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Original article

Impact of exergames on physical activity and motivation in elementary school students: A follow-up study

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Abstract

The present study was built upon a previous study on the new generation video game, exergame, in elementary school physical education (PE). The purpose of the study was to examine the effect of exergames on elementary children's in-class physical activity (PA) intensity levels and perceived situational interest over time. The results indicated that students' situational interest dropped dramatically over two semesters, but their PA intensity increased over time. The results showed that boys and girls were equally active in the exergaming lessons, but boys perceived their gaming experiences more enjoyable than girls did. The findings suggest that exergames may be a possible means to enhance PA in PE. However, whether exergaming is a sustainable way to motivate children in PA is questionable.

Keywords: Active video game; Calorie expenditure; Gender; Physical education; Situational interest

1. Introduction

Recently, a new generation of video games that require body movement during the game play has been gaining popularity among researchers who hope to find effective approaches to addressing the childhood physical inactivity epidemic leading to the childhood obesity crisis. In the U.S. the obesity crisis is evident in many health surveillance datasets. For example, Zapata et al.[1] estimated that the rate of obesity has tripled since 1980 among youth aged 6–11. The surge of obesity in children has become the greatest health threat because research has shown that more than half of obese children will become obese adults during life course.[2] Many factors have been identified as contributors to the obesity crisis. Sedentary activities are one of the most salient among them. Today, children and adolescents spend most of their spare time with sedentary activities such as watching TV for hours, using computers to surf on the Internet continuously, or playing video game consoles without stopping.[3] Because children and adolescents are more likely to spend their spare time on sedentary activities, active video games (namely exergaming) that allow players to physically manipulate and interact with the game display the potential to engage youth in physical activities (PAs). Thus, exergames have been used as a means to promote PA among children and adolescents in recent years.

The hypothesis that exergames can increase players' PA intensity levels and energy expenditure has been examined by researchers. Although there is no doubt that exergames can generate significantly more energy expenditure than sedentary activities,[4] evidence to date is mixed on whether exergames can engage children in levels of activity that are consistent with public health recommendations for receiving health benefits.[5] In a systematic review, Daley[5] concluded that only a small number of exergaming activities could engage children in moderate-intensity activity, but most do not. In another review on children's exergame playing, Foley and Maddison[6]

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revealed that exergames could elicit light to moderate intensity PA. They further indicated that definitive conclusions could not be made due to methodological limitations embedded in most studies. In a meta-analysis study of exergames,[7] researchers suggested that exergames are effective technologies that may facilitate light-to-moderate-intensity PA promotion. In addition, their analysis indicated that exergames had greater impact for children than adults with respect to energy expenditure. Therefore, they proposed that it might be promising to use exergames to promote PA among children.

It has been recognized that exergames may provide enjoyable experiences and the enjoyment may be the key factor to motivate individuals to participate in and continue the game play. However, research evidence that supports the effectiveness of using exergames to motivate users to engage in PAs is rather sparse.[8] Among the few studies on children's motivation in exergames, one study[9] found that children chose to use the exergames over the seated internet video games when given free choice. Interview data from the study revealed that attraction of the games was a predominant reason for the children's choice decision. Nevertheless, researchers have warned that the findings should be interpreted with caution. They reasoned that the strong attraction at the children's first exposure to the exergames would likely fade and with prolonged play the reinforcing value to the attractions might diminish. Consequently the motivation for continued or future play may also decrease over time.

Research has shown that boys are more physically active than girls. In addition, boys tend to engage more in higher-intensity PAs and girls are more likely to engage in lower-intensity PAs.[10] Research has also shown that gender is a stronger predictor of video game play than socioeconomic status and ethnicity.[9] It has been reported that boys play video games more often and for longer periods of time than girls.[11] Additionally, it has been found that boys are more physically active than girls in exergaming play.[4,9,12] In a pioneer study, Lam and colleagues[9] further suggested that boys and girls choose to play exergames for similar periods of time when given free choices. Despite the research evidence, little is known whether boys are more motivated by exergames than girls.

Although research has been extensively conducted to examine the physical intensity and energy expenditure, very few studies have investigated the efficacy of incorporating exergames in physical education (PE). Guided by the theory of planned behavior (TPB), a recent study[13] examined the impact of exergames on PE students' attitude, subjective norm, perceived behavioral control, intention, and behavior toward PA. In the study, 1112 participants were randomly assigned to undertake either PE lessons incorporated with exergames (DDR, Wii tennis, and Wii boxing (Nintendo, Kyoto, Japan)) or PE lessons following the regular curriculum without any exergaming element. Students in fifth and seventh grades participated in the 6-week intervention program. Results showed students in the exergame-incorporated PE lessons were more likely to emerge with more positive beliefs and behaviors. Lwin and Malik[13] concluded that exergaming-incorporated PE lessons could be more effective than regular PE in enhancing PA beliefs and behaviors. They also argued that students' attitude toward PA might be influenced by the entertainment element of exergames. Their results indicted the effect of exergames is more pronounced in elementary school students than in middle school students.[13] Therefore, Lwin and Malik[13] argued that it may be advantageous to use exergames to target children in elementary schools for changing their attitude and behavior toward PA.

Sheehan and Katz[14] articulated six components (namely 6Cs) that exergames posits to intrinsically motivate children to engage in PE: control, challenge, curiosity, creativity, constant feedback, and competition. Specifically, control refers to the sense of freedom that a player experiences in exergames to start, pause, select difficult levels, end, and restart a game at will. Challenge is the constant demand and/or obstacles that the player encounters and may or may not overcome in play, which is considered as an essential element of any successful video game. Curiosity is the continued suspense the game creates in the process where unknown has been the constant factor for the player to pursue. Curiosity can keep the player engaged and motivated during the game. Creativity represents that the potential embedded in the virtual environment that invites meaningful experimentation (try-and-error) in the process of problem solving. Constant feedback is the mechanisms built in the automated process of playing that provides detailed, but artificial, information about the player's progress. Lastly, competition refers to the general gaming environment where opportunities for the player to identify a real or imagined opponent to play against to experience the feeling of success or failure.

The 6Cs concepts discussed above are theoretically similar to the construct of situational interest that has been identified as a key function as well as outcome of exergames in terms of motivating children.[15] Situational interest has been defined as the appealing effect of characteristics of an activity on individuals.[16] It derives from a person-activity instant interaction in which the person perceives the appealing characteristics of the activity while being engaged in it.[17] Previous studies have identified novelty, attention demand, exploration opportunity, instant enjoyment, and moderate challenge as key motivating elements for a PA to become situationally motivating.[18,19]

It is assumed that the combination of motivation, appropriate PA intensity, and sustainable involvement that exergames are expected to have the potential to entice children to become physically active in playing video games, thus to contribute to the prevention of excessive sedentary behavior and prevention of childhood obesity. Nonetheless, research evidence supporting the assumption is needed.[20] Based on a longitudinal perspective[9] and guided by the framework of situational interest,[18] this study was designed to examine the effect of exergames on elementary school students' in-class PA level and situational interest motivation over two semesters. Particularly, the study attempted to determine the extent to which: (a) elementary school children's perceived situational interest in exergames and physical intensity of playing exergames changed over time and (b) the role of children's gender played in the changes; if the changes did take place.

2. Methods

2.1. The research design and setting

The present study was conducted as a follow-up study built upon the previous investigation[15] with the same group of participants. The study was conducted in an inner city elementary school in a large metropolitan area in the United States. The school enrolled more than 500 K-5 students from low socioeconomic neighborhoods evidenced by 92.55% of them being on the school-provided free/reduced meal program. The student body of the school consisted of 59.35% African, 25.36% Latino, 8.09% Caucasian, 1.44% Asian, 0.54% Native Americans, and 5.22% multi-racial Americans.

PE classes met twice a week and each lesson was 30 min long. The school had a blacktop, a small playground, and an exergaming room for PE. A certified female PE teacher taught PE to all students in all grade levels. To monitor the impact from unusual instructional and non-instructional events on students' responses, a systemic observation instrument was used to determine that the instructional structures (warm-up, cool-down, management routines, lesson organizations, *etc*.) were not altered by the presence of the researcher and other unusual events. The systematic observation instrument was adopted from Metzler's[21] time analysis − instructional information system for PE (TA-IIS). This procedure is important in that it helped preserve the integrity of data collected from the lessons.

2.2. Participants

The participants were fifth grade students aged 9−12 years ($n = 70$; 30 males, 40 females). They were chosen for the study because they participated in the previous study. This provided the opportunity for the researcher to examine the effect of exergames over semesters. Among these students, 60.7% were African American, 20.3% Latino, 9.5% Caucasian, 2.7% Asian, 1.4% Native Indian, and 5.4% multi-racial Americans. Informed parental consent was received from participants in accordance with the regulations by the University Institutional Review Board.

2.3. Exergaming facilities

The study was conducted in the same exergaming room in the school as in the previous study. Consistent to the previous study, eight different exergaming stations were used: two Cateye gamebikes, one Xavix boxing, one 3-kick, two Dog fight flight simulators, two Nintendo Wiis, two stations of four DDRs, two Gamercize activities, and two XrBoards (see Appendix 1 for the description of each game. All these games except DDR were from iTECH Fitness Inc., Denver, CO, USA.). The eight stations were used for every lesson with the variations of activities and difficult level in each station. In exergaming lessons students rotated between the stations to engage in various active games. Games that require only arm movement were eliminated from the study. All games required players to physically interact (using arm, leg, or whole-body movement) with onscreen images in a variety of activities such as tennis, baseball, football, boxing, biking, dancing, snowboarding, kicking, and stepping. Games were performed in accordance with player's movement either through infra-red sensor, pressure-sensitive mat/table or modified ergometer.[6] The maximum capacity of the eight stations was enabled to accommodate 18 students playing at one time during any segments of a lesson.

2.4. Variables and measures

2.4.1. In-class PA level

RT3 (Stayhealthy Inc., Monrovia, CA, USA) accelerometers were used to measure students' in-class PA level. The RT3 accelerometer measures motion in three dimensions and provides tri-axial vector data in metabolic equivalent units (METs). It has been reported that the RT3 model is reliable to record PA in the field settings and to convert the three dimensional movement counts into caloric expenditure data.[22−24] Using RT3 mechanisms allows the researcher to partial out the calorie expenditure due to PA from the total expenditure that includes both resting calorie cost and activity calorie expenditure. Calorie expenditure of in-class PA was used in the study. MET values were used for assessing PA levels.[25] One MET represents the average energy cost set at 3.5 mL/kg/min of oxygen, or 1 kcal/kg/h at seated, resting condition adjusted for age and gender.[26]

2.4.2. Situational interest

Situational interest was measured using the 15-item Situational Interest Scale−Elementary School.[27] The scale measures elementary PE students' responses to situational interest in PAs they are experiencing. The 15 items include five dimensional sources of the situational interest construct: attention demand, challenge, exploration intention, instant enjoyment, and novelty. The items are randomly arranged and each is attached to a 4-choice descriptor representing a 4-point Likert type interval scaling. For example, an item for the instant enjoyment dimension is: "My PE classes in game room are…" with descriptor choices of "very exciting," "somewhat exciting," "rather dull," or "very dull" scaled as 4, 3, 2, and 1 for data analysis. The scale has been determined useful with strong evidence for content and construct validity.[27] The internal consistency reliability was acceptable ($\alpha = 0.85$).

2.5. Data collection

The previous study was conducted in a spring semester. Data collection in the present study occurred during the second half of the following fall semester. During this procedure, students had an exergaming class every 2 weeks. Data collection lasted 6 weeks in which three exergaming lessons were recorded. Demographic information (gender, age, body height, and weight) used for programming the RT3 accelerometers was collected and entered into each accelerometer for each child prior to data collection. Thus the calorie expenditure data due to in-class PA were already adjusted for gender, age, body height, and weight. In-class PA was recorded on RT3 accelerometers during the PE classes. During each data collection lesson, the researcher secured the accelerometer on each child on the waist band above the right knee with a waist belt. Students were instructed to ignore the accelerometers during the lesson and not to play, tap, or take off the accelerometers. The accelerometers were collected after each lesson and the data were downloaded to data-collection computer immediately.

Situational interest data were collected at the end of the last exergaming lesson, which was also the end of the fall semester. The Situational Interest Scale was administered either in the exergaming room or in a quiet classroom. The researcher answered any questions that students had before administering the scale and read the items on the scale to students in data collection sessions. To minimize threats to data reliability, the researcher repeatedly reminded the students of rating each item honestly and independently and basing their ratings on their experiences in the exergaming lessons. The researcher also informed the students that their responses would not be shared with anyone, including their teachers, for any purposes and that their responses would not be used for grading. Students were also informed that they could decide to withdraw the study at any time they wish.

2.6. Data analysis

Responses to Situational Interest Scale were coded and aggregated according to the dimensions of novelty, attention demand, exploration, challenge, and instant enjoyment. In-class calorie expenditure data from the accelerometers from each lesson were converted into MET and averaged by total minutes of each lesson. The average MET from three exergaming classes was used to represent in-class PA level in the data analysis. Given the fact that the students were from intact classes, the assumption of independent observation for statistical analysis might be violated due to the cluster effect (autocorrelation in responses within a class). Prior to the following analyses, the data were subject to an intra-correlation analysis to determine whether and to what degree the cluster effect would affect the analysis outcome.[28] Appropriate adjustments of the critical value (p) for the decision in the null hypothesis testing were made to preserve the integrity of the analyses used for inferences.[29]

A paired-sample t test was conducted to examine the difference of MET means between the previous study and the present study. A 2×2 analysis of variance (ANOVA) (gender $\times$ time) with repeated measures on METs was conducted to examine the main effect of gender, time, and the interactions between the two factors. A two-factor split-plot/mixed design was used, which is a combination of an independent gender ANOVA and a repeated-measure ANOVA. The within-subjects factor was MET (previous-follow-up/time) and the between-subject factor was gender. A MANOVA repeated-measures model was used to analyze situational interest change with a focus on the time (change) $\times$ gender interaction.

3. Results

The systematic observation of those exergaming lessons revealed no unusual events that would affect the data and results. Descriptive statistics, reported in Table 1, showed that students' perceived situational interests in this follow-up study were moderate to low, with the exception of attention and enjoyment. The Cronbach α coefficients for all five dimensions were above 0.70, indicating satisfactory data reliability. The descriptive analysis suggested that the average METs of exergaming lessons (mean = 2.92, SD = 0.89) in this follow-up study did not meet the criterion of moderate PA level recommended for receiving health benefit (MET $\geq$ 3.0).[30] To examine if the average METs differ from the average METs in the previous study, a paired-samples t test was conducted. The results showed that the difference of METs between the two studies was statistically significant ($p < 0.001$). Exergames elicited significantly higher METs in the follow-up phrase than in the initial phrase.

The Box's test of equality of covariance matrices suggested that the assumption of homogeneity of variance-covariance-matrices was met ($p = 0.632$) in the ANOVA repeated-measures analysis on METs. Results of multivariate tests revealed a statistically significant effect of time (Pillai's Trace = 0.402, $F = 45.061$, $p < 0.001$, and $\eta^2 = 0.402$). Specifically, students in this study had significantly higher METs than they did in the previous study when they were newly exposed to the exergames. The interaction effect between gender and time, however, was not statistically significant (Pillai's Trace = 0.014, $F = 0.942$, $p = 0.335$, and $\eta^2 = 0.014$). With respect to gender, the between-subjects effects test indicated that there was no significant difference of METs between boys and girls (F (1, 67) = 0.197, $p = 0.659$, $\eta^2 = 0.003$).

In the repeated measure MANOVA of situational interest, the Box's test of equality of covariance matrices suggested that the assumption of homogeneity of variance-covariance-matrices was not met ($p < 0.05$). The α level for significance for the subsequent analysis was then set at 0.01 to compensate for the violation of this assumption.[31] Repeated measure MANOVA results showed significant multivariate effects of time (Hotelling's Trace = 2.885, $F = 16.735$, $p < 0.001$, and $\eta^2 = 0.743$) and non-significant effect of gender (Hotelling's Trace = 0.168, $F = 2.112$, $p = 0.067$, and $\eta^2 = 0.144$). Additionally, the interaction effect between gender and time was not found statistically significant (Hotelling's Trace = 0.200, $F = 1.161$, $p = 0.335$, and $\eta^2 = 0.167$).

With respect to time factor, the follow-up univariate tests indicated that students' perception of challenge ($F = 58.889$, $p < 0.001$, $\eta^2 = 0.468$), exploration ($F = 29.498$, $p < 0.001$, $\eta^2 = 0.306$), and novelty ($F = 13.290$, $p < 0.001$, $\eta^2 = 0.166$) changed significantly over the time. Results of pairwise comparisons further suggested that students' perceived challenge in this study was not only significantly lower than their initial perception ($p < 0.001$), but also lower than their retained perception in the previous study ($p < 0.001$). Similarly, students' perceived exploration opportunity also demonstrated the decline trend ($p < 0.001$ for both

Table 1
Descriptive statistics for situational interest by source dimensions in exergaming (METs, mean ± SD).

	Attention	Challenge	Exploration	Enjoyment	Novelty
Initial	3.68 ± 0.48	3.23 ± 0.61	3.37 ± 0.55	3.78 ± 0.36	3.35 ± 0.54
Post	3.50 ± 0.59	2.77 ± 0.68	3.16 ± 0.69	3.66 ± 0.50	2.93 ± 0.61
Follow-up	3.37 ± 0.65	1.91 ± 0.81	2.52 ± 0.68	3.61 ± 0.38	2.66 ± 0.76

comparisons). Their feelings of novelty dropped significantly from the initial point to the follow-up point ($p < 0.001$). But there was no statistically significant difference between the middle point and the follow-up point ($p = 0.326$).

With respect to the gender factor, pairwise comparisons suggested that boys and girls did not differ on scores in perceived attention, challenge, exploration, and novelty over the time ($p > 0.05$). However, boys and girls did perceive instant enjoyment differently during their exergaming experiences ($p = 0.006$). Particularly, the boys felt the exergaming play more enjoyable than the girls did.

4. Discussion

Researchers have suggested that studies to examine the effect of exergames on long-term PA promotion in children are needed.[9] The present study was built upon a previous study on the new generation of video games, exergames, in elementary school PE. The purpose of the study was to examine the effect of exergames on elementary children's in class PA intensity levels and perceived situational interest over two semesters.

4.1. Physical actively intensity

Descriptive analysis suggested that the average METs in the present study did not meet the public health recommendations for PA among children. The results are consistent with many previous studies that exergames could elicit only light-to-moderate PA intensity.[7] However, the findings might be associated with a measurement issue. In a previous study, Perron and colleagues[32] revealed that accelerometer data yielded the lowest scores on exercise intensity as compared to heart rate monitor and the children's run/walk OMNI scale. Perron et al.[32] speculated that possibly not all activity was sufficiently measured by utilizing the accelerometer only at the hip. Therefore, they suggested that future studies may need to include accelerometers at more joints to get more accurate results of how much activity occurs during exergames playing. Although exergames used in the present study were carefully selected to accommodate the use of accelerometer, the issue discussed above is still worth noting.

Despite the measurement issue, what matters for this study is that the PA level in the follow-up phase was significantly higher than that observed in the previous phase when the exergaming was first introduced to them in PE. The finding supported the speculation that gaming experience would possibly enhance physical intensity.[15] As Sell et al.[33] demonstrated with a sample of college students that activity intensity level was higher in experienced players than in non-experienced players.

However, children may not demonstrate a similar experience-intensity relationship as adults. For example, other researchers reported that children's physiological responses to exergames were not influenced by prior gaming experiences.[34] They explained that the inconsistence among research findings might be due to differences in the types of games used in different studies, suggesting that different types of exergames may generate different levels of exercise intensities which may or may not be contingent upon player experiences. The suggestion is supported by limited research findings. Perron et al.[32] compared two popular exergames, Wii Fit and EA Sports Active, using a sample of 36 inexperienced children (age = 9.4 ± 1.8 years, mean ± SD) in one research session and found that the EA Sports Active game elicited higher exercise intensity. White et al.[34] pointed out that some self-paced games, such as Wii Sports, provide "non-active" time during the game play that the player(s) can control their engagement without affecting the outcome of the game. The "non-active" time is more likely to reduce the physiological outcomes of the game.

In this study, a balanced game-type and experience arrangement was used to control for the impact from possible experience-intensity-game type relationship. A total of eight game stations provided a variety of game options with their variations for the participating children in PE. The combinations included dance games, Wii Sports games, and other games that require large muscle groups and whole-body movements. The results of the current study, therefore, seem to suggest that the use of a variety of types of games might result in enhanced PA intensity over time. Incorporating different types of exergames in PE might also be meaningful in that experiencing different types of games may potentially encourage students to use physical skills they have mastered in playing the games. In doing so, they are not only able to continue to develop and reinforce different physical skills but also able to increase PA intensity level to receive optimal health benefits.

The results of increased PA intensity should be interpreted carefully with respect to the sustainability of exergames in enhancing children's PA. The PA level was measured in the structured PE classes in the present and previous studies. The students in the classes were required to participate in the exergaming activities as part of the PE curriculum. In other words, students had limited autonomy regarding participation in the activities. Therefore, participating in exergaming was not equivalent to free-play. When children have relatively high autonomy in a situation such as recess, results could be different.[35] Using a control group design, Duncan and Staples[35] conducted a 6-week school based active video game play intervention on children's PA levels during recess. Their findings suggested that there was an acute effect of exergames on children's PA levels in initial presentation of the games. However, the effect was reversed at the mid and end points of the intervention with observed sharp drop in PA. Duncan and Staples,[35] therefore, concluded that exergames might not be a sustainable means to enhance children's PA. Taken all these evidence together, as Barnett et al.[20] indicated, it is premature to suggest maintenance of exergame play in children. More studies are needed along this line in order for researchers to draw a definitive conclusion.

Research has shown that boys are more active and likely to have higher PA intensity than girls in exergaming or active video game play. This might not be the case, however, in structured PE classes using exergames. There was no difference found between boys and girls on the average METs. In addition, the time and gender interaction was not statistically significant. Collectively, the results indicated that boys and girls were equally active in the exergaming lessons and such trend did not change over time. This finding is promising in that if exergames are implemented in PE, boys and girls might be able to perform at the same intensity level. However, it might be too early to conclude that exergames can be deemed as gender natural activities. Future investigations are warranted to clarify such arguments.

4.2. Situation interest sustainability

Similar to the results in the previous study, situational interest decreased dramatically during the follow-up study. Challenge and exploration, in particular, were the two dimensions with the greatest drop in scores. The results indicated that students' perceived challenge and exploration opportunities from the games were significantly lower than their initial perceptions when they were first exposed to the exergames. Additionally, their feeling about challenge and exploration were also significantly lower than their retained perceptions when they had experienced the exergames for 4 weeks. In other words, challenge and exploration decreased at a sharper or faster rate than other dimensions of situational interest.

Research on situation interest has indicated that cognitive demand (e.g., challenge and exploration) in learning experiences/tasks largely contribute to students' perceived situational interest.[27,36] The findings of this study, therefore, may have two implications. With respect to the game design, the findings suggest that exergames should provide players a variety of opportunities for exploration as well as multiple levels of challenges in order to help sustain high situational interest. More importantly, the games should be updated often with newly added addition. If exergames are to be incorporated in school PE, software that supports continuous upgrading the current version should be available at a low cost. With regard to the design of learning tasks in PE, the findings reiterate the importance of the motivational power of cognitive demand in task design and suggest that physical educators should find effective ways to not only challenge students physically but also cognitively and provide students opportunity to learning from playing.

Interestingly, results showed that students' perceptions of attention demand did not seem to drop over the time (the difference between retained attention and follow-up attention was significant at the 0.05 level, but not at the 0.01 level—the adjusted critical value). The data from the current study and the previous study were not able to answer why students' attention did not decrease even after two semesters of exergaming experiences. However, this might be due to the nature of exergames in that such games require the player to execute relatively precise body movement according to the visual or audial cues from the monitors. Players may need to keep their attention at a certain level in order to understand the cues and continue to play the game. After all, very few elementary school students could reach a level of automated skill execution that would allow them to complete the tasks (play movements) without having to pay attention to the cues.

It is also worth noting that students' recognition of instant enjoyment in exergaming play did not change over the time. Serving as the emotional/affective indicator,[37] instant enjoyment has been considered as a dominant dimensional source of situational interest for adolescent learners.[38,39] Peng et al.[7] suggested that psychological factors such as enjoyment or intrinsic motivation might play a critical role in physiological outcomes. The sustained enjoyment might have contributed to the increased PA intensity observed in this study. Future research is needed to examine the hypothesized speculation.

Results from the repeated measure MANOVA suggested that boys and girls perceived challenge, novelty, attention demand, and exploration opportunity equally in their exergaming experiences. However, boys considered their exergaming experiences more enjoyable than girls did. The role of gender in video games has been examined and it was reported[40] that boys tend to play video games more than girls do and boys are more likely to find the experience rewarding than girls.[9] The gender difference found in this study, therefore, might suggest that the games used in the PE might have stronger appeal to boys than to girls[41,42] and give greater feeling of being rewarded leading to a higher level of enjoyment. Nevertheless, such higher level of enjoyment did not result in higher level of PA intensity than the girls in the study. This disconnection must be studied in future research.

Sheehan and Katz[14] argued that the traditional PE model does not always fit with today's students' needs. Activities that are interactive, technologically driven, and ultimately more rewarding than traditional PE models might be able to motivate today's students to participate in the learning process. Therefore, exergames could provide the much needed stimulus to motivate those students who have started to lose interest in more traditional forms of PA. The argument has been supported by the previous study when exergames were first introduced in PE.[15] The sharp decrease found in this study, again, raised the question of whether situational interest is sustainable in exergaming play. It has been suggested that future exergame design should take consideration of the motivations that attract children to play and sustain their involvement for promoting PA.[20] The 5-dimension model of situational interest has provided a fundamental framework for future exergame design to trigger children's initial interest. However, it is critical for future studies to investigate important factors that could sustain motivation in exgerame for children to receive recommended health benefits.

In conclusion, the study confirmed that exergaming in PE can provide light-to-moderate PA to elementary school students. Prolonged exposure to exergaming activities may lead to decreased perception of situational interest, which might lead to lower motivation to engage in exergames-based PA in the future.

Appendix 1. Characteristic of the exergames.

Exergame	Characteristics
Gamebikes	An adjustable seat and pedals; a steering wheel with a video game controller in the middle; an individual player plays the game by using the steering wheel and pedaling
Xavix boxing	A boxing game with a console lockbox below the screen; a pair of gloves each with an electronic sensor; an individual player needs to wear gloves to virtually participate in the game
3-kick	Three towers with foam pads; a light is embedded in each pad on each tower; an individual player kicks or punches the pad when a light is on; the faster a light is hit, the higher scores are displayed on the screen
Dog fight flight	An arcade game with a seat and foot pedals and moveable handlebars on each side of the seat; an individual player presses the firing buttons located on the end of the handlebars to shoot at visual targets and pedals the foot pedals to move the selected aircraft forward
Nintendo Wiis	A game with motion controls. The remote controller responds to motion and rotation; an individual player plays sports including boxing, tennis, bowling, and baseball using the remote controller
DDR	A game with a dance pad. An individual player follows a set pattern on the screen, which matches the general rhythm of a selected song
Gamercize	A game with steppers; an individual player uses controllers play a video game (e.g., football) while stepping the steppers. The controller is activated by stepping the steppers
XrBoards	A game with snowboard simulators. An individual player balances on a board resembling a snowboard and uses his or her movements on the board to control the character's action in the game

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