School day classroom-based physical activity and sedentary behavior

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Abstract

Objectives: Many school-aged children do not meet the daily minimum recommendations for accruing moderate to vigorous physical activity (MVPA), and spend much of their day sedentary. The purpose of this study was to investigate the effects of teacher-delivered classroom-based physical activity (CBPA) on students' MVPA and sedentary behaviors. **Methods:** Participants included 157 students across seven classrooms and 500 student-days of observation. Students wore accelerometers for one week during fall of 2017, and teachers recorded their CBPA offerings daily. Minutes of scheduled recess and physical education (PE) were also recorded. **Results:** Overall, students spent the majority of the school day engaged in sedentary behavior, and accrued an average of 20 and 28 minutes of MVPA on non-PE and PE days, respectively. Students did not engage in lengthy bouts of sedentary behavior, and spent approximately 30 minutes each day in sedentary bouts. Mixed effects regressions revealed that offering any CBPA was associated with greater percent time in MVPA and less in sedentary behavior. **Conclusions**: CBPA is an important contributor to the 30 minutes of school day MVPA that students should accrue, especially since PE and recess are often not sufficient.

Key words: classroom, community health, physical activity, school health, sedentary behavior

In recent years, technological advances have made engaging in obesogenic behaviors easier than ever. Among these, sedentary behaviors—activities which elicit energy expenditures ≤ 1.5 metabolic equivalents, such as sitting, reclining, or lying[1]—increase the risk of all-cause mortality in adults, independent of engagement in physical activity.[2,3] Research examining the outcomes and determinants of sedentary behavior in children is still emerging;[4] however, preliminary evidence has linked higher levels of sedentary behaviors to health risks such as increased BMI, [5] and in some cases, such as sedentary TV viewing, to higher overall cardiometabolic risk scores.[6] In addition to the risks of total minutes spent sedentary, the duration of time spent sedentary within a specific period – such as in shorter versus longer bouts – may also moderate its effects on children's health.[7] One study has shown adverse health outcomes are more prevalent among youth who tend to spend sedentary time in 10-14 minute bouts versus those who engage in 1-4 minute bouts with more frequent breaks.[7] Recent evidence in college-aged students also shows an inverse relationship between sedentary bouts and academic achievement.[8]

School environments, where the majority of children spend a large portion of their waking hours for most of the year, can at times be a child's sole venue to access safe opportunities to be physically active during the day. However, schools can also unintentionally promote sedentary behaviors, as many classrooms utilize desks or tables and chairs for student seating, and rely on traditional seated lesson formats for instruction. Though there are no recommendations for limiting sedentary behaviors, such as sitting, during the school day, it is suggested that at least 30 of the 60 minutes of children's daily moderate to vigorous physical activity (MPVA) be accrued during regular school hours.[9] On days that children attend physical education (PE) at school, they often come closer to accruing the recommended minutes of

MVPA than on non-PE days.[10,11] However, on other days, the PA opportunities for elementary school students are more limited. Providing classroom-based physical activity (CBPA) is a promising strategy for increasing children's movement during the school day,[12–14] as well as potentially decreasing sedentary time.

CBPA can occur in different ways; it may involve a break from instruction where children stand up and move, or it can be integrated into an academic lesson. Though CBPA is not yet regularly utilized in the majority of classrooms in the US,[15] teachers who do implement CBPA generally embrace the practice.[16] Teachers report that CBPA improves student behavior, and students enjoy it.[16,17] Indeed, CBPA can improve students' on-task behavior,[18,19] and there is some evidence for the benefits of PA for cognitive function and academic outcomes.[20,21] Research relating the use of CBPA to student-level PA outcomes is limited. While accelerometry studies of the segmented school day have shown that elementary school students do accrue some MVPA during instructional time,[10,22] few studies have accounted for the amount of CBPA offered to students,[13] and none have examined how CBPA may affect sedentary behaviors during school.

To best serve student health and learning in line with the Whole School, Whole Community, Whole Child (WSSC) model,[23] schools can provide opportunities for students to be physically active, and also reduce sedentary behaviors. Characterizing when and how children engage in PA and sedentary behaviors throughout the school day is needed to fully understand how the school environment may affect health, and in turn to provide recommendations for policies. The present study utilizes ActiGraph accelerometry to examine the associations between CBPA opportunities, physical activity, and sedentary behaviors across the school day, as well as within segmented blocks of instructional time. It was hypothesized that offering CBPA

would increase MVPA and light physical activity (LPA), decrease time spent in sedentary behavior, and reduce both the number and length of bouts of sedentary behavior.

METHODS

Participants

Seven classes across four elementary schools in Southwestern Idaho participated in the study. Within the seven classes, 157 students in grades 2-4 participated in the accelerometer data collection. The data collection occurred over seven weeks during September and October 2017. Teachers were recruited for participation during a start-of-year professional development regarding the benefits of CBPA and support for CBPA implementation.

Procedure

School master calendar data (used to tabulate PE and recess minutes) and teacher-logged CBPA data were collected for each week of measurement to account for students' exposure to PA opportunities. Teachers were provided a booklet with each date, and blank fields for each day including start time, total activity time, and activity description. Teachers recorded their CBPA offerings on these pages and returned them to research staff at the end of the data collection week. A waist-worn ActiGraph GT3X-BT model accelerometer (Pensacola, FL) was used to capture each participant's LPA, MVPA, and sedentary behaviors. Participants wore the accelerometer on an elastic belt with the device positioned at their right hip. Research staff trained teachers on how to instruct placement and how to monitor students' wear of the accelerometer belts, and teachers distributed and collected the accelerometers at the beginning and end of each school day. Accelerometers were initialized to measure vertical, horizontal, and perpendicular axes at a frequency of 30 Hz.

Data Analysis

Vertical axis data were downloaded in 15 second epochs using the normal filter in ActiLife version 6.13.3. Non-wear time was defined as a period of 60 minutes with consecutive zero counts, allowing for up to two minutes of non-zero counts.[24] Sedentary behavior was defined as all minutes with 0-100 counts per minute (cpm), LPA as 101-2,295 cpm, and MVPA as ≥2,296 cpm.[25] A sedentary bout was defined as continuous counts <100 for 10 or more minutes. Sedentary bouts of 20 or more minutes were also calculated.

Filters were generated within the ActiLife software to ensure that only regular school day activity was assessed, and any wear time attributable to before/after school was omitted. Cases with less than 90% of school day wear time were excluded from further analysis. In addition to full-day filters, block filters were created to capture activity during periods of instruction ≥ 60 minutes. Block timing was based on school calendar information, and several core subjects (math, reading, and writing) occurred within most blocks. The blocks were selected as extended periods of time where students did not transition out of the main classroom for recess, specials, or lunch. Blocks of instruction lasting less than 60 minutes long were not included in the filters.

Descriptive statistics were used to summarize participant demographics. Univariate statistics were used to examine differences in sedentary behaviors (including total minutes and bout characteristics), LPA, and MVPA across grade and sex for PE and non-PE days. For analyses of average and maximum length of sedentary bouts across the full school day, only 367 participant-days were included because not all participants accrued 10 or more minutes of consecutive sedentary activity during all school days (and zeros are not included in the ActiLife calculations). Pearson chi-square was used to examine the likelihood of CBPA usage relative to the length of instructional block and time of day. The mixed function in Stata was used to calculate mixed effects regression models, nesting observations within participant, instructional

block, and teacher. For these models, effects of CBPA minutes on various PA and sedentary behavior outcomes were estimated, while covarying for grade and sex. All statistical analyses were performed using SPSS version 23 (IBM, Armonk, NY) and Stata/IC 13.0 (StataCorp, College Station, TX).

RESULTS

Summary of CBPA opportunities and instructional blocks

Demographic characteristics of the sample are listed in **Table 1**. PE was provided once per week for 30 minutes for six of the seven teachers, while one teacher had two PE days during the measurement week. Recess was provided twice (lunch recess plus one additional recess), totaling 35 minutes each day. Minutes of CBPA offered ranged from 0 to 20 minutes per day, with an average of 6.7 (SD = 6.0) minutes across all measurement days (N = 34), and 7.2 (SD = 4.8) minutes across days when any CBPA was offered (N = 26). The number of activities offered per day ranged from 0 to 3, with an average of 1.3 (SD = 0.9) activities offered across all measurement days and an average of 1.6 (SD = 0.7) activities on days when any CBPA was offered. Teachers used a variety of CBPA sources, including Energizers,[26,27] GoNoodle videos, and self-created activities such as walking to music, and acting out vocabulary words.

[place Table 1 near here]

Across the 34 days of measurement, 54 blocks of classroom instruction lasting at least 60 minutes were identified. The median instructional block length was 90 minutes, and the upper threshold was 155 minutes. A Pearson chi-square analysis utilizing a median split of the instructional blocks revealed that CBPA was more likely to be offered during blocks of instructional time lasting longer than 90 minutes than during instructional blocks lasting less than 90 minutes ($\chi^2 = 7.2$, $p < .05$; **Table 2**). Additionally, a Pearson chi square analysis examining

timing of instructional blocks (morning versus afternoon) showed that teachers were more likely to provide CBPA in the morning than the afternoon ($\chi^2 = 4.2$, $p < 0.05$; **Table 2**).

[place Table 2 near here]

Relationships between measured PA and sedentary behaviors and school-day PA offerings

Comparisons of unadjusted mean minutes of sedentary behavior, LPA, MVPA, and sedentary bouts ≥ 10 minutes over the full school day (M = 385 minutes, SD = 11 minutes) on both PE days and non-PE days are presented in **Table 3**. In addition to overall activity levels, comparisons between sex and grade-level groups on PE and non-PA days are provided. Results from all mixed effects regression models estimating the effects of CBPA on percent time engaged in LPA, MVPA, and sedentary behavior during blocks of instructional time ≥60 minutes are presented in **Figure 1**. These results depict the model-adjusted marginal means for each outcome; models accounted for grade and sex, as well as nested data. Within blocks that teachers used any CBPA, percent sedentary time was reduced and MVPA increased, while LPA was not significantly impacted. Sedentary bouts ≥ 10 minutes and ≥ 20 minutes were not significantly impacted by CBPA use.

[place Table 3 near here]

[place Figure 1 near here]

DISCUSSION

In line with previous work,[10,22,28] students in this study spent more than half of their school day engaged in sedentary behavior. Furthermore, students did not accrue the suggested 30 minutes of MVPA during school, even on days when PE was provided, and despite the provision of CBPA on most days. Other work has found that children accrue anywhere from 20 to 63[10,22,29] minutes of MVPA during school, without any targeted PA-promoting intervention. The lower

MVPA minutes seen in the current work may be partially explained by the fact that schools offered only 30 minutes of PE per week. It has also been shown that recess, which was provided daily for all students in this sample, does not consistently engage students in health-enhancing PA,[30,31] and has demonstrated disparities in its PA benefits, often engaging boys more effectively than girls.[22,31,32]

Teachers in this study implemented CBPA within the context of their own classrooms, without explicit direction from the research team aside from the initial professional development session. Teachers used CBPA in accordance with their students' needs, and their tracking logs indicated that most were able to use some CBPA, and use it on a regular basis. This is evidenced by the fact that the difference between CBPA minutes on days when teachers used any CBPA versus all measurement days, including days when no CBPA was used, was only 0.5 minutes. Teachers in this study more frequently used CBPA during instructional blocks of at least 90 minutes versus blocks lasting less than 90 minutes, and also provided CBPA in the morning more frequently than the afternoon – which is perhaps explained by the fact that all but one teacher had afternoon recess. These results show that while teachers do find it feasible to implement some CBPA, many struggle to provide an amount that aligns with the current recommendation of 10 minutes per day.[33] Many barriers to the provision of CBPA have been previously reported, the most common among them being lack of time.[16,17,34]

On days when teachers provided CBPA, students accrued slightly more MVPA, and spent less instructional time engaged in sedentary behavior. Though the absolute numbers for the increase in MVPA and decrease in sedentary behavior were small in magnitude, they suggest that teachers' usage of any CBPA (regardless of meeting guidelines for dose) not only got students out of their seats, but also helped them accrue some minutes of health-enhancing PA.

Previous work has shown that CBPA interventions are related to increased student step counts and MVPA during school, which supports these findings.[12–14,35] Thus, CBPA seems to be an important contributor to students' PA opportunities during the school day, and may be even more crucial to provide when weekly PE time is limited.

Students in this study did not engage in very many long bouts of sedentary behavior. Accordingly, CBPA use was not associated with number or length of sedentary bouts. This is not entirely surprising, as it is developmentally appropriate for pre-adolescent children to move frequently, and avoid staying stationary for long periods.[36] On average, students accrued about two sedentary bouts (lasting at least 10 minutes) over the course of their school day. To our knowledge, only one other study has reported on bouts of sedentary time over the school day, and in that study, number of bouts was not reported.[37] However, recent work found that elementary school-aged children engaged in an average of 12.8 sedentary bouts of at least ten minutes over the course of a whole day.[38] Together with evidence from our study, this may suggest that children participate in more long bouts of sedentary behavior outside of school than during school.[38] This idea – that school environments may promote more healthy behaviors than home – is supported by the structured days hypothesis, recently proposed by Brazendale and colleagues, showing that children and youth are more likely to engage in obesogenic behaviors outside of school time rather than on school days.[39]

The American Academy of Pediatrics recently issued specific guidelines suggesting a two-hour daily limit on sedentary screen time for school-aged children.[40] A similar recommendation was issued by the US Department of Health and Human Services in 2008, stating that children should spend less than 2 hours per day in screen time viewing (a proxy for sedentary behavior), during leisure time.[41] However, there are currently no recommendations

regarding limits to the length of time children (or adults) spend in individual sedentary bouts. This study contributes to the greater base of knowledge regarding patterns of sedentary behavior and PA in children, which may help inform future school wellness or public health policies regarding sedentary behavior.

Limitations

The parameters used to score accelerometer data influence the resulting estimates of physical activity and sedentary behavior. The authors acknowledge that the wear time and scoring parameters applied to the data in this study could have led to different estimations of sedentary time than alternative analysis approaches, such as using a threshold of 40 minutes of consecutive zero counts to define non-wear, or using a cut point of 150 counts per minute to score sedentary behavior.[42,43] However, our analytic decisions are consistent with many previous studies on PA and sedentary behavior in children,[44] and thus increase the comparability of this study's outcomes with other work.

Conclusions

This study provides evidence that CBPA, as well as PE, can positively impact students' MVPA and sedentary behavior during the school day. However, this study did not demonstrate that use of CBPA was related to bouts of sedentary time, which can occur during lengthy instructional blocks, and are more frequent among older students. Taken holistically, this work supports the notion that no single PA-promoting strategy results in adequate opportunities for elementary school students to be physically active during the school day, and further supports the notion that a whole-of school approach is needed to provide students with adequate PA opportunities.[45] Further investigation into factors influencing sedentary behaviors throughout the day (including during and outside of school) is warranted, given that a small reduction in

sedentary bouts, or overall sedentary time, could decrease health risk.[6,7] Future work should examine the long term effects of school-wide PA interventions on patterns of PA and sedentary behavior, as well as student health outcomes.

IMPLICATIONS FOR HEALTH BEHAVIOR OR POLICY

Healthy People 2020[46] Objective NWS-10 is to reduce the prevalence of childhood and adolescent obesity. Schools can play an active role in mitigating childhood obesity by increasing physical activity opportunities and reducing sedentary behavior opportunities for students. Classroom based physical activity has the potential to help elementary school students reduce their unhealthy sitting time as well as meet daily physical activity goals. Creating policies at the state, district, or school level to require minutes of CBPA per day is an important step for schools to set goals surrounding school day PA. Many materials which can aid in the implementation of CBPA, such as Energizers and GoNoodle (used in the current study) are freely accessible online. These materials can be shared to staff at school-wide trainings, or through emails and newsletters. School staff can also show their support for student health behaviors, such as CBPA, in the following ways:

- Administrators can encourage teachers to use CBPA materials available online, and reinforce the value of CBPA during teaching evaluations and other in-person meetings.
- Administrators can program “brain breaks” or other activities on school-wide schedules.
- Both teachers and administrators can spread knowledge regarding the benefits of physical activity to their students’ families through email contact and in-person meetings and with parents. Doing so will reinforce that physical activity is an important health behavior that children should engage in during their school day as well as their time outside of school.

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Human Subjects Approval Statement

This study was approved by the Institutional Review Board at Boise State University under protocol number 101-SB15-180. Teachers gave consent for data collection to occur in their classroom, and to provide weekly logs of their CBPA usage. No student identifying data, aside from grade level and sex, was collected. Students were allowed to opt out of wearing the accelerometer if they chose to (none did so).

Conflict of Interest Disclosure Statement

All authors of this article declare they have no conflicts of interest.

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Tables

Table 1
Characteristics of daily observations (N = 500) from 157 unique students

	Percentage	Number
Grade level		
Second	28.7	45
Third	29.9	47
Fourth	41.4	65
Sex		
Female	49.7	78
Male	50.3	79
Number of cases from each school		
School A (2 teachers)	30.8	154
School B (2 teachers)	25.6	128
School C (1 teacher)	14.4	64
School D (2 teachers)	29.2	146

Table 2

Use of CBPA in longer versus shorter instructional blocks and before vs after lunch

	Length of block		Time of day	
	< 90 min	> 90 min	morning	afternoon
Blocks with no CBPA	23	11	14	20
Blocks with any CBPA	6	14	14	6
Pearson Chi-Square		7.2*		4.2*

Note: Instructional blocks ranged from 60-155 minutes; median block length 90 minutes

Six out of seven teachers had afternoon recess (44/54 blocks)

*$p < 0.05$

Table 3

Unadjusted mean minutes of school day physical activity and sedentary behaviors on non-PE/PE days

	Minutes in activity			Characteristics of sedentary bouts ≥ 10 minutes			
	SED	LPA	MVPA	Number	Average length (min)	Max length (min)	Time in bouts (min)
On non-PE days (N = 377 cases)							
Overall	234.09	124.13	20.73	2.38	15.77	20.74	38.08
Sex							
Males	232.42	123.10	22.36	2.43	15.66	20.56	38.36
Females	235.73	125.14	19.13*	2.32	15.87	20.94	37.80
Grade							
2	226.99	138.43	17.61	1.69	13.13	15.20	22.65
3	221.71	142.91	23.51*[a]	1.82	14.04	17.03	26.92
4	248.20*[b]	100.02*[b]	21.14*[b]	3.29*[b]	18.19*[b]	25.83*[b]	57.66*[b]
On PE days (N = 123 cases)							
Overall	217.41	134.14	28.05	1.61	13.91	16.77	23.11
Sex							
Males	214.97	134.15	30.64	1.36	14.53	17.42	20.43
Females	219.66	134.13	25.67*	1.84	13.47	16.31	25.58
Grade							
2	219.80	137.31	24.86	1.41	14.25	16.89	20.83

3	207.77*[c]	145.77	34.09*[d]	1.50	13.07	15.20	20.38
4	225.52	117.16*[b]	28.05	1.97	14.45	18.34	23.11

Note. Mean school day length = 385 minutes; standard deviation = 11 minutes

PE = physical education, LPA = light physical activity, MVPA = moderate to vigorous physical activity, SED = sedentary behavior

*p = .05

[a] Grade 2 significantly different from grade 3

[b] Grade 4 significantly different from grades 2 and 3

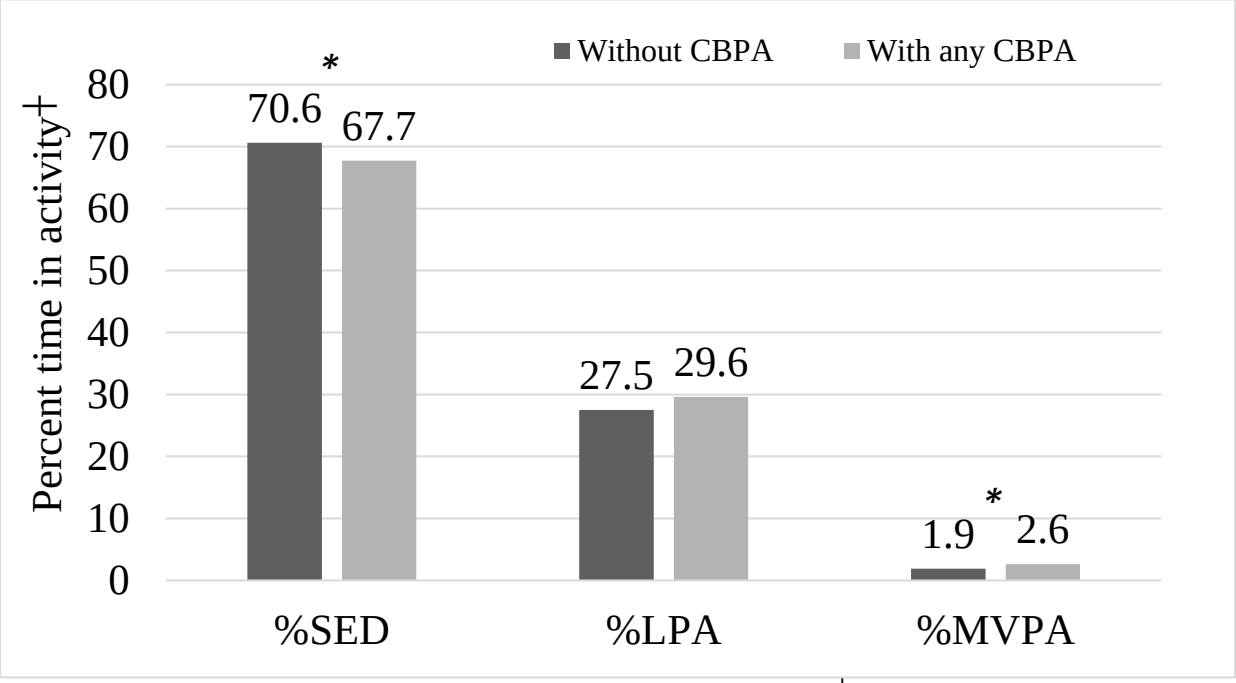
[c] Grade 3 significantly different from grade 4

[d] Grade 3 significantly different from grades 2 and 4

Figures

Figure 1

Percent time engaged in sedentary behavior and physical activity across instructional blocks ≥ 60 minutes with and without CBPA



Note. Instructional blocks ranged from 60-155 minutes. *p < .05 †model adjusted margins