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The Impact of an Elementary School Based Intervention on Physical Activity Opportunities and Aerobic Capacity

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The Impact of an Elementary School Based Intervention on Physical Activity Opportunities and Aerobic Capacity

By

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B.S.
University of Michigan
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Abstract

The Impact of an Elementary School Based Intervention on Physical Activity Opportunities and Aerobic Capacity

By Hayley A. Braun

Objectives: To determine the impact of a one-year physical activity (PA) intervention on changes in school PA opportunities and assess the relationship between changes in school-based PA opportunities and aerobic capacity.

Methods: The multi-level PA intervention was provided to 39 schools in Georgia. Pre- and post- intervention Progressive Aerobic Cardiovascular Endurance Run (PACER) data (a measure of aerobic capacity) were collected for 4th grade students (n=2,342). An online survey was administered to faculty to assess PA opportunities and school setting determinants of PA. Replicated linear regressions were run on changes in school-based PA time to measure the linear correlation with aerobic capacity.

Results: The average number of PACER laps completed increased post-intervention by 2.8 laps, with 73% of children improving or maintaining number of laps completed. Assessment of school opportunities showed 33% of schools increased days/week of recess, 35% of schools increased minutes/day of recess. Over one-third (38%) of teachers reported increased classroom time PA. In addition, 51% of schools adopted a before-school program, 52% of schools increased how often they had access to PA equipment, and increases in multiple types of school wellness initiatives were seen including wellness plans, audio/visual PA information, and school-wide events. Linear regression showed a significant relationship between change in time in school PA and aerobic capacity (r = 0.39, 95% Empirical Interval: 0.31-0.47).

Conclusion: The intervention may be responsible for changes in school opportunities and increased in-school PA, which is directly associated with increases in aerobic capacity. These positive results demonstrate need for further research including large-scale cluster-randomized control trials to assess the full impact of the intervention in a more rigorous setting.

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CHAPTER 1 BACKGROUND

Childhood Obesity

Childhood obesity is a growing national concern. Of 2-17 year olds in the United States, approximately 17%, or 12.7 million children, are obese (1). Obesity is especially concerning at such young ages given the enormous difficultly of reversing it, especially when looking at the very young children included in that estimate, who are just starting to develop any gross motor skills and have no control over their nutrition or physical activity. The consequences of obesity are numerous, complex, and dangerous. The health risks of childhood obesity include, but are not limited to, high blood pressure and cholesterol, impaired glucose tolerance, sleep apnea and asthma, joint problems, not to mention psychological issues including low self-esteem and quality of life (2). The progression of these health risks lead to even more severe health consequences later in life. The health risks of obesity as a child include obesity later in life, which is a risk factor for many potentially fatal diseases including heart disease, diabetes, metabolic syndrome, and cancer (2).

This problem is magnified in low income settings where the prevalence of obesity follows a gradient with socioeconomic status in as young as preschool children, with obesity rates increasing with increasing poverty level. In families with an income-to-poverty ratio of 151-185%, 11.8% of children are obese, and this number reaches up to 14.2% in children in families with an income-to-poverty ratio less than or equal to 50% (1). In addition, obesity has been linked to adult head of house educational levels. Obesity prevalence among children whose head of house did not complete high school was approximately double their counterparts whose head of house completed college (1).

Physical Activity

One key target in reducing obesity is physical activity. Physical activity is defined as movement that increases energy expenditure above a basal level. Bodily movement can be divided into two categories: 1) light-intensity activities of daily life, such as standing, walking slowly, and lifting lightweight objects; and 2) health-enhancing physical activity is activity that goes beyond light-intensity daily activities that results in health benefits. Examples include brisk walking, jumping rope, dancing, lifting weights, or climbing on playground equipment at recess (3).

Physical activity (PA) and physical fitness (PF) are essential factors in promoting health both in childhood and later adulthood. PA research consistently demonstrates an inverse relationship between both PA/PF and morbidity related to coronary heart disease (CHD), stroke, cardiovascular disease (CVD), cancer, or all-cause mortality (4). Pathological studies have shown a significant precursor of adult atherosclerosis is childhood obesity (5). Epidemiological data have shown obesity and associated diseases developed in childhood such as hypercholesterolemia and hypertension persist throughout adulthood, while PA, along with diet and smoking, influence these factors (5). Income and education may proliferate these negative health outcomes. Children with lower socioeconomic status (SES) are also more physically inactive than their higher SES counterparts (6). This may contribute in part to the higher rates of obesity seen in lower SES children.

Despite these known consequences of physical inactivity and additional benefits of PA, children still do not consistently get enough PA. Only 31.8% of youth in the United States met the recommended 300 minute weekly aerobic activity guideline in

2014 (7). In addition, in 2002, 62% of children age 9-13 did not engage in organized activity outside of school hours, and 23% did not engage in free-time physical activity at all (8).

School Based Physical Activity Interventions

Schools provide an ideal opportunity to encourage children to be physically active as they serve over 95% of children ages 5-17 and comprise a significant portion of time in a child's day (9). This is especially important in low socioeconomic status (SES) communities that may have restricted access to safe recreational facilities including parks and playgrounds, as these disparities have been significantly associated with decreased likelihood of engaging in PA as well as increased obesity (10). In addition, historically, poor and racial/ethnic minority students are less likely to receive school-based PA than their counterparts (11).

While historically, school PA time has been centered on physical education (PE) classes, many times PE classes cannot provide the recommended amount of physical activity alone. For example, a 2006 report indicates only 4% of elementary schools offer daily physical education to their students (12).

Recently, there has been a strong push for multi-level school PA interventions as a comprehensive strategy to integrate physical activity into the school day. Multi-level programs are novel in two aspects 1) that they targets multiple populations (students, school staff, families, community members) and 2) throughout the whole day to reach fitness goals (i.e. PE, recess, classroom, and before and after school time) (13). There is support for multi-level school PA intervention as way to achieve sustainable, long-term fitness outcomes (14). A review of PA interventions in both school-based settings and

following a multi-level approach separately have strong evidence to support their effectiveness (15). A specific example was a 12-month multi-level quasi-experimental intervention focused on incorporating families and communities to promote healthy growth. Children in the intervention school significantly lowered body fat percentage, fat mass, and improved on all measures of physical fitness (16).

To guide these efforts, the Center for Disease Control and Prevention (CDC) recently published the "National Framework for Physical Activity and Physical Education & Resources to Support CSPAP" which provides the guidelines for a multi-level physical activity intervention (17). A focus of the framework that physical activity should be structured and maximized during physical education time, but, since physical education time is limited in many schools, that there are plenty of opportunities to integrate physical activity throughout the rest of the school day (18). Some of these opportunities include recess periods, which should not serve to replace physical education, but provide a supplement physical education, after-school and lunch-time sports, and walk to school and bike to school program. The report also emphasizes integration of physical activity breaks during classes, as well as integration into classroom activities (18). For example, an elementary school math activity could ask children what 5 + 10 equals, and have the children do that many jumping jacks. Classrooms may not provide space for traditional physical activity, but can easily allow for calisthenics, which is a type of exercise consisting of gross motor movements preformed usually in place, without the assistance of machines, such as jumping jacks.

CSPAP Modeled Physical Activity Interventions

The Comprehensive School Physical Activity Program model (CSPAP) model created by (CDC) and SHAPE America targets multiple populations (students, school staff, families, community members) to reach a goal of 60 minutes of PA every day focusing on 5 key areas: (1) A strong foundation of physical education (PE); (2) increased in school PA including incorporation of PA into the classroom and promotion of recess; (3) before and after school programs; (4) family and community engagement; and (5) staff involvement (13). To date, CSPAP and other multi-level programs have not been rigorously evaluated (19). Limitations of previous studies include small sample sizes, limited participation in the program, self-reported measures, and minimal effectiveness of the intervention (15).

HealthMPowers Intervention: A CSPAP Guided PA Intervention

HealthMPowers, a nonprofit organization based in Atlanta, GA, implemented the intervention, focusing on increasing before and during school PA opportunities. The HealthMPowers program was developed using the CSPAP model and included over 20 hours of professional development, technical support, program and curriculum resources, equipment and tracking devices, and external evaluation services. The HealthMPowers program included the establishment of a school health team consisting of three to five members representing administration, physical education, and classroom teachers. This team completed a baseline assessment of current PA practices, reviewed the results, and developed a personalized action plan to increase PA opportunities at their school. Schools received low cost resources and equipment to assist with the implementation of

their plan. Tracking devices including pedometers and activity monitors were used to track activity in the classroom and physical education settings.

Personalized action plans included a variety of options so that each school could integrate the components that would work best in their school setting, and also ones they thought could be supported and maintained by staff. Some intervention options offered for before and after school programs included circuits, Zumba and line dance classes, and aerobic games, among others. To promote all school wellness, options for morning announcements to integrate PA were given, as well as pedometer 30-day staff challenges, and "catch your teacher being healthy" challenges. For in class PA, HealthMPowers provided exercise DVDs that integrate exercises into classroom activities or provide PA break activities for between lessons. In January and February, pedometers were used by the students to track step counts, and the teachers were given ways to incorporate pedometer use and step count tracking into math lessons. Options for parent letters were sent home introducing the intervention at the beginning of the school year, and tips and fitness fun packs were sent home throughout the year to emphasize integration of PA in the home setting as well.

Assessment of Physical Activity Interventions

Assessing physical activity interventions provides some difficulty. A reliable indicator of time in physical activity is physical fitness (PF), which is the ability to carry out daily tasks with vigor and alertness, without undue fatigue, and with ample energy (3). Physical fitness is comprised of endurance (aerobic capacity), skeletal muscle endurance, skeletal muscle strength, skeletal muscle power, flexibility, balance, speed of movement, reaction time and body composition (3). Engaging in health-enhancing PA

over time builds aerobic capacity, skeletal muscle endurance, strength, and power. Thus, PA and PF work in conjunction, engaging in PA increases PF, which in turn allows one to participate fully in PA. Due to PA's ability to build PF, PF provides a way to measure physiologic adaptations to PA.

One specific aspect of PF important to PA intervention assessment is aerobic capacity. Aerobic capacity is defined as the maximum amount of oxygen an individual can consume in one minute per kilogram body weight and can be used to measure physiologic changes to PA (20). Exposure to PA results in cellular adaptation of myocytes (muscle cells) and cardiovascular adaptation, which facilitate an increase in aerobic capacity. These adaptations within the myocyte include increase in mitochondria, increase in mitochondrial volume, and increase in metabolic enzymes. In terms of cardiovascular adaptations, exercise increases plasma volume and red blood cell mass, increasing venous return, which along with increased ventricular compliance and internal ventricular dimensions, increase end diastolic volume. Myocardial contractility increases simultaneously, increasing ejection fraction which thus can increase stoke volume and maximum cardiac output and distribution of oxygen rich blood to the muscles (21). With a more effective circulatory system, and increased effectiveness of cellular metabolism, the body is able to perform similar tasks more efficiently and delay fatigue longer. If PA is not maintained, these measures return to baseline within a week or two of no training, thus these measures are useful in assessing the contributions of physical activity to health (21).

Aerobic capacity adaptations to training have previously been used as a measure to assess PA intervention programs (22). Unlike body mass index (BMI), which may take

longer to change and is hindered by its inability to discern healthy muscle from adipose tissue mass, physiologic adaptations occur in a shorter time period with sizable differences after two, six, and 12 weeks (21). Thus, aerobic capacity measurement provides a useful way to assess physiologic adaptations to continuous aerobic exercise exposure.

Purpose

The purpose of this study was to determine the impact of a one-year CSPAP-modeled PA intervention in improving school PA opportunities and observing the relationship of these changes to aerobic capacity in 4th grade students. This intervention included 39 primarily low income schools, throughout five counties and served as a feasibility study for a large-scale randomized control trial of a physical activity intervention throughout elementary schools in Georgia. Specific objectives of this analysis were to: (1) Determine what changes in school PA opportunities occurred in schools with the intervention; and (2) assess the relationship between in the change in school-based PA time and improved aerobic capacity.

CHAPTER 2 MANUSCRIPT

METHODS

Study Design

This analysis utilized data collected from a multi-level school-based intervention program developed using the CSPAP model to increase and sustain health-enhancing PA. This study addressed many of these limitations of previous evaluations of multi-level interventions by examining the impact of an established, multi-level intervention on health outcomes among a large sample of diverse, low-income students. This intervention was developed as a feasibility study for a large scale statewide intervention. The non-random single group study consisted of 39 schools across five counties. Funding considerations limited the number of participating schools and determined the geographical location of the schools. School districts were approached first and priority was given to those districts willing to engage all their elementary schools in the intervention.

Data collection

School demographic variables: Demographic variables of school size and free and reduced lunch rate were collected through the Georgia Department of Education (23). Geographic categorization was determined using National Center for Education Statistics (NCES) Urban-Centric Local Coding of city, suburb, town, and rural classifications (24).

School level survey data: The HealthMPowers School Physical Activity Survey was administered to assess changes in school PA opportunities pre to post intervention (August 2013 to May 2014). An administrator, PE teacher, and 4th grade classroom

teacher from each participating school completed the web-based questionnaire. Non-responders were contacted via telephone or email by the project coordinator.

Individual level fitness data: Physical fitness was assessed using the PACER component of the FitnessGram© Assessment measures for children, the recommended aerobic capacity test for elementary aged children (25). Trained PE teachers administered the PACER and measured height and weight to calculate BMI to provide anthropometric information, although it was not expected to change with the intervention. Individual characteristics including date-of-birth and gender were collected.

Survey measures: The survey asked questions relating to four of the five CSPAP targets: PA during PE, PA before and after school, PA during school, and staff involvement. In assessing school opportunities, fourth grade teachers reported on aspects of PA during recess and in the classroom. When PE teachers, grade-level teachers (GLT), and administrators had overlapping questions, the best respondent was selected by a data team knowledgeable about school PE and PA. Information collected on recess time included frequency and duration. Information on classroom PA included duration (minutes/day), and specific times of the day the teachers would use to incorporate PA. If teachers reported that PA was not integrated into the classroom when asked the number of times per day, they were not asked any further questions about classroom PA. If teachers reported not having recess when asked how many days per week they had recess, they were not asked any further questions about recess. PE teachers reported on PE, including frequency (days/week) and (minutes/day), as well as before and after-school PA. If PE teachers reported not having PE, when asked how many days per week they had PE, they were not asked further questions about PE.

Information on physical structure and curricular structure in the schools was collected. Data were collected from PE teachers on school PA facilities (e.g. gym, blacktop, field, etc.) and wellness initiatives (whether a school had a wellness council, wellness plan, school-wide events, etc.). Data on structure of recess (unstructured, structured, combined) and availability of PE/PA equipment (e.g., balls, Frisbees, jump ropes, Hula Hoops, etc.) were collected from classroom teachers as they were most likely to be assisting in recess. While it was expected that physical facilities would not change from year to year, it was expected that PA promotion and wellness initiatives may increase after brainstorming action plans at the beginning of the intervention. It was also expected more PA may be purposefully integrated into recess and that PE/PA equipment available as part of the intervention would increase reported PE/PA equipment.

Analysis

Analysis was completed using SAS 9.4 (Cary, NC). School-level demographic data were merged with each school. Free and reduced lunch rates were categorized into quintiles and enrollment was categorized into groups with a 200 student increment. Frequencies of demographic variables were reported.

Individual level data for 2,880 students were collected and pre and post data was reported (N, mean, standard deviation (SD)). For PACER data, 538 students were removed due to missing pre or post data, gender was not specified, or if the children were administered a one mile run test substitution, resulting in a total of n=2,342 students with PACER data. The change in number of laps (post-pre) was calculated for these students. Age was reported for n=2,870 students and was calculated based on date-of-birth and date of BMI data collection, as BMI percentiles are based on CDC age- and sex- specific

growth charts (26). BMI changes, both raw and percentiles (post-pre) was calculated for those students with both pre and post BMI data for n=2,524 students. Students were removed (n= 356) if there were calculation errors because of implausible height or weight data entries, no gender specified, no date-of-birth, or if the pre and post percentile change was implausible (i.e. if the pre percentile was 1.0 and the post was 99.0).

For survey responses, pre and post results and percentages were reported. Only respondents with a pre and post response were included. For ordinal and interval variables, any increase to a higher level was reported as an increase, and any decrease to a lower level was reported as a decrease (for example, PA equipment access responses included always, often, sometimes, never, where a change from often to always represented an increase and always to never represented a decrease.) For binary variables, a change from not having a component to having a component was reported as an increase, having the component to not having it was reported as a decrease, and if there was no change it was reported as "same" (for example, before school program changes from no to yes represented an increase, yes to no represented a decrease, and yes to yes or no to no represented no change).

To assess the relationship between school PA opportunities with aerobic capacity, the changes in the amount of school-based PA were re-calculated so that linear regressions could be run. If either the pre or post survey had missing data for a particular question, the observation was not included in the regression. Due to the skip patterns this excluded 10 respondents for recess and 10 respondents for classroom PE. Eighty percent and 90% of these respondents respectively reported some level of PA post, but since they did not have pre data, these results were not included. Classroom PA, PE time, and recess

were coded as the mean of the interval selected on the survey (e.g., 40-49 min was coded as 44.5). For the largest interval with no upper bound limit (e.g., 50+), the range of the previous interval divided by two was used. (For example, for 50 +, 40-49 was the next smallest range (49-40)/2 = 4.5, so 50+ was coded as 54.5.) Weekly minutes of PA in PE was defined as daily minutes of PA in PE multiplied by the number of PE days. Weekly PA in recess was defined as daily minutes of recess multiplied by number of recess days. Weekly classroom minutes of PA was defined as daily classroom minutes of PA multiplied by five. Pre data were subtracted from post data to obtain the change in minutes PA per week. The three measures were then summed to provide an estimate of total PA per week. The change (post-pre) was calculated.

To overcome the interval range constraints on the capabilities of linear analysis of change in school-based PA time, uniform random values were generated within each range. Mean changes in PACER scores for schools were calculated from the individual PACER scores to provide an average change in aerobic capacity for schools to correlate with change in school-based PA time. We created a 95% empirical interval estimate of the linear correlation between time in school-based PA and aerobic capacity. This was done using bootstrapping methods where the bootstrap n=1000 to replicate the uncertainty produced by unrounding the categorized data. The empirical interval was then determined by 50^{th} and 950^{th} correlation coefficient calculated.

RESULTS

Demographic variables are reported in Table 1. The majority of schools (59%) had between 401-600 students, 15% had less than 400 students and 26% had over 600 students. Almost half of the schools were located in cities (41%), while 15% were suburban, 36% were rural, and 8% were in a town. The majority of the schools (49%) had over 80% of students receive free or reduced lunch and 80% of schools had over 60% of students receiving free or reduced lunch.

Student data is reported in Table 2. Average age at the beginning of the year was 9.8 years. The average number of PACER laps completed increased from 21.3 to 24.1 laps after the intervention, a 2.8 lap increase, with 73% of children improving or maintaining number of laps completed. BMI percentiles remained the same as expected.

Thirteen schools (33%) increased days/week of recess while 25 (61%) remained the same and one (3%) decreased (pre and post frequencies reported in Table 3). Of those schools that reported having recess, 10 schools (35%) increased minutes/day of recess while 12 (41%) remained the same and seven (24%) decreased. Of the 10 schools that reported no recess pre, eight (80%) reported having some level of recess post. In addition, the number of schools reporting five days of recess increased from 21 (54%) to 27 (70%). The number of minutes per PE session remained the same in 33 schools (84%) while it decreased in four schools (10%) and increased in two (5%). The number of days/week of PE remained the same for 33 schools (84%), while three schools increased and three schools decreased days/week PE (8% each). The number of schools reporting a before school program increased from eight schools (21%) to 26 (67%), while the

number of schools reporting an after school program dropped from 13 (33%) to seven (18%).

Of the 10 schools that did report any classroom PA pre, nine (90%) reported an increase to some frequency of PA. For those who reported some frequency of classroom PA four (14%) of teachers reported changing from no time in PA to incorporating some PA into the classroom (pre and post frequencies reported in Table 4). Overall, 11 (38%) of schools increased class time PA by some degree, while 11 (38%) remained the same and seven (24%) decreased. PA at the beginning of the day showed the largest change from pre to post (15% before to 64% after), although PA increased across all different times.

In terms of physical and curriculum structure, 38 schools reported having a gym (97%) pre-intervention, while all 39 reported having one post intervention. In terms of other facilities, a field, blacktop, and playgrounds were the most common facilities. Seventeen (44%) of schools reported having a blacktop, 31 (79%) reported having a field, and 25 (64%) reported having a playground pre-intervention, while 23 (59%) reported having a blacktop, 28 (72%) reported having a field, and 22% reported having a playground post intervention. The least common PA facility was a track, which is reasonably expected as we were assessing elementary schools, which do not provide team sports, such as track and field, that would require a full track. In addition, it is not expected that these changes are related to the intervention.

In terms of wellness initiatives, the number of schools with councils increased by 23%, from 12 to 21. The number of schools with a wellness plan increased by 13%, from 12 to 17 schools. The number of schools with written information on PA available

increased by 23%, from 12 to 21 schools. The number of schools with audio or visual PA information available increased from 13% from 7 to 12 schools. The number of schools hosting school-wide events increased by 25%, from 8 to 18 schools, while schools with assemblies increased 8%, from 6 to 9 schools. The number of schools with walk/bike to school programs remained the same. Five schools reported other wellness initiatives pre intervention and decreased to 5% to 3 schools post intervention.

In terms of recess, there was a shift of structure from unstructured recess to structured recess, or a combination of structured and unstructured recess. Pre-intervention, 25 schools reported unstructured recess, while this decreased by 15% to 19 post-intervention, schools with structured recess increased from 0 to 2 schools (5%), and schools with a combination increased by 31% from 4 to 16 schools. Fifteen schools (52%) increased how often they had access to PA equipment during recess while eight (28%) stayed the same and six (21%) decreased. All schools reported at least sometimes having access to equipment post-intervention.

From the linear regression we found evidence of a significant positive linear relationship between the change in school PA time and aerobic capacity ($r = 0.39$, 95% Empirical Interval: 0.31-0.47).

DISCUSSION

Results from this pilot project support the use of multi-level school-based PA interventions for children. An improvement in aerobic capacity scores were seen after the program. The changes in school-based PA time had a significant positive linear relationship with these scores, indicating that as children engage in more school-based PA, their aerobic capacity increased.

Classroom PA was integrated in the classroom much more throughout the day. Increases were seen most at the start of the day and between lessons, but PA during lessons, before and after lunch, and at the end of the day also proved to be feasible options for integrating PA, as increases were seen in all these times. This is promising because many options for PA throughout the day provides flexibility for teachers to choose when PA could best be integrated into their classroom and multiple opportunities to integrate PA throughout the day.

More schools reported offering more recess per week. The most promising change was seen from 10 schools offering no recess pre-intervention, reduced to two schools post-intervention. In addition, the number of schools reaching five days of recess largely increased. Changes in PA resources and recess structure also were seen. With over half of the schools increasing how often they had access to PA equipment and all schools reporting at least sometimes having access to equipment post-intervention we can see there is an increase in access to inexpensive equipment that can facilitate PA. In addition, recess in many schools shifted from unstructured to a combined structured and unstructured recess. With a recess structure, there is less chance children have less chance to just stand still and are more engaged in PA.

Before school programs appeared to be a promising target for the intervention as over half of schools adopted a before school program. The before school program was a focus of the intervention, and given that all aspects of the intervention were optional, this increase is quite notable. This increase is especially important given the population. A before school program that is feasible in low SES communities provides a benefit for both children and families. Children are given an extra opportunity for PA, but additionally, the program can be a huge help to parents, as a potential strain for before-school care for working parents is alleviated.

In terms of physical resources, it was not expected that the intervention would modify these physical structures at schools, as this was not feasible. Looking at curriculum structure though, after the intervention, increases were seen in many aspects of wellness initiatives at schools, recess structure, and recess physical activity resources. Number of schools with wellness councils, plans, written wellness information, and audio and visual wellness initiatives, school-wide events and assemblies all increased. This is a promising indication that physical activity and wellness is becoming a higher priority for these schools and indicates progress towards the educational aspect of the importance of physical activity.

While the number of studies investigating the effect of school based and multi-level PA interventions in children are few and have methodological challenges, these results align with school based interventions assessing changes in aerobic capacity, where a change in school-based PA was associated with a change in aerobic capacity (27). In addition, results from this study align with current research on multi-level interventions in the adolescent population (15).

One strength of this program include the ability to reach a large number of low SES schools. As the national obesity epidemic rises, an emphasis needs to be placed on programs that are feasible and impactful across schools of different sizes and across geographic locations. Focusing on low SES schools allowed assessment of a demographic disproportionally at risk as these neighborhoods tend to have the least access to resources and opportunities as well as disproportionally higher risks for negative health outcomes (6, 28). Even with barriers such as lack of access to equipment, safe neighborhoods, and other barriers that low SES neighborhoods may encounter, changes in aerobic capacity in children in these schools were seen as the incorporation of school-based PA increased.

While this information is valuable to school-based PA intervention research, this study is limited by a few factors. First, there was no control group to compare the intervention to in the general population so history bias, in the form of other interventions or initiatives outside of HealthMPowers, cannot be controlled for when looking at changes in the schools. Some schools implemented more PA than others though, so the analysis looked to compare changes between children who received less PA as opposed to more, which can help control for other factors all schools may have been exposed to that could contribute to history bias. Second, the intervention schools were not randomized, eliminating the ability to control for confounding in the design, although assessing changes pre to post allows us to establish temporality and say that after receiving the intervention, changes occurred. Finally, the survey was not designed for research purposes and had not been previously validated, although it is undergoing test-retest analysis to assess validity.

CHAPTER 3 SUMMARY, IMPLICATIONS, FUTURE DIRECTIONS

Summary

As discussed previously, these results are a positive indication for school-based PA interventions. These results align with school-based interventions assessing changes in aerobic capacity, in that school-based PA was associated with a change in aerobic capacity (27). The changes in school-based PA time, accumulated from classroom PA time, recess PA time, and PE time, had a significant positive linear relationship with these scores, indicating that as children engage in more school-based PA, their aerobic capacity increased. Reviews in both school-based settings and following a multi-level approach have strong evidence to support their effectiveness, and this study aligns with those findings (15).

Public Health Implications & Future Health Implications

Findings from this study highlight the need for further research into PA interventions and support the need for policy change. While this study showed positive indicators of change in school-based PA and aerobic capacity, further research and continued intervention efforts are needed to create successful and sustainable programs. Rigorous testing, including randomized control trials (RCTs) of large scale implementation are needed to provide insight into how these programs can be used to reach large populations of children. RCTs of interventions of this nature, which allow schools to select certain programs to adopt, will allow assessment of the efficacy of different components of the intervention.

The informative capacity of a RCT in determining component-specific efficacy and cost per component then can be used to run cost-benefit analyses to determine per

dollar, which intervention components are most valuable. This information can be hugely valuable to funding agencies and to stakeholders for future investments in interventions as well as informing policy decisions.

Table 1. School Characteristics 2013-2014

	N	%
School Enrollment[1]		
200-400	6	15
401-600	23	59
601-800	7	18
801-000	3	8
Geographic Categorization[2]		
City	16	41
Rural	14	36
Suburb	6	15
Town	3	8
Free Reduced Lunch Rates[1]		
0-20	0	0
21-40	3	8
41-60	5	13
61-80	12	31
81-1000	19	49

[1]Georgia Department of Education. Free and Reduced Lunch (FRL) – Fiscal Year 2014 Data Report. Atlanta, GA. Available from: https://app3.doe.k12.ga.us/ows-bin/owa/fte_pack_frl001_public.entry_form
[2]U.S. Department of Education. Public Elementary/Secondary School Universe Survey Data 2013-2014 v.1a. Institute of Education Sciences, National Center for Education Statistics. Available from: http://nces.ed.gov/ccd/pubschuniv.asp.

Table 2. Student characteristics, anthropometrics, and aerobic capacity

		Pre	Post
	N	Mean (SD)	Mean (SD)
Age (years)	2,870	10 (0.5)	10 (0.5)
PACER[1]	2,342	21 (13.6)	24 (14.9)
BMI[2]	2,524	20 (4.7)	20 (4.8)
BMI %tile[2]	2,524	67 (29.8)	67.4 (29.6)

[1]PACER = progressive aerobic cardiovascular endurance test score, in laps completed.
[2]BMI = Body mass index
[3]BMI %tile = BMI percentile calculated using CDC age- and sex- specific growth charts.[21]

Table 3. Pre and Post PE and Recess Survey-reported Physical Activity Opportunities

	Pre		Post	
	N	%	N	%
Recess frequency (days/week)				
no recess	10	26	2	5
1	1	3	2	5
2	2	5	1	3
3	2	5	3	8
4	3	8	4	10
5	21	54	27	69
Recess duration (min/session)				
<15 min	7	24	3	10
15-19 min	8	28	11	38
20-29 min	7	24	11	38
30 min or more	7	24	4	14
PE frequency (days/week)				
0	0	0	1	3
1	22	56	21	54
2-3	16	41	15	39
4-5	1	3	2	5
PE duration (min/session)				
20-29	1	3	1	3
30-39	4	10	6	15
40-49	24	62	22	56
50+	10	26	10	26
Before School Program	8	21	26	67
After School Program	13	33	7	18

PA=physical activity

Table 4. Pre and Post Classroom Survey-reported Physical Activity Opportunities

	Pre		Post	
	N	%	N	%
Classroom PA (min/day)				
Not integrated	11	38	7	24
1-5 minutes	8	28	7	24
6-10 minutes	4	14	8	28
11-15 minutes	4	14	1	4
16 minutes or more*	2	7	6	21
PA Incorporation into the Classroom				
Start of day	6	15	25	64
Between lessons	12	31	27	69
Part of lessons	10	26	19	49
Before/after lunch	13	33	23	59
End of day	5	13	10	26
None	8	21	1	3

PA = physical activity

*all those that reported over 16 minutes were also over 20 minutes

Table 5. School Setting Characteristics Influencing Physical Activity

	Pre		Post	
	N	%	N	%
School PA facilities				
gym	38	97	39	100
blacktop	17	44	23	59
field	31	79	28	72
playground	25	64	22	56
track	3	8	5	13
classroom	13	33	12	31
none	0	0	0	0
other	2	3	0	0
Wellness Initiatives				
council	12	31	21	54
plan	12	31	17	44
written info	12	31	21	54
audio/visual info	7	18	12	31
school-wide events	8	21	18	46
assemblies	6	15	9	23
walk/bike to school program	2	5	2	5
none	0	0	3	8
other	5	13	3	8
PA equipment access				
Always	10	35	12	41
Often	4	14	11	38
Sometimes	9	31	6	21
Never	6	21	0	0
Recess Structure				
unstructured	25	64	19	49
structured	0	0	2	5
combination	4	10	16	41

PA = physical activity

References

1. Childhood Obesity Facts. Centers for Disease Control and Prevention (CDC), Atlanta, GA. http://www.cdc.gov/obesity/data/childhood.html. Accessed April 7 2016.

2. Childhood Obesity Cause and Consequences. Centers for Disease Control and Prevention (CDC), Atlanta, GA. http://www.cdc.gov/obesity/childhood/causes.html. Accessed April 4 2016.

3. Physical activity guidelines for Americans 2008. Physical Activity Guidelines Advisory Committee, Washington D.C. 2008. http://www.health.gov/paguidelines/default.aspx.

4. Blair SN, Cheng Y, Holder JS. Is physical activity or physical fitness more important in defining health benefits? Med Sci Sports Exerc. 2001;33(6 Suppl):S379-99; discussion S419-20.

5. Gidding SS, Dennison BA, Birch LL, et al. Dietary recommendations for children and adolescents: a guide for practitioners: consensus statement from the American Heart Association. Circulation. 2005;112(13):2061-75. doi:10.1161/circulationaha.105.169251

6. Drenowatz C, Eisenmann JC, Pfeiffer KA, et al. Influence of socio-economic status on habitual physical activity and sedentary behavior in 8- to 11-year old children. BMC Public Health. 2010;10:214. doi:10.1186/1471-2458-10-214

7. State Indicator Report on Physical Activity, 2014. Centers for Disease Control and Prevention (CDC), Atlanta, GA. http://www.cdc.gov/physicalactivity/downloads/pa_state_indicator_report_2014.pdf.

8. Physical Activity Levels Among Children Aged 9--13 Years --- United States, 2002. Atlanta, GA: Center for Disease Control and Prevention (CDC)2003.

9. Table 103.10. Percentage of the population 3 to 34 years old enrolled in school, by sex, race/ethnicity, and age group: Selected years, 1980 through 2013. U.S. Department of Education. 2013. https://nces.ed.gov/programs/digest/d14/tables/dt14_103.10.asp?current=yes.

10. Gordon-Larsen P, Nelson MC, Page P, Popkin BM. Inequality in the built environment underlies key health disparities in physical activity and obesity. Pediatrics. 2006;117(2):417-24. doi:10.1542/peds.2005-0058

11. Recess Rules: Why the undervalued playtime may be America's best investment for healthy kids and healthy schools. Robert Wood Johnson Foundation (RWJF), Princeton, NJ. 2007. http://www.playworks.org/sites/default/files/d6/rwjf_sports4kids_recess_report.pdf. 2015.

12. Lee SM, Burgeson CR, Fulton JE, Spain CG. Physical education and physical activity: results from the School Health Policies and Programs Study 2006. J Sch Health. 2007;77(8):435-63. doi:10.1111/j.1746-1561.2007.00229.x

13. Comprehensive School Physical Activity Programs: a guide for schools. Centers for Disease Control and Prevention (CDC), Atlanta, GA. 2013. http://www.cdc.gov/healthyyouth/physicalactivity/pdf/13_242620A_CSPAP_SchoolPhysActivityPrograms_Final_508_12192013.pdf.

14. Sallis JF, Owen N, Fisher E. Chapter 20 - Ecological Models of Health Behaviors in Glanz, K., Rimer, B.K., Viswanath, K. (Eds.) Health Behavior and Health Education: Theory, Research, and Practice (4th ed., pp 465-485.). 4th ed. San Francisco: Jossey-Bass; 2008.

15. van Sluijs EM, McMinn AM, Griffin SJ. Effectiveness of interventions to promote physical activity in children and adolescents: systematic review of controlled trials. Br J Sports Med. 2008;42(8):653-7.

16. Zhou Z, Ren H, Yin Z, Wang L, Wang K. A policy-driven multifaceted approach for early childhood physical fitness promotion: impacts on body composition and physical fitness in young Chinese children. BMC Pediatr. 2014;14:118. doi:10.1186/1471-2431-14-118

17. National Framework for Physical Activity and Physical Education & Resources to Support CSPAP. Center for Disease Control and Prevention (CDC), Atlanta, GA. http://www.cdc.gov/healthyschools/physicalactivity/pdf/National_Framework_Physical_Activity_and_Physical_Education_Resources_Support_CSPAP_508_tagged.pdf. Accessed 2016 April 8.

18. School Health Guidelines to Promote Healthy Eating and Physical Activity. Center for Disease Control and Prevention (CDC), Atlanta, GA. 2011. http://www.cdc.gov/mmwr/pdf/rr/rr6005.pdf. Accessed April 8, 2016 60.

19. Naylor PJ, McKay HA. Prevention in the first place: schools a setting for action on physical inactivity. Br J Sports Med. 2009;43(1):10-3. doi:10.1136/bjsm.2008.053447

20. McArdle WD, Katch FI, Katch VL. Essentials of Exercise Physiology, Third Edition. Philadelphia, PA: Lippincott Williams & Wilkins; 2006.

21. McArdle WD, Katch FI, Katch VL. Exercise Physiology: Nutrition, Energy, and Human Performance: Lippincott Williams & Wilkins; 2010.

22. Strong WB, Malina RM, Blimkie CJ, et al. Evidence based physical activity for school-age youth. J Pediatr. 2005;146(6):732-7. doi:10.1016/j.jpeds.2005.01.055

23. Free and Reduced Lunch (FRL) - Fiscal Year 2014 Data Report. Georgia Department of Education (DOE), Atlanta, GA. https://app3.doe.k12.ga.us/ows-bin/owa/fte_pack_frl001_public.entry_form.

24. Public Elementary/Secondary School Universe Survey Data 2013-2014 v.1a. U.S. Department of Education. http://nces.ed.gov/ccd/pubschuniv.asp.

25. Plowman SA, Meredith MD. Fitnessgram/Activitygram Reference Guide (4th Edition). Dallas, TX: The Cooper Institute; 2013.

26. Children's BMI Tool for Schools. Centers for Disease Control and Prevention (CDC), Atlanta, GA. http://www.cdc.gov/healthyweight/assessing/bmi/childrens_BMI/tool_for_schools.html. 2014.

27. Sallis JF, McKenzie TL, Alcaraz JE, Kolody B, Faucette N, Hovell MF. The effects of a 2-year physical education program (SPARK) on physical activity and fitness in elementary school students. Sports, Play and Active Recreation for Kids. American Journal of Public Health. 1997;87(8):1328-34.

28. Singh GK, Siahpush M, Kogan MD. Rising social inequalities in US childhood obesity, 2003-2007. Ann Epidemiol. 2010;20(1):40-52. doi:10.1016/j.annepidem.2009.09.008