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The effects of the Pathways Obesity Prevention Program on physical activity in American Indian children☆

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Abstract

Background. Inadequate opportunities for physical activity at school and overall low levels of activity contribute to the high prevalence of overweight and obesity in American-Indian children.

Methods. A school-based physical activity intervention was implemented which emphasized increasing the frequency and quality of physical education (PE) classes and activity breaks. Changes in physical activity were assessed using the TriTrac-R3D accelerometer in a subsample of 580 of the students (34%) randomly selected from the Pathways study cohort. Baseline measures were completed with children in second grade. Follow-up measurements were obtained in the spring of the fifth grade.

Results. Intervention schools were more active (+6.3 to +27.2%) than control schools at three of the four sites, although the overall difference between intervention and control schools (~10%) was not significant ($P > 0.05$). Boys were more active than girls by 17 to 21% ($P \leq .01$) at both baseline and follow-up.

Conclusions. Despite the trend for greater physical activity at three of four study sites, and an overall difference of ~10% between intervention and control schools, high variability in accelerometer AVM and the opportunity to measure physical activity on only 1 day resulted in a the failure to detect the difference as significant.

Keywords: American Indian children; Physical activity; Accelerometer; Intervention

Introduction

Pediatric obesity is increasing at an alarming rate. Recent surveys suggest at least 11%, and possibly as many as 25% of all U.S. children and adolescents are overweight [1,2]. Although population-based surveys have not been reported, available data suggest the prevalence of obesity may be much higher in American Indian children, ranging from 25 to 45% [3,4]. For example, using current NCHS reference values [5,6] found 30.5% of third-grade American Indian girls and 26.8% of boys were above the 95th percentile for body mass index (BMI), and 21% of girls and 19.6% of boys were between the 85th and 95th BMI percentiles. These results contrast dramatically with reports as recent as the early 1970s, which showed underweight and dietary

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deficiencies were major health issues for American Indian children [7,8].

The health consequences of obesity are well known [9]. Although few studies have examined the long-term effects of child and adolescent obesity on adult morbidity and mortality, it is reasonable to expect the increasing prevalence of pediatric obesity will lead to an increased burden of obesity-related chronic diseases in American Indian communities. Concern for this outcome has led to obesity initiatives like the Pathways Study, the first obesity prevention study in American Indian children, reported in this issue and elsewhere [10].

The recent and rapid development of obesity in American Indian communities underscores the contribution of secular changes in environmental factors as important determinants of excessive weight gain. Although the relative contributions of various factors are unknown, low levels of physical activity and unhealthy dietary habits are thought to be important contributors [11]. Indeed, the limited available data suggest that physical inactivity contributes to excessive weight gain in American Indian children. For example, Fontveille et al. [12] reported that Pima Indian children spent more time watching television and less time playing sports than did white children. Moreover, limited opportunities for physical activity at school and at home were observed for American Indian communities who participated in the Pathways feasibility study [13,14]. It was these observations that led to efforts to increase physical activity, primarily at school, as a component of the Pathways obesity prevention program. The effects of the intervention on physical activity are provided in this report.

Methods

Design

Pathways was a multicentered, randomized trial designed to test the effectiveness of school and family-based interventions for the primary prevention of obesity in American Indian students. The primary outcome variable was the school's mean percent body fat (PBF) at the end of the 3-year study period, adjusted for baseline values. Secondary outcomes included the mean body mass index (kg/m^2) calculated from height and weight, and the impact of the interventions on physical activity level, dietary fat intake, percent fat, and saturated fat in school lunches, and knowledge, attitudes, and behaviors related to food choices and physical activity. Eligibility criteria for schools and the study design are published elsewhere [15].

Participants

Participants were residents of seven American Indian communities: Gila River Indian Community, Tohono O'Odham, White Mountain Apache, San Carlos Apache, Oglala Lakota, Sicangu Lakota, and the Navajo Nation. There were 1,704 students from 41 schools who completed baseline measures enrolled in the overall study [16]. To objectively assess changes in physical activity, a subsample of 580 of the students (34%), randomly selected from the study cohort, was measured in the spring of 1997 when they were completing the last semester of second grade. Follow-up measurements were obtained in the spring of the fifth-grade.

Physical activity intervention

The physical activity intervention focused primarily on increasing activity and energy expenditure in school by increasing the frequency and quality of physical education (PE) classes and activity breaks, including recess periods. Secondarily, the program promoted positive attitudes toward physical activity and sought to develop motor skills that would encourage children to cultivate and sustain an active lifestyle. The PE intervention was based on the SPARK program (Sports, Play and Active Recreation for Kids) [17], which is designed to increase physical activity both through PE lessons that promote motor skill development and traditional fitness lessons. Past research has shown that classroom teachers as well as PE specialists can effectively teach SPARK PE, which was important for Pathways because not all intervention schools had PE specialists on staff.

To enhance the cultural relevance of the PE component and to expand the PE curriculum, a unit of American Indian games derived from the traditional games of each Pathways nation was developed. Without changing the original object of the game, the games were modified to enhance the energy expenditure required for each game by restructuring the organization and setup (e.g., smaller teams, shorter lines, and more equipment). Designed for multiple uses, the unit was used for recess and other active times, in addition to PE class.

To encourage more opportunity for activity outside of PE and recess, classroom teachers were provided a program of exercise breaks created for Pathways. Designed to be either teacher-or student-led, color-coded activities were organized by fitness component in a file-box. Depending on the time available, one to two activities were performed to target a single fitness component (muscle strength and endurance, flexibility, aerobic endurance) or multiple activities could be organized in a circuit format to address multiple components.

The Pathways protocol called for PE specialists or classroom instructors to teach PE $\geq$ 3 times/week for at least 30 minutes per class. Daily recess ($\geq$ 15 minutes) and exercise breaks (1–2 per day, for 5–10 minutes each) were also encouraged. Centralized training sessions for PE specialists and classroom teachers, lasting ~1.5 days, were held before each fall and spring semester. In addition, PE mentors employed by each site made monthly visits to the schools to observe classes, meet with teachers, problem-solve, and provide assistance as needed.

Measurements

All methods, training, certification, and quality control procedures were developed and implemented according to standardized study protocols previously described in the literature [10,18,19]. The anthropometry, body composition, and accelerometer measures are briefly described below.

Anthropometry

Standing height was measured in duplicate to the nearest 0.1 cm using a Schorr vertical measuring board. Body weight was measured in duplicate to the nearest 0.1 kg using a portable, strain-gauge digital scale (Secca Model 770). Tricep and subscapular skinfolds were measured in triplicate to the nearest millimeter on the right side of the body. Standard protocols as defined in the Anthropometric Standardization Reference Manual were followed [20].

Body composition

Body mass index (Kg/M^2) was calculated from body weight (kg) and standing height (M). Percent fat was estimated using an equation previously validated in this population [19]. Predictors included body weight, age, gender, tricep and subscapular skinfolds, and bioelectric resistance and reactance measured on the right side of the body using a four-terminal, single-frequency (800 mA at 50 kHz) impedance plethysmograph (Valhalla Scientific Model 1990B).

Physical activity

Physical activity was measured as movement assessed with a TriTrac-R3D accelerometer (Hemokinetics, Inc., Madison, WI). The accelerometer collects minute-by-minute data in mediolateral (x), anteroposterior (y), and vertical (z) planes of movement, and provides one composite score ($[x^2 + y^2 + z^2]^{1/2}$) for all three planes called the "average vector magnitude" (AVM). Previous studies have shown that TriTrac AVM provides a valid index of children's physical activity levels [21–24]. Students wore the accelerometers in a fanny pack around the waist. Fanny packs were placed on the children at the beginning of a school day and retrieved the next day. Children were instructed to wear the fanny pack throughout the day (except while bathing) until going to bed, and to put the pack back on in the morning after dressing and wear it back to school where the accelerometers were retrieved and downloaded. Written instructions for these procedures were sent home with each student for their parents [18].

Table 1
Sample characteristics at baseline (second grade)

	Tritrac (n = 574)		No Tritrac (n = 1130)		
	$\bar{X}$	SE	$\bar{X}$	SE	P[a]
Age (years)	7.6	0.08	7.6	0.08	0.72
Height (cm)	130.2	1.19	130.1	1.18	0.67
Weight (kg)	33.2	1.54	32.3	1.52	0.04
BMI (kg · m^{-2})	19.4	0.58	18.9	0.57	0.01
% fat	33.5	1.02	32.7	1.01	0.03

[a] Significance level, tritrac vs no tritrac sample.

Table 2
Sample characteristics at follow-up (fifth grade)

	Tritrac (n = 457)		No Tritrac (n = 1247)		
	$\bar{X}$	SE	$\bar{X}$	SE	P[a]
Age (years)	10.5	0.08	10.6	0.08	0.02
Height (cm)	148.0	1.44	148.3	1.42	0.46
Weight (kg)	50.0	3.5	50.3	3.5	0.72
BMI (kg · m^{-2})	22.5	1.16	22.5	1.15	0.81
% fat	40.4	0.98	40.1	0.95	0.50

[a] Significance level, tritrac vs no tritrac sample.

Quality control

The Pathways study Coordinating Center and the study sites conducted centralized training sessions. Only certified staff persons measured body composition and placed the accelerometers in the fanny packs and positioned them on students. Each study site conducted quality control checks during measurement. Duplicate measures of body composition were obtained on 10% of the sample.

Statistical analysis

Minute-specific Tritrac AVMs were averaged over 30-minute intervals throughout the period of time the accelerometer was worn. Subjects with more than 65% of minute-specific AVMs equal to zero were excluded from the analyses. With the exception of sleep time (7 pm–7 am), the 30-minute intervals were segmented into three time periods: before school (7–9 am), during school (9 am–3 pm), and after school (3–7 pm). Intervals during school were identi-

Table 3
Sample characteristics[a] of children with measurements at both baseline and follow-up

	Tritrac (n = 278)		No Tritrac (n = 1426)		
	$\bar{X}$	SE	$\bar{X}$	SE	P[b]
Age (years)	10.5	0.08	10.6	0.08	0.11
Height (cm)	148.4	1.49	148.1	1.44	0.52
Weight (kg)	50.8	3.57	50.0	3.49	0.44
BMI (kg · m^{-2})	22.7	1.19	22.5	1.15	0.47
% fat	40.5	1.02	40.1	0.94	0.31

[a] At fifth grade.
[b] Significance level, tritrac vs no tritrac sample.

Table 4
Average vector magnitude[a] at follow-up (fifth grade) for unmatched and matched samples

Site	Intervention			Control			Diff	
	N	$\bar{X}$	SE	*N*	$\bar{X}$	SE	I-C	*P* value
Unmatched sample, 24 hours	238	267.88	12.768	219	248.61	12.835	+19.27	0.29
Unmatched sample, 9 am–7 pm	238	479.15	33.547	219	433.17	33.971	+45.98	0.18
Matched sample, 24 hours	136	267.22	16.687	142	246.79	17.277	+20.43	0.31
Matched sample, 9 am–7 pm	136	474.30	42.900	142	442.61	43.915	+31.69	0.42

Note. Matched sample models included adjustment for baseline AVM.
[a] Model: AVM = Trt/time (half-hour interval).

fied as PE, recess, or lunch intervals if more than 15 minutes were recorded for that activity during a given interval. This was done in a hierarchical fashion, with precedence given to PE and then recess, in order to achieve mutually exclusive time periods. The mixed procedure of SAS (1997) was used to make mixed model analyses of the 30-minute average AVM values as response variables, incorporating the random effects of site and school within site. To account for correlation between interval AVMs within a child, repeated measure was specified with a first order autoregressive structure.

Results

Table 1 shows the descriptive characteristics of the Pathways participants at baseline (second grade). At baseline, 33.7% of the study sample wore the Tritrac. The average age of the children who wore the Tritrac and those who did not wear the Tritrac at baseline was 7.6 years. The children wearing the Tritrac were significantly heavier (+0.9 kg; $P \leq .05$), had a greater BMI (+0.5 kg $\cdot$ m^{-2}), and a greater percent body fat (+0.8%). Although these differences were statistically significant, they were small.

Table 2 lists the descriptive characteristics of the Pathways participants following the intervention (fifth grade). The children who wore the Tritrac at follow-up were representative of the total sample, as the age and body composition of the Tritrac and no Tritrac samples were not significantly different at follow-up. From baseline (end of second grade) to follow-up (end of fifth grade), average height and weight had increased by approximately 18 cm and 17 kg, respectively ($P < .05$). Average BMI increased by 3.35 kg $\cdot$ m^{-2} and percent fat increased by 7.1% ($P < .05$). At follow-up, 26.8% of sample wore the Tritrac.

Although an attempt was made to measure the physical activity level of the same children at baseline and at follow-up, this was not always possible. Of the follow-up sample

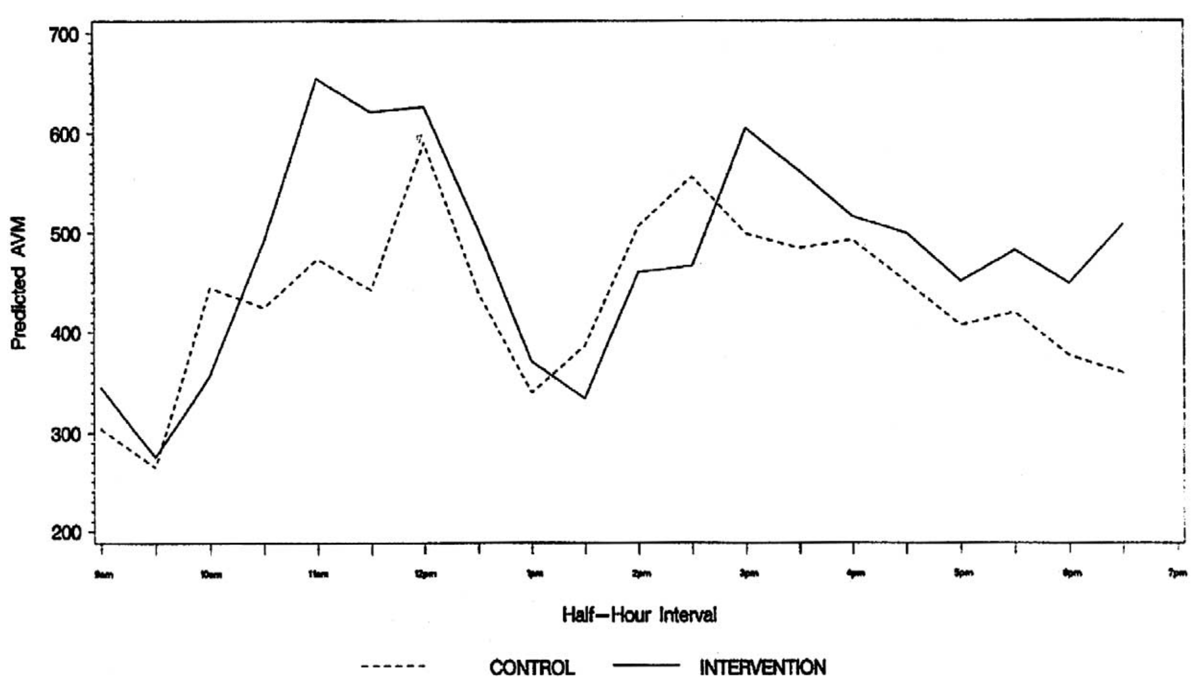

Fig. 1. Plot of half-hourly predicted AVMs over 9 am–7 pm period by treatment group. LSMeans based on unmatched sample intervals between 9 am and 7 pm.

Table 5
Average vector magnitude[a] (9 am–7 pm) at follow-up (fifth grade) by site and treatment group

Site	Intervention			Control			Diff	
	N	$\bar{X}$	SE	N	$\bar{X}$	SE	I-C	P value
1	59	512.68	55.584	33	544.34	65.278	−31.66	0.71
2	57	488.30	48.520	88	459.18	42.181	+29.12	0.65
3	100	449.33	41.851	85	353.26	42.479	+96.08	0.11
4	22	443.07	68.460	13	386.00	77.259	+57.07	0.58

[a] Unmatched sample, model: AVM = trt, trt*site. Interaction not statistically significant.

(total $n = 1704$), 16.3% wore Tritrac at both baseline and follow-up measurement intervals. The average age, height, weight, BMI, and PBF fat of children who wore Tritrac at both baseline and follow-up were not significantly different from the remainder of the follow-up sample (Table 3).

Table 4 compares the average vector magnitude (AVM) between the intervention and control schools at follow-up (fifth grade) for both unmatched and matched (children with measurements at both baseline and follow-up) samples. Children in the intervention schools (both unmatched and matched samples) were 7 to 10% more active over the day than children in control schools, although the differences were not statistically significant (Fig. 1).

Table 5 compares the AVM at follow-up across the study sites. At follow-up, children in intervention schools were more active (+6.3 to +27.2%) than children in control schools at three of the four study sites. At one site, children in the control schools were more active than children in the intervention schools (5.8%). None of the differences between intervention and control schools were significant.

Table 6 compares the AVM at baseline and follow-up for boys and girls. Boys were significantly ($P \leq .01$) more active than girls by 17 to 21% at both baseline and follow-up. Fig. 2 shows the AVM from 9:00 am to 7:00 pm for boys and girls at follow-up (the period for which we had the most complete data). At follow-up, boys were significantly more active than girls (by 12 to 43%) at each site (Table 7).

Table 8 shows that children in the intervention schools were more active than children in control schools for the following periods of the day: before school (+7.6%); lunch time (+14.0%); PE class (+10%); school time excluding lunch, recess, and PE time (6%); and after-school (19.0%). Recess, which was not targeted in the intervention, was more active in control schools than intervention schools (29%). None of these differences in physical activity between intervention and control schools were statistically significant ($P > 0.05$). Overall, for the period from 9:00 am to 7:00 pm, intervention schools were 10.6% more active than control schools. This difference was not statistically significant ($P > 0.05$).

In both intervention and control schools, the PE period was more active (~1.5 to 3.0 times) than any other time of the day. Recess and lunchtime (which often included an activity break) were other relatively active times, compared to other times of the school day. After school time was only slightly more active than classroom time (1.1 to 1.2 times), whereas PE class time was about 2.5 times more active than after school time.

Discussion

The Pathways intervention was designed to increase the amount of physical activity done by children in the intervention schools. Based on the results of one day of Tritrac measurements at baseline and follow-up, there were no statistically significant differences in activity levels between children in the intervention and control schools. This finding is consistent for both matched (children wearing Tritrac at both time points) and unmatched (all children wearing Tritrac at follow-up) samples. Nevertheless, it is encouraging that at three of the four study sites, physical activity levels were higher in the intervention schools as compared to the control schools. For both the matched and unmatched

Table 6
Average vector magnitude[a] at baseline and at follow-up by gender

		Boys			Girls			Diff	
		N	$\bar{X}$	SE	N	$\bar{X}$	SE	B-G	P value
Unmatched Sample (24 hours)	Baseline	290	321.18	14.302	284	275.18	14.363	46.01	0.00
	Follow-up	221	291.04	10.810	236	248.82	10.522	42.22	0.00
Unmatched Sample (9 am–7 pm)	Baseline	290	571.26	24.254	284	487.29	24.297	83.97	0.00
	Follow-up	221	501.13	27.035	236	412.99	26.708	88.14	0.00

[a] Model: avm = trt.

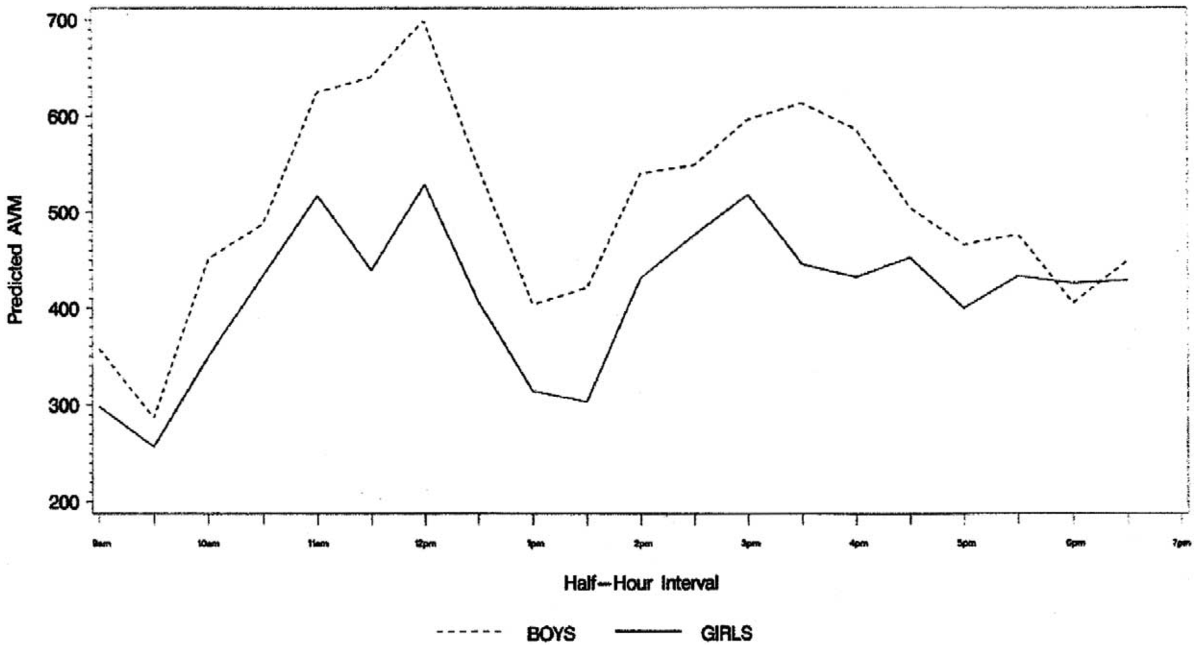

Fig. 2. Plot of half-hourly predicted AVMs over 9 am–7 pm period by gender. LSMeans based on unmatched sample intervals between 9 am and 7 pm.

samples, the children in the intervention schools were 7 to 11% more active than those in the control schools.

One reason that this increase in physical activity in the intervention schools was not statistically significant was due to the relatively large variation in AVM between study sites and across time intervals. The coefficients of variation in AVM in the present study were 10 to 25%. These values are comparable to those reported by Welk and Corbin [24] in children 9 to 11 years of age over three days of measurement. Unfortunately, there is no standard of reporting for the Tritrac accelerometer. In two additional studies of children where the Tritrac accelerometer was used, the AVM units were converted to kilocalories and no raw data were reported [25,26], making comparison with the present study impossible.

Another reason we may have failed to find significant changes in physical activity in the intervention schools is because we were only able to measure physical activity on 1 day using the Tritrac. The minimum number of days needed to adequately assess physical activity using the Tritrac has not been established, but Trost et al. [27] state that at least 4 days of monitoring are necessary to adequately assess the physical activity of children when using the CSA accelerometer. Interinstrument reliability for the Tritrac is reported as poor in adults [28], and we were unable to ensure that each child wore the same Tritrac unit at baseline and follow-up. This may have also increased the variation in AVM observed in the present study.

It is difficult to compare the changes in physical activity level in the Pathways study with other large-scale interventions, as no other large-scale trial was found that used the Tritrac accelerometer to assess changes in fitness as a result of an intervention. The Child and Adolescent Trial for Cardiovascular Health (CATCH) was a large, school-based multicomponent behavioral intervention involving mostly Caucasian, African–American, and Hispanic children. Physical activity levels were measured in CATCH using the System for Observing Fitness Instruction Time (SOFIT), a

Table 7
Average vector magnitude at follow-up,[a] by site and gender

Site	Unmatched sample, 9 am–7 pm						Diff	
	Boys			Girls				
	N	$\bar{X}$	SE	*N*	$\bar{X}$	SE	B-G	*P* value[b]
1	51	554.81	58.057	41	492.36	58.786	62.45	0.05
2	73	509.71	50.637	72	435.13	50.536	74.58	0.00
3	84	455.59	49.217	101	357.19	48.769	98.40	0.00
4	13	531.49	74.839	22	370.89	65.228	160.60	0.01

[a] Model: avm = sex sexsite; interaction not statistically significant.
[b] Significance level, boys vs girls.

Table 8
Average vector magnitude[a] at follow-up for different time periods by treatment group

	Intervention			Control			Diff	
	N	$\bar{X}$	SE	*N*	$\bar{X}$	SE	I-C	*P* value
Before school (7–9 am)	236	435.88	27.088	205	405.35	27.808	+30.53	0.43
Lunch	187	768.76	101.64	198	674.56	101.26	+94.20	0.26
Recess	73	810.69	145.49	82	1141.79	154.23	−331.10	0.12
PE class	116	1232.57	130.33	63	1120.91	153.59	+111.7	0.58
During school: other	238	404.94	27.968	219	380.98	28.318	+23.95	0.38
After school (3–7 pm)	238	496.63	38.306	219	416.15	38.523	+80.49	0.12

[a] Model: avm = trt.

self-administered physical activity checklist, and a 9-minute fitness run. The average length of time spent in PE did not change for either the control or intervention schools, but the time spent doing vigorous activities was increased in the intervention schools. Self reported total minutes of reported daily activity was not different between control and intervention schools; there was also no difference in fitness run scores between intervention and control schools [29]. Although using different assessment tools, these findings are similar in general to those for the Pathways study.

Similar to the baseline results for the Pathways study [30], boys at follow-up were significantly more active than girls. Over 24 hours, boys were approximately 17% more active at both baseline and follow-up. From 9:00 am to 7:00 pm, boys were about 17% more active than girls at baseline, and approximately 21% more active at follow-up. These findings are supported by the work of others that show boys in this age group are significantly more active than girls [25,31–34].

Another important observation that was made at baseline and at follow-up in the present study is that children are significantly more active during certain segments of the day. Lunch, PE class, and recess are times of higher activity for all children. These findings emphasize the importance of maximizing physical activity during these discrete time points. Dale et al. [35] found that third and fourth grade children did not compensate for a day of restricted physical activity at school; they were significantly more active outside of school on an active day as compared to a day of restricted activity. The children in the Pathways study (and in schools across the United States) are relatively inactive during school outside of PE, lunch, and recess time, and may not have regular opportunities to compensate for these low levels of physical activity outside of school. Thus, it is critical that schools require and provide daily opportunities to increase physical activity and subsequent energy expenditure in an attempt to reduce the risk of obesity.

In conclusion, the Pathways physical activity intervention did not result in significant increases in physical activity as measured by the Tritrac accelerometer, although there was a trend for increased physical activity in the intervention schools for three of the four study sites, and a potentially important overall difference of ~10% between intervention and control schools. High variability in AVM across sites and time intervals, the opportunity to measure physical activity on only 1 day, and a greater activity at follow-up in controls schools at one site contributed to our failure to detect the overall difference between Pathways intervention and control schools as significant. While Pathways showed the use of Tritrac in a large-scale intervention to measure physical activity is feasible, more refinement of the protocol with this methodology is necessary to ensure that potentially important changes in physical activity can be detected.

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