

# Effects of Exergaming Based Exercise on Urban Children's Physical Activity Participation and Body Composition

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**Background:** Exergaming has been considered a fun solution to promoting a physically active lifestyle. This study examined the impact of an exergaming-based program on urban children's physical activity participation, body composition and perceptions of the program. **Methods:** A sample of 185 children's physical activity was measured in August 2009 (pretest), and percent body fat was used as index of body composition. Fourth graders were assigned to intervention group engaging in 30 minutes exergaming-based activities 3 times per week, while third and fifth graders were in comparison group. Measurements were repeated 9 months later (posttest). Interviews were conducted among 12 intervention children. **Results:** ANCOVA with repeated measures revealed a significant main effect for intervention,  $F(1, 179) = 10.69, P < .01$ . Specifically, intervention children had significantly greater increased physical activity levels than comparison children. Logistic regression for body composition indicated intervention children did not differ significantly in percent body fat change from comparison children, Chi square = 5.42,  $P = .14$ . Children interviewed reported positive attitudes toward the intervention. **Conclusions:** The implementation of exergaming-based program could have a significantly positive effect on children's physical activity participation and attitudes. Meanwhile, long-term effect of the program on children's body composition deserves further investigation.

**Keywords:** active video game, aerobic dance, Dance Dance Revolution, percent body fat, underserved children

Childhood obesity has risen dramatically in the past 3 decades and has become epidemic in the United States.<sup>1,2</sup> It has been implicated in a variety of serious health concerns including metabolic syndrome, psychological disorders, and cardiovascular diseases such as hypertension and Type 2 diabetes.<sup>3,4</sup> Obesity is especially prevalent among urban children, as they have limited opportunities for physical activity due to the lack of recreational programs and facilities, lack of safety of playing sports or games in the neighborhood, and the growth of sedentary leisure activities such as television viewing.<sup>5</sup> Physical inactivity and sedentary lifestyles are viewed as major factors contributing to the increased levels of obesity. Accordingly, reducing sedentary behavior emerges as a crucial strategy to improve body composition in children. Many empirical studies focusing on reducing television or computer use, however, have not been successful.<sup>6,7</sup> As known, screen-based technologies have been pervasive and children value these activities.<sup>8</sup> Given this, health professionals may consider alternative and innovative physical activity interventions that use these technologies as part of solution rather than problem. Although this project focuses on urban children, it has implications for the identification of effective approaches to improving health status for other underserved populations.

Participating in regular physical activity has been identified as an important contributor to the prevention and reduction of obesity in children.<sup>1,9</sup> For example, empirical studies have shown that increasing an individual's physical activity levels is associated with the prevention or attenuation of weight gain over time<sup>10</sup> and with better maintenance of weight loss.<sup>11</sup> Given the fact that physical activity participation in youth declines across age, promoting daily physical activity participation in school-aged children has become

an important public health initiative.<sup>12</sup> While numerous intervention studies have focused on increasing children's physical activity participation, innovative interventions with advanced technology focusing on promoting physical activity participation and fitness among underserved children living in environmentally challenging circumstances remain largely unexplored.<sup>13</sup>

Although traditional sedentary video games have been blamed for children's increased sedentary lifestyle, which contributes to the high rate of childhood obesity,<sup>14</sup> exergaming, on the other hand, has the potential to help promote a physically active lifestyle.<sup>15</sup> Exergaming or active video games are electronic games that allow players to physically interact with figures on screens using arm, leg, or whole-body movement in various activities (eg, dancing, jogging, boxing) and are intermittent in nature.<sup>16</sup> Playing exergaming usually results in light-, moderate-, or vigorous-intensity physical activity, and thus is considered to be fun and entertaining ways for children to develop healthy habits and physically active lifestyle.<sup>5,6</sup> These types of exergaming have capitalized on children's interest in computer and video interaction by combining interactive exercise equipment and activities to get children moving and enhance physical activity. For example, Dance Dance Revolution (DDR) is an active video game that combines real physical dancing requiring fast-foot movement with energetic music and visuals. It has a built-in workout mode that allows players to track energy expenditure as they play, and therefore is deemed a good exercise to offer a viable option to fight childhood obesity.<sup>17</sup>

In the past several years, research has been conducted to examine the benefits of exergaming as a means for physical activity intervention. Short-term and/or laboratory studies indicated that these interactive games have been effective in increasing children's physical activity levels<sup>18-20</sup> and body composition.<sup>16,21</sup> However, investigations in the exergaming field have primarily been conducted in laboratory settings with small samples of Non-Hispanic White individuals.<sup>18-20,22,23</sup> No empirical work has examined the long-term

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effects of exergaming on underserved children's physical activity participation and body composition in school settings. Although urban children have both a disproportionately higher rates of physical inactivity and obesity,<sup>9</sup> few studies have been conducted to investigate the positive effects of innovative interventions on physical activity and percent body fat among underserved urban children. In addition, qualitative methodology has been rarely employed in the exergaming field. Through in-depth interviews, we aim at exploring children's perceptions (ie, attitudes and beliefs) of participating in the exergaming-based exercise.

Therefore, the 9-month intervention study was designed to implement an exergaming based exercise program during recess periods to promote urban children's daily physical activity levels with the goal of improving their body composition. Specifically, the primary aim was to examine the impact of an exergaming-based exercise program on urban children's physical activity levels and body composition. The secondary aim was to explore their attitudes and beliefs about the program. Based on the literature review and previous studies, the following hypotheses are proposed: First, it is hypothesized that the intervention children would display significantly greater increased physical activity levels than the comparison children do across time; Second, it is hypothesized that more intervention children would stay in Health Fitness Zone (HFZ) in terms of percent body fat than the comparison children do across time; Additionally, it is hypothesized that the intervention children would report positive attitudes and beliefs about the exergaming-based exercise program.

## Methods

### Subjects and the Research Setting

The current study is part of a larger project designed to investigate the effects of exergaming-based exercise program on children's physical health and academic achievement.<sup>24</sup> However, the data used in this study have not been published. The subjects were from a sample of 201 elementary school students recruited at an urban predominantly Latino elementary school at the Mountain West region in the U.S. The vast majority of the students were children of Latino immigrant families. Most of these children came from economically disadvantaged families, as approximately 76% of them received free lunch at school. The participants' parents or guardians were generally poor with minimal education, and experienced unique impacts from social and behavioral acculturation to the U.S.

This school had the highest obesity rate in the state, and was in one of the poorest communities in the County. According to the school's record, the students in this school had a disproportionately high risk of overweight and obesity (nearly 40%), Type 2 diabetes and cardiovascular disease risk. There was neither required physical education class nor physical education specialist at this school. The participants had 2 recess periods (15 minute per session) during each school day. With the support from the school principal and classroom teachers, a 30 minute exergaming-based exercise program was set up in the gym to serve the participating fourth grade children during the recess. The specific criteria for children to participate in this study included that they (a) were aged 9–12 years, (b) were able to participate throughout the study, and (c) had no physical or mental disability according to the school records. These inclusion criteria were verified via a self-reported information sheet and the school records. This project was approved by the University of Utah IRB and the school district. All parents provided consent forms and children provided assent forms before this study.

## Design

A pre- and posttest repeated measures design was used in this study. Both quantitative and qualitative methodologies were employed in this 9-month study. Specifically, the subjects' baseline physical activity levels, percent body fat and demographic information were collected in August 2009. They were then assigned to 1 of 2 groups: (a) intervention group: 90 minutes DDR-based exercise per week; and (b) comparison group. In particular, the fourth grade children were assigned to the intervention group, playing 30-minute DDR-based exercise 3 times per week; while third and fifth grade children were in the comparison group. The subjects underwent identical assessments of their physical activity levels and percent body fat about 9 months later. Finally, 12 in-depth interviews with purposively selected intervention children were audio recorded and transcribed in the ninth month of the study. The interviews focused on children's attitudes and beliefs regarding their participation in the intervention program and its effects, if any, on their physical activity participation and body composition.

## Intervention

For the fourth grade children, the exergaming-based exercise intervention was offered and monitored by the research team and classroom teachers during 3 30-minute recess periods every week. The intervention included 8 DDR stations and 1 center activity station (eg, aerobic dance, jump rope, etc.). In particular, fourth-grade children came to the gym as an intact class and then were split into 2 groups. The class size ranged from 24–28. One group played DDR under the classroom teachers' supervisions for 15 minutes, and the other group played center activities under the research assistants' supervisions for 15 minutes. Then the 2 groups switched at midway. As such, all the children were active and on tasks during the program.

For the DDR stations, a player moved his or her feet to a set pattern, stepping in time to the general rhythm or beat of a song. While the game was in play, there were 4 stationary, transparent arrows at the top of the screen. Other arrows scrolled up from the bottom of the screen and passed over the stationary arrows. When the scrolling arrow overlapped the stationary ones, the player stepped on the corresponding arrows on the dance pad. A "jump" step involved pressing 2 arrows simultaneously. In this way, the game encouraged the player to dance a prechoreographed series of steps to the beat of the music. A total of 8 DDR stations were set up in the gym. At each station, 2 electronic dance pads were connected to the Play Station 2 video system and the TV. Thus 2 children were accommodated at 1 DDR station. In general, the classroom teachers maintained the disciplines for the DDR stations. With regard to the center activities, the research assistants led the children perform aerobic dance, jump rope, play soccer, etc.

The children in the comparison group, by contrast, did not participate in the exergaming-based exercise program at school. Instead, they only had the conventional unstructured recess in the classroom and hallway (ie, sitting or walking) or the outside field (ie, playing in the playground). The recess was usually monitored by their respective classroom teachers.

## Measures

**Physical Activity Levels.** The self-reported Sports, Play, Active Recreation for Kids (SPARK) activity checklist was used as a measure of children's weekly physical activity levels. The SPARK activity checklist is a survey to assess activities that were participated

in over the last week. Specifically, it assessed the children's out of school and in-school physical activity participation with 1-week recall in a checklist format, which had previously been validated among children aged 10–12.<sup>25</sup> For example, children reported their participation in 20 activities (ie, walking, dancing, soccer). The stem questions were “For each activity that you did 15 minutes or more at one time, write down how many times you did this activity before/after school and during school, including physical education and recess (Monday to Friday)” and “Then write how many times you did the activity for 15 minutes or more on the weekend (Saturday and Sunday).” A summary metabolic equivalent (MET) score was calculated based on the intensity weightings and times of each activity, and the SPARK data were calculated into the MET scores.<sup>26</sup>

**Body Composition.** Subjects' body composition was measured by percent body fat estimated from the sum of calf and triceps skinfolds. Skinfold thickness measures were taken to the nearest 0.1 mm at the triceps (at the level of the midpoint between the acromiale and the radiale) and calf sites (a point on the medial surface of the calf, at the level of the largest circumference.) using FAT skinfold caliper (BOX 10117 Towson, MD, US) on the right side of the body. Each skinfold was measured 3 times and the median value was recorded. The assessment was conducted during regularly scheduled classes and was administered by the same research assistants to ensure consistency in test administration.

The estimated percent body fat from skinfolds was established by Slaughter et al<sup>27</sup> study. Subjects were classified into Health Fitness Zone (HFZ) and Need Improvement (NI) categories based on their FITNESSGRAM individual report which has taken age and gender into consideration. For example, HFZ for boys is 10%–25%, while HFZ for girls is 17%–32%. As subjects had 2 assessments over 9 months, they were classified into 4 percent body fat group changes based upon their changes between HFZ and/or NI categories across time. In particular, if a child fell into HFZ category at pretest, but was in NI category in posttest; then this child would be classified into negative change group (Group 1). On the other hand, if a child fell into NI category at pretest, but was in HFZ category in posttest; then this child would be classified into positive change group (Group 4). If a child fell into the same category at the pretest and posttest, then this child would be classified into the no change groups (ie, Group 2 for NI no change and Group 3 for HFZ no change).

**Interview.** In-depth, individual interviews were conducted with 12 intervention children through purposive sampling. The interviews were audio recorded and then transcribed to explore children's attitudes and beliefs regarding their participation in the exergaming-based exercise program. One sample question was: “In what ways has participating in the exercise program affected your physical activity participation?” The interviews were taken place at an individual meeting room at the school site. Each interview lasted approximately 15 minutes.

## Data Analysis

All the quantitative data were combined into Excel and were cleaned and organized to facilitate data analysis. Four steps were taken to analyze the quantitative data. First, as a preliminary analysis, a 1-way multivariate analysis of variance (MANOVA) was conducted to examine if the intervention children would differ in physical activity levels and percent body fat from the comparison children at pretest. The results of the preliminary analysis would provide a basis as to whether the intervention and comparison children were homogeneous before the intervention was implemented.

Second, descriptive statistics were used to describe the sample. Third, a 1-way analysis of covariance (ANCOVA) with repeated measures was used to analyze the impact of the intervention on children's physical activity levels, with time (pretest and posttest) as within-subject factor, intervention (intervention and comparison) as between-subject factor, and age as the covariate to control the confounding effect of age on children's physical activity levels. Follow-up *t* tests were conducted when the analysis yielded main effects for time and/or intervention. A significant intervention by time interaction effect would indicate that the intervention children have different amounts of change in physical activity levels over time compared with the comparison children. In addition, logistic regression analysis was used with the analysis of children's percent body fat group changes.

The interview data were analyzed using inductive analysis and constant comparison.<sup>36</sup> This involved reading through children's responses several times in an attempt to identify recurring themes that reflected their (a) perceived attitudes toward the exergaming-based exercise program and (b) perceived benefits of the exercise program on physical activity and fitness. Trustworthiness of the interview data were ensured by prolonged engagement, member checking, and peer debriefing.

## Results

The results from this mixed methodology project are divided by methodological techniques. The research findings are summarized separately to facilitate readability, but are addressed together in the discussion section. In particular, the results from ANCOVA with repeated measures for physical activity levels are presented in Table 1. The frequencies of children's percent body fat group changes are also shown in Figure 1, whereas the results from the qualitative portion of the project are described after the quantitative analyses.

### Quantitative Analyses

The final sample was 185 (105 boys, 80 girls; 57 third graders, 72 fourth graders, 56 fifth graders). The major reasons for attrition were student transfer; drop out; missing data on 1 or more variables; and data outliers. The average age of participating students was 10.34 years old, with standard deviation of 0.93. Subjects' average height was 134.90 cm (standard deviation = 8.68); average weight was 36.76 kg (standard deviation = 10.92).

Results of the preliminary MANOVA indicated that, before the intervention, the intervention children did not differ significantly in physical activity levels and percent body fat from the comparison children, Wilks's  $\Lambda = .98$ ,  $F(2, 182) = 1.60$ ,  $P > .05$ . Therefore, we conclude the intervention children and the comparison children had equal characteristics, and thus subsequent analyses deemed plausible. Descriptive statistics of children's physical activity levels are reported in Table 2. Generally, both intervention children and comparison children had increased physical activity levels across time.

ANCOVA with repeated measures for physical activity levels revealed a small but significant main effect for intervention,  $F(1, 179) = 10.69$ ,  $P < .01$ ,  $\eta^2 = .06$ ; and a significant interaction effect for intervention by time,  $F(1, 179) = 31.47$ ,  $P < .01$ ,  $\eta^2 = .15$ . The significant interaction effect revealed that the intervention children had significantly greater increased physical activity participation than the comparison children did across time (see the change scores in Table 2). In addition, there was a significant covariate effect for age,  $F(1, 179) = 3.98$ ,  $P < .05$ ,  $\eta^2 = .02$ . It is in line with empirical

**Table 1** Demographic Information and Baseline Variables of the Participants

| Variable                 | Grade     |       |           |       |           |       |
|--------------------------|-----------|-------|-----------|-------|-----------|-------|
|                          | 3rd grade |       | 4th grade |       | 5th grade |       |
|                          | Mean      | SD    | Mean      | SD    | Mean      | SD    |
| Age                      | 9.38      | .52   | 10.38     | .52   | 11.33     | .51   |
| Height                   | 129.34    | 6.01  | 134.26    | 7.22  | 141.46    | 8.58  |
| Weight                   | 32.70     | 8.08  | 34.95     | 9.04  | 43.02     | 13.13 |
| Body Mass Index          | 19.33     | 3.51  | 19.24     | 3.95  | 21.12     | 4.45  |
| Percent body fat         | 23.40     | 6.84  | 20.70     | 6.85  | 28.65     | 10.30 |
| Physical activity (METs) | 209.00    | 31.51 | 203.66    | 29.92 | 194.11    | 29.54 |
| Gender                   | Boy       | Girl  | Boy       | Girl  | Boy       | Girl  |
|                          | 29        | 34    | 55        | 27    | 21        | 34    |
| Free lunch               | Yes       | No    | Yes       | No    | Yes       | No    |
|                          | 43        | 20    | 63        | 19    | 45        | 10    |

Note. Body Mass Index was calculated for each subject using weight in kilogram divided by height in meter squared.  
Abbreviations: SD, standard deviation.

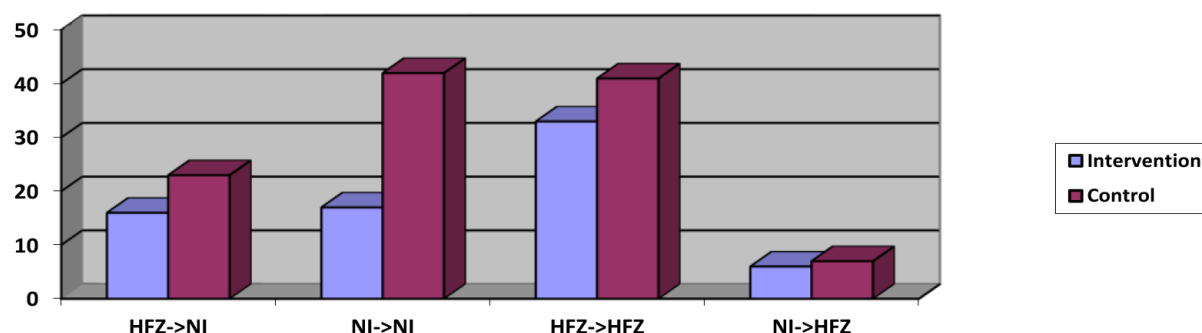


**Figure 1** — Percent body fat group changes across time. Note. The x axis represents the percent body fat group changes over 9 months. The y axis represents the number of children in specific categories.

studies indicating younger children had significantly higher daily physical activity levels than older children. In addition, the frequencies of the intervention children in different percent body change groups were as follows: 16 (22.2%) in the negative change group; 17 (23.6%) in the no change group (Group 2); 33 (45.8%) in the no change group (Group 3); and 6 (8.3%) in the positive change group. Meanwhile, the frequencies of the comparison children were 23 (20.4%) in the negative change group; 42 (37.2%) in the no change group (2); 41 (36.3%) in the no change group (3); and 7 (6.2%) in the positive change group. Logistic regression analysis for percent body fat suggests the intervention children did not differ significantly in percent body fat group changes from the comparison children, Chi square = 5.42, degree of free = 3,  $P = .14$ .

## Qualitative Analyses

The following 2 themes emerged from the interview data.

**Positive Attitudes Toward the Exergaming-Based Exercise.** All 12 urban children (100%) interviewed expressed positive attitudes toward their participation in the exergaming-based exercise stating that they felt “good” or that it was “fun” with 75% of interviewed children describing “dancing” and “music” as the part they enjoyed

most. They viewed their participation in DDR positively (“good” and “fun”), especially when they felt that they “lost weight” and had “dancing.” As one child stated, “there is lots to do, and the DDR man is fun. He teaches us some cool moves.” Another student said it this way “it’s lots of fun and I sweat a lot and it gives me enough energy.” Only 2 children (16.67%) named something negative related to their exercise participation. One comment was related to some DDR song selections and the other comment was related to not liking the aerobic dance.

### Perceived Benefits of DDR on Physical Activity and Fitness.

About 83.3% of the 12 children interviewed reported some positive changes in their physical activity participation and fitness. Nine children (75%) reported positive improvement in their ability to do push-ups and their 1-mile run after participating in the exercise program with comments such as “can do more [push-ups],” “[run] faster,” and “[push-ups and 1-mile run are getting] easier.” As one child stated, “I don’t get tired as fast as I used to.” Nine children reported positive results for their weight either maintaining their weight, losing weight, or gaining weight when they were previously underweight. As one of the children stated, “I feel different, I feel more skinnier than I used to be.” Eight children (66.67%) reported noticing positive changes to their body after participating in exercise

**Table 2** Descriptive Statistics of Physical Activity

| Variable          | Intervention children (n = 72) |                           |                    | Comparison children (n = 113) |                           |                   |
|-------------------|--------------------------------|---------------------------|--------------------|-------------------------------|---------------------------|-------------------|
|                   | Pretest (95% CI)               | Posttest (95% CI)         | Change scores      | Pretest (95% CI)              | Posttest (95% CI)         | Change scores     |
| Physical activity | 202.85<br>(195.77–209.92)      | 238.48<br>(230.36–246.61) | 35.63 <sup>a</sup> | 201.39<br>(195.74–207.04)     | 209.85<br>(203.36–216.34) | 8.46 <sup>b</sup> |

Abbreviations: CI, confidence interval;

<sup>a,b</sup> There is a significant difference between the groups,  $P < .05$ .

program, describing themselves as “stronger,” able to “run faster,” and able to “play more.” As one child stated, “when I didn’t know about DDR, my arms and legs, and my whole body were all flabby, and now, after doing DDR, they are not so much flabby.” Another child commented, “Mostly I can run longer without getting tired now.” A third child stated, “When I was doing . . . soccer I couldn’t hold my energy that long, but ever since I started I got lots of energy.” Less than 8.33% of the 12 students reported not noticing any positive changes in their physical fitness due to the exergaming-based exercise. One child (8.33%) reported not doing the push-ups and described the 1-mile run as “hard” or was unsure of DDR’s impact on their 1-mile run. Three children (18.75%) either didn’t know if their weight had changed or stated that their weight “fluctuates” and did not notice a change to their bodies.

## Discussion

The current study is the first report to our knowledge of an exergaming-based intervention on urban children’s physical activity levels and body composition from a longitudinal perspective. The exergaming-based structured exercise program that included DDR, aerobic dance and jump rope during school recess periods resulted in a small yet significant positive effect on urban Latino children’s daily physical activity participation over time. There was no difference between groups in children’s percent body fat. In addition, the qualitative findings indicate that the intervention children displayed positive attitudes toward the exergaming-based exercise and that they perceived that they could run faster, lose weight, and be energetic in school as a result of participation in the 9-month exergaming-based exercise.

Empirical studies<sup>16,20,21,28,29</sup> that examined the impact of exergaming on children’s physical activity levels have yielded mixed findings. The majority of short-term (less than 12 weeks) studies indicated modest improvements in physical activity participations,<sup>20,21,28,29</sup> while a few studies reported no significant improvement in physical activity levels as measured by accelerometers.<sup>16,30</sup> The results of the current study echoed the former studies by showing a significant intervention effect of the exergaming on children’s physical activity participation from a positive direction. The latter studies provided different explanations for their findings. For example, Maddison and colleagues<sup>16</sup> posited the overweight and obese children were quite active at baseline and exceeded the physical activity guidelines for this population. The high ceiling effect might block the intervention effect in their 24-week study. Baranowski et al’s<sup>30</sup> 2-month study focused primarily on behavioral changes with self-designed exergaming (ie, *Escape from Diab*, *Nanoswarm: Invasion from Inner Space*) to promote healthier behaviors, especially diet behaviors. They found that the exergaming motivated children to substantially improve diet behaviors. It is of no surprise that the intervention children’s daily physical activity levels did not improve significantly due to the nature of the exergaming.

In general, other research suggested that exergaming, such as DDR, can capture and maintain children’s interest and promote their physical activity levels as compared with sedentary video games or resting in laboratory settings.<sup>31,32</sup> In this 9-month study, the intervention children participated in 90-minute structured exergaming-based exercise per week at school, while the comparison children had no structured exercise at all at school. The intervention children had 15 minutes aerobic exercise and another 15 minutes DDR during the program which met the requirements for the report in the self-reported physical activity questionnaire (ie, 15 minutes activity). Accordingly, it seems logical that they displayed significant greater improvement on their daily physical activity levels than the comparison children did at posttest. Our data provide preliminary empirical support, from a longitudinal perspective, for using exergaming-based exercise to promote urban children’s physical activity participation at a school without structured physical education or physical activity programs. In addition, an exergaming-based exercise program can be a useful and attractive addition to comprehensive school physical activity program (eg, physical education, recess, after-school physical activity programs), and has potential to increase children’s daily physical activity at schools.

Contrary to the second hypothesis, there was no significant intervention effect on children’s percent body fat across time in this study. In recent studies that investigated the effects of exergaming on children’s body composition (eg, BMI, percent body fat, waist circumference), researchers reported inconclusive findings.<sup>16,20,21,29,30,33</sup> For example, Ni Mhurchu et al<sup>21</sup> reported reduction in weight and waist circumference in intervention children in their pilot 12-week randomized controlled trial. Maddison et al<sup>20</sup> also noticed a small positive effect in BMI and fat percentage (as measured by bioelectrical impedance) in their home-based exergaming intervention. On the other hand, Madsen et al examined overweight children’s use of DDR in a 6-month repeated measure study, and found that there was a lack of association between DDR use and change in BMI. Graves et al<sup>33</sup> did not find significant differences in body fat between intervention group and control groups after 12-week exergaming intervention. With educational exergaming as intervention strategies, Moore et al<sup>29</sup> and Baranowski et al<sup>30</sup> failed to identify any significant changes in BMI among intervention children. Apparently, the findings from previous studies differ due to the nature of the design, types of exergaming, type and length of the intervention, and target populations. Our finding is consistent with the latter studies. One plausible explanation may be that in this study the majority of children were from Latino families. There is consensus that there are multiple factors contributing to individuals’ BMI, including genetic heritage, cultural and environmental influences and nutrition. These factors are especially profound for the children from Latino immigrant families.<sup>34,35</sup> Future research should take multiple aforementioned factors into consideration when investigating the changes of body composition in urban children. Longitudinal exergaming interventions with sound design are also warranted to improve underserved children’s body composition.

Our interviews revealed that students believed the exergaming-based exercise program benefited their physical activity participation, performance and body weight, and thus strongly support the third hypothesis. According to the interview data, the intervention children reported that the exercise program helped them run faster, lose weight, and improve their general happiness, concentration and energy. These urban children also demonstrated positive attitudes toward the exergaming-based exercise as they reported that they enjoyed and had fun with it. Therefore, exergaming can be an optimal option for physical activity intervention for this group of children.

## Limitations and Future Studies

Although the findings advance research on the impact of exergaming-based exercise on urban children's physical activity participation and body composition, several study limitations should be identified to direct future research. First, only the fourth grade children were placed in the intervention group across time, while the other graders were in the comparison group in this study. This was due to the school schedule conflicts, space limitation, and resistances from a few classroom teachers. Consequently it is not possible to investigate the potential confounding effects that grade and growth had on the dependent variables. Future research may adopt randomized controlled trials integrating the exercise program into schools' curricula. That is, it is important to randomly assign children from each grade to the intervention group and the comparison group. Second, children's daily physical activity levels were measured by self-reported questionnaire which was subject to memory error and reliability concerns. It is highly recommended that objective instruments (eg, accelerometers, pedometers) be used to accurately capture children's physical activity participation in future research. In addition, this study only included 1 exergame—DDR in the structured exercise program. It would be beneficial to include a variety of exergaming (eg, Wii Just Dance, Xbox Kinect Sports) in future research. As such, children will be allowed a variety of choices for game playing, which will promote autonomy and sustained motivation for participation. Finally, we recommend the use of focus group to further explore children's perceptions and experiences with the exergaming programs including all kinds of exergaming activities.

## Conclusions and Implications for Public Health

The current study indicated that the exergaming-based exercise program at school had a meaningful effect on urban children's daily physical activity participation, which is comparable to other similar findings in the literature.<sup>20,21,27,29</sup> Although there was no difference in children's body composition, we found that children in this study reported positive attitudes toward the exergaming-based exercise program, and believed they benefited from the program physically and emotionally. A notable strength of this study is that, to our knowledge, it was the longest and largest of its kind to examine the effect of an exergaming-based exercise on urban children's physical activity and body composition at school. Other strengths of this study included the quality of the program, real-life setting at the school, and measurement of percent body fat with skinfolds.

Playing exergaming has been proven to be a wonderful vehicle to promote physical activity participation and physical fitness among the U.S. youth whose obesity problem has already become an epidemic.<sup>14,15</sup> The exergaming can also be responsive and culturally sensitive to minority children as this group of children generally favors playing video games.<sup>9</sup> The findings of this study indicate

that playing exergaming-based exercise benefited children physically and emotionally. Our findings can help inform local policy decisions regarding school-based physical activity interventions, especially policies that can promote in-school physical activity participation among urban children. That is, health professionals may integrate a variety of exergaming at urban schools to achieve the goal of promoting a physically active lifestyle and reducing the prevalence of obesity. Overall, this research could help inform efforts to reduce obesity rates among underserved urban children.

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