONSENT FORM

Strong Minds with Aerobic and Resistance Training during Recess (SMART Recess) Pilot Study

FOR QUESTIONS ABOUT THIS STUDY, CONTACT:

Christine St. Laurent, M.S.
University of Massachusetts Amherst
Department of Kinesiology
Totman Building, Room 110
30 Eastman Lane
Amherst, MA 01003
(413) 545-6104

WHAT IS THIS FORM?

The Informed Consent form will provide you with the information you will need to understand why this study is being done and explain the involvement of you as the parent or guardian of a child participating in this study. It will also describe what you will need to do in order for your child to participate, as well as any known risks, inconveniences, or discomforts that you may have while participating. We encourage you to take some time to think this over and ask any questions now, and at any time. If you decide to participate in this study, you will be asked to sign this form and you will be given a copy for your records.

PURPOSE OF THE RESEARCH PROJECT

You are invited to participate in a study designed to examine the feasibility, acceptability, and efficacy of a structured program fitness (a physical activity program targeting aerobic and muscular fitness) offered during school recess on the cognition and academic performance of elementary school-aged children. We hope to learn if a combined fitness program can be successfully implemented during school recess and if students will enjoy participating in such a program. We also hope to learn if this type of program can impact academic performance, such as progress report scores (data from the academic assessment program that Amherst-Pelham Regional Public Schools use), cognition, and classroom behavior in students.

ELIGIBILITY

To participate in the parent/guardian portion of this study, you must be the parent or guardian of a 3rd or 4th grade student that attends Fort River Elementary School or Crocker Farm Elementary School. As part of this study, the two elementary schools will be randomly assigned to either the recess intervention or be asked to keep their usual recess program. If your child is in either the 3rd or 4th grade at the school that will receive the recess intervention during the study period, he or she may participate in the daily recess combined fitness program. However, only children that have completed parental permission, informed consent, and assent forms will participate in the measurement portion of this study.

STUDY LOCATION AND DURATION OF INVOLVEMENT

The parent/guardian portion of this study will involve the completion of one baseline questionnaire at the beginning of the study. This questionnaire will take approximately 5 to 10 minutes to complete. The questionnaire will be available online and be completed remotely. If you prefer not to complete the questionnaire online, we can provide you a paper copy of the baseline questionnaire for you to complete.

WHAT WILL I BE ASKED TO DO?

If you decide to participate in the study, you will be asked to complete a brief online questionnaire to provide some basic demographic and background information about your child and your family. You will also be asked to remind your child to wear his/her activity monitor and track when he/she takes it on and off during the three measurement weeks of the study. (The Parent Permission for Minor to Participate in Research form describes what your child will be asked to do for this study.)

BENEFITS OF PARTICIPATING IN THIS STUDY

There are no anticipated benefits to you as a parent or guardian for your participation in this study. However, a list of anticipated benefits to your child is included in the Parent Permission for Minor to Participate in Research form.

RISKS OF PARTICIPATING IN THIS STUDY

No risks are expected for your participation in this study.

ALTERNATIVES

The only alternative to being a part of this study is not to participate. If you and your child choose not to participate in the study, your child may still participate in the recess program when it is offered at his or her school.

PROTECTION OF PERSONAL INFORMATION

The following procedures will be used to protect the confidentiality of your study information. The information obtained from this study will be treated as privileged and confidential. Each participant will be assigned a numerical identification (ID) number at the beginning of the study and all data will be identified by ID number only. The link between the participant's name and ID number will be kept as a hard copy in a locked file cabinet in the secure Pediatric Physical Activity Laboratory in the Department of Kinesiology at UMass Amherst. Study surveys and data collection forms will only have the participants' study ID, and no names will be on these documents. Any information linking your name to your ID number will be destroyed at the completion of the study data analysis. There could be a possibility of data breach. However, the research team will make every effort to maintain the confidentiality of all data. There is one exception to confidentiality we need to make you aware of. In certain research studies, it is our ethical responsibility to report situations of child abuse, child neglect, or any life-threatening situation to appropriate authorities. However, we are not seeking this type of information in our study nor will you be asked questions about these issues. For more information on this policy visit http://www.umass.edu/research/guidance/mandatory-reporting.

STUDY INCENTIVE

Financial compensation will not be provided for participation in this study. However, if your child participates in both baseline and post-assessments (and completes at least half of the measurements at each time point), he or she will be given a t-shirt at the end of the study.

MEDICAL TREATMENT

The University of Massachusetts Amherst does not have a program for compensating subjects for injury or complications related to human subjects research. In the unlikely event of injury resulting directly from participating in this study, researchers will assist you in every way to make sure you get proper medical attention.

WHAT IF I HAVE QUESTIONS?

We encourage you to take as long as you like before you make a decision about your participation in this study. If you have further questions about this project or you have a research related problem, you may contact the faculty sponsor, Dr. Sofiya Alhassan at 413-545-3475 or alhassan@kin.umass.edu, or the primary investigator, Ms. Christine St. Laurent at 413-545-6104 or cstlaurent@umass.edu. If you have questions regarding your rights as a research participant, you may contact the University of Massachusetts

Participant Initials: ______

Amherst Human Research Protection Office (HRPO) at 413-545-3428 or humansubjects@ora.umass.edu.

CAN I WITHDRAW FROM THE STUDY?

You do not have to be in this study if you not want to. If you agree to be in the study, but later change your mind, you may drop out at any time. There are no penalties or consequences of any kind if you decide not to participate. The research staff may also withdraw you from the study without your permission for one or more of the following reasons:

- Failure to follow the instructions of the research staff
- The study is canceled, other administrative reasons or unanticipated circumstances

Participant Initials: ______

PARTICIPANT STATEMENT OF VOLUNTARY CONSENT

When signing this form, I am agreeing to voluntarily enter this study. I have had a chance to read this consent form, and it was explained to me in a language which I use and understand. I have had the opportunity to ask questions and have received satisfactory answers. I understand that I can withdraw myself and my child at any time. A copy of this Informed Consent form has been given to me.

____

Parent/Legal Guardian Name (Print)

____ ______________

Parent/Legal Guardian Signature Date

____

Child's Name (Print)

By signing below, I indicate that the participant has read and, to the best of my knowledge, understands the details contained in this document and has been given a copy.

____

Study Representative's Name (Print)

____ ______________

Study Representative's Signature Date

Participant Initials: ______

APPENDIX 2

PARENT PERMISSION FORM

University of Massachusetts Amherst

PARENT PERMISSION FOR MINOR TO PARTICIPATE IN RESEARCH

Strong Minds with Aerobic and Resistance Training during Recess (SMART Recess) Pilot Study

FOR QUESTIONS ABOUT THIS STUDY, CONTACT:

Christine St. Laurent, M.S.
University of Massachusetts Amherst
Department of Kinesiology
Totman Building, Room 110
30 Eastman Lane
Amherst, MA 01003
(413) 545-6104

WHAT IS THIS FORM?

This Parental Permission form will give you the information you will need to understand why this study is being done and why your child is being invited to participate. It will also describe what your child will need to do to participate and any known risks, inconveniences or discomforts that your child may have while participating. We encourage you to take some time to think this over and ask questions now and at any other time. If you decide to participate, you will be asked to sign this form and you will be given a copy for your records.

PURPOSE OF THE RESEARCH PROJECT

Your child is invited to participate in a study designed to examine the feasibility, acceptability, and efficacy of a structured fitness program (a physical activity program that targets aerobic and muscular fitness) offered during school recess on the cognition and academic performance of elementary school children. We hope to learn if a combined fitness program can be successfully implemented during school recess and if it is well received by students. We also hope to learn if this type of program can change academic performance related factors in students.

ELIGIBILITY

To participate in this study, your child must be in third or fourth grade at either Fort River Elementary School or Crocker Farm Elementary School.

STUDY LOCATION AND DURATION OF INVOLVEMENT

This study will take place at your child's school, during your child's regularly scheduled recess period. Your child's involvement in this study will last for up to 18 weeks. Baseline measurements will be assessed within a three-week period prior to the start of the intervention. The intervention period will then last 15 weeks. Your child will be asked to wear a small activity monitor on his or her waist every day for 7 days during weeks at the beginning, middle, and end of the study. If your child is in the SMART Recess program, your child's participation in the program is expected to last for approximately 1 hour 15 minutes per week (15 minutes during each daily recess session).

WHAT WILL MY CHILD BE ASKED TO DO?

Randomization

Two schools are participating in this study. Prior to the start of the study, one school will be randomized to the SMART Recess program and one school will be randomized to the Health and Academic Tracking program (see "Programs" section for more information about these programs).

Baseline Measurements:

If you decide to have your child participate in the study, your child will be asked to complete the following steps.

The first thing that your child will do is to complete baseline measures in the three weeks prior to the start of his/her school's assigned program. These measures will be conducted during three of your child's recess sessions and will include the following:

1. Resting physical measures - A research staff member will measure your child's height and weight.

2. Psychological survey - Your child will be asked a series of questions relating to his/her feelings and attitudes towards school, his or herself, and physical activity. This will take your child approximately 10 minutes to complete.

3. Cognition tests – Your child will complete two tasks on an iPad application to assess two executive functions (inhibition and working memory). Each test will take approximately 15 minutes to complete. To measure inhibition, your child will be asked to complete a Flanker test. For each trial, a series of five arrows will be presented on the screen and your child will be asked to pay attention to the middle arrow. Two arrows will be then appear at the bottom of the screen (one pointing right and one pointing left) and your child will be asked to select the option that matches the direction of the middle arrow as quickly as possible. To measure working memory, your child will be asked to complete a List Sorting test. For each trial, a series of food items or animals (or both) will be presented on the screen and then removed. Your child will then be asked to recall the items that appeared on the screen and place them in order from smallest to largest.

4. Physical activity levels - Your child will be asked to wear a small beeper-sized motion sensor on a belt around his/her waist to measure his/her activity for one week at the start of the study (at school and at home).

5. Physical fitness measures - Your child will be asked to complete a series of brief fitness assessments at baseline, similar to those completed in a physical education program, to measure his or her aerobic and muscular fitness. To measure aerobic fitness, your child will be asked to complete a shuttle run test. Your child will be asked to run between two cones placed 20 meters apart, back and forth until he or she can no longer keep up with the target pace. To measure muscular fitness, your child will be asked to perform seven different exercises such as a squat and push-up. For each exercise, your child will be asked to perform as many repetitions as they can correctly and safely in 30 seconds.

6. Classroom observation – A researcher will observe the classroom behavior of students in your child's class (on two separate days) following his or her recess period to observe on- and off-task behavior. The researcher will quietly observe several children in the classroom, thus your child will only be observed for a few minutes (10 min). The researcher will be observing on- and off-task time during normal classroom activities. No other information will be collected.

Programs:

Depending on your child's school, he/she will either participate in the SMART Recess program or the Health and Academic Tracking program for 15 weeks.

1. If your child is in the SMART Recess program, he or she will be asked to participate in a combined fitness program during the first 15 minutes of daily school recess sessions for 15 weeks. Members of our research team will lead these sessions. The program will include aerobic and muscle-strengthening activities and cooperative games to promote fitness and increase physical activity during recess. If your child is in the SMART Recess program, his or her heart rate may be measured during two to three random recess sessions throughout the study. Heart rate will be measured with a monitor worn on the wrist (similar to a watch).

2. If your child is in the Health and Academic Tracking program, he or she will continue to participate in their usual in-school and recess activities for 15 weeks. Children of this program will be offered a chance to participate in the SMART Recess program in the Fall of 2018. No additional data will be collected at that time.

3. Children in both programs will be asked to wear activity monitors during some recess sessions.

Mid-point Measurements:

Halfway through the study (between weeks 7 and 8 of the intervention), your child will again be asked to wear the activity monitor at home and at school for one week (same as baseline).

Post-Measurements:

During the last week of the intervention, your child will be asked to repeat all of the baseline measurements.

RELEASE OF ACADEMIC PROGRESS INFORMATION

To examine the association between academic performance and physical activity and physical fitness, our research staff will collect some information about your child's current mathematics, reading, and language arts skills from the school's academic progress program (achievement and proficiency scores) in the winter and spring (at the beginning and end of the study). Similar to the other measures listed above, we will only collect information on your child if you sign this form.

BENEFITS OF PARTICIPATING IN THIS STUDY

We cannot and do not guarantee or promise that your child will receive any benefits from this study. There may be not be a direct benefit to your child participating in this study. Potential benefits of participating in this study include the possibility of improved physical activity and fitness levels. All participants will learn several new recess movements and activities that they can continue to utilize after the completion of the intervention.

RISKS OF PARTICIPATING IN THIS STUDY

The elastic belts and rubber wrist bands used to secure the activity motion sensor and heart rate monitor in place may rub on your child's skin and become uncomfortable. No skin damage should result from this and the discomfort level is minimal.

If your child is in the SMART Recess program, he or she may be at risk for injury related to physical activity during the recess intervention used in this study. This risk is no greater than the risk your child experiences during usual school recess. The intensity of these sessions will be no greater than his/her regular school physical education classes.

ALTERNATIVES

The only alternative to being a part of this study is not to participate. If you and your child choose not to participate in the study, your child may still participate in the recess program when it is offered at his or her school.

PROTECTION OF PERSONAL INFORMATION

The following procedures will be used to protect the confidentiality of your child's study information. The information obtained from this study will be treated as privileged and confidential. Each participant will be assigned a numerical identification (ID) number at the beginning of the study and all data will be identified by ID number only. The link between the participant's name and ID number will be kept as a hard copy in a locked file cabinet in the secure Pediatric Physical Activity Laboratory in the Department of Kinesiology at UMass Amherst. Study surveys and data collection forms will only have the participants' study ID, and no names will be on these documents. Any information linking your child's name to his/her ID number will be destroyed at the completion of the study data analysis. There could be a possibility of data breach. However, the research team will make every effort to maintain the confidentiality of all data. There is one exception to confidentiality we need to make you aware of. In certain research studies, it is our ethical responsibility to report situations of child abuse, child neglect, or any life-threatening situation to appropriate authorities. However, we are not seeking this type of information in our study nor will you be asked questions about these issues. For more information on this policy visit http://www.umass.edu/research/guidance/mandatory-reporting.

STUDY INCENTIVE

Financial compensation will not be provided for participation in this study. However, student participants that participate in both baseline and post-assessments (and complete at least half of the measurements at each time point) will be given t-shirts at the end of the study.

MEDICAL TREATMENT

The University of Massachusetts Amherst does not have a program for compensating subjects for injury or complications related to human subjects research. In the unlikely event of injury resulting directly from participating in this study, researchers will assist you and your child in every way to make sure your child gets proper medical attention.

WHAT IF I HAVE QUESTIONS?

We encourage you to take as long as you like before you make a decision about your child participating in this study. If you have further questions about this project or you have a research related problem, you may contact the faculty sponsor, Dr. Sofiya Alhassan at 413-545-3475 or alhassan@kin.umass.edu, or the primary investigator, Ms. Christine St. Laurent at 413-545-6104 or cstlaurent@umass.edu. If you have questions regarding your child's rights as a research participant, you may contact the University of Massachusetts Amherst Human Research Protection Office (HRPO) at 413-545-3428 or humansubjects@ora.umass.edu.

CAN I WITHDRAW FROM THE STUDY?

Your child does not have to be in this study if he/she does not want to. If he/she agrees to be in the study, but later changes his/her mind, he/she may drop out at any time. There are no penalties or consequences of any kind if he/she decides not to participate. The research staff may also withdraw your child from the study without your permission for one or more of the following reasons:

- Failure to follow the instructions of the research staff
- The research staff decides that continuing your child's participating could be harmful to your child
- The study is canceled, other administrative reasons or unanticipated circumstances

PARTICIPANT STATEMENT OF VOLUNTARY CONSENT

When signing this form, I am agreeing to voluntarily enter this study. I have had a chance to read this parent permission form, and it was explained to me in a language which I use and understand. I have had the opportunity to ask questions and have received satisfactory answers. I understand that I can withdraw myself and my child at any time. A copy of this Parent Permission form has been given to me.

Please select one of the following statements:

____ I agree to release my child's academic progress information to the researcher for the purposes of this research study.

____ I do not agree to release my child's academic progress information to the researcher for the purposes of this research study.

____

Parent/Legal Guardian Name (Print)

____ ________________

Parent/Legal Guardian Signature Date

____

Child's Name (Print)

By signing below, I indicate that the participant has read and, to the best of my knowledge, understands the details contained in this document and has been given a copy.

____

Study Representative's Name (Print)

____ ________________

Study Representative's Signature Date

University of Massachusetts Amherst-IRB
(413) 545-3428
Approval Date: 12/12/2017 Protocol #: 2017-4260
Valid Through: 12/11/2018
IRB Signature:

Participant Initials: ______

APPENDIX 3

ASSENT FORM

Strong Minds with Aerobic and Resistance Training during Recess Pilot Study
Assent Form

We would like to find out if a physical activity program offered during recess is fun for students and helps with your academic performance at school. The activities you will participate in during recess will consist of different activity movements and group games. We are asking children from your school in grades 3 and 4 to join this study. This study will take place at your school during your regularly scheduled recess period.

If you agree to join this study, here are the steps that will happen in the study and what you will be asked to do:

1. Your parent or guardian has already completed a form to give us their permission for talk to you about this study. Now we would like to explain the study to you to see if you would be interested in taking part in the study and to answer any questions that you may have about the study.

2. You will complete some measurements during your recess periods before the study starts and when it ends.
    - You will answer questions describing how you feel about school and activity.
    - You will have your height and weight measured.
    - You will complete two short activities on an iPad that are similar to playing games on a tablet.
    - You will complete some physical activity tests.
    - You will wear a small beeper-sized device on your waist to measure how much you move while you are at school and at home for one week before the study starts, for one week in the middle of the study, and for one week at the end of the study. You will also wear this device during some recess sessions.
    - You may wear a monitor to measure how hard your heart is working on your wrist (like a watch) during some recess sessions.

    If you complete at least half of the measurements at both the beginning and end of the study, you will earn a t-shirt.

3. As part of this study, a person that works for this program will visit your class after recess before the study starts and at the end of the study. He or she will observe your normal classroom activities right after recess.

4. We will randomly select one school to receive the fitness program first (like picking a name out of a hat without looking). If your school receives the program first, you will be asked to join in some activities and games with your classmates for the first 15 minutes of each recess period for 15 weeks. If your school receives the intervention second, the program will be offered at your school in the Fall of 2018.

Just like with your physical education classes, there is a risk of injury with participation in this study. You can tell the researchers if anything is uncomfortable and we will teach you how to do all of the activities safely.

We do not know if being in this study will help you. We expect that the physical activity program we offer will be fun.

Your parent or guardian knows about this study and that we are asking if you would like to be a part of it. You do not have to join this study. It is up to you. You can say yes now and change your mind later. If you decide you no longer want to participate, all you have to do is tell us that you want to stop. No one will be mad at you if you don't want to be in the study.

Before you say yes or no to being in the study, we will answer any questions you may have. If you join the study, you can ask questions at any time. Just tell your parent or the researcher that you have a question.

If you want to be a part of this study, please write your name below.

Participant Name: ______________________________________ Date: _________

Name of Person Obtaining Assent: _________________________ Date: _________

APPENDIX 4

SCHOOL STAFF INFORMED CONSENT FORM

University of Massachusetts Amherst

TEACHER/SCHOOL STAFF INFORMED CONSENT FORM

Strong Minds with Aerobic and Resistance Training during Recess (SMART Recess) Pilot Study

FOR QUESTIONS ABOUT THIS STUDY, CONTACT:

Christine St. Laurent, M.S.
University of Massachusetts Amherst
Department of Kinesiology
Totman Building, Room 110
30 Eastman Lane
Amherst, MA 01003
(413) 545-6104

WHAT IS THIS FORM?

The Informed Consent form will provide you with the information you will need to understand why this study is being done and explain the involvement of you as the teacher or school staff member associated with students participating in this study. It will also describe what you will need to do to participate, as well as any known risks, inconveniences, or discomforts that you may have while participating. We encourage you to take some time to think this over and ask any questions now, and at any time. If you decide to participate in this study, you will be asked to sign this form and you will be given a copy for your records.

PURPOSE OF THE RESEARCH PROJECT

You are invited to participate in a study designed to examine the feasibility, acceptability, and efficacy of a structured fitness program offered during school recess on the cognition and academic performance of elementary school-aged children. We hope to learn if a combined fitness program can be successfully implemented during school recess and if students will enjoy participating in such a program. We also hope to learn if this type of program can impact academic performance, such as progress report scores, cognition, and classroom behavior in students.

ELIGIBILITY

To participate in the teacher/school staff portion of this study, you must be a teacher or school staff member working with 3rd or 4th grade students at Fort River Elementary School or Crocker Farm Elementary School.

University of Massachusetts Amherst-IRB
(413) 545-3428
Approval Date: 12/12/2017 Protocol #: 2017-4260
Valid Through: 12/11/2018
IRB Signature: Nancy C. Jewett

 Participant Initials: ______

STUDY LOCATION AND DURATION OF INVOLVEMENT

The teacher/staff portion of this study will involve the completion of one questionnaire at the end of the study. This questionnaire will take approximately 10 minutes to complete. The questionnaire will be available online and can be completed remotely. If you prefer not to complete the questionnaire online, a paper copy will be provided to you at your school.

WHAT WILL I BE ASKED TO DO?

If you decide to participate in the study, you will be asked to complete a brief online questionnaire to provide some feedback on how well you think the students received the intervention program and to share any feedback you may have about the program with our research team.

BENEFITS OF PARTICIPATING IN THIS STUDY

There are no anticipated benefits to you as the teacher/staff member for your participation in this study.

RISKS OF PARTICIPATING IN THIS STUDY

No risks are expected for your participation in this study.

ALTERNATIVES

The only alternative to being a part of this study is not to participate.

PROTECTION OF PERSONAL INFORMATION

The following procedures will be used to protect the confidentiality of your study information. The information obtained from this study will be treated as privileged and confidential. Each participant will be assigned a numerical identification (ID) number at the beginning of the study and all data will be identified by ID number only. The link between the participant's name and ID number will be kept as a hard copy in a locked file cabinet in the secure Pediatric Physical Activity Laboratory in the Department of Kinesiology at UMass Amherst. Study surveys and data collection forms will only have the participants' study ID, and no names will be on these documents. Any information linking your name to your ID number will be destroyed at the completion of the study data analysis. There could be a possibility of data breach. However, the research team will make every effort to maintain the confidentiality of all data. There is one exception to confidentiality we need to make you aware of. In certain research studies, it is our ethical responsibility to report situations of child abuse, child neglect, or any life-

Participant Initials: ______

threatening situation to appropriate authorities. However, we are not seeking this type of information in our study nor will you be asked questions about these issues. For more information on this policy visit http://www.umass.edu/research/guidance/mandatory-reporting.

MEDICAL TREATMENT

The University of Massachusetts Amherst does not have a program for compensating subjects for injury or complications related to human subjects research. In the unlikely event of injury resulting directly from participating in this study, researchers will assist you in every way to make sure you get proper medical attention.

WHAT IF I HAVE QUESTIONS?

We encourage you to take as long as you like before you make a decision about your participation in this study. If you have further questions about this project or you have a research related problem, you may contact the faculty sponsor, Dr. Sofiya Alhassan at 413-545-3475 or alhassan@kin.umass.edu, or the primary investigator, Ms. Christine St. Laurent at 413-545-6104 or cstlaurent@umass.edu. If you have questions regarding your rights as a research participant, you may contact the University of Massachusetts Amherst Human Research Protection Office (HRPO) at 413-545-3428 or humansubjects@ora.umass.edu.

CAN I WITHDRAW FROM THE STUDY?

You do not have to be in this study if you not want to. If you agree to be in the study, but later change your mind, you may drop out at any time. There are no penalties or consequences of any kind if you decide not to participate. The research staff may also withdraw you from the study without your permission for one or more of the following reasons:

- Failure to follow the instructions of the research staff
- The study is canceled, other administrative reasons or unanticipated circumstances

PARTICIPANT STATEMENT OF VOLUNTARY CONSENT

When signing this form, I am agreeing to voluntarily enter this study. I have had a chance to read this consent form, and it was explained to me in a language which I use and understand. I have had the opportunity to ask questions and have received satisfactory answers. I understand that I can withdraw myself and my child at any time. A copy of this Informed Consent form has been given to me.

____

School Staff/Teacher Name (Print)

____ ______________

School Staff/Teacher Signature Date

By signing below, I indicate that the participant has read and, to the best of my knowledge, understands the details contained in this document and has been given a copy.

____

Study Representative's Name (Print)

____ ______________

Study Representative's Signature Date

APPENDIX 5

STUDY FLYER

The UMass Pediatric Physical Activity Laboratory is Looking for 3rd & 4th Graders to Join the

Strong Minds with Aerobic and Resistance Training during School Recess (SMART Recess) Pilot Study

Children in either the 3rd or 4th grade at Fort River School or Crocker Farm School are needed participate in an 18-week study!

Refer to the back of this flyer to learn more about the study and to provide your information to express interest!

You can also visit our website (www.umass.edu/kinpedlab), call us at 413-545-6104, or email us at kinpedlab@umass.edu for more information.

-NOT A SCHOOL SPONSORED EVENT-

Pediatric Physical Activity Laboratory

More About the SMART Recess Pilot Study

This 18-week study includes three weeks for baseline measures, followed by a 15-week program.

What you and your child will do:

- You will be asked to complete a brief demographic questionnaire.
- Before and at the end of the programs, your child will be asked to participate in some measures (i.e., height/weight, brief cognition tasks, fitness, and classroom behavior).
- Your child will be asked to wear a physical activity and a heart rate monitor at times throughout the study.
- Depending on what school your child attends, your child will either:
    - Participate in a 15-week fitness program during school recess, -OR-
    - Participate in a 15-week health and academic tracking program (Note: this school will receive the fitness program after the study ends)

Parent/Guardian – If you are interested in having your child participate in this study, please visit www.umass.edu/kinpedlab and complete the interest form available on our News page OR detach and return the bottom portion of this flyer to your child's teacher. Contact our study staff with any questions by phone (413-545-6104) or email (kinpedlab@umass.edu).

Child's Name: ______________________________ Grade:_________

School:________________________ Teacher: ______________________

Parent's Name: ______________________________________

Email (preferred): ____

Phone: ____

APPENDIX 6

INTERVENTION DESIGN AND SESSION PLANS

Intervention Development and Design

The combined fitness intervention was developed using youth physical activity and exercise training guidelines and recommendations from the American College of Sports Medicine, the National Strength and Conditioning Association, and the 2014 International Consensus on Youth Resistance Training. Recently, researchers have demonstrated increasing support for children's training programs that incorporate mixed modalities (i.e., programs that incorporate a variety of movements that target more than one component of fitness). Such programs combine general and specific physical activities in order to target both health- and skill-related components of fitness. Researchers refer to this as integrative neuromuscular training and have successfully implemented this type of programming into school physical education sessions and after-school programs. In addition to integrating all fitness components, the use of high-intensity training paradigms has also been increasingly researched in youth populations. Such studies have demonstrated that this type of training (alternating high and moderate-to-low intensity activities for short bursts) can be a time efficient and effective option to increase various fitness measures (i.e., cardiorespiratory endurance, muscular endurance, flexibility, balance, and power) in children, and is similar to children's natural movement and play patterns. Therefore, the proposed intervention will combine modalities to target various fitness components. In addition, because the aim of the study is to examine the effect of our intervention on cognitive and academic outcomes during school recess, a setting which has limited time, we will also incorporate high-intensity interval training.

Combined Fitness Intervention

The combined fitness intervention will incorporate cardiorespiratory endurance, muscular endurance and strength, balance, and coordination components using elastic resistance bands, medicine balls, body weight, and fundamental motor movements. Intervention sessions will be integrated into the first 15 minutes of recess periods on five days (Monday through Friday) per week for 15 weeks. Providing the intervention session for only 15 minutes will allow students to still have some free playtime in each recess session, which may help maximize participation and minimize attrition rates. Intervention leaders will lead intervention sessions with the assistance of school teachers and staff that are supervising recess periods. All intervention sessions will begin with a short (2 minute) dynamic warm-up. The participants will then be introduced to a new muscular strengthening movement. The remainder of the session will be comprised of a group activity or inclusive game. To encourage attendance in the intervention sessions, we will provide incentive prizes (e.g., collective toe tokens) for participation.

Table A. Sample session plan for the combined fitness intervention.

Component	Length	Combined Fitness Intervention
Warm-Up	2 min.	*Warm-Up Movements:* Dynamic movements & stretches such as giant steps, Jumping Jacks, and inch worm walks.
Movement of the Day	2 min.	*Introduce a New Muscular Strengthening Movement:* A new muscular strengthening movement will be taught to the students and students will have the opportunity to complete at least one 30 second set.
Group Activity	11 min.	*Fitness Bingo:* Students will be split into small groups and each group will receive a Bingo game card. Each box on the card will have a number (for repetitions) and a movement. A Bingo game will be played with the students completing the repetitions and movement on each space.

Control Condition

Due to the possibility that offering an alternative or active control program could also impact cognition and academic performance outcomes, a traditional, inactive control condition will be used for this study. The control school will follow their regular recess practice of offering unstructured and supervised free play. At the conclusion of data collection, the control school will receive the intervention protocol and material. However, no data will be collected during this period.

Combined Fitness Intervention Components

Warm-Up Segment

Dynamic stretches and light aerobic movements that will be used in the warm-up segment are listed in Table B. Each session plan will designate which movements and activities will be included in the warm-up segment for that day. Therefore, each daily session plan will typically only include three to four total movements. Refer to the Intervention Part I training video for a visual of the dynamic stretches and movements.

Table B. Dynamic Movements for Warm-Up Activity:

Stationary Dynamic Stretches	Locomotor Dynamic Stretches	Stationary Movements	Locomotor Movements
-Full arm circles -Torso twists -Squat and reach	-Walking knee hugs -Walking lunges -Straight leg kicks	-Jog -High knee jog -Pogo jumps	-Jog -High knee jog -Backward jog

-Straight leg kicks -Side lunges -Leg swings	-Inch worms -Side lunges	-Single leg hops -Butt kicks -Jumping Jacks	-Side shuffle -Gallop -Skip -Butt kicks

Indoor Recess: Stationary movements only
Outdoor Recess: Combination of stationary and locomotor movements

Movements of the Day:

One new muscular strengthening movements will be introduced each day before the group game/activity.

Group Activity:

The majority of each session will be comprised of a group activity or inclusive game that will integrate movements that students have already been exposed to or have experienced in the intervention program up to that point. There will be five blocks (3 weeks each) of muscular strengthening movements that intervention leaders can choose from in advance (Table C). Movements introduced into the sessions up to that point should also be used. High intensity aerobic and muscle-strengthening movements should be selected for the activity's main components, whereas low intensity movements may be used for instructional/waiting time to keep the participants active during the whole segment. Every Friday will be the participant's choice. Intervention leaders should poll the students on Thursdays to decide the activity.

Table C: The three muscular strength progression blocks of the intervention.

Block 1 (Weeks 1-3)	Blocks 2 & 3 (Weeks 4-9)	Blocks 4 & 5 (Weeks 10-15)
-Body weight movements -A few elastic band movements	-New body weight strength movements -Additional elastic band movements -Basic medicine ball movements	-Combined movements -Additional medicine ball movements -Basic suspension trainer movements

Table D: Low Intensity Aerobic Movements

Stationary:	Locomotor:
-March/high knee march -Step touch -Alternating knee lifts -Bob and weave -Hamstring curls -Side taps -Front kicks -Slow burpee -Skaters -Slow mountain climbers	-Walking -Forward step over cones -Giant forward/side steps

Table E: High Intensity Aerobic Movements

Stationary:	Locomotor:
-Jump forward & back -Run in place -Side to side/lateral jumps -Skaters -Burpees -Jump rope -Jumping Jacks -Sprinter pulls -Mountain climbers -Tuck jumps -Starfish jumps	-Run/sprint -Side shuffle -Power skips -Forward jumps -Side jumps -"Hopscotch" -Frog jumps -Side high knees -Lateral zig zags -Leap

Table F: Block 1 Strength Movements

Stationary Body Weight:	Locomotor Body Weight:	Stationary Elastic Band:
-Push-up -Squat -Split lunge -Plank	-Inch worms -Side squats -Walking lunges	-T-pulls -Chest press -Lat pull down -Chest fly -Upright row -Biceps Curl

Table G: Blocks 2 & 3 Strength Movements (in addition to Block 1 Movements)

Stationary Body Weight:	Locomotor Body Weight:	Stationary Elastic Band:	Stationary Medicine Ball:
-Pike push-up -Side planks -V-sit tucks -Sumo squat	-Inch worm push-ups -Side lunges -Walking lunge progression -Bear crawl -Side bear crawl	-Upright row -Biceps Curl -Squat -Bent-over row/standing row -High back row -Lateral raise -Shoulder press	-Squat -Shoulder press -Bent-over row -Front raise -Trunk rotation -Squat and press -Wood chops -Lunge and chop

Table H: Block 4 & 5 Strength Movements (in addition to Blocks 1-3 Movements)

Stationary Body Weight:	Locomotor Medicine Ball:	Suspension Trainer:
-Single leg squat -Plank knee tucks -Plank rotations -Plank up-downs	-Walking lunge & twist -Side sumo squat & upright row -Walking lunge & shoulder press	-Low row -T row -High row -Chest press -Superman/woman -Squat/squat jumps

Table I: Group Activities by Block

Block 1 (Intervention Weeks 1-3)	-Ball Toss (O) -Find Somebody Who (I/O) -I like Relay (O) -Hopscotch (I) -Spell My Name (I/O) -Would You Rather? (I/O) -Strength Tag (O) -Heads Up (I)
Block 2 (Intervention Weeks 4-6)	-Builders & Bulldozers (O) -Fitness Relay (O) -Simon Says (I) -Telephone (I) -Drop the Cookie (O) -Tic Tac Toe Relay (O) -Roll the Dice (O)
Block 3 (Intervention Weeks 7-9)	-Fitness Bingo (I/O) -Four Square Strength (O) -Luck of the Draw Relay (O) -Cat and Mice (O) -Cones Conquest (O)
Block 4 (Intervention Weeks 10-13)	-My DVD Player (I/O) -Feed the Dog/Cat (O) -Giants, Wizards, and Elves (O) -Rock, Paper, Scissors (I/O) (better for indoor) -Joey Roundup

I=Indoor; O=Outdoor

Group Activity Instructions (*listed alphabetically*)

Note: While giving instructions for these activities, or when students are waiting for their turn, designate a stationary movement they can perform (e.g., march or jog in place, toe-raises, pogo hops, etc.) Unless otherwise noted, spilt participants into groups of 10 or less for most activities.

Ball Toss – A beach ball will be prepared with various movements written on it. (There will be an "indoor" beach ball and an "outdoor" beach ball). Students will take turns gently tossing the ball to their peers. When they catch the ball, the student should shout their name and then announce the movement closest to the thumb of their writing hand. That movement will be performed for a set time or number of repetitions and then they should pass the ball to another student. (Equipment = beach ball)

Builders & Bulldozers - Divide students into two teams. One team is known as the "Tipper overs", who must knock/place the cones over. The other team as the "Picker uppers", who must stand the cones up. The "Tipper overs" must tip over all the cones, the "Picker uppers" need to stand the cones up. Cones must be tipped or picked up gently with one hand; their feet should never touch the cones. To tip the cone over, students must complete a designated muscle-strengthening movement for "x" amount of repetitions first. To pick a cone back up, students must complete a designated aerobic movement for "x" amount of repetitions. On the "stop" command all students must freeze and put their hands in the air. Count how many cones are tipped and how many are standing. After the first round switch the team's roles so each team gets a chance to do the other job. (Equipment = cones and any required muscle-strengthening equipment)

Cat and Mice – Set up cones to mark off the tag play area. Place 4 hula hoops out in the game space. Identify five students to be cats (or one cat for every four mice). Allow four students to place a foot in each hula hoop. This will be their mouse hole. Call out "Mice travel!" and all the students/mice must find a new mouse hole/hula hoop. While mice are looking for a new hole, the cat will try to tag a mouse. If a mouse gets tagged, s/he will become the cat, and the cat will get to be a mouse. Play for about 1 minute and then take a break between rounds to complete one or two sets of one to two strength movements.

Variations:

- Have mice who are tagged go to a mouse container and have other mice rescue them.
- Tagged mice turn into cats to help tag other mice.
- Tagged mice can do a set of a strength or aerobic movement to get back in the game.

Cones Conquest – For this game, you'll need 12 cones divided equally into 2 colors (6 each) and additional cones to mark the playing area. Set up one zone on each side of the field, this zone will be where players who get tagged can wait. Place 6 cones of one color on each side of the field**.** Divide players into 2 teams. Assign each team to a side of the playing field. Each team is trying to bring the opposing teams' cones to their side while keeping their own cones safe on their side. You can only carry one cone of a single color at a time (if cones are green and blue, a player can only carry one green and one blue at a time). If tagged while on the opposite side, the player must return the cones in his or her hands to where they came from and then go to the waiting zone on the opposite side of the field from their team. A movement should be designated to performed in the waiting zone. Players can be released from the waiting zone by being tagged out by a teammate and get a free walk (or jump/hop or other designated movement) back to their side. The game is over when one team has all of their cones plus the other team's cones on their side.

Drop the Cookie - Review boundaries and safe tagging. Hand out bean bags to about a third of the group. The students who do not have bean bags chase down those who do. When they tag them they yell "Drop the cookie!" The student who is tagged must drop it, perform the designated muscle-strengthening movement for “x” repetitions, and then run away. The tagger must perform another designated muscle-strengthening movement for “x” repetition, pick up the bean bag, and then is chased by the other kids. (Equipment = bean bags and any required muscle-strengthening equipment)

Feed the Dog/Cat (Relay) - Depending on how many students are playing, set up pairs of two hoops (preferably of the same color) next to each other at the end of the court or field. Opposite from the two hoops, put a cone at the other end of the court or field (preferably the same color as the hoops) to mark the team’s starting line. Each team has a cone and two hoops. So, if there are 3 teams, there should be 3 cones and 6 hoops set up. Place anywhere from 10 – 15 bean bags (or other small object) inside one of the hoops in each pair. Split students into teams (assign them each a color cone to stand behind). On the go command, the first player on each team runs to the hoops, or “doggy bowls” and transfers one object (“piece of food”) into the other bowl. The piece of food must be inside the other bowl before s/he can run back and give the next player a high-five, After receiving the high-five, the next player can take his/her turn transferring another piece of food to the other bowl. The team is done once all pieces of food are inside the other dog bowl. To add strength movements, students can perform a designated movement when it is their turn before they run, or all students can perform the a set of different movements between rounds.

Find Somebody Who – The intervention leader begins by saying, “Find somebody who...” filling in the blank. Options are endless. Here are a few:

- "has the same number of brothers and sisters as you"
- “shares the same favorite color as you"
- “was born in the same month as you”

Students must move in a designated way (e.g., skipping or hopping) to find a partner. As partners they then complete the designated muscle-strengthening movement together until the intervention leader says stop. Then the intervention leader gives another option and students must find another partner. (Equipment = depends on selected movements)

Fitness Bingo – Students should be placed in small groups (3 to 4). Intervention leaders will hand out bingo cards to each group and then quickly review the movements that are listed on the cards. Intervention leaders will randomly select rows and columns and then the groups should complete those movements and place a marker on each cell as they go. The first group to complete a full row, column, or diagonal line wins that round. (Equipment = bingo cards, markers, equipment necessary for movements)

Fitness Relay – Students will be divided into small even teams (3 to 5 per group). Cones will be placed out to create two lines – a start line and target line. Teams should line up at the start line. Movements will be selected for each relay – an aerobic movement to travel to the target line and 1-2 muscle-strengthening movements to perform at the target line. Each team has their members take turns performing the movements. Multiple rounds with different movements can be played. (Equipment = depends on selected movements.)

Four Square Strength – “Reserve” 1-3 four square court (depending on the size of your group). Split the students into groups of less than 10 per four square court. During play, players may only hit the ball with their hands. We describe the "hands" as any area between the player's wrists and fingertips, including the backs of hands. The ball may be hit with open or closed fists in the same manner as official volleyball. Players may not catch, carry or hold the ball at any time during play. Four students each stand in a square (one per square) while the other students form a line. An aerobic movement should be designated as the “waiting line” movement (aka students should jog in place or do Jumping Jacks while waiting for their turn). The ball is always served from the highest ranked square to the lowest square. Squares 1 and 4 are positioned diagonally across the court. The server must drop the ball and serve after the bounce. The ball must be allowed to bounce once in the receiving square, then the receiving player must hit the ball into another square. After the receiver touches the ball, the ball is in play. Serves are meant to place the ball fairly into play. Because the server must serve the ball the same way each time, it is the receiving player who controls the first play of the game. The normal order of play is defined in two stages for each time the ball is hit by a player.

- Once ball bounces in a square, ONLY the owner of that square must hit the ball into another square.
- After the ball has been hit by a player, and before the ball touches the ground next, ANY play is free hit the ball.
- Anyone hitting the ball at any time is subject to all other rules.

If a ball has bounced in a square and a different player hits the ball before the owner of the square hits it first, the other player is considered out. This is called Poaching. Each time a player is eliminated, that player leaves the court and all players advance to the higher numbered square squares. The lowest ranked square is then filled with a new player. All eliminated players leave the court and wait for their next turn to join in the lowest square. The eliminated player should perform a designated number of repetitions of a designated strength movement before getting into the waiting line.

Wizards, Giants, and Elves - Split group up into 2 teams, designate 2 safety zones, one on each teams side, and designate a middle area. Each team then gets in a huddle and picks what they want to be as a team, a giant, a wizard or an elf. Giants put their hands up over their heads, wizards put their hands our straight in front of them wiggling their fingers, and elves make pointy ears on their head with their pointer fingers. Once the teams have decided their character they want to be, they come up to the center spot and line up face to face, then on a count of 3, everyone does whatever action their team picked. Giants beat elves, elves beat wizards and wizards beat giants, so the team that beats the winning team chases the other and tries to tag as many members on the other team as possible before they reach the safety zone. The members from the team that get tagged become a part of the other team. Repeat until all players are on one side. After each “round”, the winning size selects a muscle-strengthening movement and everyone does that movement. Add a new movement after each round to create a series (e.g., 1 squat, 2 push-ups, 3 Jumping Jacks, 4 t rows, etc.).

I Like Relay – Designate two lines (about 10 meters apart). Students line up across one line facing the other line. A dynamic stretch or movement is announced by an intervention leader. An intervention leader states "I like ____" (e.g., "I like ice cream"). All students who like ice cream should perform the movement across to the other line. Repeat with different word selections and movements. This can be performed indoors by only using stationary movements. (Equipment = depends on selected movements, but would be best to stick with bodyweight movements)

Heads Up – Students should be placed in small groups (3 to 5 students per group) and given a deck of handmade Heads Up cards. Each deck has a theme that should be announced to the group. One person can be designated as the "guesser" for each round and hold the whole deck, or cards can be evenly distributed among the group members. When it is a student's turn to be the guesser, they should place the card on their forehead so they cannot see the word. The other group members should use descriptive words or charade actions to help the guesser figure out the word. When the guesser guesses correctly, he/she should turn the card around to read the movement and number of repetitions written on the card. The whole group should perform that movement before moving on to the next card. Each group can be timed to determine group personal bests for each round, or they can compete against other groups.

Hopscotch - Lay shapes with math problems on them out all over the floor. Have students begin at one end of the room and see if he/she can jump from shape to shape (square to square, circle to circle). Designate a shape and muscle-strengthening movement for each round. Before the student jumps on the next shape have him/her identify the sum/product of the math problem he/she is planning to jump to. Before jumping to the next shape, he/she should perform that many repetitions of the muscle-strengthening movement. (Equipment = shape cut outs)

Joey Roundup - Designate a large rectangular play area with clear boundaries with a small square inside the middle of the rectangle. Choose one or two volunteers (depending on group size) to be the Flyer or Boomer. Split players onto two teams to start at each side of the rectangular play area. The object is for the Joeys (baby kangaroos) to hop past momma or poppa kangaroo (Flyer/Boomer) and attempt to reach the other side of the play area without being tagged. Flyers (female) and Boomers (male) are able to run while all Joeys must hop/kangaroo jump. If a Joey gets tagged safely in the appropriate place, then he/she must now join the Flyers and Boomers in rounding up the rest of the Joeys (but after completing a set of a designated strength movement).

Luck of the Draw Relay – Divide the group into even teams. Each team lines up at the beginning of the circuit. Each station will have one strength movement and one aerobic movement. (Set up the stations by placing securing the index card with the movements under a cone.) An intervention leader should be the "captain" of each team. Split a deck into the number of groups. The first member of each team turns over the top card in their pile. The card number that they draw will determine how many repetitions the entire team will need to do of each exercise (Ace = 1, Jack = 11, Queen = 12, King = 13). All repetitions need to be performed correctly with proper form –intervention leaders can reinforce this and instruct team members to repeat "missed reps". The team can complete the circuit as a group or one team member can go at a time. Once the first team member completes the circuit, they will tag the next member in line. The second team member will follow the same steps, including drawing their own card from the deck. This process repeats until all members have completed the circuit. The team that finishes first, wins the round.

My DVD Player - The person calling the game may call any command found on a remote control!

- Play – Students begin walking towards finish line (or another locomotor movement)
- Fast Forward – Students run to finish line (or another locomotor movement)
- Rewind – Students move backwards (with current movement)
- Pause – Students freeze and balance
- Slow Motion – Students move super slowly in current movement
- Power Off – Students perform squats (or another muscle-strengthening movement)
- Power On – Students perform squat jumps (or another movement)

Students must react to the commands called. The goal is to make it all the way to the finish line. When a student makes a mistake s/he must do 10 jumping jacks, or another short activity, to re-enter the game. (Equipment = depends on selected movements, but bodyweight movements will work best)

Roll the Dice – Each number is assigned to a movement in advance and announced to the students. (More than one number can be assigned to a particular movement or odds and evens can be used for two movements.) An intervention leader rolls the dice and the movement that is assigned to the rolled number is performed. Each movement could be performed for a set time (e.g., 20 seconds) or for set number of repetitions (e.g., 10 repetitions).

Rock, Paper, Scissors – Similar to "Roll the Dice", a movement is assigned to rock, paper, and scissors (i.e., 3 movements total). An intervention leader plays "Rock, Paper, Scissors" with a student, and the winning play determines the movement. Intervention leaders can take turns playing with different students or two students can play at a time.

Simon Says – The intervention leader will instruct the students to mimic all movements that they perform. The traditional Simon Says game rules are followed, (i.e., students should mimic what the leader does, but only if the leader says "Simon Says" first), but students should not be eliminated. Designate a consequence (e.g., 10 stationary squats or 3 Burpees) if a student does a movement when the leader didn't say "Simon Says" first.

Spell My Name - Rather than setting a time or number of repetitions for movements, names of the students will be used to determine how many times each movement in performed. For example, if the first student called upon is named Stacey, the movement will be repeated for six repetitions because her name has six letters. As each repetition is performed, the students will spell out her name, letter by letter.

Strength Tag – Designate a tag playing area with cones and two “strength” zones on either end of the playing area. Place any needed strength equipment in the strength zones before starting. For each round, select 2 to 3 players to be taggers and designate the magic number (the number repetitions of a strength movement the players must complete) and a strength movement for each zone. When the game begins, the taggers must try to lightly tag the other players. When they tag a player, they point to which strength zone the player should go. The tagged player goes to the strength zone, completes the designated number of repetitions of the designated strength movement and then resumes playing. Play continues until intervention leaders yell “freeze” and then they start a new round (with new movements), or the taggers can “win” that round if they have all other players in a strength zone at one time. (You could time each group of taggers to see which team tags everyone the fastest.) Intervention leaders can add other “rules” or layers to the game.

Telephone - Divide group into 2 teams. Choose 1 person from each team to meet together and create a “movement message” (e.g., a squat, a Jumping Jack, and a push-up). Each team will line up facing the opposite direction (and perform a stationary movement in place as they wait their turn, such as jogging in place) of the team member that knows the movement message. At the signal, the first person on each team will tap the shoulder of the next player in line, signaling for him/her to turn around and face the first player. The first player will demonstrate the movement message and then “sit-down” (however here, they can hold a plank, sit in a squat, perform hops, etc. as directed by the intervention leaders). Then, the second player taps the shoulder of the third player, etc. The team that is closest to the correct movement message gets a point. Choose new players to create the message and play again. (Equipment = depends on selected movements.)

Tic Tac Toe Relay – This game is similar to the Fitness Relay, but in addition to the movements, students will each have a bean bag to place in one of nine spaces (a tic-tac-toe grid can be made up with hoola hoops at the target line). Two teams will compete with each other and each team will have different colored bean bags. (Equipment = bean bags, hoola hoops, and equipment for selected movements)

Wizards, Giants, and Elves - Split group up into 2 teams, designate 2 safety zones, one on each teams side, and designate a middle area. Each team then gets in a huddle and picks what they want to be as a team, a giant, a wizard or an elf. Giants put their hands up over their heads, wizards put their hands our straight in front of them wiggling their fingers, and elves make pointy ears on their head with their pointer fingers. Once the teams have decided their character they want to be, they come up to the center spot and line up face to face, then on a count of 3, everyone does whatever action their team picked. Giants beat elves, elves beat wizards and wizards beat giants, so the team that beats the winning team chases the other and tries to tag as many members on the other team as possible before they reach the safety zone. The members from the team that get tagged become a part of the other team. Repeat until all players are on one side. After each “round”, the winning size selects a muscle-strengthening movement and everyone does that movement. Add a new movement after each round to create a series (e.g., 1 squat, 2 push-ups, 3 Jumping Jacks, 4 t rows, etc.).

Would You Rather? - An intervention leader will explain to the students that they can choose between movements. The leader will ask “Would you rather ___ or ___?”- For example: “Would you rather hop on one foot or jump on two feet?” The students can select between the two movements and perform their selected movement for a set time or number of repetitions.

BLOCK ONE: WEEKS 1-3

OUTDOOR PLAN

	Monday	**Tuesday**	**Wednesday**	**Thursday**	**Friday**
Warm-Up: *2 rounds of each movement (3 rounds of ~20 seconds each) – 3 minutes*					
Movements	1. W. Knee Hugs 2. Str. Leg Kicks 3. Backward Jog	1. W. Arm Circles 2. W. Lunges 3. Jumping Jacks	1. Squat & Reach 2. Inch Worms 3. Gallop	1. Str. Leg Kicks 2. Backward Jog 3. Pogo Jumps	1. W. Lunge w/Reach 2. Skip 3. Butt Kicks
Interval Circuit: *5 minutes (Introduce the movements, followed by 3 rounds of 30 seconds each)*					
1. Low I Aerobic 2. Strength 3. High I Aerobic	1. Step Touch 2. Squat 3. Run	1. Walking 2. Band Chest-Press 3. Side Shuffle	1. Giant Steps 2. Side Squats 3. Power Skips	1. High Knee March 2. Band T-Pull 3. Forward Jumps	1. Giant Side Steps 2. Walking Lunges 3. Hopscotch
Group Activity: *7 minutes*					
Activity/Game	Leader Choice – Block 1 Activity	Leader Choice – Block 1 Activity	Leader Choice – Block 1 Activity	Leader Choice – Block 1 Activity	Participant’s Choice - Block 1 Activity
Equipment:*		Bands		Bands	

INDOOR PLAN

	Monday	**Tuesday**	**Wednesday**	**Thursday**	**Friday**
Warm-Up: *2 rounds of each movement (3 rounds of ~20 seconds each) – 3 minutes*					
Movements	1. Arm Circles 2. Squat & Reach 3. High Knee Jog	1. Torso Twists 2. Straight Leg K’s 3. Pogo Jumps	1. Side Lunges 2. Torso Twists 3. Single Leg Hops	1. Straight Leg Ks 2. Alt. back Lunges 3. Pogo Jumps	1. Arm Circles 2. Side Lunges 3. Butt Kicks
Interval Circuit: *5 minutes (Introduce the movements, followed by 3 rounds of 30 seconds each)*					
1. Low I Aerobic 2. Strength 3. High I Aerobic	1. March 2. Squat 3. Run	1. Easy Jog 2. Band Chest-Press 3. Skaters	1. Atl. Knee Lifts 2. Side Squats 3. Power Skips	1. High Knee March 2. Band T-Pull 3. Jump Rope	1. Giant Side Steps 2. Walking Lunges 3. Jumping Jacks
Group Activity: *7 minutes*					
Activity/Game	Leader Choice – Block 1 Activity	Leader Choice – Block 1 Activity	Leader Choice – Block 1 Activity	Leader Choice – Block 1 Activity	Participant’s Choice - Block 1 Activity
Equipment:*		Bands		Bands	

*Additional equipment may be needed depending on activity & selected movements for the day (i.e., beach ball, bands)

BLOCK TWO

WEEK 4

	Monday	Tuesday	Wednesday	Thursday	Friday
Warm-Up: *Select 3 movements & perform 2 rounds of each movement (3 rounds of ~20 seconds each) – 2 minutes*					
Movement of the Day: *Students practice at least one 30 second round of the new movement – 2 minutes*					
Strength Movement	Plank with knee taps	Band biceps curl	Sumo squat	Band bent over row	N/A
Group Activity: *11 minutes*					
Activity/Game	Builders & Bulldozers	Fitness Relay	Drop the Cookie	Participant Choice	N/A

*First day of indoor = Simon Says; Second day = Telephone; Third day = Heads Up

WEEK 5 (Spring break – only 2 days)

	Monday	Tuesday	Wednesday	Thursday	Friday
Warm-Up: *Select 3 movements & perform 2 rounds of each movement (3 rounds of ~20 seconds each) – 2 minutes*					
Movement of the Day: *Students practice at least one 30 second round of the new movement – 2 minutes*					
Strength Movement	N/A	Band lateral raise/Sumo squat	Band squat/band bent over row	N/A	N/A
Group Activity: *11 minutes*					
Activity/Game	N/A	Drop the Cookie	Tic Tac Toe Relay	N/A	N/A

*First day of indoor = Simon Says; Second day = Telephone; Third day = Heads Up

WEEK 6

	Monday	Tuesday	Wednesday	Thursday	Friday
Warm-Up: *Select 3 movements & perform 2 rounds of each movement (3 rounds of ~20 seconds each) – 2 minutes*					
Movement of the Day: *Students practice at least one 30 second round of the new movement – 2 minutes*					
Strength Movement	V sit tucks	Band/ball upright row	Ball squat	Band high back row	Side Bear Crawl
Group Activity: *11 minutes*					
Activity/Game	Strength Tag	Roll the Dice	Builders & Bulldozers	Drop the Cookie	Participant Choice

*First day of indoor = Simon Says; Second day = Telephone; Third day = Heads Up

BLOCK THREE

WEEK 7

	Monday	Tuesday	Wednesday	Thursday	Friday
Warm-Up: *Select 3 movements & perform 2 rounds of each movement (3 rounds of ~20 seconds each) – 2 minutes*					
Movement of the Day: *Students practice at least one 30 second round of the new movement – 2 minutes*					
Strength Movement	Full side plank	Ball shoulder press	Side lunges	Ball torso rotation	N/A – no school
Group Activity: *11 minutes*					
Activity/Game	Cones Conquest	Fitness Bingo	Cat and Mice	Participant Choice	N/A – no school

*First day of indoor = Simon Says; Second day = Telephone; Third day = Heads Up

WEEK 8

	Monday	Tuesday	Wednesday	Thursday	Friday
Warm-Up: *Select 3 movements & perform 2 rounds of each movement (3 rounds of ~20 seconds each) – 2 minutes*					
Movement of the Day: *Students practice at least one 30 second round of the new movement – 2 minutes*					
Strength Movement	Forearm side plank	Ball front raise	Band shoulder press	Lunge progressions	Plank up-downs
Group Activity: *11 minutes*					
Activity/Game	Four Square Strength	Luck of the Draw Relay	Tic Tac Toe Relay	Strength Tag	Participant Choice

*First day of indoor = Simon Says; Second day = Telephone; Third day = Heads Up

WEEK 9

	Monday	Tuesday	Wednesday	Thursday	Friday
Warm-Up: *Select 3 movements & perform 2 rounds of each movement (3 rounds of ~20 seconds each) – 2 minutes*					
Movement of the Day: *Students practice at least one 30 second round of the new movement – 2 minutes*					
Strength Movement	Ball wood chops	Ball squat & press	Inch worm push-ups	Ball lunge & chop	Pike push-up
Group Activity: *11 minutes*					
Activity/Game	Roll the Dice	Cones Conquest	Fitness Bingo	Cat and Mice	Participant Choice

*First day of indoor = Simon Says; Second day = Telephone; Third day = Heads Up

BLOCK FOUR

WEEK 11

	Monday	Tuesday	Wednesday	Thursday	Friday
Warm-Up: *Select 3 movements & perform 2 rounds of each movement (3 rounds of ~20 seconds each) – 2 minutes*					
Movement of the Day: *Students practice at least one 30 second round of the new movement – 2 minutes*					
Strength Movement	Plank knee tucks	ST low row	Side sumo squat & MB upright row	ST T-row	N/A - 4th grade only today (review any)
Group Activity: *11 minutes*					
Activity/Game	Feed the Dog/Cat	Wizards, Giants, & Elves	Joey Roundup	My DVD Player	Leader Choice

WEEK 12

	Monday	Tuesday	Wednesday	Thursday	Friday
Warm-Up: *Select 3 movements & perform 2 rounds of each movement (3 rounds of ~20 seconds each) – 2 minutes*					
Movement of the Day: *Students practice at least one 30 second round of the new movement – 2 minutes*					
Strength Movement	Plank up-downs	ST high row	MB walking lunge & shoulder press	ST chest press	Single leg squat
Group Activity: *11 minutes*					
Activity/Game	Strength Tag	Four Square Strength	Roll the Dice	Cat and Mice	Leader Choice

WEEK 13

	Monday	Tuesday	Wednesday	Thursday	Friday
Warm-Up: *Select 3 movements & perform 2 rounds of each movement (3 rounds of ~20 seconds each) – 2 minutes*					
Movement of the Day: *Students practice at least one 30 second round of the new movement – 2 minutes*					
Strength Movement	Plank rotations	ST superman/woman	MB walking lunge & twist	ST squat jumps	MB lunge & chop
Group Activity: *11 minutes*					
Activity/Game	Wizards, Giants & Elves	Joey Roundup	Fitness Relay	Drop the Cookie	Leader Choice

WEEKS 14 & 15 – Post Measures

Notes: ST = suspension trainer; MB = medicine ball; First day of indoor = Heads Up; Second day = Rock, Paper, Scissors; Third day = Hopscotch

APPENDIX 7

IMPLEMENTATION FORM

Today's Date: _____ / _____ / 20_____ Researcher Initials: _____

SMART Recess Pilot Study: Implementation Form

These items are to be recorded during each intervention session.

Grade:________ Indoor/Outdoor Recess:____________ Weather:________________________

Session Title/#:____

1. Among those with consent/assent, record participants that are in attendance (see attached sheet).
Number of participants in attendance: _______

2. How many students participated in the intervention session? ________

3a. Intervention start time: _____:______ am/pm

3b. Intervention end time: _____:______ am/pm

4. Were heart rate monitors used today? Yes No

If yes, record participant IDs and corresponding monitor #s.

Participant ID	Monitor #	Participant ID	Monitor #

Today's Date: _____ / _____ / 20_____ Researcher Initials: _____

These items are to be recorded within 20 minutes after the end of an intervention session.

Question:	**Yes**	**No**
1. Did at least 50% of the students participate? If no, why?		
2. Did the majority of students participate in at least half of the intervention session? If not, approximately how many minutes did the majority of the students participate in? _____________		
3. Did the majority of the students seem to enjoy the intervention session?		
4. Did the intervention session appear to be hold the interest/attention of the majority of the students participating? If not, explain.		
5. Did the intervention leader(s) provide encouragement during the intervention session?		
6. Was the intervention session implemented as intended? If no, why not?		
7. Did the intervention leader implement the intervention session clearly and correctly?		
8. Did the intervention leader implement all of the planned session components? If no, which components were not implemented and why?		
9. Were modifications/adaptations made from the original intervention session plan? If yes, what modifications were made?		
10. Did the intervention leaders recommend modifications or changes for the future? If yes, explain.		

SMART Recess Implementation Form Version – 10/5/17

APPENDIX 8

STUDENT POST-INTERVENTION SURVEY

UMass Amherst

Student Post-Survey

Thank you for participating in the UMass SMART Recess Pilot Study! Now that the study is over, we would like to hear about your thoughts on the program.

Please select ONE response for each of the following questions.

	Extremely likely	Slightly likely	Likely	Slightly unlikely	Extremely unlikely
1. If offered by your school, how likely would you be to continue participating in the recess activities that were included in our program?	○	○	○	○	○
2. How like likely would you to be interested in participating in these activities during other times/settings during the school day?	○	○	○	○	○

How satisfied are you each of the following components of the SMART Recess pilot study?

	Extremely satisfied	Slightly satisfied	Neither satisfied nor dissatisfied	Slightly dissatisfied	Extremely dissatisfied
3a. Timing of the intervention sessions (have the sessions during recess)	○	○	○	○	○

	Extremely satisfied	Slightly satisfied	Neither satisfied nor dissatisfied	Slightly dissatisfied	Extremely dissatisfied
3b. Length of the intervention sessions (how long the sessions were each day)	O	O	O	O	O
3c. Duration of the program (how long the entire program lasted)	O	O	O	O	O

	Extremely satisfied	Slightly satisfied	Neither satisfied nor dissatisfied	Slightly dissatisfied	Extremely dissatisfied
3d. Content of the intervention sessions (what we did during the recess sessions)	O	O	O	O	O
3e. Facilitation of the intervention sessions (how the research team lead the sessions)	O	O	O	O	O
3f. Initial meeting(s) with students (how well we explained the program in the beginning)	O	O	O	O	O

Please share any specific opinions you have on any of the following components.

4a. The SMART Recess research team:

4b. The recess intervention sessions:

4c. The study assessments/measurements:

4d. Program communication:

4e. Other:

5. What sessions or program components do you think were most fun or did you like the best?

6. What sessions or program components do you think were least fun or did you like the least?

7. Please share any additional opinions or suggestions for our physical activity and fitness program.

APPENDIX 9

SCHOOL POST-INTERVENTION SURVEY

UMass Amherst

School Post-Survey

We thank you for your assistance and accommodations with the UMass SMART Recess Pilot Study. Now that the study has concluded, we would appreciate your feedback and thoughts on the overall program.

This survey should only take a few minutes and is completely anonymous. If you wish to share any additional feedback, or have any questions for the UMass Pediatric Physical Activity Laboratory team, feel free to contact us at kinpedlab@umass.edu.

Please select ONE response for each of the following questions.

	Extremely likely	Slightly likely	Slightly unlikely	Extremely unlikely
1. How likely are you to continue using any of the SMART Recess session plans during recess?	O	O	O	O
2. How like likely are you to continue using any of the SMART Recess session plans during other periods of the school day?	O	O	O	O

How satisfied are you each of the following components of the SMART Recess pilot study?

	Extremely satisfied	Slightly satisfied	Neither satisfied nor dissatisfied	Slightly dissatisfied	Extremely dissatisfied
3a. Timing of the intervention sessions	O	O	O	O	O

	Extremely satisfied	Slightly satisfied	Neither satisfied nor dissatisfied	Slightly dissatisfied	Extremely dissatisfied
3b. Length of the intervention sessions	○	○	○	○	○
3c. Duration of the program	○	○	○	○	○
3d. Content of the intervention sessions	○	○	○	○	○

	Extremely satisfied	Slightly satisfied	Neither satisfied nor dissatisfied	Slightly dissatisfied	Extremely dissatisfied
3e. Facilitation of the intervention sessions	○	○	○	○	○
3f. Initial meeting(s) with teachers/staff	○	○	○	○	○
3g. Initial meeting(s) with students	○	○	○	○	○
3h. Communication between the research team and teachers/staff	○	○	○	○	○

Overall, how well do you think the SMART Recess pilot program was received by each of the following groups?

	Extremely well	Moderately well	Not slightly well	Not well at all
4a. Other school teachers/staff	○	○	○	○
4b. Students	○	○	○	○
4c. Families	○	○	○	○

Please share any specific opinions you have on any of the following components.

5a. The SMART Recess research team:

5b. The recess intervention sessions:

5c. The study assessments/measurements:

5d. Program communication:

5e. Other:

6. If you witnessed some of the recess intervention sessions, what sessions or program components do you think were most effective?

7. If you witnessed some of the recess intervention sessions, what sessions or program components do you think were least effective?

8. Please share any additional feedback or suggestions for our physical activity and fitness program.

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APPENDIX 10

CONTROL SCHOOL MONITORING FORM

Today's Date: _____ / _____ / 20_____ Researcher Initials: _____

SMART Recess Pilot Study: Control School Monitoring Form

These items are to be recorded during each observation session.

Grade:________ Indoor/Outdoor Recess:____________ Weather:______________________

Teacher/Room (if Indoor):___________________________

1a. Accelerometer start time: _____:______ am/pm

1b. Accelerometer end time: _____:______ am/pm

2. Select the category of activities that were offered during the recess session:

______ Unstructured ______ Structured ______ Combination

2a. If structured or combination was selected, what activities were offered:

2b. If structured or combination was selected, approximately what percentage of the students participated in the structured activities?

3. Select the category of physical activity that describes the majority of the students during the recess session.

______ Sedentary ______ Light ______ Moderate-to-Vigorous

4. Please note any additional observations:

Control School Monitoring Form Version – 8/19/17

APPENDIX 11

PHYSICAL AND FITNESS DATA SHEET

STUDY ID: [| | | | | |]   Visit # ________

SMART Recess Pilot Study

MEASUREMENTS CHECKLIST

Measurement	Date	Researcher Initials	Notes
Assent			
Height/weight			
Inhibition			
Working memory			
Accelerometer Placed			Monitor #:
Muscular fitness battery			
PACER test			
Classroom observation #1			
Classroom observation #2			
Accelerometer turned in			

STUDY ID: ☐☐☐☐☐☐ Visit # ________

PHYSICAL MEASURES

Today's Date: _____ / _____ / 20___

Order of measurements:

- Following protocol, measure first weight, first height (record interference)
- Repeat same order for 2nd measures.
- 3rd measurement(s) if needed (follow protocol).

Data should not be entered unless protocol was followed.
Box used to indicate measurement notes: R=refusal, X=margin notes regarding this measure.

	FIRST	SECOND	THIRD
WEIGHT	☐☐☐.☐ kg	☐☐☐.☐ kg	☐☐☐.☐ kg (if >.3kg apart)
MEASURED HEIGHT (including any interference)	☐☐☐.☐ cm	☐☐☐.☐ cm	☐☐☐.☐ cm (if >.5cm apart)
Interference (0.0 if none) (15.8 if used)	- ☐☐.☐ cm	- ☐☐.☐ cm	- ☐☐.☐ cm
NET HEIGHT (Measured – interference)	= ☐☐☐.☐ cm	= ☐☐☐.☐ cm	= ☐☐☐.☐ cm

STUDY ID: | | | | | | | Visit # ________

PHYSICAL FITNESS

FITNESSGRAM Pacer Test

(Data collectors: Cross off each lap as the participant completes them. Circle the number of the laps – up to two – that were missed. The test ends with the second missed lap.)

Min	Laps											
1	1	2	3	4	5	6	7					
2	8	9	10	11	12	13	14	15				
3	16	17	18	19	20	21	22	23				
4	24	25	26	27	28	29	30	31	32			
5	33	34	35	36	37	38	39	40	41			
6	42	43	44	45	46	47	48	49	50	51		
7	52	53	54	55	56	57	58	59	60	61		
8	62	63	64	65	66	67	68	69	70	71	72	
9	73	74	75	76	77	78	79	80	81	82	83	
10	84	85	86	87	88	89	90	91	92	93	94	
11	95	96	97	98	99	100	101	102	103	104	105	106	
12	107	108	109	110	111	112	113	114	115	116	117	118	
13	119	120	121	122	123	124	125	126	127	128	129	130	131
14	132	133	134	135	136	137	138	139	140	141	142	143	144
15	145	146	147	148	149	150	151	152	153	154	155	156	157

Completed # of Laps = ___________

Muscular Fitness

Test	Med. Ball Weight (kg)	# of Repetitions
Front Squat		
Push-Up	N/A	
Lunge		
Bent-Over Row		
Shoulder Press		
Calf Raise		
Curl-Up	N/A	

APPENDIX 12

DEMOGRAPHIC DATA QUESTIONNAIRE

UMass Amherst

Welcome Section

Thank you for signing up your child to participate in the UMass SMART Recess Study!

The purpose of this form is to provide us with some basic information about your child and your family. All information that you share with us is confidential. If you have any questions, please feel free to contact us at the number or email below. You can save your progress and completed information on the form as long as you use the same link and Internet browser to reopen the form. (Contact information will be available again at the end of the form.)

Contact Information

Christine St. Laurent, MS, Doctoral Candidate
Pediatric Physical Activity Laboratory
University of Massachusetts, Amherst
Department of Kinesiology
Totman Building, Room 110
30 Eastman Lane
Amherst, MA 01003
(413) 545-6104
kinpedlab@umass.edu

Demographic Info

Child's first name:

Child's last name:

Parent/Guardian's first name:

Parent/Guardian's last name:

Phone number:

Email address:

Child's date of birth:

Child's gender:

Male

Female

To which of the following races do you consider your child to belong? (You may choose all that apply.)

Native American

Asian

Native Hawaiian or Other Pacific Islander

Black or African American

White

Other

Additionally, do you consider your child to belong to any of the following ethnic groups? (You may choose all that apply.)

Mexican, Mexican American, or Chicano

Puerto Rican

Cuban

Central American (such as Guatemalan, El Salvadoran, Honduran, Nicaraguan, Panamanian, Costa Rican)

South American

African/African American

West Indian or Caribbean

Native American Indian

Japanese/Japanese American

Chinese/Chinese American

Filipino

Korean

Laotian

Cambodian

Vietnamese

Pacific Islander (such as Native Hawaiian, Guamanian, Tongan, Samoan)

Asian Indian

Middle Eastern

European

Other (please specify)

What is your current marital status?

Married

Divorced or separated

Widowed

Single - Never Married

Does your family own the home in which your child lives?

Yes

No

What is the highest level of education that **you** have completed? (select only one response)

6th grade or less	Technical school
8th grade or less	Some college
Attended some high school	College graduate
High school graduate or GED	Post graduate degree

Not including you, what is the **highest** education level among all the people living in your child's home? (select only one response)

6th grade or less	Technical school
8th grade or less	Some college
Attended some high school	College graduate
High school graduate or GED	Post graduate degree

What was the approximate **total** income, before taxes, of your **household** for the last year? (Please include wages, salaries, social security, interest, child support, public assistance, unemployment compensation, rent from property and all other income. Only select one response.)

Less than $5,000	$50,000 - $59,999
$5,000 - $9,999	$60,000 - $69,999
$10,000 - $19,000	$70,000 - $79,000

$20,000 - $29,999
$30,000 - $39,999
$40,000 - $49,999
$80,000 - $89,999
$90,000 - $99,000
Over $100,000

Has your child ever been diagnosed with a developmental disorder such as attention-deficit hyperactivity disorder (ADHD) or other learning disabilities?

Yes

No

If yes, please share your child's diagnosis.

Is your child currently taking any medication to alleviate disorder symptoms?

Has your child been prescribed with an Individualized Education Program (IEP)?

Yes

No

What is YOUR current height?

What is YOUR current weight?

Which hand would you consider your child's dominant hand?

Right hand

Left hand

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