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Evaluation of Interventions in the Clinical and School Settings to Address Child Obesity: A Step Forward in Translation

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An abstract of
A dissertation submitted to the Faculty of the
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Abstract

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Importance: Cardiometabolic risk factors in childhood cause atherosclerosis and early mortality. Interventions to prevent and treat cardiometabolic risk factors in childhood have been developed in numerous venues including clinical and school settings. Wide-scale intervention implementation has, however, been limited in part because of narrow consideration to setting-level processes.

Objective: This dissertation sought to evaluate the implementation of interventions in the clinical and elementary school settings designed to address poor body composition and fitness.

Methods: Study 1 used a pre-post study design to examine the impact of a continuing medical education program on weight-related counseling practices among 102 Georgia pediatricians. Study 2 assessed the impact of a state-wide, voluntary, school-based intervention on opportunities for physical activity offered by elementary schools by comparing intervention and non-intervention schools. Study 3 explored the 2012-2013 cross-sectional relationship between physical activity opportunities and health-related fitness aggregated at the school level across 1,176 Georgia elementary schools.

Results:
Study 1: Participation in the MOC program resulted in an increased and sustained documentation frequency of each of the recommended counseling components six months after completion of the intervention across all practice and pediatrician characteristics.
Study 2: Compared to non-intervention schools, intervention schools reported providing 36 more minutes of physical activity each week after intervention, even after controlling for baseline physical activity opportunities, school demographics, and other school characteristics.
Study 3: The amount of time that schools reported providing for physical activity (e.g. physical education, recess, etc.) was not associated with student fitness or body composition aggregated at the school-level, although before-school physical activity was weakly related to student fitness, and recess time was moderately associated with body composition.

Conclusions: Setting-level outcomes, including pediatrician counseling in the clinic and physical activity opportunities provided by the elementary school, increased as a result of two interventions delivered in respective venues. The impact of these outcomes on child-level health is likely moderate. However, small changes among a sizeable population or over an extended period of time may be impactful, and future work should investigate the long-term impacts of these interventions across diverse populations, alone or in combination with others, on child health outcomes.

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Table of Contents

List of Figures

List of Tables

Chapter 1: Introduction to Cardiorespiratory Endurance, Body Composition, and Obesogenic Behaviors

Introduction

In childhood, clinical cardiometabolic risk factors (CRFs), including abdominal obesity, elevated blood pressure, high triglycerides, low high-density lipoproteins, and high blood sugars, cause atherosclerosis and early mortality.[1–3] Almost 16% of children have two or more clinical CRFs.[4] Various health states and behaviors can affect these clinical CRFs. Poor cardiorespiratory endurance in childhood increases future heart disease risk by lowering high-density lipoproteins, elevating systolic and diastolic blood pressure, and causing arterial stiffness in childhood.[4,5] Well-known obesogenic behaviors such as low physical activity (PA) and poor nutrition exacerbate poor childhood fitness and fatness. These modifiable characteristics can be shaped in numerous settings, and improving child health behaviors, fitness, fatness, and ultimately clinical CRFs, will likely take a multipronged approach involving families, communities, and child-serving institutions such as schools and clinics[6,7] Numerous interventions have been developed to modify these behaviors in clinical and educational settings, but the ideal methods for implementing these interventions into existing infrastructure remain unknown. This dissertation contributes to the literature by evaluating the implementation strategies of behavior-oriented interventions delivered in clinical and school settings.

Importance of Health-Related Fitness

Clinical CRFs and the risk factors affecting them, such as health-related fitness and health behaviors like diet and PA, have complicated causal relationships. Some of these complex connections result from the way we define clusters of risk factors. For example, body composition is a component of health-related fitness, but is also considered a clinical CRF. Another reason for the intricate associations between CRFs is the complex nature of the causal networks between risk factors. For example, obesity is a cause of poor cardiorespiratory endurance,[8] but cardiorespiratory endurance also modifies the effect of obesity on other clinical CRFs.[9,10] Although there are numerous and convoluted relationships between cardiovascular risk factors, this dissertation is motivated by interventions attempting to impact health-related fitness in the form of cardiorespiratory endurance and body composition, and health behaviors in the form of diet and PA.

Poor childhood cardiorespiratory endurance is a strong predictor of clinical CRFs.[9,11] Although less is known about cardiovascular events resulting from low cardiorespiratory endurance in childhood, adults with low cardiorespiratory endurance have higher risk for coronary heart disease and cardiovascular events (RR: 1.6; 95% CI, 1.4-1.8) and all-cause mortality (RR:1.7; 95% CI, 1.5-1.9) compared with adults with high cardiorespiratory endurance.[12–14] Studies linking cardiorespiratory endurance with health outcomes in the US among adults inform our understanding in childhood since cardiorespiratory endurance tracks from an early age into adulthood.[15]

Despite the serious childhood and adulthood health consequences resulting from poor cardiorespiratory endurance, cardiorespiratory endurance has declined in recent years.[16,17] In 1999-2000 in the US, approximately 52% of children 12-15 years had adequate levels of cardiorespiratory endurance, as determined by estimated VO_2 max and FitnessGram health fitness zone thresholds.[17] However, only 42% of children 12-15 years had adequate cardiorespiratory endurance in 2012.[17] Whether this trend of declining cardiorespiratory endurance continues today remains unclear.[18–20]

In addition to cardiorespiratory endurance, body composition is another component of health-related fitness impacting heart disease risk. Body composition is defined as the amount and relative proportions of body tissue types (such as fat and fat-free mass). Poor body composition in the form of obesity has been linked with other suboptimal clinical CRFs in childhood, including high total-to-high density lipoproteins, elevated systolic and diastolic blood pressure, and diabetes.[21 22–24]

Childhood obesity currently affects 17% of children 2-19 years in the US.[25] Childhood obesity prevalence among children 2-5 years increased from 7% in 1988-1994 to 10% in 1999-2000. Among children 6–11 years, obesity prevalence increased from 7% to 18%, and among children 12-19 years, obesity prevalence increased from 5% to 21% between 1980 and 2012.[25–27] However, some studies have suggested that these worsening temporal trends in childhood obesity may be attenuating.[25,27]

Health Behaviors Influencing Childhood Cardiorespiratory Endurance and Body Composition

Numerous modifiable characteristics at the individual level impact cardiorespiratory endurance, body composition, and ultimately clinical CRFs. Cardiorespiratory endurance among children is impacted most strongly by characteristics such as body composition and PA.[28–32] Body composition, in turn, is impacted by diet (e.g. consuming sugar-sweetened beverage and eating out-of-home foods) and PA.[6,31,33–37] For example, a recent study followed children through time and assessed the relationship between moderate-to-vigorous PA (MVPA) at 12 years and fat mass at 14 years, where MVPA indicates PA that accelerates the heart rate and requires at least a moderate level of effort (e.g. brisk walking, dancing, etc.).[38,39] The study reported that just an extra 15 minutes of MVPA per day among 12-year-old students is associated with a 10-12%-lower fat mass when the students are14 years of age.[6]

Despite clear causal relationships between PA/diet and cardiorespiratory endurance and body composition, few children meet national diet and PA recommendations. The United States Department of Agriculture recommends children to consume one to two cups (about two to four servings) of fruits and one to three cups (about two to six servings) of vegetables daily,[40] but in 2009-2010, mean fruit consumption among children 2-18 years was 0.6 cups per day and mean vegetable consumption was 0.5 cups per day.[41] In contrast, sugar-sweetened beverages contribute 10-15% of daily calories among youth and are the highest contributors of added sugar to diets among children.[33]

Similar to dietary recommendations, children fall short of activity-based recommendations. Although organizations vary in the language around their recommendation, many organizations like the World Health Organization recommend at least 60 minutes of MVPA per day.[38,39] However, on average, children 6-11 years only engage in 88 minutes of MVPA per week (~17 minutes/day).[42] Less-than-ideal PA time is accompanied by higher-than-recommended screen time. The American Academy of Pediatrics (AAP) recommends two or fewer hours of television viewing and screen time per day for children,[43,44] but only 54% of children 6-11 meet these guidelines.[45]

The Case for Setting-level Outcomes: Translational Research

Knowledge of these individual-level health behaviors and CRFs has informed the development of national recommendations and numerous interventions to increase key health behaviors in various settings;[43,46] however, translation of such interventions into the real world has been slow. This largest barrier in this lengthy translation process is the time required for adoption of evidence-based recommendations by practitioners such as pediatricians in the clinical setting and school staff in the educational setting.[47] Currently, there is little understanding of how evidence-based recommendations are translated into practice.

The contextual differences between research and real-world settings may lead to barriers in both the adoption and implementation of evidence-based recommendations by practitioners.[48] First, in the efficacy study setting, research staff often carries out the intervention, but implementation outside of this setting falls to practitioners. If practitioners are not provided with the education and tools to adopt the recommendation, the changes may seem too burdensome to practitioners resulting in failure to adopt the intervention. Second, most researchers aim to obtain valid estimates of effect by maximizing internal validity and uniformity in intervention across all participants.[48] However, a one-size-fits-all intervention may not be appropriate for different schools and clinical settings, which differ in demographics and needs. Finally, even after the initial decision to adopt recommendations, practitioners may encounter barriers during implementation. Unlike drug trials, many public health interventions rely on settings and/or individuals to deliver the intervention, and lack of requirements at the setting or greater state levels may limit the extent to which recommendations are fulfilled. As such, an intervention that may have been effective in a limited population in a specific setting in a research study may not necessarily be extrapolated to a more diverse population with other competing demands.

For many years, practitioners were accountable for overcoming these barriers to translation. This passive process of evidence diffusion was known as “letting it happen”, where the researcher’s role was completed upon publication of their findings.[49] The practitioner was relied upon to integrate the published research into practice. In recent years, there has been a push to more actively “make it happen” through the use of implementation teams or other proactive strategies to help practitioners overcome barriers to implementation. The field of implementation science, or the study of “strategies to adopt and integrate evidence-based health interventions and change practice patterns within specific settings” has arisen, in part, to identify opportune methods to actively address this research-to-practice gap.[50] This field attempts to identify the ideal implementation strategies, or methods of helping practitioners adopt and integrate recommendations into their everyday routines (e.g. practitioner training session, setting-level systems changes, etc.).

Interventional Settings

This practice-to-research chasm exists across numerous settings attempting to impact child PA, nutrition, and health-related fitness, including the clinic, school, home, and community environments. This dissertation will focus on interventions delivered in the clinical and educational settings.

Clinics can influence obesogenic behaviors because they are a place where parents seek guidance on health risks and benefits for their children.[51] As young children are often accompanied by parents or primary caretakers in the clinic, a natural partnership between the clinic and the home is created.[51] Further, medical homes provide follow-up care throughout childhood.[51] Accordingly, studies have shown that the primary care setting is an effective intervention setting,[52] and an expert committee recommended that primary care providers be at the center of weight-related behavioral change.[43] Hence, clinics serve as a particularly important setting for educating parents and children and for reinforcing messages concerning healthy childhood behaviors.

While clinics are a source of trusted health information, schools are an optimal setting for promoting PA and nutrition due to their expansive reach. Schools serve 98% of US children 7-13 years.[53] During the school week, children are at schools for half of their waking hours. This reach of the educational system also transcends demographic boundaries and is an opportunity to reduce disparities in nutrition and PA which have been clearly reported across age,[45,54] gender,[45] race/ethnicity,[54,55] socioeconomic status (SES),[56,57] and geography.[55] Finally, physical education (PE) curricula have existed for numerous years with the primary goals of providing children with the knowledge, behaviors, and skills to sustain an active life.[58]

Given the complexity of childhood cardiorespiratory endurance, body composition, and the layers of influence on CRFs, this dissertation will focus on evaluating the implementation strategies of interventions addressing CRFs delivered in the clinical and elementary school settings. In Study 1, the impact of a continuing education program as an implementation strategy to increase weight-related counseling practices by physicians will be examined. Study 2 will assess the impact of a voluntary, statewide school-based implementation strategy to increase PA opportunity time offered by elementary schools. Finally, in Study 3, the relationship between these PA opportunity times and child cardiorespiratory endurance and body composition will be explored.

Chapter 2: Study Rationales, Objectives and Hypotheses

Intervening on Weight-Related Counseling in the Clinical Setting

Based on expert opinion and growing literature, in 2007 the AAP recommended that pediatricians should perform universal childhood obesity screening by identifying obesity; assessing each child's weight-related medical (e.g. body fat, weight-related medical problems, etc.) and health behavior risks (diet and PA); and preventing unhealthy weight gain through patient centered counseling.[43]

BMI percentile screening and medical risk assessments are important for preventing childhood obesity and consequences of obesity because it allows clinicians to tailor patient-centered communication around maintaining versus establishing healthy habits.[43] BMI percentile screening is recommended for children over the age of two by the AAP and over the age of six by the US Preventive Services Task Forces.[59] Initial BMI percentile screening and identification of obesity facilitates screening of weight-related medical issues such as CRFs.[43] In addition, the AAP recommends that pediatricians measure the blood pressure of all children and evaluate weight-related medical issues among overweight or obese children.[43]

Upon BMI screening and medical risk assessment, identification of health behaviors and prevention of unhealthy weight gain can be accomplished using patient-centered counseling. This counseling type can involve numerous techniques such as motivational interviewing and goal setting, which have been used to manage various diseases.[18, 19] Specifically, motivational interviewing involves creating a non-confrontational climate using reflective listening to facilitate a collaborative dialogue between providers, parents, and patients to identify reasons for and against behavior change and the health impact of behaviors.[43,60] Motivational interviewing is commonly used in conjunction with the “five As” of behavior change: (1) *asking* for permission to discuss the health issue; (2) *assessing* the health issue; (3) *advising* the patient about the health issue; (4) *agreeing* with the patient on targets and behavioral changes; and (5) *assisting* patients by addressing barriers, and providing resources and follow-up care.[43] Motivational interviewing has been delivered using multiple modalities (e.g. in-person, telephone), by different providers (e.g. physicians, nurses, dieticians), and in different settings (e.g. group vs. individual; clinic vs. community setting).[61] The AAP currently recommends motivational interviewing as a tool to perform patient-centered communication during obesity prevention messaging.

In addition to motivational interviewing, another patient-centered counseling technique is goal setting, which is often used in conjunction motivational interviewing. In goal setting, physicians encourage parents and patients to set achievable behavior goals (e.g., 15 minutes of PA per day), and it can be conducted in-person or by telephone.[61] Based on the evidence base supporting goal setting and behavioral assessments to improve diet among both children and adults,[61–63] the AAP recommends behavioral goal setting during weight-related counseling.[43]

Despite the AAP recommendations to provide weight-related counseling to all children in the clinic, almost 25% of children do not report receiving any lifestyle counseling at all[64,65] Further, practitioners approach non-overweight/non-obese patients differently from overweight/obese patients[64] Clinicians are less likely to provide PA counseling to normal-weight children than overweight children, even after controlling for child demographic variables, child co-morbidities like diabetes and asthma, and provider and practice characteristics,.[65] Likewise, the adjusted odds of clinicians providing combined weight, nutritional, and PA counseling to obese children is more than two-times the odds among normal-weight children (aOR range: 2.0-2.5).[65] However, failing to provide counseling to all children, not only disagrees with the current recommendations to provide universal weight-related counseling, regardless of child BMI, but also is a missed opportunity since detrimental health behaviors and childhood obesity is difficult to reverse.[43]

Almost all interventions attempting to increase weight-related counseling among pediatricians have focused on helping clinicians increase counseling for overweight and obese children.[66–73] Much less is known about the ideal ways to impact of weight-related counseling delivered to normal-weight children.[71,72,74–78] One study in Sweden assessed an intervention designed to encourage counseling across all patients and involved a five-day motivational interviewing training for nurses.[74] These nurses subsequently delivered nine counseling sessions encouraging initiation or maintenance of healthy behaviors to each participant. The intervention improved child dietary behaviors but not weight three years after baseline.[74]

To inform the literature on the efficacy of universal weight-related counseling (rather than counseling targeted to obese or overweight children), an intervention that can increase universal weight-related counseling must first be identified. Only a few studies have assessed interventions developed to increase counseling among physicians.[75,78,79] A 2009 study in Maine assessed an intervention involving: (1) a 1.5-day training on negotiation, goal setting, and guidelines for a multidisciplinary team from each clinic; (2) materials like posters and behavioral screening tools; (3) support through learning sessions, calls, and site visits; and (4) a CDS chart.[78] Using a longitudinal design, this study reported significant increases in assessment of BMI and BMI percentile, use of the behavioral screening tool by physicians, parent recall of behavioral counseling, and physician knowledge, self-efficacy, and awareness of guidelines and resources.[78] A 2015 study in Georgia assessed an intervention involving a two-hour motivational interviewing didactic and skill building session, provision of BMI charts, behavioral screening tools, and educational handouts for parents.[75] This study reported improved physician self-efficacy, documentation of BMI, and goal setting.[75] A 2013 study assessed a maintenance of certification (MOC) program in five New Mexico pediatric practices involving on-site training, patient presentations, and optional coaching calls.[73] MOCs are continuing education opportunities for physicians, which are required to maintain a board license in many specialties.[80] Documentation of BMI percentile increased from 49% to 99%, counseling for nutrition increased from 52% to 87%, and PA messaging increased from 39% to 77% after two years. Among overweight and obese patients, goal setting frequency increased from 26% at baseline to 48% at follow-up, although this was not statistically significant.

In addition to sparse data on ideal methods to increase universal weight-related counseling, it is also unclear whether practice and pediatrician characteristics are associated with counseling practices. One cross-sectional study assessed motivational interviewing among 49 physicians in academic and community practices using voice recorders and found that pediatricians were more likely to provide a collaborative motivational interviewing dialogue than family medicine physicians, and prior motivational interviewing training increased the use of motivational interviewing techniques like asking permission, affirming, etc.[81] More recent medical school graduates were more likely to use open-ended questions than other physicians.[81] Because weight-related counseling varies across practice and physician characteristics, when physicians are providing the intervention, modifiers of physician practices are particularly important to measure.

Measuring the impact of behavioral therapy in the clinical setting: Physician counseling. Although the provision of weight-related counseling has been assessed using audio-taping, parent recall, and chart reviews, data derived from audio-taping clinical visits has been considered the “gold standard”.[82] For example, one recent study transcribed dialogues during pediatric visits and assessed whether the “five A’s” (asking, assessing, advising, agreeing, assisting) were discussed.[79] While this is the most direct way to measure weight-related counseling, social desirability bias, time, labor, and cost concerns limit the feasibility of this measurement method in studies with a larger scope.

In contrast to audio tapes, chart reviews are most commonly conducted because of easy prospective and retrospective data access.[75] However, chart reviews reflect documentation and may not serve as good proxy data for pediatrician counseling behavior. One recent study suggested that electronic health record documentation may have low sensitivity for discussions of weight (42%), and out-of-home foods consumption (43%); medium sensitivity for counseling on sugar-sweetened beverage consumption (53%) and fruit and vegetable consumption messaging (51%); and higher sensitivity for screen time (92%) and PA (88%) messaging.[82] Specificity of electronic health record documentation ranged from 8% for counseling on PA and screen time messaging, and 100% for discussions around out-of-home foods and sugar-sweetened beverage consumption. The EMR system employed in this study required simultaneous documentation of reading and screen time, a subcomponent of PA, which led to the unusually low specificity of PA and screen time messaging.[82] More broadly, although few studies have assessed reasons for decreased sensitivity and specificity of chart review data the validity of chart review data are likely affected by the specific system of charting (e.g. EMR, paper) and organization of templates in each of the systems.[82] Some templates have long lists of check boxes facilitating overestimation of practices, while other templates may require too much time to chart practices, facilitating underestimation of counseling.

Study 1: Impact of a Maintenance of Certification program on weight-related counseling. The Strong4Life (S4L) Maintenance of Certification (MOC) program provides a unique opportunity to assess whether an MOC program can impact weight-related counseling practices. MOC programs are required continuing medical education and professional development programs developed by the American Board of Pediatrics to ensure that board-certified pediatricians have the knowledge and skills to deliver quality care.[80] In 2011, Children's Healthcare of Atlanta collaborated with Kids Health First Pediatric Alliance, a group of independent physicians, to design an MOC. The six-month MOC program aimed to incorporate standard evidence-based tools and techniques into clinical practice to increase and improve universal counseling related to the development of healthy diet and PA patterns, as well as long-term weight management. First, a two-hour, in-person training in behavior change counseling methods and an online refresher course involved a didactic and skill building workshop based on the "five As" of motivational interviewing (asking, assessing, advising, agreeing, and assisting with health behavioral changes) and five healthy habits: eating more fruits and vegetables, drinking fewer sugar-sweetened beverages, decreasing out-of-home foods, decreasing screen time, and increasing PA.[75] Second, a toolkit consisting of a BMI chart and behavioral screening tools and educational handouts for parents were provided to each pediatrician attending the training.[75] Third, templates used during well-child visits were updated to facilitate documentation of counseling components. Fourth, to increase accountability, peer physicians employed at the same practice as MOC pediatricians randomly selected 15 charts from patients of the MOC pediatrician during each month of the MOC. This peer pediatrician assessed whether the MOC pediatrician documented each of the counseling components. Finally, two in-practice meetings were conducted between clinical and office staff to increase communication and facilitate mutual understanding between personnel about the goals of the MOC program.

Prior evaluation of the two-hour training in behavior change counseling methods program, a core component of the MOC, indicated significant improvements in documentation of BMI, counseling, and goal setting at six months follow-up.[24] There were also sustained improvements at 12-months for BMI and goal documentation practices. However, the higher-intensity MOC study may additionally increase documentation of these counseling components, and the impact of the full MOC program, which incorporated decision support and peer monitoring in addition to training on counseling, remains unknown. Thus, the objective of Study 1 is to: (1) assess whether the more intensive MOC intervention increased and sustained weight-related counseling (e.g. health messaging, physical exam measurement, and goal setting) among Georgia pediatricians; and (2) explore whether the effect of the MOC intervention differed across practice and provider characteristics.

Study 1 Hypothesis: Across all pediatrician and practice characteristics, it is hypothesized that pediatricians will increase health messaging (counseling on fruit and vegetable consumption, sugar-sweetened beverage consumption, screen time, PA, and out-of-home consumption) and goal setting, and sustain high levels of physical exam measurement (height, weight, BMI percentile, and blood pressure measurement) upon MOC completion, and six months after MOC participation compared with before MOC participation, as indicated by physician documentation of counseling.

Intervening on Physical Activity Opportunities in the School Setting

Like the recommendations for weight-related counseling provided by pediatricians, recommendations for PA opportunities provided by the elementary school setting have been informed by studies demonstrating the promise of PA interventions to impact student health.[83] In a meta-analysis of primarily school-based studies targeting children 18 years or younger, childhood obesity prevention efforts involving PA were effective at preventing obesity compared with usual care (standardized mean difference: -0.1; 95% CI: -0.2, -0.0).[83] Compared with middle and high school, the elementary school has been studied most frequently, and thus far, shows the strongest evidence of effectiveness to prevent obesity.[83]

Schools can influence student PA through by providing PA opportunities such as PE,[84] recess,[85,86] PA breaks in classrooms,[87] before-school PA, and after-school PA.[88] Interventions aiming to improve school-based PA through these avenues vary widely by content,[89,90] although most interventions implemented in elementary schools have focused on structured didactics or activities in a specific PA opportunity. For example, all schools participating in a 12-week after-school intervention in Texas received a particular health education program (Bienestar) and the Coordinated Approach to Children's Health, a PAcurriculum.[88]

Multi-component interventions, which address multiple PA opportunities are thought to be more effective than single-component interventions.[91]With growing evidence for multi-component approaches, the Comprehensive School PA Program (CSPAP) framework has been recommended by the National Association for Sport and Physical Education to increase PA in schools.[46] One of the CSPAP goals is to "provide a variety of school-based physical activities to enable all students to participate in 60 minutes of moderate-to-vigorous PA each day." CSPAP provides a framework for providing PA: (1) through quality PE, (2) during recess and classroom, (3) before and after school, (4) involving staff, and (5) that engages the family and community.[92]

CSPAP implementation has varied widely,[36, 38, 48, 52] but most multi-component interventions offer little flexibility for adaptation at the school level, limiting potential for scale-up.[93,94] For example, a 2016 study of 1,460 low-income elementary students from three schools in the Mountain West Region of the US assessed the impact of an intervention which involved: (1) hiring an external PA leader who trained teachers monthly and conducted structured and semi-structured recess twice daily; (2) conducting more frequent PA breaks; and (3) introducing before/after school programs.[93] Another 2014 Canadian Coordinated School Health (CSH) study assessed a 3.5-year long intervention consisting of hiring a PA facilitator, six weeks of staff training on both in PA and nutrition, and developing a school level action plan.[94] The aims of CSH overlap with the CSPAP model but also target the school nutrition environment.[95] These interventions required schools to hire external personnel and have structured requirements that all schools had to complete (e.g. implementing before/after school programs, structured recess, etc.). Although both studies were effective in increasing student PA, these programs demanded a certain level of commitment from their participants because of the hiring requirement. In the real-world setting, these requirements may serve as barriers for schools with a limited budget and organizational capacity.

In addition to the need to hire additional staff, many CSPAP models have other structured program requirements such as PE curriculum changes, which create inflexibility to adaptation at the school level and limit the ability to scale up across diverse settings. However, modifications of interventions have been demonstrated to be a natural and necessary part of intervention integration to improve program suitability for the local environment in numerous settings,[96] and interventions that are adopted without adaptation are less effective than interventions that are adapted to fit local contexts.[97] In the educational system, adaptations increase intervention fit to school culture, time, or teaching style.[98] Each school's population, facilities, and needs are different, and interventions must be adaptable to allow for tailoring of content to specific schools. Increased flexibility to tailor strategies at the teacher level may allow the integration of PA into the classroom and improve the effectiveness of CSPAP-based interventions on PA during the school day.[98,99]

In recent years, evaluations of more flexible interventions have reported mixed results, and the optimal balance between fidelity and adaptation at the school level remains unknown. For example, some programs provide schools with the tools to increase or improve PA and help schools create action plans to achieve their PA goals without mandating specific actions. One study in Louisiana assessed an elementary and middle school intervention involving a six-hour workshop for PE teachers where they received training to plan and implement each CSPAP component; action plan development; resources; and technical assistance.[100] Intervention teachers provided significantly more self-reported PA opportunities during school and PA opportunities involving staff.[100] Both intervention and control students decreased MVPA from baseline to follow-up,[100] but intervention students had a smaller decrease in MVPA time. The researchers suggested several possible explanations for these negative findings, including the over-flexibility of implementation and short one-year to follow-up period, which may not have been sufficient to show PA changes, different seasons for measuring PA in the intervention and control schools, and the potential influence of standardized testing schedules.[100] In the Indiana Healthy, Energetic, Ready, Outstanding, Enthusiastic Schools (HEROES) study, the impact of an intervention based on the CSH approach was evaluated. Although CSH has a broader scope than CSPAP, the implementation of the PA component was comparable to a flexible CSPAP model. The development of wellness councils, policies, and programs in compliance with the CSH approach led to a significant increase in the proportion of students engaging in vigorous-intensity PA, from 75% at baseline to 81% at 18-month follow-up, but this was not significant after adjusting for student demographic, health, and behavioral factors.[95] These mixed findings suggest that there remains a need to identify the ideal mixture of implementation freedom and effectiveness.

One plausible reason for minimal change in MVPA and vigorous PA is that teachers may not have implemented parts of the intervention sufficiently. For school-adaptable interventions, the degree of implementation by teachers could vary tremendously, since these initiatives encourage but do not require staff to make specific changes as part of the intervention. This contrasts with interventions implemented by a research team and interventions with specific week-by-week programmatic requirements, both of which have more structured requirements. However, the degree of implementation in these flexible interventions remains largely unknown, and there is a need to assess the execution of flexible CSPAP-based interventions at the school level.

The degree of implementation at the teacher or school levels impacts student-level health outcomes, but these outcomes are not always assessed. Fidelity is the degree to which school delivered the intervention as intended. A recent study assessed an initiative involving the formation of a wellness council and the implementation of programs and policies to increase health behavior among students consistent with CSH. Fidelity was measured by rating the quality of plans addressing each of the CSH components, including the implementation plan, PE, and PA.[101] The study found that fidelity was related to student PA, even after controlling for age, BMI, gender, free/reduced lunch status, and other health behaviors.[101] Similarly, some studies report moderately-high fidelity, such as a 2006 study assessing the Action Schools! BC initiative, which reported that intervention schools receiving one-time resources and training and ongoing support provided two-thirds of the prescribed 15 minutes of daily PA.[102] Measurement of school-level outcomes is important, since they serve as intermediates between school-level interventions and student-level health outcomes.

These intermediates are often conceptualized as fidelity and process outcomes, but few of these measures are generalizable across studies. Many process measures, such as attendance in training,[83] use of teaching materials,[103] activity logs,[102] and action plan development,[100] are intervention-specific. A more general school-level outcome was a score rating PA offerings during school which was developed in a study evaluating a CSPAP-based professional development intervention involving a six-hour workshop, action plan development to increase PA outside of PE, online resources, and technical assistance.[100] Of the numerous measures used to assess the impact of elementary school PA interventions on teacher- and school-level outcomes, assessment of PA opportunities provided by the school are the most generalizable, reliable, and a direct determinant of student-level health outcomes.

Measuring the impact of physical activity interventions in the school setting: Physical activity opportunities. School-based PA opportunities are measured differently from PA at the individual level. At the individual level, PA can be defined by the student's duration, frequency, intensity, and type. In contrast, PA opportunities at the school level are typically characterized by teacher- or administrator-reported frequency and duration of PA offered to students.[104,105] However, students are not necessarily active for the length of time provided for school-based PA opportunities. For example, a prior study using accelerometer-measured MVPA reported that students spend only 33% of time during PE class performing MVPA.[106] Despite this concern, school-based PA opportunities can be considered the upper limit of PA children can perform per day, as children are not usually active outside of such opportunities within school hours.

Although school-based PA opportunities vary by grade, at the typical elementary school, PE contributes the most time to PA opportunities at the school level. In the US, only 15% of elementary students have PE three or more days per week, and of these, only 4% have daily PE.[107] Elementary school students generally have 37-41 minutes per PE class period. Recess is the second-largest contributor to PA in elementary schools. Almost all (91%-95%) elementary students receive regularly scheduled recess, although it is only required in 59% of US school districts.[104,107] On average, recess in the US lasts for 27 minutes each day.[107] Nationally in-class PA breaks are provided by 33% of elementary schools,[108] before-school PA is provided by 10% of elementary schools,[107] and after-school PA is provided by between 45% and 52% elementary schools.[107,108] After-school PA can take the form of sports or intramural teams. Unlike participation in during-school PA opportunities, however, not all students enrolled in the school partake in before- or after-school PA opportunities.

Differences in PA opportunities exist across school demographics. For example, schools with a high enrollment of minority, poor, or urban students receive the shortest recess time and are most likely to lose recess altogether.[34] Disparities in elementary PA opportunities exist across geography, race/ethnicity, SES, and school size.

Although PE is ensured through legislation mandating 90 or more hours of health and PE instruction per school year in elementary school settings, generally, school-based PA opportunities are provided less frequently in the southeast region of the US. Only 46% of administrators in the South Atlantic census division (DE, DC, FL, GA, MD, NC, SC, VA, WV) report providing 20 or more minutes of daily recess to third grade students, which is much lower than the US overall (72%).[109] Beyond geographical region, the level of urbanization may also impact PA opportunities, with urbanized areas often found to provide fewer recess opportunities compared with rural areas,[110,111] but this urban-rural disparity has not been supported in all studies.[112]

Although few studies have assessed PA opportunities across race/ethnicity, almost all of those that have done so report some degree of racial/ethnic disparities in recess, in-class PA breaks, and before-school PA programs. Across the US, predominantly non-white schools are less likely to provide recess.[111,113] Daily recess of 20 minutes or more is offered by 77% of predominantly white schools, but only 43% of predominantly black and 55% of predominantly Hispanic schools.[113] A Nevada study reported that each additional 10% increase in proportion of Black students was associated with a lower odds of in-class PA breaks (aOR: 0.6, 95% CI= 0.5–0.9), and each additional 10% increase in proportion of Hispanic students was associated with a lower odds of before-school PA programs (aOR=0.9, 95% CI=0.8–1.0), even after controlling for geographic setting, student-teacher ratio, race/ethnicity, and SES.[112]

Low-SES schools are generally observed to be less likely to offer some PA opportunities but more likely to offer others. For example, schools with the largest proportion of low-SES students are least likely to provide recess,[111] with 22% of schools with >75% free/reduced lunch rate reporting no recess and 4% of high-SES schools reporting no recess. One contrasting study conducted in Washington and California reported that moderate-SES schools were less likely to provide 20 or more minutes per recess period but most likely to provide 100 minutes of PE per week compared with low- and high-SES schools.[114] Furthermore, low-SES schools are most likely to provide after-school interscholastic sports programs and other after-school PA programs, even after controlling for geographical setting, student-teacher ratio, race/ethnicity, and SES (aOR 1.1; 95% CI: 1.0-1.3).[112,114] It has been theorized that Title I funds supporting after-school academic programming may offset costs to allow more after-school PA programs in low-income schools,[112] and low-SES parents may rely on after-school programs for childcare.

Research examining the relationship between school size and PA opportunities in elementary schools is sparse and inconsistent. In a nationally representative study, larger schools were less likely to provide PA outside of PE class (e.g. in-class PA breaks), even after controlling for geographic setting, district expenditures, PA environmental characteristics, and PE teacher employment status (aOR=0.7, 95% CI: 0.5, 0.9).[108] Conversely, in a Nevada study, each five-student increase in student-to-teacher ratio increased the odds of providing after-school PA programming by 50% even after adjusting for geographic setting, race, and SES (aOR: 1.5; 95% CI: 1.1-2.1).[112] Smaller schools sometimes share teachers or employ part-time staff, limiting PA opportunities, while larger schools potentially have more student demand for PA opportunities.[108,112] Some of these discrepancies in the relationship between school size and PA opportunities may be due to use of measures of total school size versus student-to-teacher ratio, however, these measures are highly correlated.[112]

Study 2: Impact of Power Up for 30 on school physical activity opportunities. Power Up for 30 (PU30), a statewide initiative to increase PA in Georgia elementary schools, serves as an opportunity to assess the impact of a school-adaptable implementation strategy of CSPAP on school-based PA opportunities. Guided by CSPAP, the PU30 initiative involves: (1) a voluntary commitment by each elementary school to increase PA outside of regular PE to 30 minutes or more per day; (2) a baseline needs assessment of current PA opportunities and environmental answered by administrators, PE teachers, and grade level chairs for kindergarten-5th grades; (3) a tailored full-day training based on evidence-based strategies and resources for increasing PA before, during, or after school; and (4) resources and technical support.

PU30 strongly recommends that a team of at least one administrator or administrative designee, one PE teacher, and one grade level chair from each school attends the training. Teams from up to 10 schools can simultaneously attend the in-person training at a nearby site. The PU30 initiative is implemented by HealthMPowers, an organization aiming to increase health knowledge and promote health-enhancing behaviors among youth. HealthMPowers staff members have had prior experience in elementary schools as administrators, PE teachers, and classroom teachers. During the training, HealthMPowers staff discuss barriers and facilitators to PA and the importance of PA; provide strategies for integrating PA before, during and after school; share and model use of low- and no-cost resources including exercise DVDs, internet-based PA resources, PA curricula and integrated PA-academic lessons; and assist school teams in developing an action plan to increase PA outside of PE based on the results of the needs assessment. To increase adherence, electronic resources (two webinars, PowerPoint slides, handouts, DVDs, and monthly newsletters) and technical support are continuously provided throughout the year.

PU30 is unique not only because of the school-adaptable implementation strategy, but also because it involves multiple staff members at each school and statewide adoption. With CSPAP's whole-of-school approach, which takes advantage of all the possible PA opportunities before, during, and after school, collaboration across administrators and staff is vital;[115] however, few studies have evaluated interventions involving inter-departmental collaboration,[99,116] as most interventions only involve training of a PE teacher.[100] Additionally, most studies have only involved a small number of schools (an average of 21 schools),[99] precluding the opportunity to assess impact across diverse settings. However, elementary schools across Georgia have been PU30-trained, allowing a unique opportunity to assess the impact of the initiative in diverse contexts.

A recent analysis of the PU30 initiative found that PU30 increased teacher-reported PA opportunities before and after school, as well as increased daily recess and classroom PA.[117] However, the effects of the initiative on PA opportunities after controlling for baseline PA opportunities, demographics, and other school characteristics have not been examined. Hence, the objective of Study 2 is to assess the impact of PU30 on PA opportunities one year after PU30 training by comparing 79 trained and 80 untrained schools in Georgia after controlling for baseline PA opportunities, demographics, and other school characteristics.

Study 2 Hypothesis: It is hypothesized that PU30-trained schools will provide more PA opportunities compared with untrained schools at one-year follow-up after adjusting for baseline PA opportunities (e.g. PE, recess, in-class PA time, before-school PA, and after-school PA), demographics, and other school characteristics.

Measuring the impact of physical activity interventions in the school setting: Cardiorespiratory endurance and body composition. Numerous studies have linked cardiorespiratory endurance and body composition, the focus of this dissertation, with health outcomes in youth.[36] The FitnessGram® battery of tests, which includes cardiorespiratory endurance and body composition (BMI) assessment, is the most common fitness test currently employed by US schools, with 58% of schools reporting FitnessGram use in 2014.[104,107]

Cardiorespiratory endurance. Cardiorespiratory endurance can be assessed by laboratory or field measurements, although field measurements, including FitnessGram, are preferred for school settings. One laboratory measure, VO_2 max, is the maximum oxygen uptake in an individual, or the “highest rate at which an individual can consume oxygen during exercise”.[118] It is considered the gold standard measurement to measure cardiorespiratory endurance for adults and children. However, VO_2 max measurement requires an indirect calorimeter, which is cumbersome and expensive to use in a large population. Since laboratory measurements of cardiorespiratory endurance like VO_2 max require sophisticated instruments, many field tests such as the Progressive Aerobic Cardiovascular Endurance Run (PACER) have been developed

The PACER is now the recommended method of assess cardiorespiratory endurance in school settings.[36,119] During the PACER test, students are instructed to run back and forth between two 20-m spaced lines. The pace is signaled by music broadcasted from a compact disc.[120] Students must complete each lap in the allotted time, and the pace is increased with each lap until the student cannot complete the lap in the allowed time on two occasions. Each student is scored by total number of completed laps, with increasing laps indicating higher cardiorespiratory endurance. PACER has been established to be a reliable and valid measure of aerobic capacity in children 10 years or older,[121,122] but validity and reliability also depend on running efficiency, environmental conditions, footwear, running surface, and body composition.[32]

Cardiorespiratory endurance tracks through life and is thought to increase through childhood, peaking in mid-adolescence. A recent study found that higher cardiorespiratory endurance at six years of age was a predictor of high cardiorespiratory endurance or levels of PA at age 10.[123] Additionally, cardiorespiratory endurance improves through childhood and early adolescence, but subsequently declines particularly for adolescent girls during the late teen years.[124] Much of the cardiorespiratory endurance increase across age is thought to be due to increased cardiac output due to increasing body size and higher stroke volume.[125] However, not all studies have noted these cardiorespiratory trends by age.[17]

Gender impacts cardiorespiratory endurance, with boys having higher cardiorespiratory endurance than girls.[17,29,124] In 2012, 50% of boys aged 12-15 years had adequate cardiorespiratory endurance levels, as determined by FitnessGram healthy fitness zone standards, compared with only 34% of girls.[17] Some of these cardiorespiratory endurance gender differences may be partially mediated by physiologic differences such as body composition, heart size, stroke volume; social expectations and factors in the home environment such as maternal PA behaviors and parenting style; and behavioral differences in PA.[28,30,32,125]

There are unclear patterns of cardiorespiratory endurance by race/ethnicity and SES. Some studies using PACER or submaximal treadmill tests report minimal to no differences in cardiorespiratory endurance by racial group, Hispanic origin, or family income-to-poverty ratio.[17,124,126] However, others have observed effect heterogeneity between race and gender on mile run/walk time. For example, compared with other races, white boys have the fastest one-mile run/walk between 10-15 years, but the differences in one-mile run/walk between racial/ethnic group declines with increasing age for boys, even after accounting for height and weight.[32,127] In contrast, among girls, even after adjusting for height and weight, racial/ethnic disparities in one-mile run/walk increase with age.[32,127] Differences in cardiorespiratory endurance may be partially explained by decreasing levels of PA and higher risk of overweight and obesity with age among racial/ethnic minorities.[42,128]

Body Composition. Body composition is the "amount and relative proportions of body tissue compartments" and can include measurements of fat-free mass (mass of all other components such as water, proteins, minerals, salts of the body), fat mass (or "fatness"), weight-for-height, or subcutaneous fat (e.g. skinfold thickness).[21,129,130] Numerous methods exist to measure each of these different body composition components.[130] However, only measures such as skinfold thickness, BMI, and waist circumference are suggested for use in studies with a larger scope, such as national surveys, because of limitations in equipment, training, and time.[36] The IOM recommends BMI for the school setting over skinfold thickness and waist circumference because measurement of BMI requires less training, is less linked to self-esteem issues, and is easier to ensure privacy.[36] Reference values also exist for child BMI, unlike skinfold thickness, which makes it easy to track children over time.[43] In population-based school and clinical settings, BMI is used most frequently to assess body composition.

Because BMI changes as children mature into adulthood, child obesity definitions are based on growth curves representing normal values. In the US, the CDC defines children over two years as overweight if they are in the 85th to 95th percentile and obese if they are at least in the 95th percentile of BMI for their age and gender.[131,132] These values are based on the 2000 growth charts developed from nationally representative National Household Education Surveys (NHES II-III) and National Health and Nutrition Examination Survey (NHANES I-III) conducted between 1963-1994.[131,132]

Although BMI suffers from numerous limitations, it generally correlates with health and is used in studies with a larger scope due to labor, time, and cost considerations. First, BMI is a measure of heaviness and not fatness,[32] so it cannot distinguish between lean and fat masses.[129]As such, BMI does not indicate distribution of fat, which affects health risks, particularly if fat has accumulated in the central abdominal area. Second, changes in BMI during childhood may simply indicate pubertal maturation or muscle mass changes rather than changes in fat mass.[32,129] Finally, race/ethnicity also affects BMI. For example, among adults, Asians have more percent body fat than other races of the same BMI.[133] Despite these limitations, BMI is easy and cheap to measure and generally correlates with other body composition measures and future health.[134]

Some body composition changes occur naturally through life, but unnatural changes like obesity also increase with age. Typical maturation is characterized by weight-for-height declines until 5-6 years, and then weight-for-height increases again ("adiposity rebound") through the rest of childhood.[130] In addition, the prevalence of obesity also increases with age,[135] with obesity prevalence at 9% among children 2-5 years, 18% among children 6-11 years, and 21% among 12-19 years.[27] While obesity prevalence increases with age, child obesity incidence is thought to decrease with age, with annual obesity incidences among kindergarten students at 5% compared to 2% among children in fifth-eighth grades.[135,136] Decreases in incidence may be due to low remission (obese to non-obese states) rates resulting in a declining pool of at-risk individuals with increasing age.

Obesity prevalence and incidence is higher among boys than girls in elementary and middle school. Prevalence ranges from 13% for boys in kindergarten to 24% in fifth and eighth grades. Obesity prevalence for kindergarten girls is 11%, which increases to 20% among fifth-grade and 18% among eighth-grade girls.[135] Similarly, the cumulative obesity incidence for boys and girls between kindergarten and eighth grade is 14% and 10% respectively.[135] Some of these changes may be attributable to differences in obesogenic behavior patterns between boys and girls, as boys are more likely to consume recommended amounts of fruits and vegetables, but less likely to meet screen time and sugar-sweetened beverage recommendations than girls.[57]

Compared with other racial/ethnic groups, Blacks and Hispanics bear the highest burden of obesity prevalence and incidence.[135,137] Hispanics have the highest obesity prevalence in kindergarten, with 18% of Hispanic kindergarten students obese, compared with 13% among non-Hispanic Blacks and 10% among non-Hispanic Whites.[135] In eighth grade, 27% of Hispanics and non-Hispanic Blacks are obese, compared with 17% of Whites.[135] Cumulative incidence between kindergarten and eighth grade follow a similar pattern, at 17%, 14%, and 10% for Non-Hispanic Blacks, Hispanics, and Non-Hispanic Whites respectively.[135] Obesity differences across race/ethnicity may be driven by racial/ethnic differences in PA behaviors and food patterns, as black and Hispanic adolescents are less likely than whites to meet sugar-sweetened beverage, fruit/vegetable, screen time, or PA goals.[57]

Obesity prevalence is highest among children in the second socioeconomic quintile, while children in the highest socioeconomic quintile have the lowest obesity prevalence, ranging from 7% in kindergarten and 11% in fifth grade.[135] Similarly, cumulative incidence of obesity across 5-11 years is lowest among highest-SES quintile (7%) and highest among the third SES quintile (15%). Accordingly, children in high-SES households are more likely to reach PA and screen time goals,[57] which may contribute to improved body composition.

In the US, geographical region and urbanization influence obesity prevalence. Many southeastern US states including Arkansas, Mississippi, Louisiana, Tennessee, and South Carolina, have the highest obesity prevalence in the US among children 10-17 years, ranging from 20-25%.[138] In Georgia, 17% of 10-17 year-old children are obese.[138] Rural-urban differences in obesity prevalence are also observed, with children living in rural areas generally having higher BMI than children living in urban areas or small cities.[110] Indeed, individual-level factors do not completely explain geographical differences in BMI, which may be due to population-level determinants such as policies influencing the availability of nutritious foods, PA, and marketing environments.[139]

Study 3: Association between school physical activity opportunities and health-related fitness. Although most school-based PA interventions have demonstrated success in increasing student PA, the impact of elementary school-based interventions on cardiorespiratory endurance and body composition is more variable.[91] One potential reason for inconsistent effects of school-based PA interventions is that interventions may affect multiple aspects of school PA, including frequency, duration, intensity, and type of PA. For example, one quasi-experimental study assessed the impact of funding for a daily evidence-based PE program of each school's choice to provide 30 minutes of daily PE to students in low-income Pennsylvania middle schools and found that the daily PE significantly decreased mile-run time, a measure of cardiorespiratory endurance.[140] However, it is unclear whether the impact on cardiorespiratory endurance was improved because of increased PA time and opportunity in the form of daily 30 minutes of PE, or due to increased PA intensity and different PA type as a result of implementing the evidence-based program. One of these aspects of PA, PA opportunity time, is regulated by legislation in many states.[58] However, few studies have examined whether school-based PA opportunity time is related to health-related fitness among students in the US elementary school system. In a cross-sectional study, fifth-grade students in California districts complying with PE mandates were more likely to meet or exceed cardiorespiratory endurance standards, even after adjusting for child age, race/ethnicity, and gender, and school-level variables (size, FRL, race/ethnicity, census tract SES).[141] Among adolescents, organized PA opportunities outside of PE, including before/after school PA programs, have been associated with improved cardiorespiratory endurance.[35,142,143] The relationship between elementary school-based PA opportunity time and body composition remains inconclusive.[144] One study using data from the Early Child Longitudinal Study-Kindergarten cohort data found that PE time was associated with decreased BMI z-score among fifth grade boys, but not for other grades.[144] Another study using the same dataset and longitudinal growth curve analyses identified that additional recess time, but not PE time, was associated with a decrease in BMI between kindergarten and fifth grade.[145] In contrast, a study conducted in Alabama, California, and Texas reported that PA resources/programs were not associated with fifth-grade student BMI.[146] Most research assessing the relationship between school PA opportunities and body composition have focused on middle and high schools and many cross sectional studies in this setting have suggested a null relationship between school PE and student obesity.[142,147,148]

Due to the mixed findings and sparse data on the relationship between PA opportunities and student cardiorespiratory endurance and body composition, the objective of Study 3 is to evaluate the relationship between school-based PA opportunities and student cardiorespiratory endurance and body composition aggregated at the school level.

Study 3 Hypothesis: It is hypothesized that schools offering fewer PA opportunities (e.g. PE, recess, in-class PA, and overall PA) will have fewer students with healthy levels of cardiorespiratory endurance and body composition.

Chapter 3: Impact of an American Board of Pediatrics Maintenance of Certification on Weight-related Counseling at Well-Child Check-Ups

Abstract

Background and Objectives: The Strong4Life Healthy Weight Counseling Maintenance of Certification (MOC) program promotes pediatrician use of evidence-based, diet- and activity-related counseling messages and techniques during well-child visits. This longitudinal study assessed the impact of this MOC program on provision of weight-related counseling.

Methods: Ten to fifteen well-child visit charts were randomly selected before (three time points) and after (two time points) MOC participation in 2012-2015 from 102 Georgia pediatricians. Weight-related messaging (fruit and vegetable consumption, sugar-sweetened beverage consumption, out-of-home food consumption, physical activity, and screen time), physical exam measurement (height, weight, body mass index percentile, and blood pressure measurement), and behavior-change goal setting documentation was compared before and after the MOC.

Results: Depending on counseling component assessed, pediatricians who inconsistently provided each counseling component before the MOC provided between 40% (99.5% CI: 17-62%; physical activity messaging) and 63% (99.5% CI: 41-85%; out-of-home consumption messaging) more patients with health messages and goal setting six months after MOC completion.

Conclusions: Pediatricians improved and sustained weight-related health messaging and goal setting following Healthy Weight Counseling MOC program participation. A long-term study assessing child health outcomes is needed to assess the program's impact on children's obesity risk.

Background

Today, childhood obesity affects over 12.5 million children in the US.[131] Obese children are more likely to have poor metabolic profiles compared to their normal-weight peers.[22,23] Childhood obesity is thought to track into adulthood,[149] and adult obesity causes increased morbidity and mortality due to diabetes, heart disease, and cancer.[150] Childhood an important stage during which to intervene, as it is a sensitive period for developing eating, physical activity, and screen time patterns.[151,152]

The primary healthcare system is an opportune setting to affect child diet and nutrition to prevent and treat childhood obesity.[51] Children regularly visit their physicians with their parents or primary caretakers, many of whom look to physicians for guidance on reducing their child's health risks.[51] A 2007 expert committee recommendation placed primary care providers at the center of patients' weight-related behavioral change efforts,[43] with numerous studies indicating that the primary care setting is an effective place for treating childhood overweight and obesity.[52]

The American Academy of Pediatrics (AAP) currently recommends motivational interviewing and goal setting as tools to perform patient-centered communication during weight-related counseling.[43] Motivational interviewing involves provider use of reflective listening to facilitate a collaborative dialogue between providers, parents, and patients to identify the impact of health behaviors and reasons for and against behavior change.[43,60] In goal setting, physicians encourage parents and patients to set achievable behavior goals (e.g. 15 minutes of physical activity per day).[61] Motivational interviewing and goal setting should be used to advise families on evidenced-based diet and physical activity strategies in the form of health messages.[43]

Despite the AAP recommendations to provide weight-related counseling to all children, almost 25% of children do not report receiving any lifestyle counseling at all.[64,65] Most interventions aiming to improve physician counseling have targeted counseling for overweight and obese children.[72] Physicians are more likely to provide weight-based counseling for obesity treatment than prevention,[65] and only a few studies have assessed interventions developed to address obesity counseling targeting both obese/overweight and normal-weight children.[73,75,78]

Participation in approved Maintenance of Certification (MOC) programs was added to the American Board of Pediatrics' (ABP's) licensing requirements in 2003 to ensure that board-certified pediatricians have the knowledge and skills to deliver quality care.[80] In 2011, the Strong4Life Initiative of Children's Healthcare of Atlanta collaborated with a local pediatric practice group to create the Healthy Weight Counseling MOC program, an ABP-approved MOC program designed to increase and improve obesity prevention and treatment counseling provided by pediatricians.[153] The current study aimed to: (1) assess whether participation in the MOC program was associated with increased use of evidence-based weight-related counseling strategies, operationalized as documentation of health messaging, physical exam measurement, and goal setting, among participating Georgia pediatricians; and (2) determine whether practice and pediatrician characteristics were associated with the degree of increased use of evidence-based weight-related counseling strategies.

Methods

MOC program intervention. The six-month Strong4Life Healthy Weight Counseling MOC program consisted of four activities to increase weight-related counseling delivered to children 6-11 years during well-child visits: (1) participate in a two-hour in-person Strong4Life training and a one-hour refresher webcast on evidence-based strategies for promoting healthy weight management; (2) update electronic medical record (EMR) or well-child form templates to increase ease of standard diet and activity assessment; (3) review clinical charts from other participating pediatricians at baseline and monthly thereafter to monitor use of strategies and documentation; and (4) lead two in-practice meetings to review changes and results with the rest of the clinical team.

The Strong4Life training has been previously described.[75] Briefly, during the training, pediatricians received a toolkit containing a Healthy Habits Assessment Form (a one-page survey for parents and/or children to complete in the waiting room prior to the clinical visit), a color-coded BMI poster, and educational handouts for patients.[153] The evidenced-based strategies for healthy weight ("health messages") highlighted in the in-person training and webcast included increasing fruit and vegetable consumption, decreasing outside-of-home eating, increasing daily physical activity, decreasing sugar-sweetened beverages, and decreasing screen time. In addition, pediatricians were encouraged to work with patients to establish wellness goals and incorporate growth monitoring into regular practice. Two tracks were available to pediatricians. Pediatricians who previously attended the in-person training independently of the MOC program 60 or more days prior to MOC initiation (n=76 pediatricians) were required to attend the one-hour webcast but not re-attend the in-person training. Pediatricians who had never previously received the Strong4Life training participated in both the training and webcast, so that all pediatricians received the same level of training.

In addition to the educational components of the MOC, if practices had an EMR system, they updated templates to increase ease of healthy weight-management strategy documentation. This could be accomplished by either uploading the Healthy Habits Assessment Form or incorporating reminders for each of the individual weight-management strategies. Practices also included a method of documenting physical exam measures including height, weight, BMI percentile or growth chart plotting, and blood pressure, as well as a wellness goal in their EMR system. If practices did not have an EMR system, they updated hard-copy, well-child forms to capture the same information.

As part of the MOC, a physician peer of each MOC pediatrician working at the same practice conducted monthly reviews of charts written by the MOC pediatricians to ensure accountability in counseling. Peer review occurred immediately before the start of the MOC and during each subsequent month of the six-month program. Fifteen well-child visit charts of children aged 6 to 11 years were randomly selected for review each month during the MOC. For each chart, peer pediatricians reported whether the MOC pediatrician documented: (1) a discussion regarding weight management characterized by use of the Healthy Habits Assessment Form or discussion of each of the individual weight management strategies; (2) physical exam measurements (height, weight, BMI percentile, blood pressure); and/or (3) a wellness goal.

During the first in-practice meeting with clinical and office staff occurring at the start of the MOC, pediatricians reviewed weight management strategies and the Healthy Habits Assessment Form, changes to the well-child forms/EMR templates, and data abstraction reporting requirements with clinical staff. In the second in-practice meeting occurring three-and-a-half months after the start of the MOC, pediatricians reviewed and compared chart abstraction data, identified barriers to weight-related counseling, brainstormed solutions, and discussed comfort and confidence level when using motivational interviewing.

Study design and population. This study employed data collected at three time points occurring before MOC initiation (six months before baseline, three months before baseline, baseline) to produce a stable estimate of the counseling frequency before the MOC. Data were collected at two time points after MOC initiation (upon MOC completion six months after baseline, and six months after MOC completion; Figure 3.1). Of the 111 pediatricians completing the MOC between August 2012 and August 2015, eight pediatricians were excluded because they were simultaneously enrolled in another Children's Healthcare of Atlanta child obesity outreach program, leaving 102 pediatricians in the main analytic dataset. The study was reviewed by the Emory University Institutional Review Board and determined to be exempt.

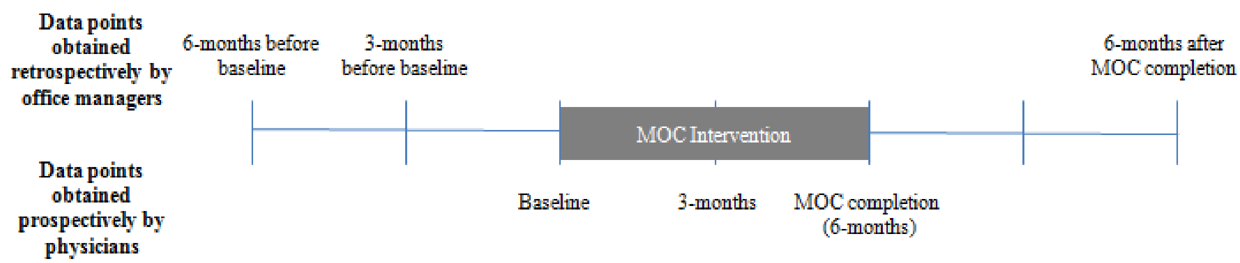


Figure 3.1. Study design to evaluate the six-month Strong4Life Healthy Weight Counseling Maintenance of Certification (MOC) program conducted among 102 Georgia pediatricians.

Data collection. As part of the MOC program, a pediatrician peer at the same practice of each MOC pediatrician abstracted chart review data at baseline and six months after baseline. Chart review data obtained during other months of the MOC were not available for the current study. Although pediatricians obtained data during the MOC, they were not available to perform chart reviews at other time points. As such, office managers were enlisted to review charts at the other three time points by randomly selecting 10 well-child visit charts of children 6 to 11 years at each of the other measurement periods. Office managers were also interviewed by research staff by telephone to collect information on practice and pediatrician characteristics.

Study measures. On each well-child visit chart, goal setting was assessed by documentation of at least one weight-related diet or activity goal in each clinical chart. Communication of each evidenced-based weight-related strategy was assessed by documentation (presence versus absence) of each health message (fruit and vegetable consumption, sugar-sweetened beverages, out-of-home consumption, physical activity, screen time). Alternatively, use of the Healthy Habits Assessment Form indicated documentation on all five health messages. In every chart, documentation of each physical exam measure, including height, weight, BMI percentile, and blood pressure were also assessed. At each time point, pediatrician counseling frequency for each counseling component was calculated as: number of charts with the counseling component documented/total number of charts reviewed. For each counseling component, counseling frequency was categorized to identify the proportion of consistent counselors (≥80% charts with documentation) at each time point.

Continuous practice and pediatrician characteristics were categorized at the median since no a priori cut-points have been consistently used. Practice characteristics included use of EMR, practice size (≤7 versus >7 physicians employed at the practice), and percent Medicaid (≤12% versus >12%). Pediatrician demographics included pediatrician gender, age (≤50 versus >50 years), employment status (full-time versus part-time), and prior Strong4Life training (yes versus no).

Statistical analysis. Descriptive statistics (medians and inter-quartile ranges [IQR] or sample sizes and frequencies) of demographics and pediatrician practice variables were computed. For each counseling component, ten charts six-months before baseline, ten charts three-months before baseline, and fifteen charts at baseline were combined to denote before-MOC counseling frequency (n=35 charts). Histograms of counseling frequency before the MOC, at MOC completion, and six months after MOC completion were produced for each counseling component. The proportion of pediatricians counseling 80% or more of patients was calculated before the MOC, at MOC completion, and six months after the MOC.

For each physician, two paired differences were calculated: (1) counseling frequency at the end of the MOC -counseling frequency before MOC, and (2) counseling frequency six months after the end of the MOC-counseling frequency before the MOC. For example, a pediatrician documenting goal setting in 5 of 35 charts (14%) before the MOC and 10 of 15 charts (66%) at MOC completion had a paired difference of 52% at MOC completion. To answer the primary research question, linear regression using generalized estimating equations (GEE) to account for clustering of pediatricians within practices summarized each paired difference across counseling frequency at baseline (≥80% vs. <80%). To answer the secondary research question, linear regression using GEE assessed the paired difference in counseling frequency for each component across each practice and pediatrician covariate.

Counseling frequency outcomes may have been misclassified because chart documentation and actual pediatrician weight-related counseling practice may not always be concordant.[82,154–158] Various approaches can be used to correct for outcome misclassification bias.[159] In a sensitivity analysis for the current study, sensitivities and specificities from prior studies comparing chart documentation to tape recorder data were used to explore the extent to which estimates in the current study could be affected by outcome misclassification (Supplementary File 3.1).[82,154–158]

All analyses were performed using SAS version 9.4 (Cary, NC). Using the Bonferroni correction, alpha was set to 0.005 to account for multiple outcomes.

Results

The median practice size of the 102 pediatricians in the analytic dataset was seven pediatricians (IQR: 5-13; Table 3.1). Eighty-one percent of physicians worked in practices using EMRs, and the median percent of Medicaid patients was 12% (IQR: 3- 50). Pediatricians were mostly female (70%) and full-time (85%). The median pediatrician age was 49 years (IQR: 44-55) and most had received prior Strong4Life training (76%).

Physical exam measurements, including height, weight, BMI percentile, and blood pressure measurement, were documented in almost all charts before and after the MOC, so physical exam components were not explored further. The proportion of pediatricians who were consistent goal setters (performing goal setting with at least 80% of their patients) increased from 9% before the MOC to 93% at MOC completion, and remained high six months after the MOC (80%; Figures 3.2-3.3; Supplementary Fig. 3.1). Similarly, before the MOC, the proportion of pediatricians consistently providing each health message ranged between 14% (sugar-sweetened beverage messaging) and 49% (screen time messaging). Six months after the MOC, 80-86% of pediatricians were consistent providers of health messaging, depending on health message component.

Table 3.1. Descriptive statistics of 102 Georgia pediatricians completing the Maintenance of Certification program in 2012-2015.

	N or Median	**% or Interquartile range**
Practice Characteristics		
Practice Size (# physicians)	7	5, 13
Electronic medical record use	81	80.2%
Percent Medicaid	12	3, 50
Physician Characteristics		
Male	31	30.4%
Full-time employment	86	84.3%
Physician age	49	44, 55
Prior training	76	74.5%

Pediatricians who consistently set goals (≥80%) with their patients before the MOC increased the proportion of patients setting goals by 11% (99.5% CI: 2-21%; Table 3.2). However, among pediatricians providing 80% or more of patients with each health message before the MOC, health messaging frequency did not change after the MOC.

Among pediatricians setting goals with fewer than 80% of patients before the MOC, the average increase in proportion of patients setting a goal with their pediatricians was 70% at MOC completion (99.5% CI: 58-83%) and 58% at six months after MOC completion (99.5% CI: 38-78%; Table 3.2). Similarly, among pediatricians who inconsistently provided health messages before the MOC, the increase in proportion of patients receiving each health messaging component at MOC completion ranged from 51% (99.5% CI: 40-66%; physical activity messaging) to 78% (99% CI: 64-91%; out-of-home consumption messaging) compared with before the MOC, depending on specific health message. Counseling frequency at MOC completion was higher than the counseling frequency six months after MOC completion, with increases in proportion of patients receiving each health messaging component six months after MOC completion ranging from 40% (99.5% CI: 17-62%; physical activity messaging) to 63% (99.5% CI: 41-85%; out-of-home consumption) compared to before the MOC. Paired differences in counseling frequency comparing six months after MOC completion and before the MOC did not differ across practice or pediatrician characteristics (Supplementary Table 3.1).

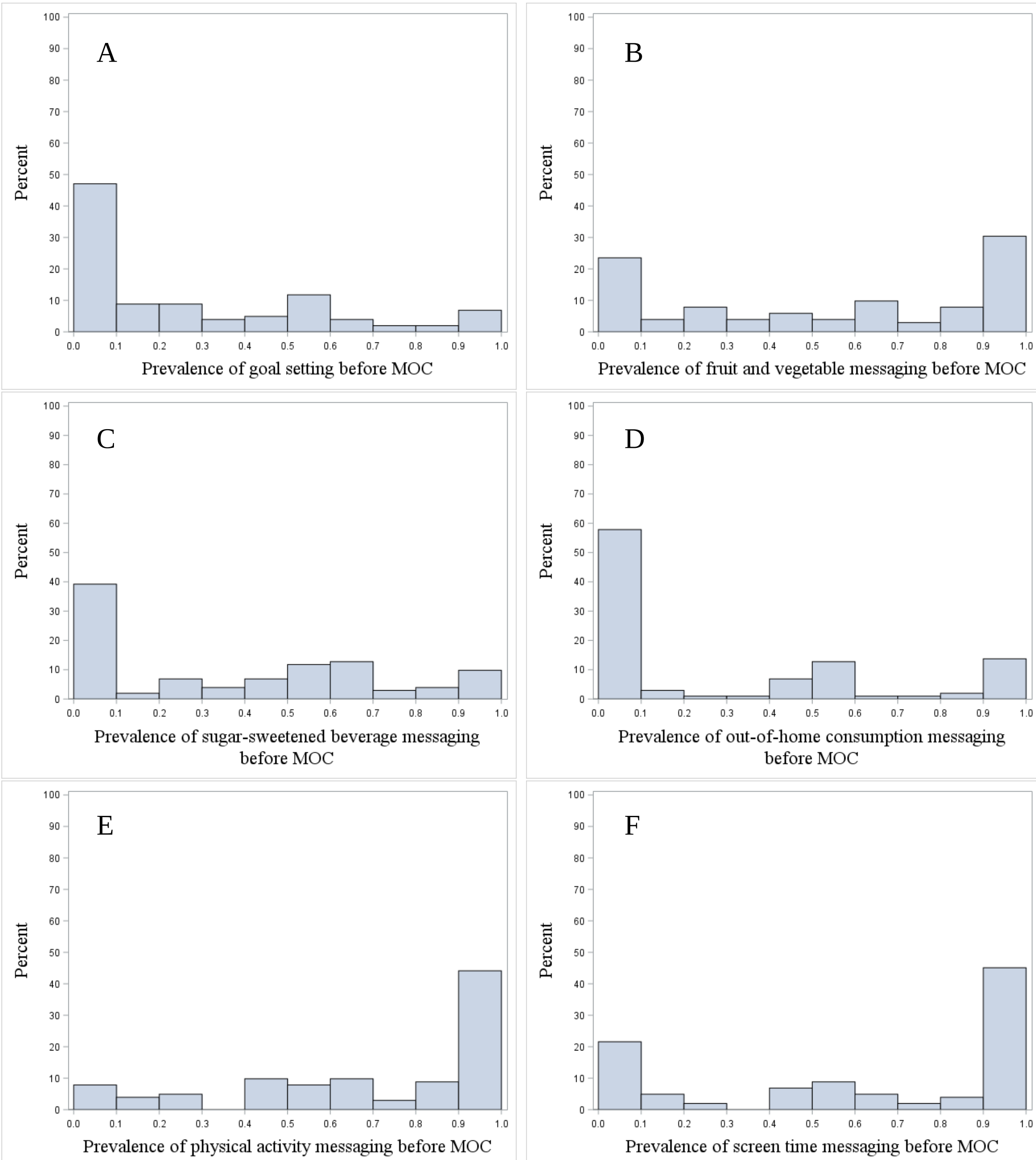


Figure 3.2. Histograms of physician counseling components (goal setting [panel A], fruit and vegetable messaging [panel B], sugar-sweetened beverage consumption messaging [panel C], out-of-home foods consumption messaging [panel D], physical activity messaging [panel E], screen time messaging [panel F]) before the Strong4Life Healthy Weight Counseling Maintenance of Certification (MOC) completion among Georgia pediatricians.

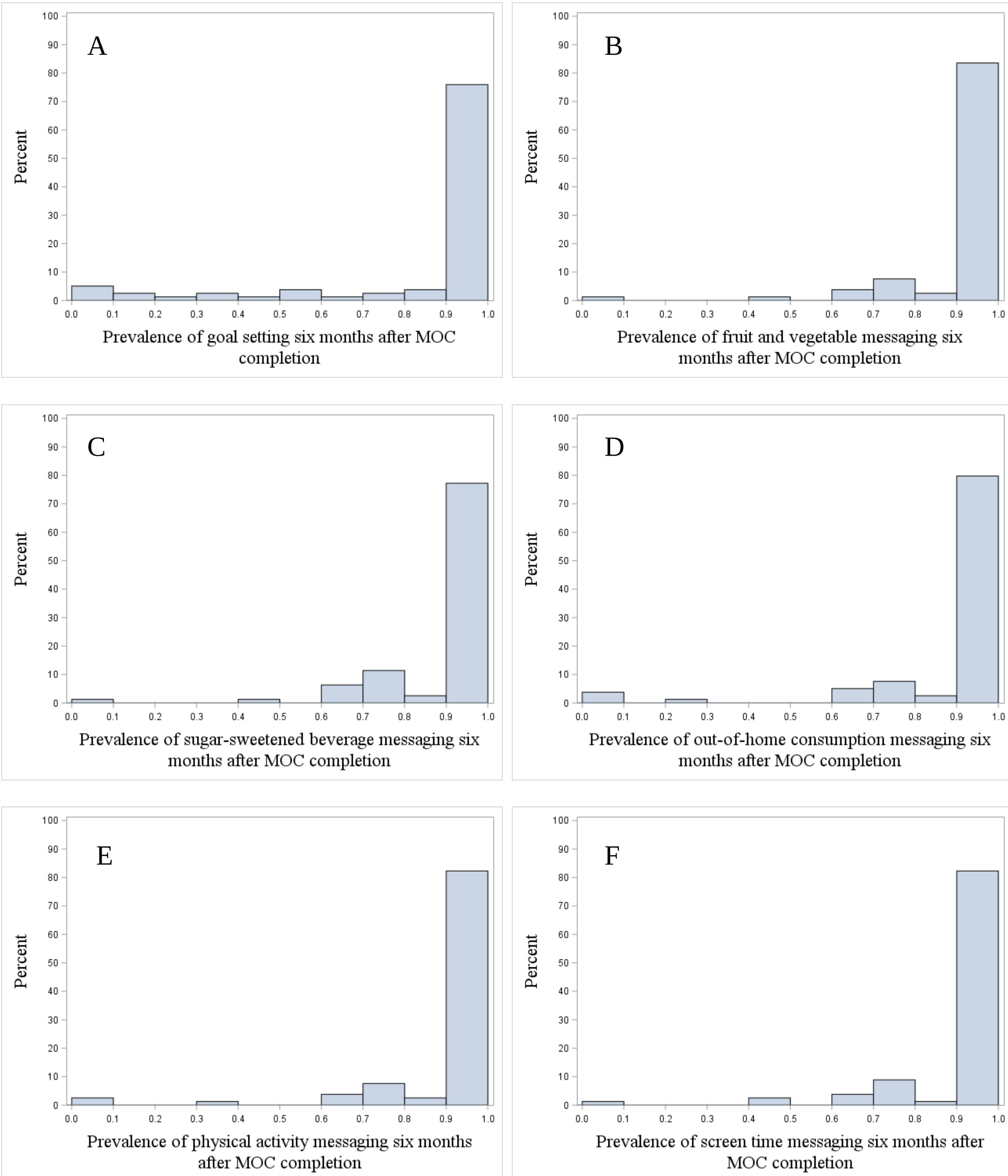


Figure 3.3. Histograms of physician counseling components (goal setting [panel A], fruit and vegetable messaging [panel B], sugar-sweetened beverage consumption messaging [panel C], out-of-home foods consumption messaging [panel D], physical activity messaging [panel E], screen time messaging [panel F]) six months after Strong4Life Healthy Weight Counseling Maintenance of Certification (MOC) completion among Georgia pediatricians.

Table 3.2. Paired difference in counseling components at Strong4Life Healthy Weight Counseling Maintenance of Certification completion (MOC) compared to before MOC (n=102 pediatricians), and six months after MOC completion compared to before MOC intervention (n=76 pediatricians). Mean differences are stratified by baseline counseling frequency for each counseling component (≥80% versus <80%).

Counseling components	MOC completion						Six months after MOC completion					
	<80% baseline counseling frequency			≥80% baseline counseling frequency			<80% baseline counseling frequency			≥80% baseline counseling frequency		
	Mean difference (%)	99.5% CI		Mean difference (%)	99.5% CI		Mean difference (%)	99.5% CI		Mean difference (%)	99.5% CI	
Goal setting	**70.3**	**58.0**	**82.6**	**11.2**	**1.5**	**20.9**	**57.6**	**37.8**	**77.5**	2.8	-7.7	13.2
Fruit and vegetable consumption messaging	**61.2**	**44.7**	**77.7**	5.7	-4.4	15.8	**52.7**	**28.6**	**76.8**	-4.3	-16.6	8.0
Sugar-sweetened beverage messaging	**63.5**	**48.1**	**78.8**	9.8	-18.4	37.9	**46.2**	**25.9**	**66.4**	17.2	-11.3	45.7
Out-of-home consumption messaging	**77.6**	**64.0**	**91.2**	3.3	-2.4	8.9	**63.0**	**40.6**	**85.3**	-11.8	-44.3	20.6
Physical activity messaging	**51.0**	**35.9**	**66.0**	4.9	-4.1	14.0	**39.5**	**17.1**	**62.0**	-1.1	-11.5	9.3
Screen time messaging	**65.1**	**50.4**	**79.7**	-0.5	-8.6	7.6	**59.8**	**40.2**	**79.4**	-6.6	-17.3	4.2

CI=confidence interval

Boldface indicates significance

After accounting for possible counseling misclassification due to dependence on chart review data as a proxy for counseling in the sensitivity analysis, all estimates were attenuated (data not shown). The MOC remained positively associated with counseling frequency for all components except when the sensitivity of documentation before the MOC decreased to 0.7 (for physical activity messaging only) or 0.5 (for sugar-sweetened beverage consumption, out-of-home food consumption, and screen time messaging).

Discussion

This study assessed whether the Strong4Life Healthy Weight Counseling MOC could improve pediatrician practices related to pediatric weight-related counseling during well-child visits and found that the MOC program was associated with increased provision of health messaging strategies (discussions around eating more fruits and vegetables, eating fewer out-of-home foods, limiting sugar-sweetened beverages, increasing the amount of daily activity, and limiting screen time) and goal setting between pediatricians and their patients, as well as sustained physical exam measurement. Changes were particularly large for sugar-sweetened beverage and out-of-home food consumption messaging, as well as goal setting, the three counseling components performed the most infrequently before the MOC. The high frequency of weight-related counseling practices was sustained six months after pediatricians completed the MOC, suggesting that the impact of the program may be long-lasting.

The results from the current study support prior evaluations of interventions aiming to increase weight-related counseling among physicians. A 2015 study assessed only the provider training program part of the Strong4Life Healthy Weight Counseling MOC six- and 12-months after training.[75] Similar to the results in the current study, this study reported high BMI percentile plotting before and after training and increased goal-setting frequency from 4% at baseline to

58% 12 months after training.[75] Results from this study are also consistent with a 2009 quasi-experimental study conducted in 12 residency programs, family practices, and pediatric practices in Maine evaluating an intervention involving a 1.5-day training on motivational interviewing, and provision of resources (e.g. posters and a parent assessment forms).[78] Similar to the current study, the Maine study reported an increase in behavioral screening tool use from 0% to 82% one to nine years after baseline, and high (>90%) and sustained measurement of height, weight, and blood pressure through follow-up. BMI percentiles were only documented in 38% of charts at baseline, which increased to 94% at follow-up. This low baseline prevalence of BMI percentile documentation contrasted with the current study that reported a median of 100% BMI percentile documentation at all time points. The prior study was conducted in 2004-2006, and the recent emphasis on BMI percentile charting, including the 2007 AAP recommendations, may have led to differences in baseline documentation.

Results from the current study are also consistent with physician-centered interventions aiming to treat or attenuate the excess weight of overweight and obese children. One physician-randomized study in 2016 evaluated a 60-minute, online intervention involving didactive sessions on the "five As", an exemplar video, and feedback on their own audio-recorded encounters with patients.[79] Intervention physicians more frequently assessed patient's readiness to change, assisted during counseling, and arranged follow-up with a physician or nutritionist compared with controls. In contrast to the current study, physicians in this study were not more likely to ask about weight and weight-related behaviors after intervention. However, one possible reason for the difference may be that the baseline frequency of asking about weight and related behaviors was higher in that study (89%) than in the current study (41-71%). Differences may also be explained by variations in intervention design, including the use of CDS in the current study.

Findings from the secondary question in the current study suggest that the impact of the MOC on weight-related counseling does not vary across practice and pediatrician characteristics; however, these results should be considered in light of the small sample size, use of a stringent alpha, and clustering of pediatricians within practices, which resulted in wide confidence intervals. Future studies should use a large sample of practices to further explore the relationship between practice-level moderators and individual counseling components to inform barriers and facilitators to weight-related counseling and assist with targeting future physician interventions.

Strengths. This study has several strengths. First, with multiple time points of data, the design allowed for assessment of a stable baseline measure of pediatrician practices (standardized Cronbach's alpha before the MOC ranged between 0.69 and 0.85 for health messaging and goal setting counseling components). Second, the final time point occurred six-months after the conclusion of the six-month MOC intervention, allowing for assessment of sustained program impact beyond completion of the intervention. Third, this study fills a gap in the literature, as few studies have assessed combined behavioral therapy training and decisional support programs to assess pediatrician counseling practice towards regardless of their weight status.

Limitations. Despite the strengths of this study, there are at least five limitations. First, chart reviews reflect documentation and may not reflect actual pediatrician counseling behavior. However, the results were generally robust the outcome misclassification bias sensitivity analysis (data not reported). Second, different data abstractors (e.g. office managers versus pediatricians) were employed at specific time points and may have resulted in variation in estimating health messaging and goal setting counseling frequency. However, analyses were also conducted after stratifying by abstractor (pediatrician versus office manager) and produced similar conclusions regarding the direction of change and significance (Appendix 3.1). Third, the lack of a comparison group precludes the ability to compare the MOC cohort against what may have been expected in the absence of the MOC. However, the large magnitude of change in pediatrician counseling frequency after the MOC, multiple data collection points before and after the start of the MOC, and varying MOC start times for each pediatrician reduce the likelihood of chance and history biases. Fourth, the multi-component nature of the MOC program precluded the ability to identify independent effects of each program element (resources, counseling, CDS). However, we were able to explore the effect of prior versus concurrent Strong4Life training by further stratifying pediatricians into the two MOC tracks. This produced largely overlapping confidence intervals suggesting consistent effects of the MOC across tracks (Supplementary Table 3.1). Finally, health messaging and goal setting outcomes in the current study indicate frequency, but do not provide a measurement of counseling quality.

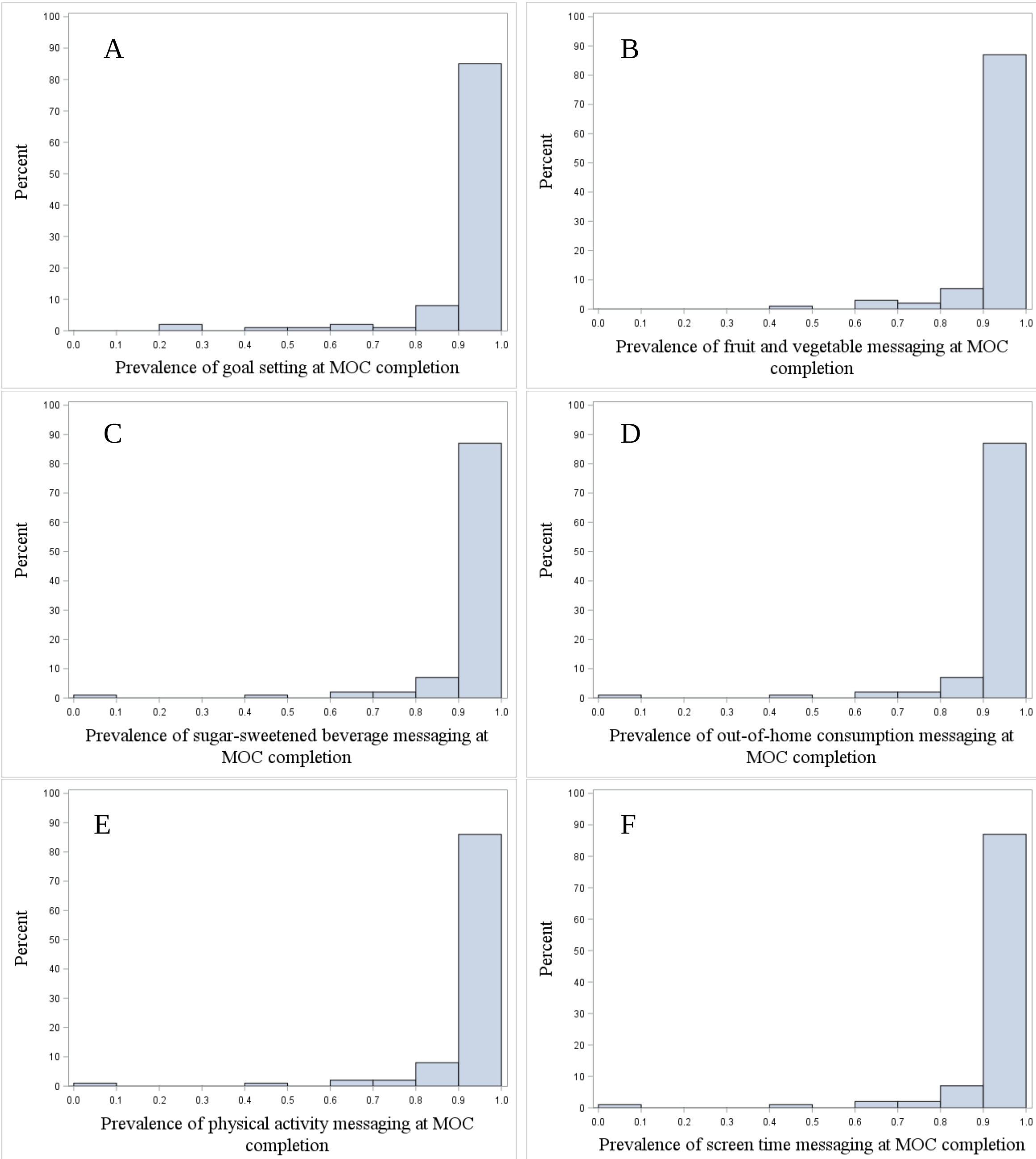
Conclusion

The current study suggests that training in evidence-based educational messages and counseling techniques combined with incorporation of decisional supports can increase healthy weight-related counseling provided by pediatricians. There were consistent and positive MOC-counseling associations across all practice and pediatrician characteristics. The extent to which this improvement in weight-related counseling documentation translates into long-term weight management requires further study.

Supplementary File 3.1: Sensitivity Analysis Methods

A sensitivity analysis assessed the extent to which outcome misclassification bias impacted the validity of chart documentation changes. Documentation of counseling components may not accurately reflect counseling practice, since pediatricians may not document a counseling component when performed, or may document a counseling component that was not performed.[82,154–158] To assess this potential bias, the total number of charts with and without each counseling component was calculated at each time point. Similar to the primary analyses, the sensitivity analyses compared: (1) the counseling components at MOC completion and components present before the MOC, and (2) the counseling components six months after MOC completion and components before the MOC. However, for simplicity, sensitivity analyses did not involve a *paired* difference in counseling frequency (pre-post difference in counseling frequency for each physician) that was conducted in the primary analyses. Instead, the 35 charts from each pediatrician before the MOC were summed across all physicians to indicate the total number of charts with documentation of each counseling component and the total number of charts reviewed before the MOC. Similarly, at each post-MOC time point, charts were pooled across physicians to indicate the total number of charts with each counseling component documented and the total number of charts reviewed.

Sensitivity analyses were conducted using multidimensional bias analyses. These analyses expand upon simple bias analyses by using bias parameters like sensitivity and specificity, while allowing for uncertainty in employed parameters by using multiple combinations of sensitivities and specificities.[159] External counseling validation data informed sensitivities and specificities.[82,154–158] Multiple combinations of parameters were assessed and presented results represent the most extreme case of differential misclassification. Before MOC initiation, three sensitivities (0.5, 0.7, and 0.9) and three specificities (0.8, 0.9, and 1.0) were used to correct counseling components. At MOC completion and six months after MOC completion, we assumed improved documentation of counseling practices in the form of increased sensitivity (0.8, 0.9, 1.0) and maintained specificity (0.8, 0.9, 1.0) compared with before the MOC.



Supplementary Figure 3.1. Histograms of physician counseling components (goal setting [panel A], fruit and vegetable messaging [panel B], sugar-sweetened beverage consumption messaging [panel C], out-of-home food consumption messaging [panel D], physical activity messaging [panel E], screen time messaging [panel F]) at Maintenance of Certification (MOC) program completion.

Supplementary Table 3.1. Paired difference in frequency of each counseling component (% difference) comparing six months after MOC completion and before MOC, stratified across practice and pediatrician characteristics (n=79 pediatricians).

	Goal Setting			Fruit and Vegetable Consumption			Sugar-sweetened Beverage			Out-of-home Consumption			Physical Activity			Screen Time		
	Mean	**99.5% CI**		**Mean**	**99.5% CI**		**Mean**	**99.5% CI**		**Mean**	**99.5% CI**		**Mean**	**99.5% CI**		**Mean**	**99.5% CI**	
Practice Characteristics																		
≤7 physicians	**44.4**	**18.6**	**70.3**	22.0	-1.6	45.6	**35.7**	**13.7**	**57.7**	**39.3**	**7.2**	**71.3**	21.2	-1.0	43.4	**34.0**	**10.3**	**57.7**
>7 physicians	**65.9**	**32.4**	**99.3**	29.4	-13.9	72.6	**50.7**	**11.5**	**90.0**	**58.4**	**21.5**	**95.3**	7.2	-19.0	33.3	15.2	-26.4	56.8
No EMR	**60.7[a]**	**20.3**	**100.0**	29.6	-32.6	91.8	45.4[a]	-10.1	100.0	41.3[a]	-18.0	100.0	4.7	-13.2	22.7	15.4	-26.2	57.0
EMR	**50.2**	**27.0**	**73.5**	**23.1**	**0.9**	**45.3**	**38.5**	**17.3**	**59.6**	**45.3**	**17.4**	**73.2**	17.8	-2.9	38.5	**29.6**	**4.4**	**54.7**
≤12% Medicaid	**53.0**	**15.8**	**90.2**	28.0	-4.6	60.6	**45.9**	**12.9**	**79.0**	38.7	-9.8	87.3	12.8	-14.7	40.3	20.4	-14.9	55.7
>12% Medicaid	**50.6**	**25.3**	**75.8**	19.7	-7.5	46.9	**33.5**	**8.7**	**58.3**	**42.4**	**14.1**	**70.6**	19.3	-6.0	44.6	**31.2**	**5.0**	**57.3**
Physician Characteristics																		
Part time	**57.0**	**29.6**	**84.3**	24.6	-8.4	57.7	**37.5**	**7.8**	**67.2**	**45.0**	**13.0**	**77.0**	10.9	-16.6	38.5	25.5	-13.5	64.4
Full time	**51.1**	**29.7**	**72.6**	**24.1**	**2.9**	**45.3**	**40.0**	**20.5**	**59.5**	**44.5**	**19.5**	**69.6**	16.6	-2.3	35.4	**27.3**	**5.4**	**49.2**
Female	**50.3**	**28.9**	**71.7**	**25.8**	**3.9**	**47.6**	**41.9**	**21.7**	**62.1**	**45.9**	**20.1**	**71.7**	17.0	-1.3	35.4	**27.4**	**4.8**	**50.0**
Male	**57.5**	**36.4**	**78.5**	19.5	-7.1	46.0	**32.8**	**11.0**	**54.5**	**40.9**	**15.5**	**66.3**	11.1	-9.5	31.8	25.7	-1.2	52.6
≤50 years	**48.0**	**25.4**	**70.5**	**26.5**	**3.9**	**49.1**	**39.9**	**19.5**	**60.3**	**45.8**	**20.9**	**70.8**	15.6	-2.5	33.6	**28.2**	**4.0**	**52.4**
>50 years	**59.3**	**38.8**	**79.8**	20.0	-2.5	42.5	**39.1**	**19.2**	**59.1**	**42.3**	**16.5**	**68.2**	15.6	-5.0	36.3	**24.6**	**4.2**	**45.0**
No prior training	**56.1**	**26.2**	**85.9**	16.2	-8.8	41.2	**39.4**	**18.7**	**60.1**	**43.7**	**18.8**	**68.6**	15.8	-12.2	43.8	19.0	-12.5	50.4
Prior training	**50.7**	**28.2**	**73.2**	**27.8**	**3.9**	**51.6**	**39.7**	**18.6**	**60.8**	**45.0**	**18.0**	**72.1**	15.5	-2.9	33.9	**29.9**	**6.2**	**53.6**

EMR=electronic medical record; CI=confidence interval
[a]Confidence interval truncated at 100%
Boldface indicates significance

Appendix 3.1. Paired difference in obesity counseling documentation frequency (% difference) at Strong4Life Health Weight Counseling Maintenance of Certification completion (MOC) compared with baseline (n=102 pediatricians) and six months after MOC completion compared to six- and three-months before baseline (n=79 pediatricians).

	MOC completion[a]						**Six months after MOC completion[b]**					
	<80% baseline counseling frequency			**≥80% baseline counseling frequency**			**<80% baseline counseling frequency**			**≥80% baseline counseling frequency**		
	Mean difference (%)	**99.5% CI**		**Mean difference (%)**	**99.5% CI**		**Mean difference (%)**	**99.5% CI**		**Mean difference (%)**	**99.5% CI**	
Goal Setting	**83.1**	**74.0**	**92.2**	**9.0**	**2.3**	**15.7**	**35.4**	**0.8**	**70.1**	2.6	-35.3	40.6
Fruit and Vegetable Consumption	**72.3**	**57.6**	**87.0**	9.5	-1.2	20.3	37.0	-3.5	77.6	-7.0	-28.9	14.8
Sugar-sweetened Beverage	**73.1**	**60.8**	**85.3**	12.4	-3.5	28.3	**26.5**	**2.6**	**50.4**	**27.9**	**4.0**	**51.8**
Eating Out	**90.6**	**84.7**	**96.5**	2.5	-1.3	6.3	**47.4**	**11.6**	**83.2**	-12.3	-45.8	21.2
Physical Activity	**62.7**	**46.1**	**79.3**	2.4	-8.7	13.5	26.3	-6.4	58.9	1.5	-12.2	15.2
Screen time	**72.9**	**59.1**	**86.6**	-1.2	-9.5	7.0	**45.0**	**13.7**	**76.2**	-5.9	-17.5	5.6

CI=confidence interval

[a]Data abstracted by physicians

[b]Data abstracted by office managers

Boldface indicates significance

Chapter 4: Impact of a Georgia Elementary School-Based Intervention on Physical Activity Opportunities: A Quasi-Experimental Study

Abstract

Background: Power Up for 30 (PU30) is a statewide elementary school initiative to increase physical activity (PA) time to 30 minutes or more per day in addition to physical education (PE). This study evaluated the impact of PU30 on school PA opportunities (i.e. PE, recess, in-class PA, before-school PA, and after-school PA) one year after PU30 training.

Methods: In 2013-2014, 1,333 Georgia elementary schools received the School PA survey assessing school PA opportunities prior to PU30 participation. From the 719 schools which provided responses from at least one administrator, one PE teacher, and three grade level chairs, 300 had been PU30-trained between 2/2014 and 9/2014 and 419 had not been trained during this time. Seventy-nine trained and 80 untrained schools were randomly selected to receive a one-year follow-up survey assessing frequency and duration of PA opportunities. Analyses adjusted for baseline PA, demographics, and other school characteristics compared weekly minutes of PA opportunities at follow-up between PU30-trained and untrained schools.

Results: Trained schools provided 36 more minutes of weekly PA opportunities compared to untrained schools (99% confidence interval [CI]: 16-56). Much of this difference was due to increased recess time (mean difference: 8 minutes per week; 99% CI: 0-17), in-class PA time (mean difference: 11 minutes per week, 99% CI: 3-20), and before-school PA time (mean difference: 8 minutes per week, 99% CI: 4-12).

Conclusions: Flexible Comprehensive School Physical Activity Program-based interventions increase PA opportunities provided by elementary schools. Future research should explore the extent to which increased opportunities for PA translates into increased student-level PA.

Background

Physical activity (PA) has many benefits for children, including improved cardiovascular fitness, muscular fitness, and decreased levels of body fat.[160] However, only about half of U.S. youth receive the recommended 60 or more minutes of moderate-to-vigorous PA (MVPA) per day.[161] At least 30 of the daily 60 MVPA minutes should occur during regular school hours, since the majority of children aged five to seventeen spend up to half of their waking hours in school.[161] The school setting offers PA opportunities through physical education (PE), recess, classroom PA, and before- and after-school programs.[161]

The World Health Organization (WHO) has called for comprehensive approaches to health in school settings. Likewise, the Centers for Disease Control and Prevention (CDC) and Society for Health and Physical Educators America recommends the multi-component Comprehensive School PA Program (CSPAP).[46] The CSPAP approach involves: (1) providing quality PE, (2) offering PA during recess and in the classroom, (3) making before- and after-school PA available, (4) involving staff in PA, and (5) engaging the family and community in PA. Almost all prior studies assessing multi-component interventions have evaluated their impact on health behaviors such as steps or MVPA of students, but these fail to capture changes occurring at the school level as a result of the intervention.[93,94,100]

Prior studies have suggested that PA interventions effectively but modestly increase PA.[89–91,100,162] Many multi-component interventions that have been previously tested are highly structured and require all intervention schools to complete the same components (e.g. hiring PA leaders, making PE curriculum changes, etc.).[93,162] The numerous requirements of these complex interventions limit their scalability. In contrast, interventions allowing for adaptation at the school or teacher levels facilitate integration of PA into the school. Only a few studies have explored interventions that can be modified at the school or teacher levels and have reported that such adaptable multi-component interventions can increase PA opportunities during school.[100,102] A recent review reported that even less is known about how school staff are implementing PA throughout the school day.[99] Given the limited research on the implementation of adaptable CSPAP-based interventions, the PA opportunities that are modified to impact student PA remain unclear.

Georgia Shape, a statewide multi-agency initiative to address childhood obesity, along with the support of Georgia Department of Public Health (DPH), Georgia Department of Education (DOE), HealthMPowers (a nonprofit organization), and other key partners, created Power Up for 30 (PU30), a statewide initiative to increase PA in schools. PU30 uses specific components of CSPAP to encourage 30 minutes of PA outside of PE each school day.[163] PU30 builds on prior work demonstrating the efficacy of multi-component interventions, while encouraging school-wide involvement of administrators, PE teachers, and grade level chairs, and allowing flexibility for tailoring at the school level. A prior evaluation of PU30 suggested that the initiative increased PA opportunities offered during recess, in classroom breaks, before school, and after school, but only performed crude analyses.[117] The current study explores the impact of PU30 on the PA opportunities offered by elementary schools one year after PU30 training by using a quasi-experimental design adjusted for baseline school PA opportunities, demographics, and other school characteristics. It was hypothesized that PU30 would increase staff-reported recess, in-class PA, before-school PA, and after-school PA time, but not PE time as PU30 emphasized PA during PE less than other PA opportunities.

Methods

Intervention. Between October 2013 and September 2014, all 1,333 Georgia public elementary schools were emailed an invitation to participate in PU30. Guided by CSPAP, the PU30 initiative involved: (1) a voluntary commitment by each elementary school to increase PA outside of regular PE to 30 minutes or more per day; (2) a baseline needs assessment of current PA opportunities and environmental characteristics (School PA Survey) answered by the school team consisting of at least one administrator, one PE teacher, and one grade level chair for kindergarten through fifth grades; and (3) a tailored full-day training based on evidence-based strategies and resources for increasing PA before, during (recess, in-class PA), or after school. PU30 strongly recommended at least one administrator or administrative designee, one PE teacher, and one grade level chair from each school attend the training. The training was conducted by HealthMPowers, an organization aiming to increase health knowledge and promote health-enhancing behaviors among youth. Teams from up to 10 schools could simultaneously attend the in-person training at a nearby site. During the training, HealthMPowers (1) discussed barriers and facilitators to PA and the importance of PA; (2) provided strategies for integrating PA before, during and after school; shared and modeled the use of low- and no-cost resources including exercise DVDs, internet-based PA resources, PA curricula, and integrated PA-academic lessons; and (3) assisted school teams in developing an action plan based on the results of the needs assessment. Electronic resources (two webinars, PowerPoint slides, handouts, DVDs, and monthly newsletters), and technical support were continuously provided throughout the year.

Study population. This study employed a quasi-experimental design to compare PU30-trained and untrained comparison groups. Of the 1,333 schools elementary schools in the state in 2013-2014 , 719 elementary schools (54%) provided responses from at least one administrator, one PE teacher, and at least three grade level chairs (Fig. 4.1). Three hundred of these schools completed the School PA Survey and participated in PU30 training between February 2014 and September 2014, and 419 of the responding schools completed the School PA Survey and did not participate in PU30 training during this time. From the 300 participating schools, 79 PU30-trained schools were randomly selected to form the PU30 arm, and from the 419 schools that did not participate in PU30 training, 80 schools were randomly selected to form the untrained comparison arm. The sample size was determined based on preliminary data from the PU30 baseline survey and adjusted to take advantage of the finite number of schools eligible for this current study.

Among the 79 PU30 and 80 untrained schools randomly selected for inclusion in the study, 71 PU30 and 62 untrained schools provided one-year follow-up data from at least one PE teacher and at least one grade level chair. Schools included in this analytic dataset did not significantly differ from sampled school by FRL, race/ethnicity, school size, gender, or geographical setting from non-responding schools (Appendix 4.3).

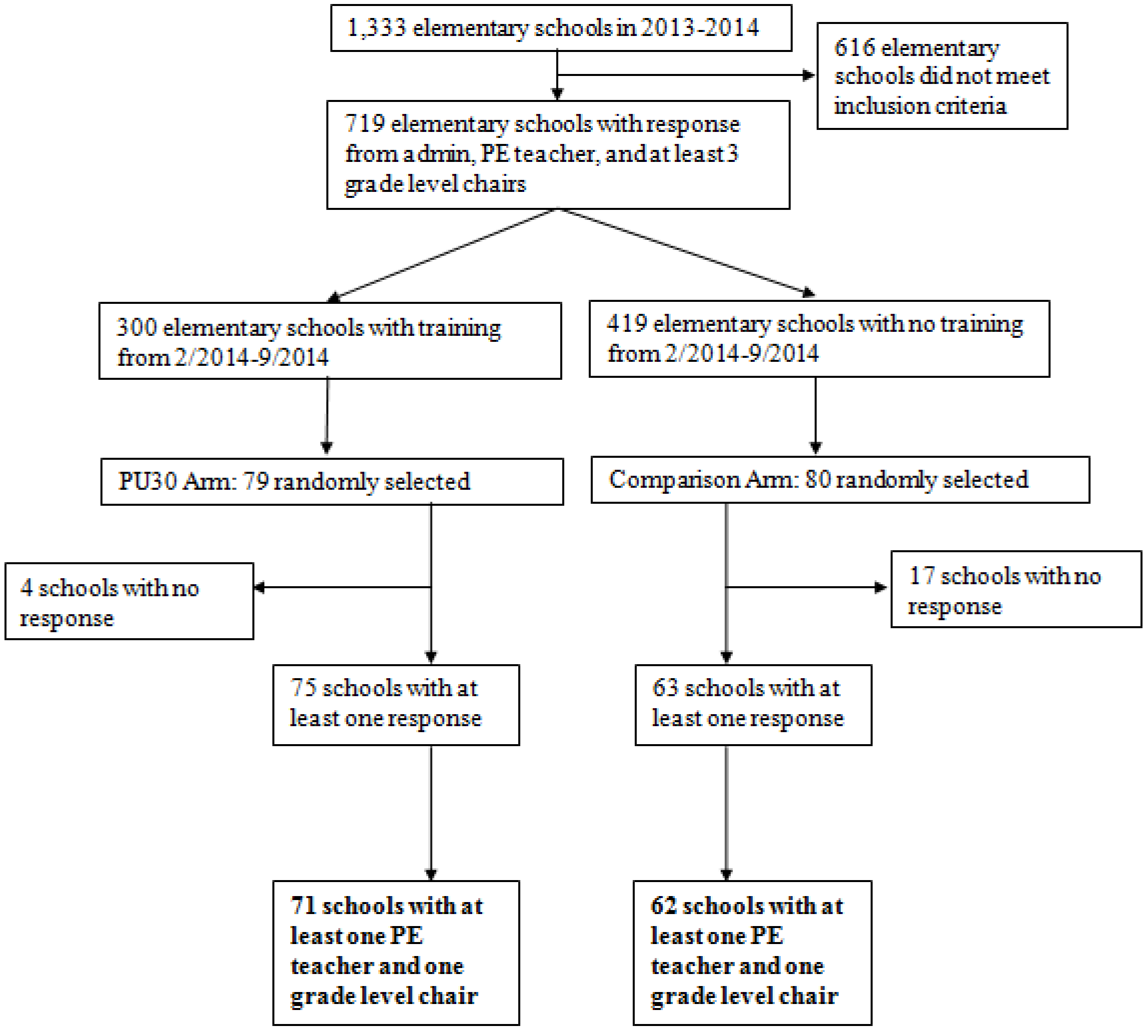


Figure 4.1. Participant flow chart describing target population (1,333 Georgia elementary schools), participant selection (79 Power Up for 30 [PU30]-trained and 80 untrained schools), and analytic sample (71 PU30-trained and 62 untrained schools).

Data collection. The School PA Survey was created by a multidisciplinary team, including HealthMPowers, Georgia Department of Education, Georgia Department of Public Health, Georgia State University, University of Georgia, and Emory University. The survey was adapted from other widely used and validated school PA survey tools (survey available upon request).[92,161,164–167] Thirty-four questions assessed PA opportunities and environmental characteristics and took approximately 10-15 minutes to complete. *A priori*, a respondent type (e.g. administrator, PE teacher, or grade level chair) was selected based on the individual position most responsible for implementation and knowledgeable of the accurate response. PE teachers provided data for PE, before-school, and after-school PA, while grade level chairs provided data on recess and in-class PA breaks. Administrator data were not used in the current study since these questions were not relevant for the current research questions. Respondent selection has been supported by a concurrent qualitative study (data unpublished).

Study measures. PA opportunity outcomes at follow-up included PE frequency (0, 1, 2-3, 4-5 days per week) and duration (<15, 15-19, 20-29, 30-39, 40-49, ≥50 minutes per PE class); recess frequency (0, 1, 2, 3, 4, or 5 days per week) and duration (<15, 15-19, 20-29, ≥30 minutes per recess); in-class PA time (0, 1-5, 6-10, 11-15, 16-20, 21-25, ≥25 minutes per day); before-school PA frequency (0, 1, 2, 3, 4, or 5 days per week) and duration (<10, 10-15, 16-20, 21-25, and ≥25 minutes per day); and after-school PA frequency (0, 1, 2, 3, 4, or 5 days per week) and duration (<10, 10-15, 16-20, 21-25, and ≥25 minutes per day). To convert these categorical responses into a continuous measures of PA time in minutes/week, we simulated samples from a uniform distribution within each category using Monte Carlo techniques.[168] For PE, recess, before-school PA, and after-school PA, each replicate used a Monte Carlo sampling approach to randomly draw a duration (minutes/occurrence) from the category indicated by the respondent, which was multiplied with the selected frequency (occurrences/week) to obtain minutes of PA per week. For in-class PA time, each replicate randomly drew an in-class PA time within each category. Calculations of PE, recess, in-class, and total weekly PA time per week were repeated 1,000 times. Analyses were also conducted after using the midpoint of PA frequency and duration intervals to calculate the PA opportunity minutes per week. Both measures generated similar results, so the Monte Carlo simulation was reported since they were more likely to correspond to the uncertainty in PA opportunity estimation (Appendices 4.1-4.2). Total weekly PA time was defined as the sum of PA time during school (PE, recess, and in-class PA breaks), before school, and after school.

Covariates included school baseline PA time, school-level demographics (percent free/reduced lunch rate [FRL], percent White and percent Hispanic), and other school-level characteristics (school size and geographical setting). A few questions on the baseline School PA Survey differed from the one-year follow-up survey. As described above, at follow-up, PE frequency categories included 0, 1, 2-3, 4-5 days per week, and both frequency (0, 1, 2, 3, 4, or 5 days per week) and duration (<10, 10-15, 16-20, 21-25, and ≥25 minutes per day) of before- and after-school PA were assessed. However, the baseline survey included different PE frequency responses (0, 1, 2, 3, 4, 5 days) and assessed only presence/absence of before-school and after-school PA. Prior to Monte Carlo simulation, baseline PE frequency was re-coded to match the categories of PE frequency at follow-up. With the exception of binary variables indicating presence of before-school and after-school PA at baseline, all other baseline PA variables (total weekly PA time, PE time, recess time, and in-class PA time) underwent a Monte Carlo simulation described above. Total weekly PA time at baseline was defined as the sum of PA time during school (PE, recess, and in-class PA breaks).

Demographic and school characteristics data were obtained from the Georgia DOE and National Center for Education Statistics.[169,170] FRL (≤25%, 25.1-50%, 50.1-75%, >75%) and geographical setting (city, suburb, town, rural) categorization was based on prior National Center for Educational Statistics publications.[170] When no a priori categorizations were identified, covariates were retained as continuous variables (e.g. percent White, percent Hispanic, and school size). Race/ethnicity could be characterized almost completely by percent White, Black, and Hispanic because the sum of percent White, Black, and Hispanic was almost always 100%, so percent Black was excluded and served as the referent group in the models.

Analysis. To assess whether school demographics and other school characteristics differed between PU30-trained and untrained schools, standardized differences (difference between means/pooled standard deviation) were computed. Standardized differences are independent of sample size and their absolute values can be interpreted as indicating a meaningful imbalance when greater than 0.1 and a large imbalance when greater than 0.2. Three models were used to compare PA opportunities (PE, recess, in-class PA, total weekly PA, before-school PA, and after-school PA time per week) between trained and untrained schools at follow-up. First, the naïve approach assessed the impact of PU30 on PA opportunities alone using linear regression and generalized estimating equations (GEE), which accounted for clustering of multiple respondents per school, and of schools within districts. Monte Carlo replicates were summarized using PROC MIANALYZE to obtain the mean difference and 99% confidence intervals (CIs). The second approach additionally accounted for baseline PA time (total PA, PE, recess, in-class PA break, before-school PA or after-school PA time). All baseline PA-exposure interaction terms were assessed, but no baseline PA-exposure terms were significant. In the third model, in addition to baseline PA time, inverse probability of treatment weights were used to account for imbalance of baseline school demographics and characteristics. All school demographics and characteristics were included in the propensity score model. To account for multiple testing, alpha was set at 0.01. All analyses were performed using SAS version 9.4 (Cary, NC).

In a sensitivity analysis to additionally control for potential unmeasured confounding due to participation in other PA programs, the analyses was repeated for model 3 and additionally included covariates indicating the involvement of schools in other PA programs during the prior (0, 1, or 2 PA programs in 2012-2013) and concurrent years of PU30 training (0, 1, 2, or 3 or more PA programs in 2013-2014). Data on prior and concurrent PA programming in each school were obtained from the Stong4Life School Programs database maintained by Children's Healthcare of Atlanta. This database includes information on nutrition- and PA-related programs being implemented in schools throughout Georgia, although only PA program data were included in the current study. This data set is believed to include all programs with a broad reach in the state; however, information is submitted voluntarily, and therefore may not be equally comprehensive across all years.

Results

PU30-trained schools were more likely than untrained schools to be of high (>75%) FRL, but less likely to be of mid-high FRL (50% < FRL ≤ 75%; Table 4.1). Trained schools had a lower proportion of white students, had a higher proportion of Black and Hispanic students, and were larger. A greater proportion of trained schools were in suburbs while more untrained schools were in rural areas. Trained schools were more likely to have at least one school PA program in the year prior to the study (2012-2013) and in the concurrent year of study (2013-2014) compared with untrained schools.

At baseline, PU30-trained schools had 11 fewer minutes of recess, but 10 more minutes of in-class PA breaks each week compared to untrained schools (Table 4.2). At follow-up, the average recess and in-class PA time provided by trained school was 9 and 11 minutes per week higher than the average time at baseline. Among untrained schools, the average recess time was lower at follow-up by 4 minutes per week and the average in-class PA time was higher at follow-up by 6 minutes weekly. At follow-up, trained schools had 11 more before-school PA minutes per week and 9 more after-school PA minutes per week than untrained schools.

At follow-up, in unadjusted models, trained schools reported 43 more minutes of total PA time compared with untrained schools (99% CI: 23-63; Table 4.3; model 1). Trained schools had 16 more minutes of in-class PA breaks (99% CI: 8-23), 11 more minutes of before-school PA (99% CI: 7-16), and 9 more minutes of after-school PA each week than untrained schools (99% CI: 0-18). This association was attenuated after accounting for differences in baseline PA opportunity time, as trained schools had 37 more minutes of PA than untrained schools at follow-up (99% CI: 16-58; model 2). Further adjustment by inverse probability of treatment weight to account for confounding by demographic and other school characteristics reduced this total PA time difference to 36 min/week between trained schools and untrained schools (99% CI: 16-56; model 3). Most of this difference was due to more time during recess (mean difference: 8 minutes/week; 99% CI: 0-17), in-class PA breaks (mean difference: 11 minutes/week; 99% CI: 3-20), and before school (mean difference: 8 minutes/week; 99% CI: 4-12) among trained schools.

In the sensitivity analysis additionally adjusting for prior and concurrent PA program participation, results were attenuated but consistent with the main analysis (Supplementary Table 4.1).

Table 4.1. School demographics and other characteristics of 71 Power Up for 30 (PU30)-trained and 62 untrained Georgia elementary schools in 2013-2014.

Characteristic	Untrained (n=62 schools)		Trained (n=71 schools)		Absolute Value of Standardized Difference
	N or Mean	% or SD	N or Mean	% or SD	
Free/reduced lunch rate					
High (>75% FRL)[a]	22	35.5%	36	50.7%	0.31
Mid-high (50%<FRL≤75%)[a]	18	29.0%	11	15.5%	0.33
Mid-low (25%<FRL≤50%)	13	21.0%	12	16.9%	0.10
Low (≤25% FRL)	9	14.5%	12	16.9%	0.07
Mean % White[a]	50.8	27.8	39.0	27.0	0.43
Mean % Hispanic[b]	11.2	11.7	19.8	18.4	0.56
School Size					
Large (>735 students)[a]	17	27.4%	28	39.4%	0.24
Medium (550-735 students)[b]	23	37.1%	22	31.4%	0.12
Small (<550 students)[b]	22	35.5%	21	30.0%	0.12
School Geographical Location					
City	9	14.5%	9	12.7%	0.05
Suburban[a]	21	33.9%	46	64.8%	0.65
Town	8	12.9%	7	9.9%	0.10
Rural[a]	24	38.7%	9	12.7%	0.62
Mean # School Physical Activity Programs in 2012-2013					
0[a]	51	82.3%	49	69.0%	0.31
1[a]	9	14.5%	19	26.8%	0.31
2	2	3.2%	3	4.2%	0.05
Mean # School Physical Activity Programs in 2013-2014					
0[a]	46	74.2%	20	28.2%	1.04
1[a]	10	16.1%	22	31.0%	0.36
2[a]	4	6.5%	23	32.4%	0.69
3 or more[a]	2	3.2%	6	8.5%	0.22

SD=standard deviation; FRL=free/reduced lunch rate

[a]Absolute value of the standardized difference >0.2 is considered a large imbalance
[b]Absolute value of the standardized difference > 0.1 is considered a meaningful imbalance

Table 4.2. Crude physical activity (PA) time per week across 71 Power Up for 30 (PU30)-trained and 62 untrained Georgia elementary schools at baseline (2013) and follow-up (2014).

	Baseline				**Follow-Up**			
	Untrained (n=62)		**Trained (n=71)**		**Untrained (n=62)**		**Trained (n=71)**	
	Mean (min/wk)	**SD**	**Mean (min/wk)**	**SD**	**Mean (min/wk)**	**SD**	**Mean (min/wk)**	**SD**
PE	105.6	5.3	107.7	4.4	105.5	5.5	104.9	4.3
Recess	100.3	3.9	89.8	4.2	96.2	3.7	98.7	3.6
In-class PA	30.4	2.3	40.5	2.6	36.1	2.6	51.9	2.5
Before-school PA	Time Not Assessed at Baseline				3.8	1.4	14.9	3.3
After-school PA	Time Not Assessed at Baseline				23.7	6.1	32.5	5.4

SD= standard deviation; PE= physical education

Table 4.3. Mean difference in physical activity (PA) time per week at follow-up between Power Up for 30 (PU30)-trained schools and untrained schools, one year after PU30 training (2014) among 71 PU30-trained and 62 untrained Georgia elementary schools.

	Model 1[a]			**Model 2[b]**			**Model 3[c]**		
	Mean Diff (min/wk)	**99% CI**		**Mean Diff (min/wk)**	**99% CI**		**Mean Diff (min/wk)**	**99% CI**	
Total PA time[d]	**42.80**	**22.74**	**62.86**	**37.20**	**16.46**	**57.95**	**36.31**	**16.19**	**56.43**
PE time	-0.61	-9.38	8.16	-2.74	-9.57	4.10	-3.38	-10.19	3.42
Recess time	2.50	-6.55	11.55	6.51	-1.79	14.80	8.07	-0.37	16.50
In class PA time	**15.82**	**8.22**	**23.43**	**11.95**	**3.83**	**20.07**	**11.39**	**3.02**	**19.77**
Before school PA time	**11.15**	**6.54**	**15.75**	**9.96**	**5.36**	**14.56**	**7.91**	**3.62**	**12.21**
After school PA time	**8.83**	**0.09**	**17.57**	6.94	-0.88	14.77	3.65	-3.96	11.25

CI= confidence interval; PE=physical education

[a]Model 1 was the unadjusted model

[b]Model 2 was adjusted for baseline physical activity time of the outcome

[c]Model 3 was adjusted for baseline physical activity time of the outcome, demographics, and other school characteristics

[d]Total PA time may not equal the exact sum of PE time, recess time, in-class PA time, before-school PA time, and after-school PA time because of randomness generated when using the Monte Carlo model or adjustment for varying baseline PA opportunities

Boldface indicates statistical significance (P<0.01)

Supplementary Table 4.1. Mean difference in physical activity (PA) minutes per week between Power Up for 30 (PU30)-trained schools and untrained schools, one year after PU30 training (2014) among 71 PU30-trained and 62 untrained Georgia elementary schools after accounting for baseline PA , school demographics other characteristics, and PA engagement.

	Mean Diff (min/wk)	**99% CI**	
Total PA time[a]	**29.68**	**9.26**	**50.09**
PE time	0.60	0.51	0.68
Recess time	**9.70**	**1.05**	**18.36**
In class PA time	7.89	-1.15	16.93
Before school PA time	**6.69**	**2.56**	**10.81**
After school PA time	0.97	-6.20	8.14

CI= confidence interval; PE=physical education

[a]Total PA time may not equal the exact sum of PE time, recess time, in-class PA time, before-school PA time, and after-school PA time because of randomness generated from the Monte Carlo model or adjustment for varying baseline PA opportunities

Discussion

This quasi-experimental study found that at follow-up, PU30-trained schools reported 36 more minutes of PA opportunities each week compared with untrained schools after controlling for baseline PA, demographics, and other school characteristics. This overall difference in PA time was attributable to small differences (8-11 minutes per week) in PA time offered throughout the week from recess, in-class PA breaks, and before-school PA.

Studies on CSPAP-based interventions involving structured requirements such as external facilitators have been reported to be effective.[93,94,162] However, rigid requirements of many prior CSPAP-based interventions may serve as barriers to implementation, making these interventions less feasible to scale up across diverse settings. PU30 is an adaptable CSPAP-based initiative, allowing the school team to develop an action plan based on existing PA opportunities thus meeting the specific needs of the school while avoiding costly changes such as hiring of external staff. Further, PU30 builds on current evidence by obtaining school-wide support through involvement from administrators, PE teachers, and grade level chairs to facilitate PA opportunity changes within each school.

The current study supports some but not all findings from a prior study assessing PU30 but without control for school characteristics.[117] In both the prior and current studies, more opportunities for PA were observed during in-class breaks, before school, and recess among trained schools compared with untrained schools. However, in contrast to the current study, Barrett-Williams et al. concluded that there was an increase in after-school PA program time. Some of the discrepancies between the current and prior study are likely due to methodological differences such as adjustment for covariates, use of combined PA frequency and duration data, and adjustment for the hierarchical nature of the data.

Findings from this study are comparable to other studies using multi-component PA interventions. One quasi-experimental study evaluating the impact of a CSPAP-based model involving PE teacher training in Louisiana elementary schools reported that teachers receiving the intervention provided more PA opportunities during school for students and more PA involving staff compared with control groups.[100] A cluster-randomized controlled trial assessing a Comprehensive School Health program, Action Schools! BC in Canada, found that teachers with initial training and resources delivered 46 more minutes of PA per week, and teachers with initial training, resources, and ongoing mentorship provided 63 more minutes of PA per week, six to ten months after baseline compared with usual practice.[102] The current study additionally identifies the opportunities most positively affected (e.g. recess, in-class, and before-school PA) when teachers and administrators are provided the flexibility to develop their own methods to increase PA opportunities.

Although the current study did not assess the impact of CSPAP models on student PA, the increased PA opportunities identified in the current study is consistent with prior studies that have reported increased PA resulting from CSPAP-based programs.[100,162] A 2015 CSPAP study assessed ongoing teacher training and PE and recess changes in Southwest US.[162] Six months after the intervention, fourth and fifth grade students had 1,126 more daily steps than before the intervention ($p<0.05$). Some of the increases in PA reported by prior studies may be due to increased PA opportunities provided by the school, particularly in-class and before-school PA programming, although further studies are needed to assess the mediated effect of CSPAP through PA opportunities on student PA.

Even after adjustment for baseline PA, demographics/other school characteristics, and prior and concurrent health and PA programming in the sensitivity analysis, staff-reported PA time during school was higher among trained schools compared with untrained schools. While prior and concurrent PA programming variables were conceptualized as indicators of school-level support for health and PA promotion, participation in prior or concurrent health and PA programming could also indicate increased opportunities for school administrators and staff to learn about and adopt school PA practices. However, sensitivity analysis results must be interpreted with caution, as the Stong4Life School Programs database used to create the prior and concurrent PA programming variables is not comprehensive and further exploration of data completeness and construct validity is needed.

This study had at least three strengths. First, the survey had a high response rate (84%), although the response was lower in untrained (76%) than trained schools (90%). Data were provided by both grade level chairs (for questions involving in-classroom PA and recess) and PE teachers (for questions related to PE and before- and after-school activity). This contrasts with prior studies which relied only on PE teachers, who may have less accurate knowledge than grade level teachers about in-class PA or recess time.[100] Second, the assessment of PA opportunities during PE, during recess, in class, before school, after school, and overall, allowed identification of specific PA opportunities most amenable to change such as recess, in-class breaks, and before school PA. Third, this study built on prior literature and additionally adjusted for confounders, combined duration and frequency measures into a continuous outcome, and used GEE to account for hierarchical nature of the data to produce more valid estimates of the effects of PU30 on PA opportunities in the elementary school setting.

Despite these strengths, there were at least six limitations with this study. First, the PU30 initiative was not randomized across schools, which increases the possibility of unmeasured or residual confounding because schools opting into PU30 training may differ in important ways from those not volunteering for PU30. However, adjusted analyses likely diminished much of the potential bias. Second, only 76% of untrained schools responded to the follow-up survey, and the loss to follow-up may further bias estimates if the analytic sample differed from the overall sample by unmeasured covariates, but responding and non-responding schools did not differ on measured demographics and other school characteristics (Appendix 4.3), and the number of respondents in each school did not differ between PU30-trained and untrained schools. Third, similar to prior studies,[100,102] this study design only involved an approximately one-year follow-up time, which may be insufficient time for effects of the PU30 initiative to occur. Further exploration indicated that schools with longer follow-up time had larger differences in total PA time between trained and untrained schools (Appendix 4.4), which is consistent with some,[171] but not all,[99] prior publications. Fourth, assessment of PA opportunities relied on self-reported data and increased reporting accuracy among trained individuals as a result of being more familiar with the survey topics could have resulted in differential outcome misclassification. However, alternative forms of PA opportunity measurement, such as researcher observation, may have likely further biased the outcome data. The School PA Survey has not yet been validated, but it was developed by a large multidisciplinary group and adopted from widely used and validated surveys. Our group is also currently exploring a survey validation study. Fourth, the grade-level chair response represented each grade level and these data may also not have adequately represented the variability between teachers, particularly for in-class PA breaks; however, grade-level chair response to questions about in-class PA is likely more accurate than PE teachers employed in prior studies.[100] Finally, the current study did not explore PA intensity occurring during each PA opportunity. Prior studies using accelerometers have reported that students spend only 33% of PE time in MVPA and even less time in other segments of the school day in MVPA, and it is possible that just a fraction of the PA opportunity time reported in this study is spent in MVPA.[106,172] Future studies using activity monitoring devices may detail the amount and intensity of PA performed at the individual level.

Conclusion

Power Up for 30 is a flexible and adaptable CSPAP-based initiative to increase physical PA in the elementary school setting. This adaptable, whole-of-school approach increases staff-reported PA opportunities, particularly during recess, in class, and before school. If future studies identify a positive impact of school PA opportunities on student PA, this adaptable CSPAP-based model may be a viable strategy for scale up across diverse settings.

Appendix 4.1. Mean difference in physical activity (PA) time between Power Up for 30 (PU30)-trained schools and untrained schools, one year after PU30 training (2014) among 71 PU30-trained and 62 untrained Georgia elementary schools after imputation. Analyses were conducted using the midpoint of each PA opportunity frequency interval and each duration interval.

	Model 1[a]			**Model 2[b]**			**Model 3[c]**		
	Mean Diff (min/wk)	**99% CI**		**Mean Diff (min/wk)**	**99% CI**		**Mean Diff (min/wk)**	**99% CI**	
Total PA time[d]	**43.78**	**7.05**	**80.52**	**42.06**	**5.82**	**78.30**	**35.67**	**15.19**	**56.14**
PE time[e]	-1.17	-20.62	18.29	-3.39	-16.54	9.75	-4.16	-10.50	2.17
Recess time	1.96	-11.07	14.99	6.36	-2.49	15.21	**8.39**	**0.26**	**16.52**
In class PA time	**16.04**	**6.94**	**25.14**	**12.24**	**2.87**	**21.61**	**11.40**	**1.46**	**21.33**
Before school PA time	**11.72**	**2.11**	**21.33**	**11.01**	**1.70**	**20.33**	**7.92**	**4.06**	**11.78**
After school PA time	9.96	-9.90	29.82	10.45	-7.79	28.69	3.65	-4.46	11.77

CI= confidence interval; PE=physical education

[a]Model 1 was the unadjusted model

[b]Model 2 was adjusted for baseline physical activity time for the outcome of interest

[c]Model 3 was adjusted for the factor in model 2 and propensity for training

[d]Total PA time may not equal the exact sum of PE time, recess time, in-class PA time, before-school PA time, and after-school PA time because of randomness generated when using the Monte Carlo model or missing variables.

Boldface indicates significance

Appendix 4.2. Mean difference in physical activity (PA) minutes per week between Power Up for 30 (PU30)-trained schools and untrained schools, one year after PU30 training (2014) among 71 PU30-trained and 62 untrained Georgia elementary schools Analyses were conducted using the midpoint of each interval.

	Mean diff[a] (min/wk)	**99% CI**	
Total PA time[b]	**28.92**	**6.78**	**51.06**
PE time	-4.16	-10.50	2.17
Recess time	10.14	-0.52	20.80
In class PA time	7.90	-7.97	23.77
Before school PA time	**6.69**	**3.29**	**10.09**
After school PA time	0.97	-6.17	8.12

CI=confidence interval; PE= physical education

[a]Accounting for baseline PA , school demographics other characteristics, and PA engagement.

[b]Total PA time may not equal the exact sum of PE time, recess time, in-class PA time, before-school PA time, and after-school PA time because of randomness generated when using the Monte Carlo model or missing variables

Boldface indicates significance

Appendix 4.3. Descriptive statistics of school demographics and other characteristics comparing the analyzed (n=133) and non-analyzed schools (n=26).

	Analytic Dataset (n=133 schools)		Not Analyzed (n=26 schools)		p-value
Characteristic	**N or Mean**	**% or SD**	**N or Mean**	**% or SD**	
Free/reduced lunch rate					0.36
High (>75% FRL)	58	43.6	11	42.3	
Mid-high (50%<FRL≤75%)	29	21.8	8	30.8	
Mid-low (25%<FRL≤50%)	25	18.8	6	23.1	
Low (≤25% FRL)	21	15.8	1	4.6	
Mean % White	44.5	27.9	43.3	24.1	0.83
Mean % Hispanic	15.4	16.1	17.6	20.7	0.55
Mean school size (students)	659.7	197.8	665.0	275.9	0.93
School geographical location[a]					0.67
City	18	13.5	4	15.4	
Suburban	67	40.4	10	38.5	
Town	15	11.3	4	15.4	
Rural	33	24.8	8	30.8	

SD=standard deviation; FRL=free/reduced lunch rate
[a]Fisher's Exact Test was used

Appendix 4.4. Total physical activity (PA) opportunity, recess, in-class PA, and before-school PA time (min/week) across season of Power Up for 30 training (Spring 2014, Summer 2014, Fall 2014; n=133 schools).

		Model 1[a]			Model 2[b]			Model 3[c]			Model 4[d]		
	Training Season	**Mean difference (min/week)**	**99% CI**		**Mean difference (min/week)**	**99% CI**		**Mean difference (min/week)**	**99% CI**		**Mean difference (min/week)**	**99% CI**	
During-school PA time	**Untrained**		REF			REF			REF			REF	
	Spring	**61.09**	**37.90**	**84.27**	**54.73**	**31.08**	**78.38**	**52.21**	**28.07**	**76.35**	**48.00**	**23.15**	**72.84**
	Summer	26.18	-6.92	59.27	27.88	-7.19	62.95	**33.26**	**0.77**	**65.75**	38.86	-0.47	78.20
	Fall	16.35	-13.79	46.49	7.28	-22.51	37.08	15.20	-12.39	42.78	11.37	-13.45	36.19
Recess time	**Untrained**		REF			REF			REF			REF	
	Spring	-8.16	-18.60	2.28	1.59	-8.27	11.44	2.64	-7.76	13.04	5.83	-5.22	16.87
	Summer	**28.20**	**12.62**	**43.79**	**15.87**	**1.41**	**30.33**	**18.08**	**3.86**	**32.31**	**17.35**	**0.27**	**34.43**
	Fall	6.06	-6.89	19.01	8.95	-2.63	20.53	8.81	-2.46	20.09	**10.60**	**0.20**	**21.01**
In-class PA time	**Untrained**		REF			REF			REF			REF	
	Spring	**14.99**	**5.97**	**24.00**	**10.57**	**1.08**	**20.06**	8.40	-1.92	18.71	4.29	-7.41	15.98
	Summer	**16.01**	**2.65**	**29.36**	11.35	-2.79	25.48	13.13	-1.05	27.32	4.66	-14.22	23.54
	Fall	**17.30**	**6.04**	**28.56**	**14.75**	**3.27**	**26.24**	**14.31**	**3.09**	**25.54**	**11.26**	**0.55**	**21.96**
Before-school PA time	**Untrained**		REF			REF			REF			REF	
	Spring	**16.35**	**11.14**	**21.55**	**14.14**	**8.77**	**19.51**	**13.33**	**8.05**	**18.60**	**12.29**	**7.17**	**17.42**
	Summer	**12.16**	**4.86**	**19.46**	**12.80**	**5.58**	**20.02**	**8.61**	**2.24**	**14.98**	**13.49**	**6.25**	**20.72**
	Fall	-2.22	-9.28	4.83	-1.49	-8.47	5.50	-1.48	-7.68	4.72	-1.03	-6.03	3.97

CI=confidence interval

[a]Model 1 was the naïve model

[b]Model 2 was adjusted for baseline physical activity time for the outcome of interest

[c]Model 3 was adjusted for the factor in model 2 and propensity for training

[d]Model 4 was model 3 and additional controlled for PA engagement (sensitivity analysis)

Boldface indicates significance

Chapter 5: Statewide Study of Elementary School Physical Activity Opportunities, Student Body Composition, and Student Aerobic Capacity

Abstract

Background: Physical activity time and intensity are known to modify obesity and chronic disease risk. This cross-sectional statewide study of Georgia elementary schools aimed to assess the relationship between the amount of time that schools provide for physical activity (PA) and the prevalence of students having a healthy body mass index or aerobic capacity.

Methods: In 2013-2014, Georgia elementary school PE teachers and kindergarten to fifth grade level teachers were surveyed about the frequency and duration of school-based PA opportunities before, during (physical education, recess, in-class PA breaks), and after the school day (n=1,244 schools). Survey results estimating the PA opportunity time provided to students were linked with statewide, school-aggregated FitnessGram data indicating the prevalence of children with a healthy aerobic capacity or body mass index. Regression models related the amount of PA time offered by schools to the prevalence of children in these healthy fitness zones after adjusting for school characteristics.

Results: Most associations were relatively weak and insignificant, but the presence of before-school PA programs was weakly associated with higher school-wide prevalence of healthy aerobic capacity (PR_{girls}: 1.06; 99% CI: 0.98-1.16; PR_{boys}: 1.03; 99% CI: 0.98-1.09). Each additional 30 minutes of recess was associated with no more than a 3% higher school prevalence of healthy body composition (PR_{girls}: 1.01; 99% CI: 1.00-1.03; PR_{boys}: 1.01; 99% CI: 0.99-1.03).

Discussion: Most Georgia elementary schools have children who are considered to have healthy levels of aerobic capacity and body composition, which limited the association between school-based PA time and the prevalence of children reaching the healthy fitness zone. Future studies should assess the relative importance of school-based PA opportunity time compared to intensity of PA offered by the school.

Introduction

Poor aerobic capacity and body composition, components of fitness, have been strongly and consistently linked with health consequences in childhood and adulthood, including hyperlipidemia, hypertension, metabolic syndrome, and even poor academic achievement.[9,11,22,23,173] The FitnessGram battery of tests, which includes aerobic capacity and body composition (body mass index [BMI]) assessment, is the most common fitness test currently employed by US schools.[104,107] In the US, only 61-62% of elementary-aged children meet FitnessGram health fitness zone (HFZ) standards for aerobic capacity, and 53-60% of students meet the HFZ for BMI.[174]

Schools are an optimal setting for improving childhood fitness levels since they serve 98% of US children 7-13 years.[53] Moreover, during the school week, children are at schools for half of their waking hours.[175] The educational system also transcends demographic boundaries. Thus, schools are an opportunity to reduce disparities in physical activity (PA) observed by age,[45] gender ,[45] race/ethnicity,[55] socioeconomic status,[56,57] and geography. [55] As a result, the Institute of Medicine recommends that more than half of the recommended 60 minutes of moderate-to-vigorous PA (MVPA) per day should be performed during the regular school day.[115]

Almost all US state policies regarding elementary school PA mandate it by specifying the amount of time that schools should offer PA.[58] However, the relationship between school-based PA opportunities and student fitness remain unclear.[58] Although there is growing support suggesting that interventions influencing school-based PA can positively impact student fitness,[171,176] few studies have exclusively examined the relationship between PA time and student fitness. For example, in low-income California middle schools, an ecologic study found that performing PA on school grounds outside of school time (e.g. after-school PA) and having a full-year of physical education (PE) was associated with increased aerobic capacity.[142]

Similarly, the relationship between elementary school-based PA opportunity time and body composition remains inconclusive.[144] In the Early Child Longitudinal Study-Kindergarten cohort, schools offering more PE had lower BMI z-scores among fifth grade boys, but not for girls or other grades.[144] Another study using the same dataset and longitudinal growth curve analyses showed that offering additional recess time, but not PE time, was associated with a decrease in BMI between kindergarten and fifth grade.[145] In contrast, a cross-sectional study conducted in Alabama, California, and Texas reported that PA resources and programs were not associated with fifth-grade student BMI.[146] Due to the limited research and inconsistent findings regarding the relationship of PA opportunity time with child fitness, the objective of this cross-sectional study was to assess the association between school-level PA opportunities (PE time, recess time, in-class PA time, before-school PA, and after-school PA) and school-aggregated fitness levels of Georgia elementary students.

Methods

Data collection. This cross-sectional study targeted Georgia public elementary schools educating first through fifth grade students (n=1,244 schools). Staff members from all 1,244 public elementary schools were surveyed about opportunities that they provide for physical activity between October 2013 and September 2014. Administration of the School PA Survey has been described elsewhere.[177] Briefly, the on-line survey was created by a multidisciplinary team and adapted from other widely-used or validated school PA survey tools (survey available upon request).[92,161,164–167] Thirty-four questions assessed PA opportunities and environmental characteristics and took approximately 10-15 minutes to complete. At each elementary school, one administrator, one PE teacher, and one grade level chair from each grade were surveyed with the goal of estimating the amount of time during which PA was offered each week before school, during school (PE, recess, and in-class PA), and after school. The administrator provided information on all types of activity, while PE teachers and grade level chairs only provided information on a subset of questions. We utilized survey responses based on those that we believed *a priori* to have the most direct knowledge of the PA opportunities that were provided in the school for children in each grade. Respondent selection has been supported by a concurrent qualitative study (data unpublished). PE teachers provided data on PE, and PA occurring before school, and after school; grade level chairs provided data on recess and in-class PA breaks. The study was reviewed by the Emory University Institutional Review Board and determined to be exempt.

Publically available data from the 2013-2014 Georgia FitnessGram provided fitness data aggregated at the school level and stratified by sex.[169,178] Beginning in the 2011-2012 school year, FitnessGram data have been collected annually in Georgia schools. In Georgia elementary schools, the test is composed of five assessments, including tests for aerobic capacity (Progressive Aerobic Cardiovascular Endurance Run [PACER]), body composition (BMI), abdominal strength, trunk extension strength, upper body strength, and flexibility. All assessments are required for Georgia fourth and fifth grade students, but only body composition is required for Georgia students in first to third grades. Only PACER and BMI, the two assessments most strongly linked to health outcomes,[9,11,22,23,173] were included in the current study. At the elementary school level, FitnessGram testing is conducted at least annually by certified PE teachers late in the Spring semester. Prior to testing, PE teachers attend a one-day training and are provided with equipment to carry out the testing. These PE teachers conduct testing during regular school hours and report results to the Department of Education (DOE) through a web-based client. Students are exempted from testing if they are absent on both testing and make-up days, are not enrolled in a PE class led by a certified PE teacher, or have a medical conflict.

Study measures. Aerobic capacity and body composition, outcomes for the current study, were measured according to the FitnessGram test administration manual.[178] Aerobic capacity was assessed using the PACER, a multi-stage, shuttle-run timed to music. The objective of the PACER is for the student to run as long as possible between two lines 20-meters apart while maintaining the specified pace indicated by a song on a compact disc. The test ends when the student cannot complete the lap in the allotted time on two runs. PACER has been established to be a reliable and valid measure of aerobic capacity in children.[121,179] Body composition was assessed by height and weight, which was converted into BMI, calculated as weight (kg) divided by height squared (m^2). Height was measured using a wall chart to the nearest quarter-inch and weight was measured using a scale rounding to the lowest whole-pound, or tenth-of-a-pound if the scale allowed.

Raw test scores (the number of laps and BMI) were compared against age- and gender-specific criterion-referenced standards to classify students into three categories (HFZ, needs improvement, or needs improvement health risk).[178] Both aerobic capacity and BMI HFZ cutoffs were derived from studies using National Health and Nutrition Examination Survey data between 1999 and 2004 to assess the risk of metabolic syndrome in youth.[180,181] At each school, publicly available data include the number of youth classified in the HFZ for each test event and the number of students taking each test event, stratified by gender.

Exposure variables were obtained from School PA Survey questions assessing PA opportunities at each grade level. These questions evaluated the frequency of PE and recess (0, 1, 2, 3, 4, or 5 days per week). The duration of each PE class (<15, 15-19, 20-29, 30-39, 40-49, or ≥50 minutes per PE class) and recess period (<15, 15-19, 20-29, or ≥30 minutes per recess) were assessed in separate questions. In-class PA time (0, 1-5, 6-10, 11-15, 16-20, 21-25, or ≥25 minutes per day) and presence or absence of school-sponsored PA opportunities before (yes/no) and after school (yes/no) were also assessed. To approximate continuous estimates of PA time (minutes/week) from categorical responses for each during-school PA opportunity (PE, recess, and in-class PA breaks), a Monte Carlo simulation was used.[168] For PE and recess, each replicate used a Monte Carlo sampling approach assuming a uniform distribution within each category to randomly assign a duration (minutes/occurrence), which was multiplied by its frequency (occurrences/week) to obtain minutes of PA per week (example in Supplementary Table and Figure).[168] For in-class PA time, each replicate randomly drew an in-class PA time within each category. This was repeated to produce 500 estimates. Results from the Monte Carlo simulation method were compared to results using the midpoint of the PA frequency category and its duration to calculate PA opportunity minutes per week (Appendices 5.1A-5.1B). Both measures generated similar results, so the estimates from the Monte Carlo simulation were reported as they incorporated the uncertainty in PA opportunity time estimation.

Since aerobic capacity was only assessed among fourth and fifth grade students, but body composition was assessed among kindergarten through fifth grades, non-missing grade-specific PA opportunity times were averaged between fourth and fifth grades (when assessing aerobic capacity) or averaged across first to fifth grade (when assessing body composition). During-school PA time was defined as the sum of the estimated time spent in PE, recess, and in-class PA breaks across each week.

Covariates included school-level demographics (free/reduced lunch rate [FRL] and race/ethnicity) and other school-level characteristics (school size and geographical setting). These covariate data were obtained from the Georgia DOE and the National Center for Education Statistics (NCES) to control for school-level confounding and to identify disparities in school-level fitness to inform future intervention dissemination efforts.[169,170] Nominal categories for FRL (≤25%, 25.1-50%, 50.1-75%, >75%) and geographical setting (city, suburb, town, rural) were based on prior NCES publications.[170] When no a priori categorizations were identified, covariates were retained as continuous variables where appropriate (e.g. percent White, percent Hispanic, and school size). Race/ethnicity could be characterized almost completely by percent White, Black, and Hispanic (the sum of percent White, Black, and Hispanic was almost always 100%), so percent Black was excluded to serve as the referent group for adjusted models as it did not provide much additional information in the adjusted models beyond percent White and Hispanic.

In the current study, six unique respondents were requested to complete the survey within each school (first through fifth grade level chairs and a PE teacher). Some schools did not have all six respondents, and the missing respondents could have led to selection bias (Appendices 5.2A-5.2B), so all analyses were conducted using a multiply imputed dataset. Fully conditional specification was used to generate plausible values for frequency and duration of PE, frequency and duration of recess, in-class PA, before-school PA, after-school PA, FRL, percent White, percent Hispanic, school size, and geographical setting. SAS PROC MI was used to impute five values for each missing observation.

Analysis. Descriptive statistics (mean and standard deviations, or sample sizes and frequencies) were calculated for demographics and other school covariates, exposures (PA opportunities), and outcomes (aerobic capacity and body composition HFZ prevalence). Bivariate analyses were conducted to examine the aerobic capacity and body composition HFZ prevalence by demographics and other school characteristics. In the bivariate analyses, HFZ prevalence estimates were reported at the 33rd and 66th percentiles for percent White, percent Hispanic, and school size since these covariates were continuous.

In the main analysis, unadjusted and adjusted models additionally controlling for demographics and other school characteristics were computed to assess the relationship between school PA opportunities and school-level HFZ prevalence. Both unadjusted and adjusted models used log-binomial models (or a log-Poisson model when log-binomial model did not converge) to estimate prevalence ratios (PRs). For some reported exposures (during-school PA, PE, recess, and in-class PA break time), PRs can be interpreted as the relative change in HFZ prevalence associated with each 30-minute increase in PA opportunity time. For before- and after-school exposures, PRs can be interpreted as the HFZ prevalence among schools with before/after school PA programs compared with the HFZ prevalence among schools without a before/after school PA program. Estimates from each Monte Carlo simulation were summarized using PROC MIANALYZE to obtain a PR and 99% confidence intervals (CIs). For all models, schools were weighted by the number of students in the school, because some schools conducted and reported FitnessGram data on more than one occasion within the same school year, overestimating the number of students taking the Spring semester test. Additive and multiplicative interaction between PA time and all covariates were tested, and significant additive and multiplicative interaction was noted across school size and geographical setting (Appendix 5.3). Stratum-specific estimates and confidence intervals largely overlapped (Appendices 5.4A-5.4D), so overall estimates are presented. All analyses were stratified by gender, as prior literature has suggested that fitness and PA differ by gender.[45,174] To account for multiple testing and to be consistent with prior studies, alpha was set at 0.01. Analyses were also repeated using alpha at 0.05, and estimates, direction, and significance were consistent across both alphas. All analyses were performed using SAS version 9.4 (Cary, NC).

Results

Of the 1,244 eligible Georgia elementary schools, 68 schools were excluded because data used to determine the prevalence of children in the HFZ were missing, and 271 schools were excluded due to missing School PA Survey data, leaving 905 schools (73%) in the analytic dataset. Schools in the analytic data set were more likely to be located in suburban areas and less likely to be in rural areas than excluded schools, but FRL, percent White, percent Black, percent Hispanic, and mean school size did not differ between analyzed and non-analyzed schools (Appendix 5.5).

Forty-five percent of Georgia elementary schools in this analysis had more than 75% FRL, and only 11% of schools had 25% FRL or less (Table 5.1). The schools were diverse, with schools having a means of 42% white, 37% black, and 14% Hispanic students. On average, schools had 648 students, and the largest proportion of students attended schools in suburban areas (42%). Most PA time offered during the school day came from PE (100 min/week). The average proportion of girls and boys meeting aerobic capacity HFZ was 61% and 71% respectively. The average prevalence of healthy body composition was 59% for both boys and girls.

Table 5.1. Descriptive statistics of school demographics and other characteristics of participating Georgia elementary schools in 2013-2014 (n=905 schools).

Characteristic	**N or Mean**	**% or SD**
Free/reduced lunch rate		
Low (≤25% FRL)	97	10.7
Mid-low (25%<FRL≤50%)	144	15.9
Mid-high (50%<FRL≤75%)	253	28.0
High (>75% FRL)	411	45.4
Mean % White	42.0	29.1
Mean % Black	37.2	30.1
Mean % Hispanic	13.7	15.8
Mean school size (students)	647.7	230.2
School geographical location		
City	178	19.7
Suburban	382	42.2
Town	94	10.4
Rural	251	27.7
During-school physical activity opportunities[a]	216.2	58.7
Mean physical education time (min/week)	99.6	46.2
Mean recess time (min/week)	86.4	34.6
Mean in-class physical activity (min/week)	29.9	18.4
% schools offering before-school physical activity	118.0	13.0
% schools offering after-school physical activity	300.0	33.2
Mean percent of students at each school in HFZ		
Aerobic capacity among females	61.2	23.9
Aerobic capacity among males	71.2	19.9
Body composition among females	59.3	10.3
Body composition among males	59.3	10.0

FRL=free/reduced lunch rate; SD=standard deviation; HFZ=healthy fitness zone
[a]Estimated from monte carlo simulation.Total PA time may not equal the exact sum of PE time, recess time, in-class PA time, before-school PA time, and after-school PA time because of randomness generated from the Monte Carlo model and missing variables

Both aerobic capacity and body composition differed across school racial/ethnic distribution, size, and location (Table 5.2). For both genders, schools with 25% FRL or less had the highest percent of students with healthy aerobic capacity (77-85%) and body compositions (71-74%), while schools with more than 75% FRL had the lowest percent of healthy aerobic capacity (58-68%) and body composition (55%). Across both genders, schools with a large proportion (60%) of white students had a higher proportion of students with a healthy aerobic capacity (67-76%) than schools with a lower proportion (23%) of white students (63-72%). Similarly, schools with a higher frequency of white students had higher prevalence of healthy body composition (63-64%) compared with schools with 23% white students (57-58%). However, the prevalence of children in the health fitness zone for body composition and aerobic capacity did not differ substantially by the percentage of students who were Hispanic or school size. Schools in suburban areas had the highest prevalence of healthy aerobic capacity (68-78%) and body composition (61-63%) and towns had the lowest prevalence of aerobic capacity (57-67%) and body composition (57-58%).

Aerobic capacity. For both boys and girls, unadjusted analyses and analyses adjusted for demographics and other school characteristics showed that during-school PA time, PE time, and in-class PA time were not associated student aerobic capacity (Table 5.3). In unadjusted models, presence of before-school PA was associated with an 8-12% higher prevalence of healthy aerobic capacity (PR_{girls}: 1.12; 99% CI: 1.03-1.21; PR_{boys}: 1.08; 99% CI: 1.02-1.14). For example, the estimated prevalence of healthy body composition was 71% among girls and 78% among boys in schools with before-school PA programs, compared with 64% and 73% among girls and boys in schools without before-school PA programs. This relationship between before-school PA and healthy aerobic capacity was attenuated in the fully adjusted models (PR_{girls}: 1.06; 99% CI: 0.98-1.16; PR_{boys}: 1.03; 99% CI: 0.98-1.09). The adjusted prevalence of healthy aerobic capacity was moderately higher among schools with after-school PA than schools without after-school PA among girls (aPR_{girls}: 1.05; 99% CI: 0.97-1.13; aPR_{boys}: 1.03; 99% CI: 0.97-1.08), but this did not achieve statistical significance.

Table 5.2. Mean school prevalence of healthy aerobic capacity and body composition across school demographics and other characteristics among Georgia elementary schools in 2013-2014 (n=905 schools).

Characteristic	Aerobic capacity						Body mass index					
	Girls (n=1, 1770 schools)			Boys (n=1, 166 schools)			Girls (n=1, 176 schools)			Boys (n=1, 176 schools)		
	Mean %	99% CI		Mean %	99% CI		Mean %	99% CI		Mean %	99% CI	
Free/reduced lunch rate												
Low (≤25%)	76.9	71.1	83.3	84.7	80.5	89.2	73.5	70.5	76.6	70.8	68.0	73.8
Mid-low (25%<FRL≤50%)	70.0	64.6	75.9	78.3	74.1	82.8	65.1	63.2	67.0	64.1	62.5	65.8
Mid-high (50%<FRL≤75%)	64.3	60.7	68.1	73.8	71.1	76.6	59.3	57.8	60.7	58.6	57.2	60.0
High (>75%)	58.2	53.4	63.5	68.4	64.4	72.6	54.9	53.5	56.2	54.7	53.0	56.4
Mean % White[a]												
Low % White	62.6	59.0	66.4	72.2	69.3	75.2	58.0	56.9	59.2	57.1	55.8	58.4
High % White	67.2	64.4	70.0	75.9	73.7	78.2	63.8	62.6	65.1	62.9	61.8	64.0
Mean % Hispanic[b]												
Low % Hispanic	65.4	62.5	68.4	74.6	72.2	77.1	62.9	61.5	64.3	63.0	61.8	64.2
High % Hispanic	65.3	62.7	68.0	74.5	72.4	76.6	61.7	60.6	62.9	61.2	60.2	62.2
School size[c]												
Small school	63.6	60.6	66.8	72.9	70.5	75.4	60.1	58.3	61.9	60.5	58.6	62.3
Large school	64.7	62.2	67.2	73.9	71.9	76.0	60.6	59.6	61.7	60.2	59.2	61.2
School geographical location												
City	66.4	61.2	72.0	74.9	71.0	79.0	59.9	56.8	63.1	59.6	56.7	62.7
Suburban	67.5	63.7	71.5	76.6	73.8	79.6	62.5	60.8	64.4	60.6	58.7	62.5
Town	57.2	49.4	66.2	67.3	60.1	75.5	56.8	54.0	59.8	58.3	55.8	61.0
Rural	63.6	59.4	68.1	72.7	69.3	76.3	59.4	57.8	61.1	59.7	58.1	61.4

[a]HFZ prevalence shown at the 33rd and 66th percentiles of percent White (23%, 60%)
[b]HFZ prevalence shown at the 33rd and 66th percentiles of percent Hispanic (5%, 12%)
[c]HFZ prevalence shown at the 33rd and 66th percentiles of school size (524 students, 700 students)

Table 5.3. Associations between physical activity (PA) opportunities and school-wide healthy fitness zone prevalence in aerobic capacity among Georgia elementary schools in 2013-2014. Unadjusted and multivariate-adjusted prevalence ratios (PRs, aPRs) are stratified gender (n=905 schools).

	Girls						Boys					
	PR	**99% CI**		**aPR[c]**	**99% CI**		**PR**	**99% CI**		**aPR[c]**	**99% CI**	
During-school physical activity[a, b]	1.01	0.99	1.03	1.00	0.98	1.01	1.00	0.99	1.02	1.00	0.98	1.02
Physical education[a]	0.99	0.97	1.02	1.00	0.97	1.02	1.00	0.98	1.01	1.00	0.98	1.02
Recess[a]	1.02	0.99	1.06	1.00	0.96	1.04	1.02	0.99	1.04	1.00	0.97	1.02
In-class physical activity breaks[a]	1.00	0.94	1.06	0.99	0.94	1.05	1.00	0.96	1.04	1.00	0.96	1.03
Before-school PA program[d]	**1.12**	**1.03**	**1.21**	1.06	0.98	1.16	**1.08**	**1.02**	**1.14**	1.03	0.98	1.09
After-school PA program[d]	1.04	0.96	1.13	1.05	0.97	1.13	1.02	0.97	1.08	1.03	0.97	1.08

CI=Confidence interval

[a]PR indicates the change in associated with each additional 30 minutes of physical activity per week

[b]During-school PA time may not equal the exact sum of PE time, recess time, and in-class PA time because of randomness generated from the Monte Carlo model or missing variables

[c]Adjusted for free/reduced lunch rate, percent White, percent Hispanic, school size, geographical setting

[d]PR indicates the additional prevalence associated with presence (versus absence) of a program

Boldface indicates significance

Body composition. During-school PA, PE, and in-class PA time were not associated with the prevalence of children in the healthy fitness zone for body composition (Table 5.4). In the crude analyses, each additional 30 minutes of recess per week was associated with a 3-4% higher prevalence of healthy body composition (PR_{girls}: 1.04; 99% CI: 1.02-1.05; PR_{boys}: 1.03; 99% CI: 1.01-1.04). For example, schools with the 25th percentile recess time offered 67 minutes of recess per week and reported 59% of girls and boys to have healthy body composition, while schools with the 75th percentile recess time (108 minutes per week) had 62% of girls and 61% of boys in the HFZ for body composition. However, after accounting for demographics and other school characteristics, the association between recess and healthy body composition was attenuated (aPR_{girls}: 1.01; 99% CI: 1.00-1.03; aPR_{boys}: 1.00; 99% CI: 0.99-1.03). In adjusted analyses, prevalence of healthy body composition was not associated with before-school (aPR_{girls}: 1.02; 99% CI: 0.98-1.06; aPR_{boys}: 1.02; 99% CI: 0.98-1.06) or after-school PA programs (aPR_{girls}: 0.99; 99% CI: 0.96-1.02; aPR_{boys}: 1.00; 99% CI: 0.97-1.02).

Discussion

The current study suggests that the amount of time schools provide for PA before, during, and after school have minimal impact on the prevalence of children who are in the healthy zone for aerobic capacity and body composition. At most, the current study found weak associations between before-school PA programming and school-aggregated aerobic capacity, and between recess time and school-aggregated body composition.

Table 5.4. Associations between physical activity (PA) opportunities and school-wide healthy fitness zone prevalence in body composition among Georgia elementary schools in 2013-2014. Unadjusted and multivariate-adjusted prevalence ratios (PRs, aPRs) are stratified gender (n=905 schools).

	Girls						**Boys**					
	PR	**99% CI**		**aPR[c]**	**99% CI**		**PR**	**99% CI**		**aPR[c]**	**99% CI**	
During-school physical activity[a, b]	1.02	1.00	1.03	1.00	0.99	1.01	1.02	1.00	1.03	1.01	0.99	1.02
Physical education[a]	1.00	0.99	1.02	1.00	0.99	1.01	1.01	1.00	1.03	1.00	0.99	1.02
Recess[a]	**1.04**	**1.02**	**1.05**	1.01	1.00	1.03	**1.03**	**1.01**	**1.04**	1.01	0.99	1.03
In-class physical activity breaks[a]	0.99	0.96	1.03	1.00	0.97	1.02	0.99	0.95	1.03	1.00	0.97	1.02
Before-school PA program[d]	1.05	0.99	1.12	1.02	0.98	1.06	1.03	0.95	1.11	1.02	0.98	1.06
After-school PA program[d]	0.97	0.94	1.01	0.99	0.96	1.02	0.97	0.93	1.02	1.00	0.97	1.03

CI=Confidence interval

[a]PR is for each additional 30 minutes per week

[b]During-school PA time may not equal the exact sum of PE time, recess time, and in-class PA time because of randomness generated from the Monte Carlo model or missing variables

[c]Adjusted for free/reduced lunch rate, percent White, percent Hispanic, school size, geographical setting

[d]PR indicates the additional prevalence associated with presence (versus absence) of a program

Boldface indicates significance

Consistent with prior literature, this study found that boys have higher aerobic capacity than girls.[17,29,124] Prior studies report minimal-to-no differences in aerobic capacity at the individual level by racial group, Hispanic origin, or family income-to-poverty ratio,[17,124,126] while describing differences in obesity prevalence and incidence by these demographic characteristics.[135,137] At the school level, the current study reports that schools with a larger proportion of white students or higher SES have a higher prevalence of healthy aerobic capacity and body composition. Across geography, the lowest prevalence of healthy aerobic capacity and body composition was identified among schools located in towns, which is consistent with prior literature.[110] One potential explanation for fitness differences across school demographics is that population-level determinants such as policies influencing the availability of nutritious foods, PA, and marketing environments lead to differences in health-related fitness across these demographic characteristics.[139]

Findings from the current study contrast with prior literature assessing the relationship between PA opportunities and aerobic capacity, although few studies have assessed this association in the US, and even fewer studies have focused on the impact of PA opportunity time in the elementary school setting specifically. A quasi-experimental study conducted among middle schools in Pennsylvania to assess the impact of a daily evidence-based PE program of 30 minutes or more reported faster mile time for both boys and girls compared with students who did not receive daily PE.[140] Similar conclusions were reported in one rural Norwegian study comparing daily PE of 60 minutes (in which MVPA was encouraged) against the standard PE curriculum (45 minutes, twice weekly) in two elementary schools over two school years.[182] One potential explanation is that prior studies used mile-run time as a measurement of aerobic capacity while the current study relied on PACER outcomes conceptualized as binary healthy fitness zone categories. Beyond the decreased power when relying on categorized variables, classification agreement between PACER and one mile run/walk tests also varies by child characteristics such as level of motivation as well as environmental conditions.[134]

Only a few studies have assessed the relationship between elementary school PA opportunities and student body composition, and similar to the current study, almost all have reported modest or null findings. Similar to the current study, a cross-sectional study of 4,387 fifth-grade students in Alabama, California, and Texas found that a composite variable for PA and nutrition resources and programs (including recess) was not associated with BMI.[146] Two longitudinal studies using Early Child Longitudinal Study-Kindergarten class data followed children from kindergarten through fifth grade.[144,145] In contrast to the current study, one of these studies reported that additional minutes of recess per week were associated with a slower increase in BMI with time, even after adjusting for home and school covariates.[145] Like the current study, this study identified no association between weekly minutes of PE and BMI.[145] In contrast, the second study found that PE lowered BMI z-score and the probability of obesity only among boys, after controlling for child-, family- and state-level covariates.[144] Findings similar to the current study have also been reported in middle schools.[142,148] A 2009 nationally representative study of middle and high schools reported associations between various PE and after-school PA characteristics (e.g. required PE, percent of students in PE, percent of students in interscholastic sports, etc.) and student BMI, but these results were no longer significant after controlling for school- and student-level confounders (e.g. school size, FRL, region, urbanicity, gender, race/ethnicity, parental education).[148]

It is possible that school-based PA opportunity time is not as influential on student aerobic capacity and BMI as PA and dietary behaviors outside of the educational system. A study assessing the relationship between school contextual factors and fitness found that school-level median household income, but not PA resources/programs, was inversely associated with BMI among girls.[146] This is not surprising, as many obesogenic risk factors inside and outside of the school PA environment have been linked with low SES, including insufficient PA and poor nutrition as well as high consumption of sugar-sweetened beverages and fruit juices.[57,183] Prior studies have noted that differences between schools only account for a small part of the total variation in student BMI percentile or percent of overweight/obese students (intraclass correlation coefficients [ICCs]: 0.03-0.10), as well as aerobic capacity (ICC: 0.10) because energy intake and expenditure also occur outside of school.[145,184,185] Further, it has long been suggested that exercise interventions may lead to compensatory responses in the form of increased energy intake or decreased energy expenditure through exercise and non-exercise activity outside of school.[186,187] However, the effect of school-based PA on leisure-time PA remains unclear, as other studies have reported that PA performed in the school can actually increase out-of-school PA.[91,188]

Another possible explanation of the moderate and null findings may be that the intensity of PA during school PA opportunities may vary between schools offering the same frequency and duration of PA. The estimated difference in kilocalories expended by students in first through tenth grades when spending more than 50% of PE time in MVPA compared with students spending only 35% of PE time in MVPA is over 67,000 for both boys and girls.[189] Without specifying MVPA goals, intensity of PA can vary widely, since various levels of influence affect intensity of PA performed in school-based PA opportunities.[190,191] A study using accelerometry and survey data from sixth grade students in Australia identified characteristics of the school physical environment (e.g. grassy areas, etc.), policies (e.g. meeting PA guidelines), classroom (e.g. professional development for PE teachers), and the child (e.g. gender, primary language, weight, etc.) to be associated with MVPA during recess.[190] Similarly, the proportion of PE spent in MVPA is thought to vary by gender, with third-grade boys in the National Institute of Child Health and Human Development Study of Early Child Care and Youth Development spending a larger proportion of PE time in MVPA compared with girls.[191] Consistently, many prior studies specifying PE programs designed to increase PA intensity or encourage MVPA have reported improved aerobic capacity among students.[140182]

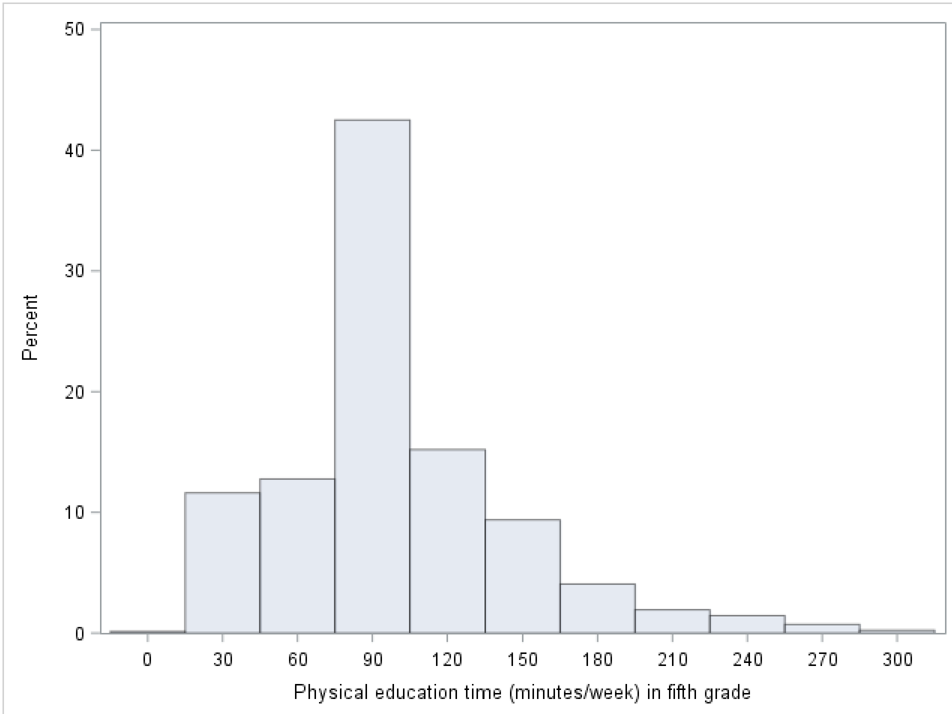
Strengths. This study had at least three strengths. First, this study included a large number of schools, with relatively high response rates on the School PA Survey (73%) and FitnessGram (95%) compared to similar studies conducted in school settings. Second, this statewide study involved diverse settings, increasing generalizability of findings. Finally, this study builds on existing knowledge by identifying the effects of specific PA opportunities offered to students during the elementary school day on physical fitness.

Limitations. Despite the strengths of this study, there were at least five limitations. First, the cross-sectional design does not exclude the possibility of reverse causation, where fitness levels among students may have influenced school-based PA opportunities. In addition, with a cross-sectional design, it is not possible to observe the impact of elementary school PA opportunities on long-term fitness trends,[145] which could not be assessed in the current study. Second, PA opportunities were assessed using a non-validated survey and relied on self-reported data, which may be affected by social desirability biases and may not accurately reflect the amount of PA time offered to students. However, the survey was adapted from widely used and validated surveys by a large, multidisciplinary team,[92,161,164–167] and our group is currently exploring a validation study. Further, alternative forms of PA opportunity measurement, such as researcher observation, would have likely further biased the outcome data. Third, to maximize school response, the School PA Survey was open for 10 months, and the timing of early versus late responses could have impacted estimates. However, none of the reported PA opportunities differed by season of survey completion except after-school PA program presence (Appendix 5.6). Fourth, the current study did not explore the quality of PA occurring during each PA opportunity. Prior studies using accelerometer-measured MVPA have reported that students spend only 33% of time during PE class performing MVPA, and it is possible that time spent in MVPA is just a fraction of the PA opportunity time reported in this study.[106] Further, fitness data were aggregated at the school level, and aside from gender, we were unable to assess for differences across other individual demographic, behavioral, or health characteristics. Future studies using activity monitoring devices may detail the amount and intensity of PA performed at the individual level. Finally, the maximal observable effect size was limited since the HFZ prevalence was high among most schools (even among schools with low PA opportunities) while the maximum HFZ prevalence was 100%. Thus, it is possible that there was simply insufficient power to detect differences in healthy fitness zone prevalence aggregated at the school level.

Conclusion

This study suggests that total school-based PA opportunity time does not influence the prevalence of children who have healthy aerobic capacity or who have healthy BMIs. However, offering before-school PA programs may slightly increase the proportion of children who have healthy aerobic capacity, and offering additional minutes of recess may be associated with increased prevalence of health body composition. Fitness outcomes are determined by more than just school PA time and future studies should attempt to identify important predictors of childhood fitness, particularly those that can be implemented within a school setting

Additionally, if other studies confirm that the amount of time PA is offered in elementary schools does not improve student fitness, then the implications of current time-based school PA policies on student health should be re-examined.



Supplementary Figure 5.1. Histogram of physical education (PE) time (minutes per week) across Georgia elementary schools to demonstrate the creation of the continuous PE time variable. Schools offering two days of PE for 40-49 minutes per fifth grade class (boldfaced in Supplementary Table 1) is represented in tallest bar of the histogram between 80-98 minutes.

Supplementary Table 5.1. The joint distribution (n and frequencies) of physical education (PE) frequency and duration for Georgia fifth-grade students in 2013-2014. Schools offering 2 days of PE for 40-49 minutes per class is boldfaced to demonstrate the creation of the continuous PE time variable.

PE Frequency (classes per week)	**PE duration (minutes per class)**			
	20-29 minutes	**30-39 minutes**	**40-49 minutes**	**> 50 minutes**
1	0 (0%)	6 (0.8%)	144 (19.3%)	21 (2.82%)
2	2 (0.27%)	1 (1.34%)	**291 (39.01%)**	71 (9.52%)
3	1 (0.13%)	5 (0.67%)	104 (13.94%)	28 (3.75%)
4	2 (0.27%)	4 (0.54%)	12 (1.61%)	5 (0.67%)
5	0 (0%)	12 (1.61%)	19 (2.55%)	8 (1.07%)

Appendix 5.1A. Unadjusted and adjusted prevalence ratios (PR, aPRs) comparing healthy fitness zone student aerobic capacity for each additional 30 minutes of during-school physical activity time and recess time per week, stratified across free/reduced lunch rate, school size, and percent Hispanic. Analyses used the midpoint of physical activity frequency and duration to calculate minutes of physical activity per week (instead of Monte Carlo simulation; n=905).

	Girls						Boys					
	PR	**99% CI**		**aPR[a]**	**99% CI**		**PR**	**99% CI**		**aPR[a]**	**99% CI**	
During-school physical activity	1.00	0.98	1.02				1.00	0.99	1.02			
Lowest free/reduced lunch rate[b]				1.00	0.94	1.07				0.99	0.95	1.03
Highest-free/reduced lunch rate[c]				1.00	0.96	1.03				1.00	0.97	1.02
Large (762-student) school				0.99	0.96	1.02				0.99	0.98	1.01
Small (484-student) school				1.01	0.98	1.05				1.01	0.98	1.03
High percent Hispanic[d]				0.96	0.90	1.03				0.98	0.93	1.03
Low percent Hispanic[d]				1.00	0.95	1.05				1.00	0.96	1.04
Recess time	1.02	0.99	1.05				1.02	0.99	1.04			
Lowest-free/reduced lunch rate[b]				1.01	0.86	1.16				0.98	0.90	1.06
Highest-free/reduced lunch rate[c]				1.01	0.94	1.09				1.01	0.95	1.06
Large (762-student) school				0.99	0.94	1.04				0.99	0.96	1.03
Small (484-student) school				1.01	0.95	1.07				1.01	0.96	1.06
High percent Hispanic[c]				0.97	0.86	1.09				0.98	0.91	1.06
Low percent Hispanic[c]				0.98	0.89	1.07				0.99	0.92	1.05

CI=confidence interval; SD=standard deviation

[a]Adjusted for free/reduced lunch rate, percent White, percent Hispanic, school size, geographical setting

[b]PRs at schools with ≤25% FRL

[c]PRs at schools with >75% FRL

[d]PRs at schools with percent Hispanic ≥8.2%

[e]PRs at schools with percent Hispanic <4.1%

Boldface indicates significance

Appendix 5.1B. Unadjusted and adjusted prevalence ratios (PRs, aPRs) comparing healthy fitness zone student body composition for each additional 30 minutes of during-school physical activity time and recess time per week, stratified across free/reduced lunch rate, school size, and percent Hispanic. Analyses used the midpoint of physical activity frequency and duration to calculate minutes of physical activity per week (instead of Monte Carlo simulation; n=905).

	Girls						**Boys**					
	PR	**99% CI**		**aPR[a]**	**99% CI**		**PR**	**99% CI**		**aPR[a]**	**99% CI**	
During-school physical activity	1.01	1.00	1.02				1.01	1.00	1.02			
Lowest free/reduced lunch rate[a]				1.02	0.99	1.04				1.02	0.99	1.04
Highest-free/reduced lunch rate[b]				1.00	0.99	1.02				1.02	0.99	1.06
Large (762-student) school				1.00	1.00	1.01				1.02	1.00	1.04
Small (484-student) school				1.00	0.99	1.01				1.00	0.97	1.03
High percent Hispanic[c]				1.00	0.98	1.02				1.00	0.98	1.02
Low percent Hispanic[d]				1.00	0.98	1.02				0.97	0.92	1.02
Recess time	**1.03**	**1.02**	**1.05**				**1.02**	**1.01**	**1.03**			
Lowest-free/reduced lunch rate[a]				1.06	1.00	1.12				1.05	0.99	1.10
Highest-free/reduced lunch rate[b]				1.01	0.99	1.03				1.05	0.98	1.11
Large (762-student) school				1.01	1.00	1.02				1.03	1.00	1.06
Small (484-student) school				1.00	0.99	1.02				1.03	0.99	1.07
High percent Hispanic[c]				1.01	0.99	1.03				1.02	0.99	1.04
Low percent Hispanic[d]				1.00	0.97	1.03				0.98	0.92	1.05

CI=confidence interval

[a]Adjusted for free/reduced lunch rate, percent White, percent Hispanic, school size, geographical setting

[b]PRs at schools with ≤25% FRL

[c]PRs at schools with >75% FRL

[d]PRs at schools with percent Hispanic ≥8.2%

[e]PRs at schools with percent Hispanic <4.1%

Boldface indicates significance

Appendix 5.2A. Bivariate analyses comparing physical activity (PA) opportunity as reported by administrators across number of respondents in schools (n=905 schools).

	Number respondents in the school											
	<4		**5-6**		**7-9**		**10-11**		**>12**		**F or X^2**	**p-value**
	Mean or N	**SD or Freq**	**Mean or N**	**SD or Freq**	**Mean or N**	**SD or Freq**	**Mean or N**	**SD or Freq**	**Mean or N**	**SD or Freq**		
During-school PA time[a, b]	202.14	77.61	213.49	67.98	220.69	67.06	223.73	68.21	230.59	65.59	1.84	0.12
PE time[b]	96.25	42.13	99.78	45.20	104.26	50.67	101.83	54.33	101.39	50.13	0.67	0.61
Recess[b]	102.09	40.51	91.70	42.58	88.60	39.82	90.98	41.24	96.51	39.00	2.25	0.06
In-Class PA time[b]	26.23	32.55	25.36	23.13	27.90	17.38	31.05	18.60	32.49	20.31	3.37	0.01
Before-school PA[c]	5	7.46	19	9.79	32	12.08	13	9.29	31	16.76	7.22	0.12
After-school PA[c]	13	19.40	30	15.46	47	17.70	33	23.57	48	25.95	8.53	0.07

PE= physical education

[a]Total PA time may not equal the exact sum of PE time, recess time, in-class PA time, before-school PA time, and after-school PA time because of randomness generated from the Monte Carlo model or missing variables

[b]In minutes per week

[c]Presence of a program (vs. absence)

Appendix 5.2B. Bivariate analyses comparing mean school prevalence of healthy fitness zone aerobic capacity and body composition across number of respondents in schools (n=905 schools).

	Number respondents in the school[a]													
	0		1-4		5-6		7-9		10-11		>12		F or X	p-value
	Mean (%)	SD	Mean (%)	SD	Mean (%)	SD	Mean (%)	SD	Mean (%)	SD	Mean (%)	SD		
Aerobic capacity (girls)	54.33	24.75	56.16	24.00	59.15	24.38	59.90	22.80	62.13	23.69	61.77	21.11	3.48	<0.01
Aerobic capacity (boys)	64.68	22.66	66.71	20.88	69.06	20.91	69.99	18.75	72.93	19.73	72.14	16.83	4.82	<0.01
Body composition (girls)	58.18	10.94	57.29	10.27	59.49	9.47	58.95	10.30	59.75	11.16	58.90	11.40	1.23	0.29
Body composition (boys)	58.15	10.85	58.53	9.76	58.85	9.19	58.97	10.43	60.19	10.11	58.39	11.07	0.84	0.52

SD=standard deviation

[a]Some schools had more than one respondent per position (e.g. physical education, grade-level chair, administrator), which were excluded prior to analysis.

Appendix 5.3. Interaction contrasts ($p_{11}-p_{01}-p_{10}+p_{00}$) and their 95% confidence intervals (CIs) to assess additive effect heterogeneity between physical activity (PA) time and covariates (e.g. school size and geographical setting; n=905 schools).

Covariate	**Exposure**	**Aerobic Capacity (Girls)**			**Aerobic Capacity (Boys)**			**Body Composition (Girls)**			**Body Composition (Boys)**		
		IC	**95% CI**		**IC**	**95% CI**		**IC**	**95% CI**		**IC**	**95% CI**	
Mean school size (3rd tertile vs. 1st tertile)	**During-school PA**	0.001	-0.009	0.011	**-0.005**	**-0.010**	**-0.001**	**0.003**	**0.001**	**0.005**	**0.004**	**0.002**	**0.007**
	PE	**-0.006**	**-0.007**	**-0.004**	**-0.003**	**-0.004**	**-0.001**	**0.000**	**0.000**	**0.000**	**0.003**	**0.003**	**0.003**
	Recess	**-0.005**	**-0.007**	**-0.003**	**-0.005**	**-0.006**	**-0.003**	**0.004**	**0.004**	**0.004**	**0.004**	**0.004**	**0.004**
	In-Class PA	-0.002	-0.005	0.001	**-0.005**	**-0.008**	**-0.003**	**0.002**	**0.002**	**0.002**	**-0.003**	**-0.003**	**-0.003**
School geographical location													
City	**During-school PA**		REF			REF			REF			REF	
Suburb		**-0.029**	**-0.048**	**-0.010**	**-0.022**	**-0.037**	**-0.007**	0.004	-0.007	0.014	0.005	-0.006	0.016
Town		-0.012	-0.040	0.015	-0.008	-0.036	0.020	-0.003	-0.014	0.009	-0.005	-0.016	0.006
Rural		**-0.026**	**-0.048**	**-0.003**	**-0.021**	**-0.040**	**-0.003**	0.005	-0.006	0.017	0.003	-0.008	0.015
City	**PE time**		REF			REF			REF			REF	
Suburb		-0.016	-0.052	0.019	-0.012	-0.037	0.013	0.001	-0.012	0.014	0.006	-0.008	0.020
Town		-0.026	-0.063	0.010	-0.023	-0.050	0.004	0.008	-0.006	0.022	0.003	-0.011	0.016
Rural		-0.024	-0.074	0.026	-0.026	-0.067	0.016	-0.001	-0.016	0.013	-0.001	-0.016	0.013
City	**Recess**		REF			REF			REF			REF	
Suburb		-0.015	-0.053	0.024	-0.008	-0.036	0.021	0.007	-0.007	0.022	0.007	-0.008	0.022
Town		-0.008	-0.050	0.033	-0.005	-0.035	0.025	-0.001	-0.016	0.015	0.003	-0.012	0.018
Rural		0.005	-0.054	0.064	0.024	-0.024	0.071	-0.009	-0.041	0.024	-0.007	-0.038	0.025
City	**In-class PA time**		REF			REF			REF			REF	
Suburb		-0.023	-0.081	0.034	-0.026	-0.066	0.014	0.009	-0.026	0.044	-0.015	-0.048	0.018
Town		-0.040	-0.097	0.018	-0.033	-0.075	0.009	0.016	-0.015	0.047	-0.006	-0.037	0.024
Rural		0.025	-0.069	0.118	-0.001	-0.070	0.068	0.020	-0.016	0.057	-0.003	-0.036	0.029

PE=physical education

Boldface indicates significant additive interaction

Appendix 5.4A. Prevalence ratios (PRs) and adjusted PRs (aPRs) of healthy fitness zone student aerobic capacity for each additional 30 minutes of during-school physical activity, physical education, recess, or in-class PA per week among girls stratified by school size and geographical setting.[a]

PA Opportunities	Model 1			Model 2[c]			Model 3[d]			Model 4[e]		
	PR	99% CI		aPR	99% CI		PR	99% CI		aPR	99% UI	
During-school physical activity	1.01	0.99	1.03				1.0	0.98	1.03			
762-student school				1.00	0.9	1.0				1.00	0.97	1.02
484-student school				1.02	0.9	1.0				1.01	0.99	1.04
City				1.03	1.0	1.0				1.02	0.98	1.06
Suburb[a]				0.99	0.9	1.0				1.00	0.96	1.03
Town				1.01	0.9	1.0				0.99	0.91	1.07
Rural[a]				0.99	0.9	1.0				0.99	0.95	1.03
Physical education (each additional minute)	0.99	0.97	1.02				1.0	0.97	1.03			
762-student school				0.99	0.9	1.0				1.00	0.97	1.03
484-student school				1.00	0.9	1.0				1.01	0.97	1.05
City				1.02	0.9	1.0				1.02	0.96	1.07
Suburb				1.00	0.9	1.0				1.00	0.96	1.05
Town				0.98	0.8	1.0				0.98	0.90	1.07
Rural				0.98	0.9	1.0				0.99	0.94	1.04
Recess (each additional 30 minutes per week)	1.03	0.99	1.06				1.0	0.98	1.05			
762-student school				1.00	0.9	1.0				0.99	0.95	1.03
484-student school				1.02	0.9	1.0				1.02	0.96	1.07
City				1.01	0.9	1.0				1.02	0.96	1.08
Suburb				0.99	0.9	1.0				0.98	0.93	1.04
Town				1.00	0.8	1.1				1.00	0.82	1.18
Rural				1.01	0.9	1.0				1.00	0.93	1.06
In-class physical activity breaks (each additional 30 minutes per week)	1.01	0.96	1.06				1.0	0.95	1.07			
762-student school				1.00	0.9	1.0				1.00	0.94	1.06
484-student school				1.01	0.9	1.0				1.00	0.94	1.07
City				1.04	0.9	1.1				1.02	0.90	1.13
Suburb				1.00	0.9	1.0				1.01	0.91	1.11
Town				1.09	0.9	1.2				1.04	0.82	1.26
Rural				0.97	0.9	1.0				0.97	0.88	1.06
Before-school PA (presence vs. absence)	**1.12**	**1.04**	**1.22**				**1.1**	**1.05**	**1.23**			
762-student school				1.06	0.9	1.1				1.05	0.96	1.14
484-student school				1.02	0.9	1.1				0.99	0.88	1.11
City				1.08	0.9	1.2				1.09	0.92	1.29
Suburb				1.05	0.9	1.1				1.05	0.97	1.14
Town				1.22	1.0	1.4				1.07	0.75	1.53
Rural				1.15	1.0	1.2				1.12	1.01	1.24
After-school PA (presence vs. absence)	1.05	0.96	1.14				1.0	0.98	1.15			
762-student school				1.05	0.9	1.1				1.06	0.99	1.14
484-student school				1.06	0.9	1.1				1.05	0.95	1.14

City	0.93	0.8	1.0	0.92	0.82	1.03
Suburb	1.05	0.9	1.1	1.08	0.99	1.17
Town	1.18	0.9	1.4	1.18	0.97	1.42
Rural	1.10	0.9	1.2	1.06	0.96	1.18

CI=confidence interval

[a]Adjusted for free/reduced lunch rate, percent White, percent Hispanic, school size, geographical

[b]Model 1 was the unadjusted analysis (n=905)

[c]Model 2 adjusted for SES, percent White, percent Hispanic, school size, and geographical setting (n=905)

[d]Model 3 applied model 1 to multiply imputed data. The multiple imputation model included physical activity opportunity time (unlike the more conservative approach in the main analyses; n=1,176).

[e]Model 4 applied model 2 to multiply imputed data. The multiple imputation model included physical activity opportunity time (unlike the more conservative approach in the main analyses; n=1,176).

Boldface indicates significance

Appendix 5.4B. Prevalence ratios (PRs) and adjusted PRs (aPRs) of healthy fitness zone student aerobic capacity for each additional 30 minutes of during-school physical activity, physical education, recess, or in-class PA per week among boys stratified by school size and geographical setting.[a]

PA Opportunities	Model 1[b]			Model 2[c]			Model 3[d]			Model 4[e]		
	PR	99% CI		aPR	99% CI		PR	99% CI		aPR	99% CI	
During-school physical activity	1.00	0.99	1.02				1.00	0.99	1.02			
762-student school				1.00	0.98	1.02				1.00	0.98	1.01
484-student school				1.02	0.99	1.04				1.01	0.99	1.03
City				1.02	1.00	1.04				1.02	0.99	1.04
Suburb				0.99	0.98	1.01				1.00	0.98	1.02
Rural				1.01	0.95	1.07				0.99	0.93	1.05
Town				0.99	0.97	1.02				0.99	0.96	1.02
Physical education (each additional minute)	1.00	0.98	1.01				1.00	0.98	1.02			
762-student school				0.99	0.97	1.02				1.00	0.98	1.02
484-student school				1.01	0.96	1.06				1.00	0.97	1.03
City				1.02	0.99	1.06				1.02	0.98	1.05
Suburb				1.00	0.98	1.03				1.00	0.97	1.04
Town				0.98	0.91	1.06				0.99	0.93	1.05
Rural				0.98	0.95	1.02				0.99	0.96	1.02
Recess (each additional 30 minutes per week)	1.02	0.99	1.04				1.01	0.99	1.04			
762-student school				1.00	0.97	1.04				0.99	0.97	1.02
484-student school				1.03	0.98	1.07				1.01	0.97	1.05
City				1.00	0.96	1.04				1.01	0.97	1.05
Suburb				1.00	0.96	1.03				0.99	0.96	1.03
Town				1.02	0.91	1.14				1.00	0.90	1.10
Rural				1.00	0.97	1.04				1.00	0.95	1.04
In-class physical activity breaks (each additional 30 minutes per week)	1.01	0.97	1.04				1.01	0.96	1.05			
762-student school				1.01	0.96	1.05				1.00	0.96	1.04
484-student school				1.01	0.95	1.07				1.01	0.96	1.05
City				1.03	0.98	1.09				1.02	0.95	1.08
Suburb				0.99	0.94	1.04				1.00	0.94	1.07
Town				1.04	0.92	1.17				1.02	0.87	1.18
Rural				0.98	0.93	1.04				0.98	0.92	1.05
Before-school PA (presence vs. absence)	**1.08**	**1.02**	**1.14**				**1.09**	**1.03**	**1.15**			
762-student school				1.04	0.99	1.10				1.03	0.98	1.09
484-student school				1.04	0.97	1.12				1.02	0.94	1.10
City				1.04	0.95	1.15				1.05	0.95	1.16
Suburb				1.02	0.96	1.07				1.03	0.97	1.08
Town				**1.18**	**1.05**	**1.32**				1.07	0.84	1.37
Rural				**1.12**	**1.05**	**1.20**				**1.11**	**1.04**	**1.18**
After-school PA (presence vs. absence)	1.02	0.96	1.08				1.04	0.99	1.10			
762-student school				1.03	0.98	1.09				1.05	0.99	1.10
484-student school				1.05	0.99	1.13				1.05	0.98	1.12

City	0.97	0.90	1.05	0.97	0.90	1.04
Suburb	1.02	0.97	1.08	1.05	0.99	1.11
Town	1.13	0.98	1.31	1.12	1.00	1.26
Rural	1.04	0.95	1.15	1.04	0.96	1.13

CI=confidence interval

[a]Adjusted for free/reduced lunch rate, percent White, percent Hispanic, school size, geographical

[b]Model 1 was the unadjusted analysis (n=905)

[c]Model 2 adjusted for SES, percent White, percent Hispanic, school size, and geographical setting

[d]Model 3 applied model 1 to multiply imputed data. The multiple imputation model included physical activity opportunity time (unlike the more conservative approach in the main analyses; n=1,176).

[e]Model 4 applied model 2 to multiply imputed data. The multiple imputation model included physical activity opportunity time (unlike the more conservative approach in the main analyses; n=1,176).

Boldface indicates significance

Appendix 5.4C. Prevalence ratios (PRs) and adjusted PRs (aPRs) of healthy fitness zone student body composition for each additional 30 minutes of during-school physical activity, physical education, recess, or in-class PA per week among girls stratified by school size and geographical setting (n=1,176 schools).[a]

PA Opportunities	Model 1[b]			Model 2[c]			Model 3[d]			Model 4[e]		
	PR	99% CI		aPR	99% CI		PR	99% CI		aPR	99% CI	
During-school physical activity	**1.02**	**1.01**	**1.0**				1.01	1.0	1.0			
762-student school				1.00	1.0	1.0				1.00	0.99	1.0
484-student school				1.00	0.9	1.0				1.00	0.99	1.0
City				1.00	0.9	1.0				1.00	0.98	1.0
Suburb				1.01	0.9	1.0				1.00	0.99	1.0
Town				1.00	0.9	1.0				1.00	0.98	1.0
Rural				1.01	0.9	1.0				1.00	0.99	1.0
Physical education (each additional minute)	1.00	0.99	1.0				1.00	0.9	1.0			
762-student school				1.00	0.9	1.0				1.00	0.99	1.0
484-student school				1.00	0.9	1.0				1.00	0.98	1.0
City				1.00	0.9	1.0				1.00	0.98	1.0
Suburb				1.00	0.9	1.0				1.00	0.98	1.0
Town				0.99	0.9	1.0				0.99	0.98	1.0
Rural				1.01	0.9	1.0				1.01	0.99	1.0
Recess (each additional 30 minutes per week)	**1.04**	**1.02**	**1.0**				**1.03**	**1.0**	**1.0**			
762-student school				1.01	1.0	1.0				1.01	1.00	1.0
484-student school				1.00	0.9	1.0				1.00	0.99	1.0
City				1.01	0.9	1.0				1.01	0.98	1.0
Suburb				1.02	1.0	1.0				1.01	0.99	1.0
Town				1.00	0.9	1.0				1.00	0.96	1.0
Rural				1.01	0.9	1.0				1.00	0.98	1.0
In-class physical activity breaks (each additional 30 minutes per week)	1.01	0.98	1.0				0.99	0.9	1.0			
762-student school				1.01	0.9	1.0				0.99	0.97	1.0
484-student school				1.00	0.9	1.0				0.99	0.94	1.0
City				0.99	0.9	1.0				0.97	0.91	1.0
Suburb				1.00	0.9	1.0				1.00	0.96	1.0
Town				1.03	0.9	1.0				0.99	0.93	1.0
Rural				1.02	0.9	1.0				0.99	0.96	1.0
Before-school PA (presence vs. absence)	1.05	0.99	1.1				1.06	1.0	1.1			
762-student school				1.03	1.0	1.0				1.03	1.00	1.0
484-student school				1.06	1.0	1.1				1.05	1.00	1.1
City				1.05	0.9	1.1				1.02	0.94	1.1
Suburb				1.00	0.9	1.0				1.02	0.98	1.0
Town				1.07	0.9	1.1				1.09	1.03	1.1
Rural				1.02	0.9	1.0				1.01	0.97	1.0
After-school PA (presence vs. absence)	0.97	0.93	1.0				0.97	0.9	1.0			
762-student school				0.99	0.9	1.0				0.99	0.96	1.0
484-student school				1.01	0.9	1.0				1.00	0.96	1.0

City	0.99	0.9	1.0	0.98	0.93	1.0
Suburb	0.98	0.9	1.0	0.98	0.95	1.0
Town	1.07	0.9	1.1	1.05	0.96	1.1
Rural	1.02	0.9	1.0	1.01	0.98	1.0

CI=confidence interval

[a]Adjusted for free/reduced lunch rate, percent White, percent Hispanic, school size,

[b]Model 1 was the unadjusted analysis (n=905)

[c]Model 2 adjusted for SES, percent White, percent Hispanic, school size, and geographical setting

[d]Model 3 applied model 1 to multiply imputed data. The multiple imputation model included physical activity opportunity time (unlike the more conservative approach in the main analyses; n=1,176).

[e]Model 4 applied model 2 to multiply imputed data. The multiple imputation model included physical activity opportunity time (unlike the more conservative approach in the main analyses; n=1,176).

Boldface indicates significance

Appendix 5.4D. Prevalence ratios (PRs) and adjusted PRs (aPRs) of healthy fitness zone student body composition for each additional 30 minutes of during-school physical activity, physical education, recess, or in-class PA per week among boys stratified by school size and geographical setting.[a]

	Model 1[b]			Model 2[c]			Model 3[d]			Model 4[e]		
PA Opportunities	PR	99% CI		aPR	99% CI		PR	99% CI		aPR	99% CI	
During-school physical activity	1.02	1.00	1.0				1.02	1.0	1.0			
762-student school				1.01	1.0	1.0				1.00	0.99	1.0
484-student school				1.00	0.9	1.0				1.00	0.99	1.0
City				1.00	0.9	1.0				1.00	0.99	1.0
Suburb				1.01	0.9	1.0				1.01	0.99	1.0
Town				1.00	0.9	1.0				1.00	0.98	1.0
Rural				1.01	0.9	1.0				1.00	0.99	1.0
Physical education (each additional minute)	1.01	1.00	1.0				1.01	0.9	1.0			
762-student school				1.00	0.9	1.0				1.00	0.99	1.0
484-student school				1.00	0.9	1.0				1.00	0.98	1.0
City				1.00	0.9	1.0				1.00	0.98	1.0
Suburb				1.01	0.9	1.0				1.00	0.98	1.0
Town				0.99	0.9	1.0				1.00	0.98	1.0
Rural				1.00	0.9	1.0				1.00	0.99	1.0
Recess (each additional 30 minutes per week)	**1.03**	**1.01**	**1.0**				**1.02**	**1.0**	**1.0**			
762-student school				1.01	1.0	1.0				1.01	0.99	1.0
484-student school				1.01	0.9	1.0				1.00	0.98	1.0
City				1.00	0.9	1.0				1.00	0.98	1.0
Suburb				1.02	1.0	1.0				1.01	0.99	1.0
Town				1.00	0.9	1.0				1.01	0.97	1.0
Rural				1.01	0.9	1.0				1.01	0.99	1.0
In-class physical activity breaks (each additional 30 minutes per week)	1.00	0.96	1.0				0.99	0.9	1.0			
762-student school				1.01	0.9	1.0				0.99	0.97	1.0
484-student school				1.01	0.9	1.0				1.00	0.96	1.0
City				1.02	0.9	1.0				1.01	0.95	1.0
Suburb				1.00	0.9	1.0				1.00	0.96	1.0
Town				1.02	0.9	1.0				0.99	0.93	1.0
Rural				1.01	0.9	1.0				0.98	0.95	1.0
Before-school PA (presence vs. absence)	1.03	0.95	1.1				1.04	0.9	1.1			
762-student school				1.03	0.9	1.0				1.03	1.00	1.0
484-student school				1.06	1.0	1.1				1.06	1.00	1.1
City				1.02	0.9	1.1				0.99	0.88	1.1
Suburb				1.01	0.9	1.0				1.03	0.98	1.0
Town				1.01	0.9	1.1				1.06	0.98	1.1
Rural				0.99	0.9	1.0				1.00	0.95	1.0
After-school PA (presence vs. absence)	0.97	0.93	1.0				0.97	0.9	1.0			
762-student school				1.00	0.9	1.0				0.99	0.97	1.0
484-student school				1.01	0.9	1.0				0.99	0.95	1.0

City	1.00	0.9	1.0	0.99	0.95	1.0
Suburb	0.99	0.9	1.0	0.99	0.96	1.0
Town	1.06	0.9	1.1	1.05	0.98	1.1
Rural	1.01	0.9	1.0	1.01	0.98	1.0

CI=confidence interval

[a]Adjusted for free/reduced lunch rate, percent White, percent Hispanic, school size,

[b]Model 1 was the unadjusted analysis (n=905)

[c]Model 2 adjusted for SES, percent White, percent Hispanic, school size, and geographical setting

[d]Model 3 applied model 1 to multiply imputed data. The multiple imputation model included physical activity opportunity time (unlike the more conservative approach in the main analyses; n=1,176).

[e]Model 4 applied model 2 to multiply imputed data. The multiple imputation model included physical activity opportunity time (unlike the more conservative approach in the main analyses; n=1,176).

Boldface indicates significance

Appendix 5.5. Descriptive statistics of school demographics and other characteristics comparing the analyzed (n=905) and non-analyzed schools (n=339).

	Analytic Dataset (n=905)		Not Analyzed (n=339)		p-value
Characteristic	**N or Mean**	**% or SD**	**N or Mean**	**% or SD**	
Socioeconomic status					0.05
Low (≤25% FRL)	97	10.7	35	10.3	
Mid-low (25%<FRL≤50%)	144	15.9	37	10.9	
Mid-high FRL (50%<FRL≤75%)	253	28.0	87	25.7	
High FRL (>75% FRL)	411	45.4	180	53.1	
Mean % White	42.0	29.1	40.6	31.7	0.47
Mean % Black	37.2	30.1	40.9	33.2	0.08
Mean % Hispanic	13.7	15.8	13.0	16.6	0.50
Mean school size (students)	647.2	226.8	622.9	246.9	0.12
School geographical location					0.01
City	178	19.7	51	15.7	
Suburban	382	42.2	116	35.7	
Town	94	10.4	45	13.9	
Rural	251	27.73	113	34.8	

SD=standard deviation; FRL=free/reduced lunch rate

Appendix 5.6. Physical activity (PA) opportunities across season (Fall 2013 or Spring 2014) of School PA Survey completion in Georgia elementary schools (n=905).

	Fall Respondents		**Spring Respondents**		**p-value**
	Mean or N	**SD or Freq (%)**	**Mean or N**	**SD or Freq (%)**	
During-school PA time[a, b]	216.50	62.84	206.50	53.65	0.08
Physical education time[b]	99.27	48.09	96.85	38.73	0.52
Recess time[b]	86.67	35.74	82.48	36.86	0.23
In-class PA time[b]	28.94	20.62	29.07	18.69	0.95
Before-school PA[c]	93	14.10	7	11.90	0.49
After-school PA[c]	213	32.20	64	44.80	<0.01

[a]Total PA time may not equal the exact sum of PE time, recess time, in-class PA time, before-school PA time, and after-school PA time because of randomness generated from the Monte Carlo simulation or missing data in one or more during-school PA opportunities
[b]In minutes per week
[c]Presence of a program (vs. absence)

Chapter 6: Implications

This dissertation focuses on evaluating the implementation of interventions for improving diet and physical activity (PA) behaviors of children in the school and clinical settings. Given that clinics are a trusted source of health-related information and schools have expansive reach, cutting across all levels of demographic and social strata, these are promising settings to implement interventions to improve aerobic capacity, body composition, and ultimately, clinical CRFs in childhood. Translations of rigorously controlled trials in clinical and education settings have yielded many evidence-based programs, but far fewer studies have attempted to evaluate these programs in real-world settings. Everyday applications of research are important to assess in addition to controlled trials, as practitioners are ultimately the implementers of evidence-based programs in the real world. This dissertation builds on efficacy studies to evaluate the implementation of evidence-based interventions for improving health-promoting strategies and outcomes in the clinical and school settings.

Key Findings

Study 1 explored the ability of a Maintenance of Certification (MOC) program to increase adherence to American Academy of Pediatrics' (AAP's) weight-related counseling guidelines. Although the AAP recommends weight-related counseling for all children, in practice, physicians infrequently provide counseling to all patients, especially patients with normal BMIs. However, expansion of counseling beyond overweight and obese individuals is important for prevention purposes. It has been established that motivational interviewing can stabilize or decrease weight among obese children,[66–73] but few studies have explored whether training and clinical decisional support can help physicians apply the same counseling concepts to normal-weight children.[71,72,74–78]

Findings from this dissertation support the effectiveness of a six-month MOC program, a continuing education opportunity consisting of a two-hour training program, practice-level changes including decisional support, and other resources to increase weight-based counseling documentation after MOC completion, and even six months after the MOC cessation. The sustained increase in physician-reported counseling indicates that the MOC may impact weight-based counseling in the long term. Physicians increased weight-related counseling documentation, supporting the potential for a combined MOC and clinical decisions support intervention to decrease weight-related counseling disparities.

Study 2 explored elementary school PA opportunities. Although multi-component PA interventions like the Comprehensive School Physical Activity Program (CSPAP) are thought to be most effective at increasing PA among students,[91] little is known about the effectiveness of low-intensity, school-adaptable CSPAP-based models. Findings from Study 2 examining the Power Up for 30 (PU30) initiative support the effectiveness of such a model to increase staff-reported PA during recess, in-class, and before-school. Although only a modest change in school-based PA opportunities was reported, these opportunities may translate, to some degree, into increased individual-level physical activity during the school day.

Study 3 explored the association between PA time offered by schools and aerobic capacity/body composition. Individual-level PA has been shown to increase individual-level fitness.[28] However, school PA opportunities are regulated by time (e.g. hours of physical education per year), rather than intensity (e.g. >50% of PE spent in PA) and time. Few studies have explored whether PA opportunity time offered by the school setting is related to student health outcomes.[58] In this study, PA opportunities offered by the school were generally not associated with student aerobic capacity and body composition after accounting for school-level demographics and other characteristics, although before-school PA programs may be weakly associated with aerobic capacity and recess may be moderately associated with body composition of students aggregated at the school level. It is possible that school-based PA is insufficient in intensity, frequency, duration, or type to impact student level fitness, or other factors such as the home environment or policies simply exert stronger influences on student level fitness. Clinical CRFs are impacted by many levels of influences, and interventions involving multiple settings are most likely to be effective. As such, there should be a focus on creating a culture of health around each child, involving clinical, educational, and household environments.

Limitations

Although Studies 1 and 2 suggest that clinic- and school-level interventions can positively affect system-level outcomes, whether these interventions can affect distal child-level health outcomes remains unknown. For example, although the MOC program impacted documentation of weight-related counseling, the impact of the MOC program on the prevalence and incidence of childhood obesity within each clinic continues to be unclear. Similarly, PU30 increased staff-reported PA opportunity time, but it is uncertain whether PU30 increases PA among students, as PA is characterized by multiple components beyond PA duration and frequency offered by the school. Beyond PA, it remains unknown whether this observed increase in PA opportunity time can impact child aerobic capacity and body composition, particularly in light of the findings in Study 3.

The three studies were also limited by study design. The studies could benefit from cluster-randomized controlled trials (RCTs) at the clinical and school levels. Although the large magnitude of change in documentation after MOC completion supports the effectiveness of the program, a comparison group would have helped to minimize unmeasured confounding factors such as concurrent clinical emphasis of childhood obesity prevention. Similarly, in Study 2, a cluster-RCT could have balanced unmeasured variables such as presence of a school champion at each school. Finally, Study 3 used a cross-sectional study design, which precluded the ability to exclude reverse causation and limited the study's causal implications, but a prospective cluster-RCT could inform this causal relationship. From a policy perspective, this remains an important question, as current state policies only regulate school PA by frequency and duration and not by intensity or type of activity performed.

Finally, though real-world settings inform the translation of efficacy research into practice, such research is limited by numerous measurement issues that should be addressed in future studies. In Study 1, chart abstraction was conducted due to its ease, speed, and ability to be collected retrospectively. However, the use of a voice recorder to measure weight-related counseling could drastically improve sensitivity and inform the quality of counseling in addition to its frequency. Alternatively, consistent data abstractor (e.g. only office managers or only pediatricians) for all time points would have minimized misclassification bias concerns. Similarly, in Studies 2 and 3, the School PA Survey was used to measure PA opportunity time. While instruments must be pragmatic when deployed in the real world, these two studies could also benefit from survey instrument validation, which our research team is currently exploring.

Future Directions

This dissertation identified interventions that produced clinical and school-level changes associated with child health. Whether these translate into child-level health outcome remains unknown, and findings in this dissertation suggest that impacts of these setting-level changes on child health may be moderate. As with most of public health, however, small changes among an expansive population or over an extended period of time may be impactful. Combating the obesogenic environment that has developed over the past half-century among children will require a cultural shift and a long-term commitment from multiple contexts, including clinics, schools, homes, and communities, to create change.

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