



CDC childhood physical activity strategies fail to show sustained fitness impact in middle school children

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ARTICLE INFO

Keywords:

Fitness
School
Child
Physical activity

ABSTRACT

An increasing number of children are now obese and fail to meet minimum recommendations for physical activity (PA). Schools play a critical role in impacting children's activity behaviors, including PA. Our objective was to assess whether CDC-based school-centered strategies to promote PA increase long-term cardiovascular fitness (CVF) levels in students in schools. A prospective observational trial was conducted in 26 middle schools to implement CDC school-based strategies to increase PA for 3 years. Students had CVF assessed by Fitnessgram (PACER), a 20-meter shuttle run, at the start and end of each school year. A post-study questionnaire was administered to assess each school's strategy adherence. At baseline, 2402 students with a mean age 12.2 ± 1.1 years showed a mean CVF measured by PACER of 33.2 ± 19.0 laps (estimated VO_{2max} 44.3 ± 5.3 ml/kg/min). During the first year, there was a significant increase in the mean PACER score ($\Delta = 3$, 95% CI: 2–4.1 laps, $p < 0.001$) and PACER z-score ($\Delta = 0.09$, 95% CI: 0.04–0.14, $p = 0.001$). Subsequently, however, a significant negative trend in PACER z-scores occurred ($\beta = -0.02$, $p < 0.0001$) so that over the 3-year study period, the intervention did not increase overall CVF. This effort to implement CDC school-based PA strategies in middle schools did not result in sustained increase in CVF over 3 years. It remains to be clarified whether this limited efficacy indicates that CDC physical activity strategies are not sufficiently robust to meaningfully impact health outcomes and/or additional support is needed in schools to improve fidelity of implementation.

1. Introduction

An increasing number of children and adolescents are now classified as obese and fail to meet minimum recommendations for physical activity (Pate et al., 2006). Improving cardiovascular fitness (CVF) during childhood is critical, since health related behaviors cultivated in this time significantly impact future health (Herman et al., 2009). Physical activity (PA) level is the primary determinant for an individual's CVF. Low CVF, like obesity, is a risk factor for type 2 diabetes mellitus (T2DM) and cardiovascular disease (Allen et al., 2007; Brambilla et al., 2011; Dietz, 1998a; Katzmarzyk et al., 2004; Ortega et al., 2008). In adults, low CVF occurs independently of obesity (Blair et al., 2001), and is a stronger predictor of mortality than obesity (Lee et al., 1999). Both CVF and body fat have been independently related to metabolic syndrome in adolescents (Silva et al., 2017). Thus CVF is an important health outcome.

To reverse population trends in obesity and physical inactivity,

public health interventions to create healthier physical movement environments for children are needed (Dietz et al., 2017; Borawski et al., 2018). Schools play a central role in impacting the PA behaviors affecting children. Accordingly, the Centers for Disease Control (CDC) promotes school-based strategies to increase PA including implementation of high quality physical education classes and increased opportunities for students to be physically active in other school settings (Centers for Disease Control and Prevention (CDC), 2011; Fulton et al., 2015). For tracking of metabolic risk factors on a “population-level,” such as a school or community, studies have often been limited to assessing adiposity by BMI. From a public health standpoint, assessment of CVF is an important, yet underperformed assessment (Kriemler et al., 2011). Recently published pediatric population fitness assessments based upon school-centered fitness testing using the Progressive Aerobic Cardiovascular Endurance Run (PACER) testing provide context for fitness changes (Borawski et al., 2018; Carrel et al., 2012; Lang et al., 2017). PACER is a component of the Fitnessgram®

Abbreviations: BMI, Body Mass Index; PACER, Progressive Aerobic Cardiovascular Endurance Run; CVF, cardiovascular fitness; PA, physical activity

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<https://doi.org/10.1016/j.pmedr.2018.08.007>

Received 16 August 2018; Accepted 19 August 2018

Available online 23 August 2018

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and consists of a multistage progressive 20-meter shuttle test (20MST). The PACER is a valid school-based test of CVF in pediatric populations (Lang et al., 2016; Welk et al., 2011; Lang et al., 2018). This testing was designed for classrooms, is feasible to conduct on a “large-scale” and yields valid data that enables schools to compare their students and track effectiveness of their programs (Lang et al., 2016).

Given the multiple factors contributing to the current epidemic of childhood obesity, effective strategies for its prevention and treatment must be pervasive and collaborative in scope. Partnerships with schools to promote childhood fitness have potential to be an important public health approach to improving children's health (Dietz, 1998b; Kang et al., 2002; Skar et al., 2015), and in small and controlled settings over relatively short periods of time, increasing physical activity in children in the school environment has been an effective in reducing obesity and improving CVF (Carrel et al., 2005). However, there are limited data on larger and longer-term studies examining the efficacy and feasibility of implementing CDC strategies. While a statewide, long-term controlled study of this question in a real-world public school setting is best, important information can still be obtained about the health-improvement value of a policy implementing CDC PA guidelines from prospective observation of key outcomes. While large controlled studies have evaluated school-based interventions to increase PA, fewer have evaluated the effects on CVF (Kriemler et al., 2011; Metcalf et al., 2012; Sims et al., 2015). Toward this objective, the current study builds upon previous work and evaluates whether implementation of CDC strategies to increase PA over a 3-year period results in sustained increase in students' CVF in the school setting.

2. Methods

Twenty-six Wisconsin public middle schools were invited by the Wisconsin Department of Public Instruction to participate in this study. The University of Wisconsin dedicated a secure website to allow uploading of local school's PACER/Fitnessgram® data, and also provide links to evidenced-based CDC supported strategies for schools (<http://fitness.pediatrics.wisc.edu>). School staff received training, software, and support to perform Fitnessgram® testing including PACER determination at the schools and to securely upload de-identified student fitness data. After consultation with our University Human Subjects Committee, this project was deemed “exempt from research” since there were no identifiable research subjects, and the PACER testing was being performed as a routine part of the school curriculum. A total of 26 middle schools voluntarily submitted 11,873 fitness assessments over 3 years. Students were initially assessed in the fall of 6th grade, and had repeat assessments at the end of the school year, and again at the start and end of their 7th and 8th grade. All students who were present on the testing days were included in this dataset (Fig. 1).

The PACER, a component of Fitnessgram®, is a multistage progressive 20-meter shuttle run. Subjects run back and forth along a 20-meter course, and each minute the pace required to run the 20 m increases. The pace is set from a pre-recorded audio file. The initial running speed is 8.5 km/h, and the speed increases by 0.5 km/h every minute. The test is finished when the subject fails to complete the 20-meter run in the allotted time twice (Welk et al., 2011). The PACER is expressed as number of laps completed. All schools performed PACER testing at baseline and repeat PACER testing at the beginning and end of each school year. Schools submitted data securely by electronic submission to the University research team. To account for expected age-related increases in CVF, absolute PACER was converted to PACER z-scores for age and gender in addition to analyzing fitness data by absolute PACER score. The reference values for the z-scores were derived from previously collected large population study of 20,631 Wisconsin school children (Carrel et al., 2012). The PACER score has been shown to correlate closely with VO₂ max (Welk et al., 2011), as well as insulin resistance (Varness et al., 2009). While Fitnessgram® contains other fitness and body composition tests, only PACER was performed in

order to minimize class disruptions and teacher time requirements.

All schools agreed to attempt implementation of 4 CDC recommended evidenced-based strategies to promote increased physical activity (PA) in schools including 1) increase time spent in moderate to vigorous physical activity in physical education class [> 70% of class time], 2) encourage active classroom breaks (2 five-minute breaks per day), 3) document structured organized physical activity opportunities during recess, and 4) provide organized physical activity opportunities before and after school (Centers for Disease Control and Prevention (CDC), 2011; WI Department of Public Instruction, n.d.). The Wisconsin Department of Public Instruction provided technical assistance and financial support to all participating schools with specific training immediately after baseline testing, and again at the start of each year. Schools also received in-person professional development and ongoing consultation to support implementation of the physical activity strategies (Wisconsin Department of Public Instruction, 2016). Wisconsin requires middle schools to have comprehensive physical education 3 times per week, every semester. While all schools have unique time requirements for physical education class, the schools involved in this study averaged 39 min per PE class. While schools did not have an onsite monitor to document interventions, teachers were surveyed each year to determine how effectively each of the CDC strategies was met.

2.1. Data analysis

Student and school level demographic information were summarized in frequencies and percentiles or means and standard deviations. A linear mixed effects model with school specific random effects and a compound symmetry correlation structure was used to evaluate longitudinal changes in PACER and PACER z-scores over the 3-year study period. Times (Fall 1, Spring 1, Fall 2, Spring 2, Fall 3 and Spring 3) were included as factors. Model assumptions were verified by examining residual plots. For the analysis involving the PACER scores, age and gender were included as covariates. There were no covariates included in the model for analyzing PACER z-scores. Least squares adjusted means were reported along with the corresponding 95% confidence intervals. All reported *p*-values are two-sided and *p* < 0.05 was used to define statistical significance. Data analysis was conducted using SAS software (SAS Institute, Cary NC) version 9.4.

Adherence to implementation of CDC strategies was examined with a post-study questionnaire filled out by the lead physical education teacher at each school. After 3 years, there were 13 schools that completed all 4 strategies, 8 (31%) completed 2 strategies, and 3 (12%) completed only 1 strategy. A subgroup analysis was performed excluding schools that reported < 100% compliance with implementation of all 4 strategies. A linear mixed effects model with school specific random effects and time, compliance (100% vs. < 100%) and the interaction effect between time and compliance was used to evaluate the effect of compliance on changes in PACER and PACER z-scores. This subgroup analysis revealed no differences in fitness changes compared to the intent-to-treat analysis used above.

3. Results

Twenty-six schools participated in this study with a total of 2403 students and 11,873 PACER assessments. The mean age at baseline for the student population was 12.2 ± 1.1 (range 10.9–13.5 years), 52% were male and 20% Hispanic (Table 1). Fourteen (54%) of the schools were in an urban environment and 62% of the study population was eligible for free or reduced lunch (Table 1B). Based upon funding and staffing, 24 schools were able to continue this intervention for all 3 years, while 2 schools completed the intervention for only the first year. No differences in school size or demographics were found between these two school groups.

The PACER score, after adjusting for age and gender, at baseline was 29.0 (95% CI: 26.7–31.4) corresponding to a predicted VO₂ of 42.4

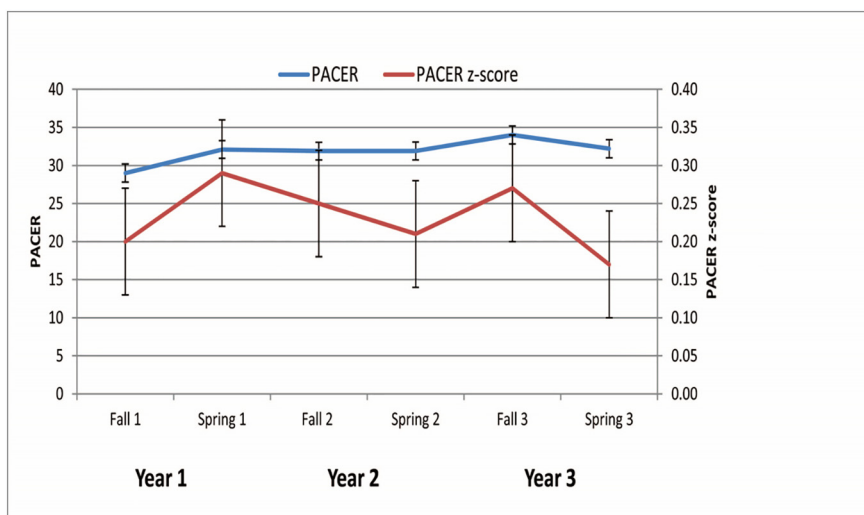


Fig. 1. PACER (laps) and PACER z-scores (means and 95% CI) over 3-year study period.

(mL/kg/min), and the PACER z-score was 0.20 (95% CI: 0.06–0.34), which was just above the mean for CVF level when compared to the general population in this age range (Pate et al., 2006; Leger et al., 1984). From baseline (Fall year 1) to the end of the first school year there was a significant increase in the PACER ($\Delta = 3.0$, 95% CI: 2–4.1 laps, $p < 0.001$) and PACER z-score ($\Delta = 0.09$, 95% CI: 0.04–0.14, $p = 0.001$). Over the ensuing summer break and throughout the second school year there were no significant changes in PACER observed. However, from the beginning of the third school year to the end of the third school year a significant decrease was observed for both the PACER ($\Delta = -1.8$, 95% CI: 0.6–3.0 laps, $p = 0.004$) and PACER z-score ($\Delta = -0.11$, 95% CI: 0.05–0.18) $p = 0.001$ (Table 2). Similar patterns were observed for males and females. A year-by-year linear regression model of PACER z-score between the start of year 1 to the end of the 3-year intervention period showed a significant decline from the end of the first school year to the end of the 3-year intervention period ($\beta = -0.02$, $p < 0.0001$). Thus, over the 3-year study period, the intervention did not increase overall PACER z-score scores. Further, the subgroup analysis examining the effect of compliance on changes in PACER and PACER z-scores revealed no differences in fitness changes

compared to the intent-to-treat analysis.

4. Discussion

In middle school settings, programmatic efforts to implement CDC school-based PA recommendations did not result in sustained increase in overall CVF measured by PACER over a 3-year period of implementation. While CDC school-based PA recommendations have increased PA (Dobbins et al., 2009; Dobbins et al., 2013), and increased CVF in controlled settings over short periods of time (Seibert et al., 2018), data presented here suggest that, over a longer evaluation time of 3 years, either the CDC intervention is not robust enough to meaningfully increase CVF or implementation challenges limit its effectiveness in real world settings.

Survey data collected from participating schools indicated that despite best efforts many schools were not able to implement all of the 4 PA strategies. Nevertheless, analysis of “all schools” and of “only schools that successfully completed all 4 strategies” did not reveal any differences in fitness outcomes. While variation in adherence could clearly lead to underestimation of the potential impact of CDC physical

Table 1 Demographics.

N	Year 1		Year 2		Year 3		Overall
	Fall	Spring	Fall	Spring	Fall	Spring	
	2403	2465	1907	1828	1589	1681	11,873
Gender							
Male	51%	52%	53%	53%	53%	52%	52%
Age (years)							
Mean \pm SD	12.2 \pm 1.1 years		13.1 \pm 1.1 years		14.1 \pm 1.0 years		
Race ^a							
White	70%	72%	71%	73%	82%	88%	75%
Black	10%	8%	9%	9%	9%	11%	9%
Multiracial	12%	11%	10%	9%	0%	0%	8%
Other	9%	9%	10%	9%	9%	1%	8%
Ethnicity ^a							
Hispanic	23%	19%	19%	19%	19%	18%	20%
Age (years)							
Mean (SD)	11.1 (0.9)	11.8 (1.0)	12.1 (0.7)	12.4 (0.8)	13.0 (0.7)	13.5 (0.7)	12.2 (1.1)
Pacer							
Mean (SD)	26.5 (15.7)	31.9 (19.2)	34.0 (18.2)	34.5 (18.9)	38.0 (20.4)	37.5 (19.8)	33.2 (19.0)
PACER z-score							
Mean (SD)	0.15 (0.92)	0.27 (1.01)	0.33 (0.94)	0.27 (0.96)	0.33 (0.97)	0.24 (0.95)	0.26 (0.96)

^a Information was missing for race ($n = 1964$) and Hispanic ethnicity ($n = 762$).

Table 1B
Demographics and school characteristics.

Student level demographics (N = 11,873)		
	N	%
School year/semester		
Year 1:		
Fall	2403	20
Spring	2465	21
Year 2:		
Fall	1907	16
Spring	1828	15
Year 3:		
Fall	1589	13
Spring	1681	14
Gender		
Male	6196	52
Age		
9 years	219	2
10 years	489	4
11 years	2409	20
12 years	3832	32
13 years	3382	28
14 years	1542	13
Race ^a		
White	7459	75
Black	896	9
Multiracial	760	7
Other	794	8
Hispanic ^a	2170	20
School level demographics (N = 26)		
	N	%
Urban school	14	54
	Mean	SD
% student body eligible for free/reduced lunch	62%	14%
% student body minority	37%	29%

^a Information was missing for race (n = 1964) and Hispanic ethnicity (n = 762).

Table 2
PACER and PACER z-scores over time.

Time	PACER				p-Value ^d	PACER z-score				p-Value ^d
	Mean ^a	95% CI	Δ ^b	p-Value		Mean	95% CI	Δ ^b	p-Value ^c	
Fall 1	29.0	26.7–31.4				0.20	0.06–0.34			
Spring 1	32.1	29.8–34.4	3.0	< 0.001	< 0.001	0.29	0.15–0.43	0.09	0.001	0.001
Fall 2	31.9	29.6–34.3	–0.1	0.81	< 0.001	0.25	0.11–0.39	–0.04	0.14	0.09
Spring 2	31.9	29.6–34.2	0.0	0.96	< 0.001	0.21	0.07–0.35	–0.04	0.19	0.73
Fall 3	34.0	31.6–36.3	2.1	0.001	< 0.001	0.27	0.13–0.41	0.06	0.05	0.02
Spring 3	32.2	29.9–34.6	–1.8	0.004	0.0001	0.17	0.02–0.31	–0.11	0.001	0.28

^a Adjusted for age and gender.

^b Mean delta difference from previous time point (Fall 1 to Spring 1, Spring 1 to Fall 2, etc.)

^c p-Value for evaluating delta difference from previous time point (Fall 1 to Spring 1, Spring 1 to Fall 2, etc.)

^d p-Value for evaluating delta difference from baseline (Fall 1) to Spring 1, to Fall 2, to Spring 2, to Fall 3, and Spring 3.

activity interventions, it also highlights factors that influence the true effectiveness of an “evidence-based” program applied in the real world setting. Further, without a control group of schools specifically not implementing these guidelines, it is unknown if the intervention is the sole cause of these effects. Based on barriers identified to implementation of all CDC recommendations, time constraints, inadequate staffing and insufficient funding, successful implementation of physical activity strategies in schools likely requires additional staffing and increased funding. Nearly all physical education teachers reported successful implementation of increased time in moderate to vigorous activity during physical education class. However, this strategy would be expected to have limited effectiveness when students do not participate in physical education class. Thus, policy initiatives to increase physical education class frequency and funding for after school

programs are needed to enable successful implementation of CDC physical activity strategies.

Physical activity and physical fitness possess both independent and shared health benefits. For adults, low CVF increases risk for cardiovascular disease, hypertension, T2DM, cancer, and other chronic disease (Sui et al., 2007; Wei et al., 1999). Improved physical activity attenuates these morbidities so that, for example, overweight but active individuals can have lower risk for T2DM and cardiovascular disease than sedentary normal-weight individuals (Lee et al., 1999). Physical fitness during childhood appears to reduce a person's risk for developing cardiovascular disease in adulthood (Lang et al., 2017; Biddle et al., 2004; Racette et al., 2015). Childhood physical activity benefits are not limited to reducing chronic disease risk; a positive relationship has been shown between school-based physical activity and increased

short-term concentration and academic achievement (Esteban-Cornejo et al., 2014). Students who are more physically active and fit also have higher levels of self-esteem, and a lower prevalence of depression (Tremblay et al., 2000; Santos et al., 2014). Consequently, a curriculum that facilitates and encourages high levels of physical fitness and activity contributes to optimal health status, academic achievement, and positive psychological outcomes in this age group. We acknowledge that our study did not assess these important variables.

Fitness testing is a common component of most physical education programs, and appropriately receives attention due to the strong link between poor fitness and chronic disease. From a public health standpoint, schools provide a key opportunity for assessing and influencing childhood health and fitness. In recent years a few states have passed legislation to mandate implementation of PA strategies and adopt youth fitness testing with PACER® (Morrow Jr & Ede, 2009). The strategies were chosen based on recommendations from the Centers for Disease Control and Prevention.

Strengths of this study include the ability to assess the sustained impact of a programmatic effort to implement CDC-based PA recommendations in a large number of schools. Analysis was also strengthened by utilization of PACER z-scores that were previously developed from collected data from > 26,000 Wisconsin children, and which takes into account sex and age-related expected increases in fitness (Carrel et al., 2012). While it cannot be guaranteed that the study sample is representative of all student populations, the relatively large size as well as the geographic and socio-demographic coverage in the sample helps to support the generalizability of the study findings. The schools include urban and rural schools, as well as geographically distributed in all sectors of the state. Their low SES designation by the Wisconsin DPI increases the relevance of these findings, since children with low SES are at greater risk for morbidities associated with low physical activity.

This study has limitations. Without a control group of schools that deliberately avoided use of any CDC school-centered strategies, it is not possible to draw definitive conclusions regarding effectiveness or lack of effectiveness of the CDC-based strategies themselves. Another potential limitation of this study due to its focus on middle schools include (1) the sample may not be representative of all Wisconsin students and (2) consistent implementation of strategies may be more challenging in certain school settings without sufficient resources or limited infrastructure. In addition, the PACER test is effort-dependent, and therefore subject to variability based on study subject and supervisor attitude and motivation. Given the statewide nature of the study, it was not possible to precisely regulate and assess the quality and consistency of CDC strategy implementation at all schools. As noted, additional analyses were performed to evaluate whether schools that implemented all 4 strategies had a different effect on fitness than those with lesser compliance, and no differences were found.

5. Conclusions

While low cost school-based programs have potential to increase physical activity and fitness and favorably impact health in large numbers of students, a programmatic effort to implement CDC recommended strategies to increase physical activity in Wisconsin schools did not have a discernible sustained impact on fitness over three years of study. Increases in CVF observed during the first year were not sustained over the course of 3 years. Widespread assessment, reporting, and tracking of childhood fitness remain limited. This study demonstrates the feasibility and value of using PACER testing to assess CVF changes and suggests that CVF assessment can be added to BMI as an important health indicator for all children. Additional controlled research is needed to determine how physical activity-promoting interventions can be changed and/or barriers to implementation overcome to inform future policy recommendations and resource allocation for school-based interventions that will more effectively improve long-term

health outcomes in children.

Funding sources

NIH T32 DK077586 and the University of Wisconsin Partnership Program.

The sponsor had no involvement in the design, data collection, analysis, or decision for publication.

Financial disclosure

The authors have no financial interests relevant to this article to disclose.

Authorship and conflict of interest

The authors have no financial relationships or conflict of interest to disclose. An honorarium, grant, or other form of payment was not given to anyone to produce the manuscript. Tasa Seibert, MD MPH wrote the first draft of the manuscript. Each author listed on the manuscript has seen and approved the submission of this version of the manuscript and takes full responsibility for the manuscript.

Acknowledgment

Funding was provided by NIH T32 DK077586 and the Wisconsin Partnership Program. The authors had full access to all of the data in the study and the PI takes responsibility for the integrity of the data and the accuracy of the data analysis. This work was greatly helped by Doug White MS and Jon Hisgen from the Wisconsin Department of Public Instruction (DPI), as well as Jon Morgan MS from the Wisconsin Department of Health Services.

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