

Original article

# Impact of exergaming on young children's school day energy expenditure and moderate-to-vigorous physical activity levels

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## Abstract

**Background:** Although emerging research is demonstrating the potential health impact of exergaming, investigations have primarily been conducted in laboratory settings among small samples with short-term interventions. Information on the effectiveness of exergaming in underserved children's objective physical activity (PA) in population-based settings is also scarce. Moreover, most empirical studies have only included 1 type of exergame in the intervention. Therefore, this study's purpose was to investigate the long-term impact of a multigame exergaming intervention among underserved children integrated within school curricula. Specifically, this study examined the effect of exergaming on children's accelerometer-determined sedentary behavior (SB), light PA, moderate-to-vigorous PA (MVPA), and energy expenditure (EE) over 2 years as compared with regular physical education (PE) classes.

**Methods:** A total of 261 second- and third-grade children (134 girls, 127 boys; mean age 8.27 years) were recruited from 2 Texas elementary schools. Children's pre-test 3-day SB, light PA, MVPA, and EE at school were assessed in the fall of 2012. Participants were assigned to 1 of 2 groups: (1) exergaming/PE group (125 min weekly of exergaming-based PA program) and (2) comparison group (125 min weekly of PE). PA (SB, light PA, and MVPA) and EE outcome variables were assessed again in 2013 (post-test) and 2014 (follow-up).

**Results:** Significant time effects were observed for SB ( $F(1, 162) = 25.0, p < 0.01, \eta^2 = 0.14$ ), light PA ( $F(1, 162) = 9.6, p < 0.01, \eta^2 = 0.06$ ), and MVPA ( $F(1, 162) = 6.2, p = 0.01, \eta^2 = 0.04$ ) but not for EE ( $F(1, 162) = 0.63, p > 0.05, \eta^2 = 0.004$ ). Subsequent pairwise comparisons revealed significant increases from pre- to post-test for light PA ( $p < 0.01$ ), MVPA ( $p < 0.01$ ), and EE ( $p = 0.02$ ) with no changes in SB ( $p > 0.05$ ). Conversely, significant decreases occurred in light PA ( $p < 0.01$ ) from post-test to follow-up with no differences seen in MVPA ( $p = 0.08$ ) and EE ( $p = 0.06$ ) over the same time period. A significant increase was seen, however, for SB from post-test to follow-up.

**Conclusion:** Exergaming PE can have the same positive effect on children's light PA, MVPA, and EE as regular PE. More research is necessary to discern how to promote long-term PA participation after conclusion of the intervention.

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**Keywords:** Active video games; Childhood obesity; Light physical activity; Moderate-to-vigorous physical activity; Physical education; Sedentary behavior

## 1. Introduction

Low physical activity (PA) participation and increasing obesity trajectories of children from families of lower socioeco-

nomie status continue to be a concern in the USA.<sup>1-3</sup> In particular, underserved children have limited opportunities to engage in moderate-to-vigorous PA (MVPA), in large part because of limited availability of recreational programs and facilities, reduced quality of physical education (PE) time, and growth of sedentary leisure activities such as television viewing and playing sedentary video games.<sup>4</sup> As a result, these children are more likely to be overweight and/or obese and develop

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cardiovascular disease, diabetes, and obesity as adults.<sup>5-7</sup> Unfortunately, recent large-scale research indicated only 42% of U.S. children aged 6–11 years and 8% of adolescents participated in the recommended 60 min of MVPA per day.<sup>8</sup> Schools reach nearly 95% of children in the USA and are important venues to promote weekday PA participation. A need exists to develop and promote novel approaches to improving children's PA and health through effective and innovative school-based PA programs.

Traditional sedentary video games have been criticized for promoting children's sedentary lifestyle because of its association with high rates of childhood obesity.<sup>9</sup> Alternatively, exergaming, which refers to active video games that are also a form of exercise, has great potential to help children engage in a physically active lifestyle.<sup>10</sup> In the past decade, the fast growth of exergaming has led to the development of new interactive exercise strategies, which in turn has had an impact on the implementation of school-based PA programs.<sup>11,12</sup> Exergames have been increasingly used in public schools because they capitalize on children's interest in technology to promote PA. For example, Dance Dance Revolution (DDR) combines dancing, which involves agility, balance, and cardiorespiratory endurance, with energetic music and visuals, which capture children's interest and promote a health-enhancing level of PA for fitness.<sup>13-16</sup>

Although emerging research is demonstrating the potential health impact of exergaming, investigations in the field have primarily been conducted in laboratory settings using small samples with short-term interventions.<sup>17,18</sup> Information on the effectiveness of exergaming in underserved children's objective PA in population-based settings is also scarce. Moreover, most empirical studies have included only 1 type of exergame in the intervention.<sup>13,14,19</sup> Because evidence suggests that children are more active on days when PE is held<sup>20-23</sup> and do not compensate with increased PA on days devoid of PE,<sup>21</sup> it is imperative to find novel intervention strategies capable of increasing children's PA. Notably, researchers have long highlighted the need for these activities to be fun and developmentally appropriate—promoting long-term maintenance of regular PA behavior among youth.<sup>7,24</sup>

Therefore, the purpose of this study was to investigate the long-term impact of a multigame exergaming intervention among underserved children integrated within the children's school PE class. Specifically, this study examined the impact of exergaming on children's accelerometer-determined sedentary behavior (SB), light PA, MVPA, and energy expenditure (EE) over 2 years as compared with PE. It was hypothesized that exergaming in combination with PE would promote decreased SB and increased light PA, MVPA, and EE at least as well as traditional PE class.

## 2. Methods

### 2.1. Participants and research setting

A total of 261 second- and third-grade children (134 girls, 127 boys;  $8.27 \pm 0.70$  years) from 2 suburban schools in Texas participated in this study. Both schools were Title I schools (i.e., greater than 50% of children receive free or reduced-price school

meals), with a majority of children from low-income families. The ethnicity breakdown was as follows: 192 whites (including Latino and non-Latino), 42 native Hawaiians or other Pacific Islanders, 16 Native Americans, 7 African Americans, and 4 Asian Americans. Both schools served grades K–5 with student populations ranging from 400 to 500 and had similar curricula, quality teachers, and sociocultural environments. The schools' policy required 125 min of weekly PA and a daily 20 min recess. Because randomization of individual students was not possible owing to class assignments, a quasi-experimental research design with repeated measures was used, with 1 school purposely assigned to the intervention group because of its ability to install exergaming on site and the other to the comparison group. In the intervention school, the exergaming program was integrated into the school's overall curriculum with the school administrators' support such that exergaming and PE alternated on a daily basis for a combined total of 125 min of weekly PA. That is, children had three 25 min PE classes plus two 25 min exergaming sessions in 1 week, followed by two 25 min PE classes plus three 25 min exergaming sessions the following week. PE was taught by a certified PE teacher, and the exergaming was supervised by a full-time teacher at school. In the comparison school, children had 125 min (25 min per day) of weekly PE classes taught by 2 certified teachers. Participants were recruited from 16 classes (average of 20 per class) at the schools, with 8 classes from each school site.

This age range (7–9 years) of participants was chosen because children aged 7 or older were able to understand, perform, and enjoy all the specific exergaming activities. The specific inclusion criteria for this study were children who were (1) enrolled in a public Title I elementary school; (2) aged 7–9 years; (3) from low socioeconomic status families; (4) without a diagnosed physical or mental disability according to school records; and (5) able to provide parental consent and child assent. Inclusion eligibility was verified through school records and the demographic information sheet. The study was approved by the Texas Tech University Institutional Review Board. Parental consent and child assent were obtained from each participant prior to data collection.

Children's pre-test 3-day SB, light PA, MVPA, and EE at school was assessed in September/October 2012. Children were purposely assigned to 1 of the 2 groups with the school as the experimental unit: (1) exergaming/PE group (125 min of weekly structured PA programs, with exergaming and PE alternating daily each week) and (2) comparison group (125 min of weekly traditional PE). All children underwent identical assessment of SB, light PA, MVPA, and EE in April/May 2013 (post-test) and follow-up in April/May 2014.

### 2.2. Procedures

In the intervention school, a total of 12 stations were set up in a large classroom with each station equipped with 2 exergaming systems (Wii (Nintendo Co., Ltd., Kyoto, Japan) and Xbox Kinect (Microsoft Corp., Redmond, WA, USA)) and a television. A number of exergames were offered, including but not limited to Kinect Ultimate Sports, Just Dance, Wii Sports, and Wii Fit, allowing a variety of choices and promoting

autonomy and sustained motivation for participation throughout the duration of the intervention. A trained teacher supervised the participation of exergaming. Each station accommodated the gameplay of 2 children, who rotated stations twice during each session, allowing for a short-duration transition. All children in class had the opportunity to play exergaming simultaneously and were able to engage in different activities during the program. The PE classes at both schools were taught by certified PE teachers. All teachers adopted a conventional multiactivity curriculum during the data collection period representative of typical state and national PE programs. Congruent with the definition of a multiactivity curriculum,<sup>25</sup> different learning activity or sport units (e.g., basketball, tag games, soccer, fitness, *etc.*) were taught in rotation every 4 weeks. That is, children had approximately 8 PE learning units in 2 semesters. In typical 25 min and 50 min classes, the actual time that children spent in the main activities was approximately 20 min and 40 min, respectively.

2.3. Measures

2.3.1. Demographic and anthropometric data

Children’s demographic information (e.g., race/ethnicity, age, and gender) was obtained using a demographic information sheet completed by students, with assistance from research assistants and teachers, at each data collection time point (baseline, post-test, and follow-up). Moreover, anthropometric data (i.e., height and weight) at each time point were obtained using a seca stadiometer (seca GmbH, Hamburg, Germany) and Detecto digital weight scale (Detecto, Web City, MO, USA), with each child measured in a private room adjacent to the gym in which the PE class was held.

2.3.2. SB, Light PA, MVPA, and EE

Children’s randomly selected 3-day SB, light PA, MVPA, and EE during school were assessed using ActiGraph GTX3 accelerometers (ActiGraph, Fort Walton Beach, FL, USA). ActiGraph accelerometers have been proven to be a valid and reliable measure of PA in children in both school and free-living settings.<sup>26</sup> Children were instructed to wear the accelerometers on the right hip during school hours. Accelerometers were attached using a neoprene belt and worn by the child for an entire 3-day period during school hours.<sup>26</sup> In this study, activity counts were set at 15 s epochs. The activity counts recorded were interpreted using empirically based cut-points that define different intensities of PA (SB: 0–100; light PA: 101–2295;

MVPA: ≥2296).<sup>27</sup> Furthermore, the accelerometers also provided each child’s EE in metabolic equivalents (equivalent to 3.5 mL/kg/min of oxygen consumption) after entering age, height, weight, race/ethnicity, and gender into the ActiLife data analysis software (ActiGraph). The outcome variables were the means of the children’s school day minutes in SB, light PA, and MVPA, in addition to the children’s average school day EE.

Prior to data collection in September 2012 (pre-test), trained research staff explained the purpose of the study to the children and provided instruction on how to appropriately wear the accelerometers. Accelerometers were individually fitted for each child during homeroom before class started in the morning (7:50 a.m.–8:00 a.m.) on each data collection day. The accelerometers were collected 1 week later. All data for a class of children were collected over a 3-week period. The same procedures were repeated in May 2013 (post-test) and May 2014 (follow-up).

2.4. Data analysis

Data from each accelerometer were downloaded to ActiLife Version 6.10 for data sorting and processing. Data were truncated and matched to the wear time associated with the children’s school day (7 h 20 min; 8:00 a.m. to 3:20 p.m.), with 3 days’ worth of school-day accelerometer data used at each time point for the intervention and comparison school. Next, data were imported into an SPSS Version 22.0 (IBM Corp., Armonk, NY, USA) dataset for descriptive and inferential statistical analyses. A descriptive analysis was conducted to describe the sample characteristics. A repeated measures multivariate analysis of variance was then conducted to observe changes in the dependent variables of children’s SB, light PA, MVPA, and EE over time. The between-subject factor was group (i.e., intervention vs. comparison school), and the within-subject factor was time. The significance level was set at 0.05 for all statistical analyses, with effect sizes reported for each comparison.

3. Results

Thirty children were removed from this study from pre-test to post-test owing to transfer (*n* = 12) or missing data for SB, light PA, MVPA, or EE on more than 1 occasion (*n* = 18). Furthermore, 67 children were removed from the sample from post-test to follow-up for similar reasons. The final sample comprised 164 children. Table 1 shows the descriptive results for children’s daily mean duration, in minutes, of SB, light PA, and MVPA, as well as EE, between groups and across time.

Table 1  
Descriptive statistics of children’s daily SB, light PA, MVPA, and EE during school day (mean ± SD).

	SB			Light PA			MVPA			EE (MET)		
	Pre	Post	Follow-up	Pre	Post	Follow-up	Pre	Post	Follow-up	Pre	Post	Follow-up
Exergaming/PE group ( <i>n</i> = 85)	303.44 ± 57.83	319.91 ± 51.26**	338.21 ± 50.53	87.81 ± 31.25	91.04 ± 28.79**	72.25 ± 36.35	10.28 ± 4.33	13.19 ± 4.98**	12.69 ± 8.93	1.56 ± 0.21	1.57 ± 0.19	1.59 ± 0.56
Comparison group ( <i>n</i> = 79)	319.50 ± 50.63	307.53 ± 55.28	337.29 ± 40.70	81.52 ± 32.91	109.88 ± 41.13**	76.53 ± 33.53	10.62 ± 5.93	14.01 ± 6.32**	11.37 ± 6.01	1.52 ± 0.24	1.63 ± 0.24	1.44 ± 0.20
Whole sample ( <i>n</i> = 164)	311.18 ± 54.91	313.95 ± 53.43	337.77 ± 45.92***	84.78 ± 32.12	100.12 ± 36.41**	74.31 ± 34.98***	10.44 ± 5.15	13.59 ± 5.66**	12.05 ± 7.67*	1.54 ± 0.23	1.60 ± 0.22*	1.52 ± 0.43

\* *p* < 0.05, \*\* *p* ≤ 0.01; compared with pre-test.

# *p* < 0.01, compared with post-test.

Abbreviations: EE = energy expenditure; MET = metabolic equivalent; MVPA = moderate-to-vigorous physical activity; PA = physical activity; PE = physical education; SB = sedentary behavior.

The repeated measures multivariate analysis of variance did not reveal any group by time interactions for SB ( $F(1, 162) = 2.6, p = 0.11, \eta^2 = 0.02$ ), light PA ( $F(1, 162) = 2.5, p = 0.11, \eta^2 = 0.02$ ), MVPA ( $F(1, 162) = 1.7, p = 0.19, \eta^2 = 0.01$ ), or EE ( $F(1, 162) = 2.5, p = 0.11, \eta^2 = 0.02$ ), nor was a significant group effect found for SB ( $F(1, 162) = 0.04, p = 0.90, \eta^2 = 0.00$ ), light PA ( $F(1, 162) = 2.3, p = 0.13, \eta^2 = 0.01$ ), MVPA ( $F(1, 162) = 0.01, p = 0.9, \eta^2 = 0.00$ ), or EE ( $F(1, 162) = 2.0, p = 0.16, \eta^2 = 0.01$ ). These results suggest that integrating exergaming into school curricula acted as an effective supplement to traditional PE, with this exergaming/PE condition found to be equally effective as the traditional PE curriculum at promoting increased light PA, MVPA, and EE while demonstrating no negative effects on SB. However, a significant time effect was seen for SB ( $F(1, 162) = 25.0, p < 0.01, \eta^2 = 0.14$ ), light PA ( $F(1, 162) = 9.6, p < 0.01, \eta^2 = 0.06$ ), and MVPA ( $F(1, 162) = 6.2, p = 0.01, \eta^2 = 0.04$ ) but not for EE ( $F(1, 162) = 0.63, p = 0.43, \eta^2 = 0.004$ ).

Pairwise comparisons were then conducted to better evaluate these longitudinal time trends in study variables among the whole sample given the fact that no group effect was seen. Indeed, light PA significantly increased between pre-test and post-test ( $p < 0.01$ ; 95% confidence interval (CI): 8.04–23.55) but significantly decreased between follow-up and both post-test ( $p < 0.01, 95\%CI: -34.67$  to  $-17.47$ ) and pre-test ( $p < 0.01, 95\%CI: -18.31$  to  $-2.24$ ). Similarly, MVPA increased significantly from pre-test to post-test ( $p < 0.01, 95\%CI: 2.04$ – $4.27$ ) and to follow-up ( $p = 0.04, 95\%CI: 0.40$ – $3.13$ ) but marginally significantly decreased between post-test and follow-up ( $p = 0.08, 95\%CI: -3.27$  to  $0.12$ ).

Trends in SB and EE were more variable. Specifically, no significant change was seen in SB from pre-test to post-test ( $p > 0.05, 95\%CI: -12.12$  to  $16.61$ ), but a significant increase in SB was found between follow-up and both post-test ( $p < 0.01, 95\%CI: 11.46$ – $36.61$ ) and pre-test ( $p < 0.01, 95\%CI: 13.57$ – $38.99$ ). Finally, regarding EE, a significant increase was seen in this variable from pre-test to post-test ( $p = 0.02, 95\%CI: 0.008$ – $0.11$ ), whereas a marginally significant decrease was found overall from post-test to follow-up ( $p = 0.06, 95\%CI: -0.003$  to  $0.18$ ). No significant change, however, was seen between pre-test and follow-up for EE ( $p > 0.05, 95\%CI: -0.11$  to  $0.06$ ). The preceding results indicate that although no interaction or group effect was found for any of the study variables, the 2 PA curricula used among children in this study were capable of increasing light PA, MVPA, and EE from pre-test to post-test while not negatively affecting children's SB during this same time period.

#### 4. Discussion

Because exergaming has the potential to promote PA among children and is more often being incorporated into PE curricula given this population's interest in current technology,<sup>12</sup> it is important to investigate the long-term outcomes of exergaming interventions as well as to evaluate these interventions against traditional PE. The present study found that children in the exergaming/PE intervention accumulated significantly greater light PA and MVPA time at school ( $p < 0.01$ ) and nonsignificant

yet higher EE at post-test than was seen during pre-testing. However, a significant increase in SB was seen among the intervention children from pre-test to post-test at school.

The findings are in line with a number of previous exergaming studies<sup>28–32</sup> supporting the positive effects of exergaming interventions on children's PA levels. For example, Gao et al.<sup>19</sup> found that an exergaming intervention promoted greater self-reported PA in upper elementary children over time. Researchers have argued that the positive effect may be attributed to the motivating or entertaining nature of exergaming.<sup>30</sup> That is, the innate fun and novel components of exergaming attract children to engage in gameplay, thus keeping them physically active. In line with increases seen in light PA and MVPA from pre-test to post-test among children in the exergaming/PE intervention, an increase in EE—albeit not significant—was found in the current study over the same time period. These results are, to our knowledge, the first of their kind because the data were obtained via accelerometry in a school-based setting as opposed to the laboratory-based settings seen in previous literature.<sup>29–32</sup> These results are encouraging given the fact that greater EE through regular PA can aid in obesity control<sup>7</sup> as well as leading to a potentially reduced risk of future health problems among obese children. Unfortunately, the study found that the intervention children also had an increase in SB from pre-test to post-test ( $p < 0.01$ ). These results are perplexing given that the literature shows that exergaming promotes increased PA over time.<sup>19,31</sup> This suggests that although measures of PA during the school day may have increased among the exergaming children, SB operates independently of increases in PA—a finding validated by past research.<sup>33</sup> More mixed-methods research is needed to discern why children's SB would be higher, despite increases in light PA and MVPA, throughout the course of the school day.

Findings indicated that no group by time interaction was seen for SB, light PA, MVPA, or EE at any time point. Regarding MVPA, the comparison children demonstrated higher MVPA than the intervention children at both pre-test and post-test in this study. Despite the 2 schools being similar with regard to socio-cultural characteristics, the preceding result may be attributable to differences in each school's geographic location. Precisely, comparison children lived in a location situated between suburban and rural areas, which might provide more activity space at home and within neighborhoods than purely suburban areas. Nevertheless, our data show a significant increase in MVPA over time in both intervention and comparison groups, suggesting exergaming in combination with PE to be at least as effective as traditional PE in promoting children's PA. At follow-up, however, intervention children were found to engage in higher amounts of MVPA than comparison children. Further research using a mixed-methods design would need to be conducted to qualitatively determine whether the greater time in MVPA seen was related to exergaming and, perhaps, this PA modality's ability to increase intrinsic motivation for PA.<sup>34</sup>

Findings with regard to light PA showed trends much the same as seen for MVPA. From pre-test to post-test, both groups increased duration spent in light PA, with the comparison group having markedly longer light PA duration than the intervention

group at post-test (approximately 110.0 min *vs.* 91.0 min, respectively). Moreover, despite MVPA's being higher at follow-up for intervention children *vs.* comparison children, the opposite was true for light PA, with comparison children engaging in approximately >4 min of light PA at this time point. The results are similar to that of Gao and colleagues<sup>16</sup> in that higher PA levels were seen during a PE-based aerobic dance activity compared with DDR. In the current study, the fact the children rotated to different games throughout the session and had to adjust to the different gameplay situations present might have limited their light PA participation. Decreasing rotation time between different gaming stations is, therefore, recommended for future interventions.

Regarding SB and EE, both groups demonstrated different trends. For the comparison children, a decrease was seen in SB from pre-test to post-test, whereas a dramatic increase was seen from post-test to follow-up. This contrasts with the results seen among intervention children, wherein SB increased slightly from pre-test to post-test and from post-test to follow-up. Notably, both groups ended up with nearly identical durations of SB at follow-up. Age might represent a contributing factor for the increase in SB among all children because other research has shown decreased levels of PA as children age into adolescence.<sup>35</sup> Finally, the present study indicated that intervention children have increased EE from pre-test to post-test to follow-up, with an increase in EE seen only from pre-test to post-test among the comparison children. Of note is the fact that the comparison children had lower EE at follow-up *vs.* the intervention children. Not only has previous research shown exergaming to promote significantly increased EE—equal to that of moderate-intensity treadmill walking<sup>11</sup>—but the findings of this study also suggest that engagement in exergaming might be able to provide children with an increase in self-efficacy and enjoyment of PA, which extends to PAs beyond exergaming.<sup>16</sup> More longitudinal research is needed, however, on the psychosocial factors contributing to the higher EE seen among intervention children at follow-up.

The findings of this study are especially important given the findings related to the potential effectiveness of exergaming in promoting children's daily MVPA when it is integrated into the school's overall curricula. Specifically, previous research has found that exergaming can facilitate children's accumulation of daily PA levels.<sup>31,36</sup> In fact, compared with conventional PE, exergaming utilizes advanced technology to keep children intrinsically motivated and physically active as a result of the entertaining and active nature of the games.<sup>37</sup> Therefore, exergaming can be deemed a viable component of comprehensive school-based PA programs.<sup>38</sup> Given that increased intrinsic motivation is correlated with greater long-term adherence to PA, it is suggested that if a school's budget is sufficient, health professionals and educators might think about incorporating exergaming into the school's PA programs (e.g., recess, after-school programs, and PE) as a PA intervention option. It is also worth noting that exergaming sessions alternated with PE classes in the intervention school but still managed to show similar effects as PE in this study. Previous literature has shown exergaming to hold great promise as a PA intervention when

replacing children's school-time sedentary activities.<sup>30</sup> Had exergaming been used to replace sedentary time at schools beyond daily PE, the intervention would have likely been more effective. More research is needed, however, to confirm this postulation.

## 5. Conclusion

Overall, the most significant results of this study were that exergaming and PE had similar effects on children's MVPA, light PA, SB, and EE over time. This suggests that exergaming may be a worthwhile component of a well-rounded school curriculum. The strengths of this study lie in the fact that exergaming, a fun and innovative PA, was effectively integrated into the school's curriculum and that objective quantification of daily MVPA, light PA, SB, and EE were determined via accelerometry in a school-based setting. However, there are limitations in the study that warrant consideration. Although the study represents the first examination of the effect of exergaming/PE on elementary school children's school-day PA levels as compared with PE, randomization at the individual level was not used. Thus, researchers were not able to control some threats to the internal validity of this experiment, such as the history threat of amount of home space. Future research on school-based exergaming interventions should adopt a randomized approach to minimize the threats to internal validity. Second, participants came from only 2 suburban schools and the majority were white, which limits the generalizability of the findings. Consequently, a larger sample of multiple school sites and ethnically diverse children should be recruited in future research. Finally, although the results of this study are positive with regard to the integration of exergaming into a school's curriculum, it is worth noting that because exergaming did not operate as a stand-alone intervention, firm conclusions cannot be drawn on how this PA modality affected children's PA participation—both physiologically and psychologically. Although the content of PE at both schools was the same in the current study, with the only difference being the integration of exergaming within the intervention school, future research might consider an exergaming-only group, with outcomes in this group evaluated against those of traditional PE.

In conclusion, findings of the present study add to the growing body of literature on the roles of exergaming in contributing to children's daily MVPA, light PA, SB, and EE in comparison with traditional PE. Specifically, exergaming elicited the same effect on children's MVPA, light PA, SB, and EE as PE and played into the higher MVPA and EE levels seen at follow-up among intervention children. More study regarding why intervention children maintained MVPA to a greater degree than comparison children is warranted, because this might allow for more effective integration of exergaming into PE curriculum.

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## Authors' contributions

ZG conceived of the study, participated in its design and coordination, carried out the study, and drafted the manuscript; ZP performed the statistical analysis and helped draft the manuscript; JEL performed the data sorting and analysis and helped draft the manuscript; DS participated in its design and coordination, carried out the study, and revised the manuscript; DF participated in its design and coordination and carried out the study; DP helped with the data analysis and helped draft the manuscript; NR helped with the data collection and helped draft the manuscript; CCH performed the data sorting and analysis and helped draft the manuscript. All authors have read and approved the final version of the manuscript, and agree with the order of presentation of the authors.

## Competing interests

None of the authors declare competing financial interests.

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