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Investigating Elementary School Children's Daily Physical Activity and Sedentary Behaviors during Weekdays

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Abstract

Purpose—The purpose of the study was to quantify the contributions of physical education, exergaming (active video games that also are a type of exercise), recess, lunch break and after-school time segments to children's daily physical activity and sedentary behaviors.

Methods—Participants were 138 second and third graders (71 girls) who attended 20-minute recess and 75-minute lunch time daily, 25-minute regular physical education or exergaming-based classes being alternated daily. The after-school period was defined as 3:20-10:00pm. Physical activity was assessed via accelerometry and the dependent variables were children's time spent in moderate-to-vigorous physical activity (MVPA), light physical activity, and sedentary behavior.

Results—Children's percentages of time spent in MVPA ($p < .001$; except for the difference between exergaming and lunch break: $p = .63$), light physical activity ($p < .001$), and sedentary behavior ($p < .001$) differed significantly across the time segments (i.e., physical education/exergaming, recess, lunch break, and after-school). Additionally, children accumulated significantly more MVPA ($t = 10.22$, $p < .001$) but less light physical activity ($t = -3.17$, $p = .002$) and sedentary behavior ($t = -3.91$, $p < .001$) in physical education than in exergaming.

Conclusions—Overall, physical education was more effective in generating MVPA than other segments over the school day. The after-school segment holds potential as an avenue for promoting children's MVPA, as this long period could be better utilized to organize structured physical activity.

Keywords

childhood obesity; light physical activity; moderate-to-vigorous physical activity; school-based physical activity programs

Physical inactivity among children is a major contributing factor for the increasing childhood obesity in the U.S. in the past decades (Ogden, Carroll, Curtin, Lamb, & Flegal, 2010; Skinner & Skelton, 2014). The obesity epidemic remains a public health concern to the nation as it is related to cardiovascular and other chronic diseases in children and adults (Magnusson, Hrafnkelsson, Sigurgeirsson, Johannsson, & Sveinsson, 2012; McManus & Mellecker, 2012). To promote health and reduce childhood obesity, health professionals need to increase children's physical activity participation and decrease their sedentary behavior. Unfortunately, evidence suggests that only 42 % of the U.S. children ages 6-11 years participate in 60-minute moderate-to-vigorous physical activity (MVPA) recommended by various organizations for optimal health and reduced obesity risk (Troiano et al., 2008). Meanwhile, many children spend longer time in sedentary behaviors (about 6.1 hours) on a daily basis (Pate, Mitchell, Byun, & Dowda, 2011) than recommended sedentary time of no more than two hours a day spent in electronic media for entertainment (Australian Government Department of Health, 2015). As nearly 95% of children in the U.S. attend schools, school-based physical activity programs are common environments where children can accumulate time being physically active (Naylor & McKay, 2009). Moreover, after-school is another critical time for physical activity opportunities. This study was designed to compare the physical activity behaviors in different segments within a school-based setting and in after-school leisure time with the goal of better understanding regular physical activity and sedentary behaviors in children's daily life.

Physical education is a primary venue for physical activity promotion for children at schools (Baranowski et al., 1997; Pate et al., 2006). Researchers recommended that physical education should promote engagement in MVPA for more than 50% of class time (Sallis et al., 2012; Stratton, Fairclough, & Ridgers, 2008). However, given the multiple learning outcomes of physical education, this recommendation is rarely met nationwide. Alternatively, comprehensive school physical activity programs have gained popularity for promoting youth physical activity (Institute of Medicine, 2013; Centers for Disease Control and Prevention, n.d.; Sallis et al., 2012). Children are often afforded the opportunity to be active outside of physical education. For instance, most schools allot recess for children to participate in leisure activities and free play during the school day. However, similar to physical education, on average children generally spend less than 50% of their recess time (including regular recess and lunch break) in MVPA (Fairclough, Beighle, Erwin, & Ridgers, 2012; Ridgers, Salmon, Parrish, Stanley, & Okely, 2012; Ridgers, Stratton, Fairclough, & Twisk, 2007a, 2007b).

Recently, exergaming has been integrated into many schools as a supplement to enable students to increase physical activity either in or beyond physical education classes (Gao, Chen, Pasco, & Pope, 2015). Exergaming refers to active video games that also are a type of exercise; and it attracts children for active participation due to its fun and motivating nature

(Gao & Chen, 2014; Gao, Hannan, Xiang, Stodden, & Valdez, 2013; Gao, Zhang, & Stodden, 2013). Systematic evidence has identified that exergaming reduces children's sedentary behaviors, while certain types of exergames (e.g., Dance Dance Revolution) can be as physically active as conventional MVPA activities such as jogging or brisk walking (Gao & Chen, 2014).

Outside of school, children have the opportunity to participate in a variety of activities, which include but are not limited to typical after-school programs (i.e., a part of a school program), family activities, recreational activities, and structured inter- and intra-mural sports (Parsad & Lewis, 2009; Ross, Dowda, Colabianchi, Saunders, & Pate, 2012; Trost, Rosekranz, & Dziewaltowski, 2008). The actual time children spend on physical activity and sedentary behaviors during after-school hours has rarely been examined empirically. No known study yet has objectively quantified children's physical activity levels that include during-school (e.g., physical education, recess, and exergaming) and after-school segments. In addition, comparison of children's physical activity levels and sedentary behaviors among these segments has been recommended recently (Gao, Chen, & Stodden, 2015).

Objectively quantifying and comparing MVPA, light physical activity and sedentary time derived from physical education/exergaming, recess, lunch break, and after-school segments will help understand children's physical activity patterns in and outside of school. The present study has the potential to offer practical implications for schools and health professionals to provide appropriate and effective physical activity interventions during week days, which comprises approximately 180 days each year. The purpose of this study was to quantify children's MVPA, light physical activity and sedentary behavior in different segments of school-based and after-school physical activity programs. We hypothesized children would accumulate higher percentages in MVPA time in structured physical activity programs (physical education /exergaming) as compared to non-structured segments (i.e., recess, after-school). We also hypothesized children would accumulate the highest total MVPA during after-school segments, followed by the structured physical activity programs.

Methods

Research Design

This study employed a single-group repeated measure design. Children's MVPA, light physical activity, and sedentary behavior were measured on three physical education days and three exergaming days (with recess on each day) in 2012 - 2013. The participants were instructed to wear accelerometers for all waking hours for six full weekdays to capture physical activity in and after-school. After the distribution of accelerometers on day one, research staff individually adjusted the wearing of accelerometers for each child during his/her class starting time (7:50-8:00 am) on each data collection day. Each morning research staff also prompted children to follow the accelerometer protocols. If a child did not show up in school with her/his accelerometer worn on body, s/he was asked to wear it for an additional weekday.

Participants and the Research Setting

Participants were 138 second and third grade children enrolled in a suburban Title I elementary school (defined as schools with high numbers or high percentages of children from low-income families; U.S. Department of Education, 2016) in Western Texas. The school was selected as a convenience sample, yet it well represented the suburban schools in the area in terms of demographic characteristics such as social-economic status and race/ethnicity. The age range (7-9 years) of the participants was chosen because the complexity of exergaming and children's ability to successfully navigate and participate in the various types of exergames is appropriate for this age range. Participants were recruited from all eight 2nd and 3rd grade classes (N = 150) in the school, with a very high volunteer participation rate (92%). The average class size ranged from 17 to 22 children. Specific inclusion criteria for participation in this study were: (a) enrolled in a public Title I elementary school; (b) aged 7-9 years; and (c) without a diagnosed physical or mental disability according to school records. The study was approved by the University Institutional Review Board. Parental consent and child assent forms were obtained prior to this study.

The school required 125 minutes of weekly structured physical activity, a daily 20-minute recess and approximately 40 minutes of lunch time. According to the school's overall curriculum, the structured physical activity was organized in physical education or exergaming that was alternated each day. Physical education was taught by a certified physical education teacher and the exergaming class was led and supervised by a full-time staff member. During the data collection period, the physical education classes were engaged in a soccer unit. In a typical 25-minute physical education class, the actual time spent in the main activities was approximately 20 minutes, with approximately 5 minutes for class organization and transition. On exergaming days, students participated in the school's "Brain Gym," which included a wide variety of Wii and Xbox active videogames. A total of 12 stations were set up in the "Brain Gym" with each station equipped with 2 exergaming systems (Wii and Xbox Kinect) and a 32 inch TV. Examples of exergames at each station included, but were not limited to: Kinect Ultimate Sports, Just Dance, Wii Sports, and Wii Fit. A trained teacher supervised children during the exergaming session. Each station accommodated up to two children to play at the same time, and children rotated from one station to another station twice during each session with approximately 30 seconds to one minute of transition time. As such, all children participated in exergaming simultaneously and were able to play different activities within the allowed time. In a typical 25-minute exergaming class, the actual time spent in the exergaming activities was approximately 20 minutes.

Recess was held outside on a spacious playground that included a large multi-station playground equipment apparatus, a basketball court, and a large grass field. Recess was not structured, but was supervised by classroom teachers. The activities that children participated in during the data collection period included, but were not limited to: chasing, four square, tag, swing, sliding, jumping rope, and playing with other playground equipment. Approximately three minutes was spent lining up for recess. The lunch break was offered either in the cafeteria or the school hallway after lunch under direct supervision

of classroom teachers. Additionally, students had some classroom-based physical activities led by their respective classroom teachers at school. The form and duration of such activities varied from class to class.

Instruments

Children's daily physical activity intensity and time were measured using ActiGraph GTX3 accelerometers (Pensacola, FL), a valid and reliable device used to measure physical activity and sedentary behavior among children in free-living conditions (Lee, Macfarlane, & Cerin, 2010). Accelerometers were attached using a neoprene belt and worn at right hip. One recording day was delimited as the time frame between 8:00am-10:00pm (i.e., 14 hours) although the accelerometer was worn throughout each day during the data collection period. In this study, activity counts were set at 15-second epoch. The conventional standard for including a person's accelerometer data is 10 hours of wearing time per day (Trost et al., 2005); while we set a more stringent inclusion criterion for physical activity data as a minimum of 14 hours of wearing time per day. That is, all children wore the accelerometer at least 14 hours a day but only the time window of 8:00am -10:00pm was used for data analysis in the present study (Trost, Mciver, & Pate, 2005). Raw activity counts were interpreted using empirically established cut points that defined different intensities of physical activity (sedentary: 0-100; light PA: 101-2295; and MVPA: 2296 and above) (Evenson, Catellier, Gill, & Al, 2008). The dependent variables were children's time spent in MVPA, light physical activity, and sedentary behavior in physical education, exergaming, recess, lunch break, and after-school segments.

Of the 14 hours (8am to 10pm) when the children wore the accelerometers, the during-school period was defined as 8:00-3:19pm, whereas the after-school period was defined as 3:20-10:00pm. Data from each accelerometer were downloaded to ActiLife 6.0 for data sorting and processing. In particular, data were truncated and matched to the original time frames for each of the four segments on a daily basis. As physical education and exergaming classes were offered on alternating days, three days were allocated for physical education day and exergaming day data analysis, respectively. If a child missed a day, we conducted make-up assessment for him/her. In addition, children's body height was measured using a Seca stadiometer for height rounded in centimeters, and weight were measured with Detecto digital weight scale (Detecto, Web City, MO) rounded up in kilograms to calculate body mass index for this study (Nihiser et al., 2007).

Data Analysis

Data were imported into an SPSS document for descriptive and inferential statistical analyses. Descriptive analyses (e.g., mean, standard deviation, percentage) were conducted to capture the daily MVPA, light physical activity, and sedentary time by the targeted PA/sedentary behavior segments. Additionally, separate repeated measure analyses of covariance (ANCOVA) were conducted to examine differences in children's MVPA, light physical activity, and sedentary time across the four segments (i.e., physical education/exergaming, recess, lunch break, and after-school hours) after controlling for body mass index, age, grade, sex, and race. Both main effects (segment and day) and interaction effect (segment $\times$ day) were examined. Bonferroni multiple comparison post-hoc analyses were

conducted to determine differences between every two segments. To further determine the differences in these variables between physical education and exergaming, paired t-tests were performed. A 95% confidence interval was used for all statistical analyses ($\alpha = .05$).

Results

There were 63 second graders and 75 third graders with completed data (71 girls [51.5%]; 120 non-Hispanic White [87.0%], 16 Hispanic [11.6%], 2 African American [1.5%]; $\text{Mean}_{\text{age}} = 8.1$ years, $\text{SD} = .7$). Children's average body mass index was 18.7 (Standard Deviation = 3.6). Table 1 shows the descriptive results for children's daily MVPA time across each segment. On average, children accumulated approximately 44 and 41 minutes of MVPA on physical education days and exergaming days, respectively, weighed as 5.5 % and 5% of the total daily time (i.e., 14 hours). After-school hours contributed the most MVPA time (> 22 minutes, > 52%) of all segments. On physical education days, children accumulated the most MVPA time from after-school segment, followed by classroom-based activities, physical education class, lunch break, and recess. In addition, children spent 26.1% of the total physical education class time, 12.3% of recess time, 6% of after-school time and 4.5% of lunch break time in MVPA during each segment (See Table 1). On exergaming days, after-school segment again contributed the most MVPA time, followed by classroom-based activities, lunch break, exergaming, and recess. Also, children spent 15.9%, 12.2%, 5.2%, and 5.8% of their total exergaming class time, recess time, after-school time and lunch break time in MVPA during each segment, respectively.

Table 1 also shows the children's time spent in light physical activity across the four segments on physical education days and on exergaming days. Specifically, the children accumulated approximately 245 and 250 minutes of daily light physical activity on physical education days and exergaming days, respectively, weighting 29.1% and 29.8% of the total daily time. After-school hours contributed the most light physical activity time (>100 minutes, ~40%) and recess the least (< 9 minutes, ~3%).

Interestingly, as shown in Table 1, children were sedentary for approximately 504 and 527 minutes per day on physical education days and exergaming days, respectively, each accounting for 60% and 63% of the total daily time. Again, after-school hours contributed the most sedentary time (>254 minutes, >50%) and physical education /exergaming the least.

Repeated measure ANCOVAs revealed significant effect for segment. Children's MVPA time on physical education days was significantly different across the segments (*Wilk's Lambda* = .86, $F = 7.08$, $p < .01$) after controlling for BMI, age, grade, sex, and race. Specifically, the rank of MVPA time from the most to the least is: after-school, classroom-based activities, physical education class, lunch break, and recess. MVPA time on exergaming days was statistically different across almost all the segments ($p = .001$) except for the difference between exergaming and lunch break ($p = .63$). The rank is as below: after-school, classroom-based activities, exergaming class/ lunch break, and recess. Similarly, the results showed significantly different light physical activity time across the segments on physical education days and exergaming days ($ps < .001$) after controlling for

the covariates. Additionally, there were significant differences across the segments for sedentary time on physical education days and exergaming days ($p < .001$) after controlling for the covariates. Lastly, t-tests demonstrated children accumulated significantly more MVPA time ($t = 10.22, p < .001$) but less light physical activity ($t = -3.17, p = .002$) and sedentary time ($t = -3.91, p < .001$) in physical education than they did in exergaming.

Discussions

This study quantified young children's MVPA, light physical activity and sedentary behaviors in and after-school on weekdays. An important finding was that the children averaged 41.03 to 43.50 minute daily MVPA on either physical education days or exergaming days. This was unfortunate given the opportunities for MVPA provided at school. For instance, the 25-minute exergaming session was structured to purposefully increase students' physical activity time. The children generated 3.66 minutes MVPA and approximate 12 minutes light physical activity from exergaming. This finding indicates that exergaming mainly provided light physical activity. The amount of MVPA minutes derived from other school-based segments (14.4 to 14.6 minutes/day) were moderate. Overall, the children's actual total minutes spent in MVPA were not sufficient (<60 minutes per day), although school indeed offered reasonable amount of structured physical activity, recess and lunch break on a daily basis (i.e., 85 minutes). In fact, the children failed to accumulate even half of recommended daily MVPA (i.e., 60 minutes) at school. This finding points out the need to organize and implement these school-based programs more effectively to fully engage students and increase their physical activity levels. That is, the time allotted to these programs needs to be better utilized through more effective programing (Institute of Medicine, 2013; Centers for Disease Control and Prevention, n.d.). For example, the loss of time in children's physical activity participation because of class management and activity transition for the young children can be remedied through better planning and organization by the teachers.

A scrutiny on the school-based physical activity programs showed these programs yielded different relative percentage time in MVPA. Specifically, physical education demonstrated the highest percentage time in MVPA, followed by exergaming, recess, after-school, and lunch break. This finding supports that the more structured programs (i.e., physical education /exergaming) are evident to be better in providing relative percentage time in MVPA than the unstructured or less-structured programs (i.e., recess, lunch break, after-school). Similarly, results on sedentary data further substantiated that children demonstrated the least absolute sedentary time (in minutes) and lowest relative sedentary time (in percentage) in physical education and exergaming sessions as compared to other segments. Collectively, the findings pinpoint the need for intentionally improving programing in the less structured programs to increase MVPA and decrease sedentary behaviors. Recently, researchers have recommended appropriate strategies to promote MVPA among young children of this age group. In particular, Gao and colleagues suggested arranging eligible staff (e.g., trained PA leaders) to lead children's activities during recess will not only enhance students' overall participation experiences, but also promote MVPA time and decrease sedentary time (Gao, Chen, & Stodden, 2015). Other strategies such as redesigning school's playground environments (e.g., drawing multicolor markings, adding physical

structures) also are noted to be effective in promoting students' physical activity participation (Ridgers et al., 2007b).

The children accumulated more than half of their daily MVPA time after-school. This pinpoints the potential use of the prolonged after-school time to promote youth physical activity. However, children in the present study were only able to obtain approximately 22-minutes MVPA from after-school time (400 minutes/day). In fact, they had more time in sedentary during after-school segment. Our data showed children spent, on average, over 250 minutes on sedentary behaviors during the after-school period.

In addition, the children also showed 245-250 minutes of light physical activity per day, a significant proportion of which was acquired from after-school hours. Although light physical activity is not as beneficial as MVPA, it is associated with physical health and well-being (Carson et al., 2013). Furthermore, with increased structuring and staff guidance, children may be able to convert some of these light physical activity time into MVPA, which will increase their likelihood of meeting the national physical activity guidelines. Thus, teachers, administrators, parents, and community leaders should continue their efforts to provide more effective opportunities for children to be physically active both in school and after-school. Research studies have been focused on the effect of after-school based programs on physical activity promotion (Pate & O'Neill, 2009); but little evidence is available to inform about the activity pattern and time beyond those structured programs during after-school hours.

It is also noteworthy that children's total daily sedentary time was at least 6.4 hours per day. This amount of sedentary time exceeded the national average of 6.1 hours/day for children 6-11 years old based on the National Health and Nutrition Examination Survey (Matthews et al., 2008). As emerging evidence demonstrates the independent detrimental effect of sedentary behavior on health (Pate et al., 2011) beyond the risk derived from inadequate MVPA, more effort should be devoted to the reduction of sedentary time and promote MVPA to lower children's health risks.

Conclusion

In summary, the quantitative comparison of children's MVPA, light physical activity, and sedentary behavior across the four different segments in and after-school enabled us to assess their corresponding contributions to physical activity and sedentary guidelines (Australian Government Department of Health, 2015; U.S. Department of Health and Human Services, 2012). The after-school segment was identified as the primary segment for MVPA, light physical activity, and sedentary time, mostly due to its longer duration as a time period. However, the more structured programs (i.e., physical education/exergaming) showed higher relative percentages of MVPA time and lower relative percentages of sedentary time in comparison to the less structured segments. Unfortunately, the time allotted to these programs is limited during the school day.

This study is not without limitations and as such, the findings should be interpreted with caution. First, the participants were sampled from only one school, which limits the

generalizability of the findings. Accordingly, a larger sample of multiple school sites and a broader age-range of children should be targeted in future research. Second, we used aggregate data (i.e., average data) to make inference rather than breaking down the sample into children who met or did not meet the 60-minute daily MVPA recommendation for analysis. Future study may investigate the differences between the most active and least active children to offer appropriate interventions in promoting the least active children's physical activity. In addition, soccer was the singular content being taught in physical education classes during the time period of data collection in the present study. Various contents might have promoted different effects on children's physical activity levels in physical education (Gao, Hannon, Newton, & Huang, 2011). Thus, future studies should capture a broader range of physical education content, such as fitness aligned programming and/or other sports to investigate their potential contribution to physical activity and sedentary behavior. Additionally, we were unable to survey children's sports participation outside of school due to limited research resources. It is likely that some children participated in outside of school sports events. Future study should measure children's participation in physical activities and events outside of school to reveal more the nature of after-school physical activity. Finally, the present study only investigated children's physical activity and sedentary behavior during the weekdays. Future research should target children's physical activity and sedentary behavior on both weekdays and weekends, as their behavioral pattern may differ between these days.

Findings of this study add to the growing body of literature on the roles of different school-based physical activity programs and after-school time in influencing children's daily physical activity levels and sedentary behaviors. In addition, the following practical implications to physical and health educators are suggested: (a) A sole reliance on physical education classes for physical activity promotion in school is insufficient; (b) The after-school segment holds potential as an avenue to promoting children's MVPA; (c) Policy makers and administrators should more effectively implement children's time in structured PA programs at schools to promote MVPA and decrease sedentary time; and (d) Professionals should give special attention to innovative PA promotion activities like exergaming to reduce sedentary time in their physical activity programs.

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Table 1
Daily moderate-to-vigorous physical activity, light physical activity, and sedentary time (in minutes and percentages) distributions in different time segments

Time Segment	MVPA Time (%)			LPA Time (%)			SB Time (%)		
	PE Days	Exergaming Days	γ , ^a	PE Days	Exergaming Days	γ , ^a	PE Days	Exergaming Days	γ , ^a
PE/Exergaming	6.43(14.8%) ^β , ^a	3.66(8.9%) ^γ , ^a		11.22(4.6%) ^β , ^a	12.21(4.9%) ^γ , ^a		6.84(1.4%) ^β , ^a	8.30(1.6%) ^γ , ^a	
Recess	2.45(5.6%) ^b	2.49(6.1%) ^b		7.60(3.1%) ^b	8.29(3.3%) ^b		9.73(1.9%) ^b	9.64(1.8%) ^b	
Lunch break	3.36(7.7%) ^c	4.06(9.9%) ^a		26.78(10.9%) ^c	27.69(11.1%) ^c		46.16(9.2%) ^c	47.09(8.9%) ^c	
After-School	22.68(52.1%) ^d	22.72(55.4%) ^d		100.91(41.2%) ^d	103.83(41.5%) ^d		254.17(50.4%) ^d	263.79(50.0%) ^d	
Classroom activities	8.59(19.7%) ^e	8.09(19.7%) ^e		98.30(40.2%) ^e	98.34(39.3%) ^e		187.03(37.1%) ^e	198.43(37.6%) ^e	
Total	43.50(100%)	41.03(100%)		244.81(100%)	250.37(100%)		503.94(100%)	527.26(100%)	

Note. MVPA: moderate-to-vigorous physical activity; LPA: light physical activity; SB: sedentary behavior; PE: physical education; Other: classroom-based activities. The numbers in the parentheses represent the percentages of time in different categories. Time: in minutes.

β γ : there are significant differences between these two segments

a,b,c,d,e: there are significant differences between the segments