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Original research

Trends in physical activity, health-related fitness, and gross motor skills in children during a two-year comprehensive school physical activity program

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ABSTRACT

Objectives: The purpose of this study was to examine the trends in school-day step counts, health-related fitness, and gross motor skills during a two-year Comprehensive School Physical Activity Program (CSPAP) in children.

Design: Longitudinal trend analysis.

Methods: Participants were a sample of children (N = 240; mean age = 7.9 ± 1.2 years; 125 girls, 115 boys) enrolled in five low-income schools. Outcome variables consisted of school day step counts, Body Mass Index (BMI), estimated VO_{2 Peak}, and gross motor skill scores assessed using the Test of Gross Motor Development-3rd Edition (TGMD-3). Measures were collected over a two-year CSPAP including a baseline and several follow-up time-points. Multi-level mixed effects models were employed to examine time trends on each continuous outcome variable. Markov-chain transition models were employed to examine time trends for derived binary variables for school day steps, BMI, and estimated VO_{2 Peak}.

Results: There were statistically significant time coefficients for estimated VO_{2 Peak} (b = 1.10 mL/kg/min, 95% C.I. [0.35 mL/kg/min–2.53 mL/kg/min], p = 0.009) and TGMD-3 scores (b = 7.8, 95% C.I. [6.2–9.3], p < 0.001). There were no significant changes over time for school-day step counts or BMI. Boys had greater change in odds of achieving a step count associating with 30 min of school day MVPA (OR = 1.25, 95% C.I. [1.02–1.48], p = 0.044).

Conclusions: A two-year CSPAP related to increases in cardio-respiratory endurance and TGMD-3 scores. School day steps and BMI were primarily stable across the two-year intervention.

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1. Introduction

High levels of physical activity are associated with a myriad of benefits in children including improved cardio-metabolic risk,^{1,2} emotional well-being,³ and improved cognitive control.⁴ It has been documented that children in the U.S. do not participate in the 60 min of moderate-to-vigorous physical activity (MVPA) per day guideline set by various health agencies.⁵ Low levels of physical activity are most prevalent in children from low-income families, as these children tend to have additional barriers that preclude optimal physical activity participation.⁶ As a response to the low

prevalence of children in the U.S. meeting daily physical activity guidelines, and the fact that most children spend a large portion of waking hours in school settings, the U.S. Centers for Disease Control and Prevention (CDC) and the Society for Health and Physical Educators (SHAPE America) has recommended that schools adopt Comprehensive School Physical Activity Programs (CSPAPs).^{7,8}

Multi-component school-based programs have been shown to be effective in increasing physical activity in youth, although the pooled effect has been weak.⁹ Recent research has also provided empirical evidence of the possible effectiveness of school-based physical activity interventions to improve the number of provided physical activity opportunities,¹⁰ health-related fitness,^{11,12} cardio-metabolic risk,¹² and gross motor skills.¹⁴ However, for CSPAP, past studies have only focused on variable trends across an intervention duration of one-year or less,^{11–13} therefore the

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effectiveness of CSPAP across a multi-year program has not been explored. Establishing long-term effectiveness of school-based programs is important, because decreases in available resources (e.g., equipment, personnel funding) are possible especially in low-income schools, in addition to decreases in motivational constructs (e.g., enjoyment) at the student-level that may manifest additional physical activity participation barriers.¹⁵ Indeed, multi-year trends in behavioral and health outcomes may reflect real-world results, in contrast to short-term and highly controlled efficacy-based interventions.¹⁶ Therefore, the purpose of this study was to examine the trends in school-day step counts, health-related fitness, and gross motor skills during a two-year CSPAP in children from low-income schools.

2. Methods

This study was funded by a Carol White PEP Grant from the U.S. Department of Education. The funding source did not have any role in the collection of data, analysis and interpretation of data, or the right to approve or disapprove publication of the finished manuscript. Participants were a convenience sample of 240 school-aged children (mean baseline age = 7.9 ± 1.2 years; 125 girls, 115 boys) recruited from 5 elementary schools receiving government financial assistance in the U.S. The analyzed sample for this study was a part of a larger sample of children ($N \approx 1732$ children) across the 5 schools. All children enrolled in the five schools under the Carol White PEP Grant agreed with parent consent to participate in the study (100% response). However, because of very high student turnover over two years, only children who had complete data and were present at the beginning and ending of the CSPAP were included in the current study (240/1732, 13.9% response). Written assent was obtained from the students and written consent was obtained from the parents prior to data collection. The University Institutional Review Board approved the procedures used in this study (IRB.00078226).

As part of the CSPAP, each school hired Physical Activity Leaders (PALs) that had the main responsibility of working with school personnel to improve physical activity culture by encouraging and facilitating physical activity throughout the school day. PAL positions were hourly and part time paraprofessionals who received CSPAP training. Recesses during CSPAP were led by the PAL and offered a significant number of opportunities for children to engage in free play or semi-structured physical activity. Each school offered a 15-min recess immediately following lunch as well as a 15-min afternoon recess. Classroom teachers were also asked to implement at least one classroom activity break per day. Approximately 80% of teachers infused at least one activity break into the class schedule most days of the week. Examples of physical activity breaks in the classroom included: a stretching or relaxation break, walking around the classroom or hallway, jumping with an invisible jump rope, doing squats, push-ups, or sit-ups, and/or passing a ball around the classroom.

During the CSPAP, several outcome measures were collected to monitor program effectiveness. Physical activity was assessed using Yamax DigiWalker CW600 pedometers (Tokyo, Japan). Pedometers were worn on the right hip at the level of the iliac crest, aligned with the kneecap. School staff and members of the research team ensured that the device was worn during the entirety of the school day. The pedometers included a seven-day memory that was used to record steps each day of the school week. Yamax DigiWalker models have been shown to provide an accurate recording of steps within $\pm 3\%$ of actual steps and have been shown to be a valid assessment of free-living physical activity.¹⁷

Body Mass Index (BMI) was calculated using standard procedures taking a student's weight in kilograms divided by the square

of his or her height in meters. Height was measured to the nearest 0.01 m using a portable stadiometer (Seca 213; Hanover, MD, USA) and weight was measured to the nearest 0.1 kg using a portable medical scale (BD-590; Tokyo, Japan). Height and weight were collected in a private room during each student's physical education class.

Cardiorespiratory endurance was assessed using the 20-m Progressive Aerobic Cardiovascular Endurance Run (PACER). The PACER was conducted on a gymnasium floor with background music provided by a compact disk. Each student was instructed to run from one floor marker to another floor marker across a 20-m distance within an allotted time frame. The allotted time given to reach the specified distance incrementally shortened as the test progressed. If the student twice failed to reach the other floor marker, the test was terminated. The final score was recorded in laps.¹⁸ Children were blinded to the total number of PACER laps completed at each time-point to attenuate the possibility of a testing effect. Estimated VO_2 was calculated from achieved PACER laps using a validated regression equation.¹⁹

The Test for Gross Motor Development 3rd Edition (TGMD-3) was the instrument used to assess gross motor skills. Psychometric properties of the TGMD-3 have been recently reported with high levels of reliability and validity.²⁰ The TGMD-3 assessed gross motor competency across thirteen movement skills within separate locomotor and ball skill subtests. Each student performed the test items across 2 trials that were each scored based on specific performance criteria (0 = did not perform correctly; 1 = performed correctly). The locomotor and ball subtest scores were 46 and 54 respectively, and the total TGMD-3 scores were out of 100. Motor skill competency was scored using a locomotor and ball skill subtest score and a total motor skill score. All scoring was coded live during each student's physical education class. One member of the research team collected locomotor information at each school and one member of the research team collected ball skill information at each school to maintain testing consistency.

For all measures, data were collected at baseline and at 4–5 follow-up time-points across the two-year CSPAP. Data collection time-points were chosen based on school and investigator scheduling and to provide a meaningful time window conducive for behavioral and physiological change on each of the respective variables. Data were collected by the same trained Principle Investigator, Research Associate, and graduate research assistants to maintain testing constancy.

Differences between sexes at the baseline time-point on all observed measures were analyzed using independent *t*-tests with unequal variances. Magnitude of the differences were quantified using effect sizes (Cohen's *d*), where $d < 0.20$ represented a small effect size, $d = 0.50$ a medium effect size, and $d > 0.80$ a large effect size.²¹ Time trends over the two-year CSPAP on each continuous outcome variable were analyzed using multi-level general linear mixed effects models. Random intercepts and random slopes were employed at the student-level and school-level with unstructured covariance across the random effects. Age and sex were tested as effect modifiers via derived interaction terms that were entered into each of the models. The reported outcomes included the adjusted parameter estimates and corresponding 95% Confidence Intervals.

For categorical data analysis, children were stratified into groups that either met school-day step counts associating with 30 min per day of MVPA and those who did not based on a threshold (5505 steps) established in past empirical studies using receiver operating characteristic curves.²² Children were also stratified into those who met FITNESSGRAM's age and sex-specific standards (i.e., Healthy Fitness Zone) for BMI and estimated $\text{VO}_{2\text{Peak}}$ and those who did not (i.e., Needs Improvement). To examine time trends in these derived binary variables, first-order Markov-chain transition mod-

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