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PEDAGOGY

Exergaming: Comparison of On-Game and Off-Game Physical Activity in Elementary Physical Education

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Abstract

The purpose of this study was to describe fifth grade students' physical activity (PA) while playing a dance-based video game, Just Dance 4, and to examine the influence direct feedback about their performance had on their level of activity. Twenty-seven students in the 5th grade from an elementary school in the Rocky Mountain West participated. Participants wore a pedometer and recorded step count, PA, and moderate to vigorous physical activity (MVPA) while playing the game. Over 6 days of data collection, each participant collected on-game and off-game data for each song danced. Participants' mean step count was 1,891.63 (SD = 435.3) per class. The difference of total steps taken between on-game (M = 345.61, SD = 78.8) and off-game (M = 313.82, SD = 78.6) was not significantly different, t(27) = 1.50, p = .1289. Participants were physically active for a mean of 15 min, 40 s (SD = 174.63 s) and MVPA for 9 min (SD = 210.39 s). Although no significant difference was found between on-game and off-game PA, participants mean step count equated to nearly 16% of the daily recommended steps. Engaging in Just Dance 4 allows children to achieve part of the daily recommended PA in a 30-min physical education class.

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Physical activity (PA) contributes to a healthy lifestyle. Regular PA can provide numerous physical, social, and cognitive benefits to children such as improved muscular and cardiovascular health, increased health promotion knowledge and skills, disease prevention, and enhanced cognition (Janssen & LeBlanc, 2010; Keays & Allison, 1994; Strong et al., 2005). To achieve substantive health benefits, children should accumulate 60 min of moderate to vigorous intensity PA (MVPA) every day, which equates to approximately 12,000 steps/day (Colley, Janssen, & Tremblay, 2012). It is recommended that students take between 120 and 140 steps/min to reach MVPA levels (Graser, Vincent, & Pangrazi, 2009). Some research suggests that only 42% of children meet the daily recommended amount of PA (Troiano et al., 2008). Riddoch et al. (2007) determined that the median time spent in MVPA was only 20 min/day (boys: 25 min/day; girls: 16 min/day).

Physical education (PE) classes have the potential to increase levels of PA in school children effectively (Trost, 2006). It can also influence the overall PA they accrue over a typical day. For some elementary students, PA accumulated during the school day accounts for nearly 30% to 50% of their total daily activity (Cox, Schofield, Greasley, & Kolt, 2005; Gidlow, Cochrane, Davey, & Smith, 2008; Tudor-Locke, Lee, Morgan, Beighle, & Pangrazi, 2006). Although a relatively small amount of time during the school day is spent in PE, Alderman, Benham-Deal, Beighle, Erwin, and Olsen (2012) found that steps taken during PE accounted for nearly 12% of boys' and 10% of girls' total steps per day.

Although PE can provide the setting for PA, it is not clear if teachers design programs to maximize MVPA. For instance, in a review of research on elementary PE, Fairclough and Stratton (2006) reported that only 34% of available time in PE was spent in MVPA. This included activities such as ball games, fitness activities, games, and dance.

Dance and rhythmic activities may elicit higher percentages of MVPA than traditional activities. Huang, Hogg, Zandieh, and Bostwick (2012) found that students engaged in ballroom dance recorded MVPA for at least 50% of a class period. Exergaming, a form of dance or exercise performed while playing a video game,

has also been shown to be effective in increasing MVPA time (Fogel, Miltenberger, Graves, & Koehler, 2010).

Most dance-related exergaming research has been conducted on *Dance Dance Revolution* (*DDR*). Noah, Spierer, Tachibana, and Bronner (2011) found that *DDR* elicited in players a level of PA high enough to meet vigorous activity guidelines. Similarly, Tan, Aziz, Chua, and Teh (2002) reported a mean heart rate of 137 BPM for adolescents playing *DDR*. Exergaming may also contribute to sustaining longer periods of PA. Fogel et al. (2010) found that fifth grade students were active for over 90% of PE time while playing *DDR*. In a similar study, when 7- to 8-year-old children participated in a 10-week intervention study of playing *DDR,* results showed that PA increased by 42 min/week (Maloney et al., 2008).

The Xbox Kinect gaming system allows students to analyze their dance movements. The game *Just Dance 4* utilizes this technology and allows students to earn a score based on performance of the instructed moves and provides students the opportunity to be physically active. Although an entire class can participate in the game by mirroring the dance moves that appear on the screen, the game system is limited to providing instant feedback to only four students at a time. That is, only four students see their "scores" on the large screen (i.e., on-game). It is important for teachers to know if students can receive the same benefits when they participate on and off the game. Therefore, the purpose of this study was to describe fifth grade students' PA while playing a dance-based video game, *Just Dance 4*, and to examine the influence direct performance feedback from the game has on their level of activity. The specific objective of this research was to determine if PA levels were greater when students interacted directly with the game (i.e., on-game) than when they mirrored the actions but did not receive direct feedback (i.e., off-game) from the video game about their performance. The following questions were addressed:

- How many steps do students accumulate when playing the *Just Dance 4* video game during a 30-min PE class?
- How much MVPA is accumulated when students play the *Just Dance 4* video game during a 30-min PE class?
- Do students accumulate more steps when they receive direct feedback about their performance from the video game?

- Do students accumulate more MVPA when they receive direct feedback about their performance from the video game?

Method

Setting and Participants

This study was conducted at one elementary school in the Rocky Mountain West. Participants were 27 boys and girls (aged 10–11) in the fifth grade classes. The intervention (i.e., participating in exergames and measuring PA with pedometers) was conducted during regular PE class and had been implemented in the elementary school PE curriculum in previous and current years. Therefore, all 45 students in the class participated in the intervention, but data were only analyzed from the 27 participants who provided consent (parent/guardian and school principal).

Instruments

Just Dance 4 is a dance video game requiring participants to perform dance routines by mirroring moves displayed on a TV screen. The Xbox Kinect system is a motion sensing input device that allows users to control and interact with the gaming console without using a game controller. A built-in Web camera detects the student's movement and interprets those movements as if the student's body were a controller. The movements are analyzed and automatically assessed a score based on how accurate the movements are compared to the movements of the dancers displayed on screen.

The Walk4Life LS2525 digital pedometer was used to measure PA. The pedometer, an unobtrusive instrument about the size of a small matchbox, attaches to the participants' waistband and measures vertical movement. Pedometer measurements yield the participants' number of steps per minute, total activity time, and MVPA time count during a PE class. Pedometers have been shown to provide an objective and valid measure of steps taken in children (Beets, Patton, & Edwards, 2005; Schneider, Crouter, Lukajic, & Bassett, 2003) and for estimating activity (Beighle & Pangrazi, 2006; Rowlands & Eston, 2005).

Process

All students wore a pedometer while performing the dance routines. Prior to beginning the first dance, students cleared the pedometer (i.e., pressed the reset button). Pedometers recorded the number of steps taken during the dance routine for each song and were programmed to calculate time in PA and MVPA.

Students were divided into six groups; each group was assigned to one song of on-game activity per class session. This occurred across six class periods and students were on-game for a different song each day. When on-game, those four students stood in a designated spot in front of the Xbox Kinect to receive instant game feedback. The remaining students, who were off-game, were positioned in marked areas near the designated Xbox Kinect area, but did not receive instant feedback from the game.

After each song concluded, students recorded their PA data (i.e., step count, PA time, and time in MVPA) on a personalized record sheet (see Figure 1). Then students rotated to the next designated area and reset the pedometers in preparation for the next song. This process was repeated for all six songs each class session.

Physical Activity Record Sheet			
Name _____		ID number _____	
Song	**Step count**	**MVPA time**	**Activity time**
Everybody Needs Somebody			
Livin' La Vida Loca			
So What			
Good Feeling			
Rock N' Roll			
We Speak No Americano			

Figure 1. Student data recording sheet.

Description of Participants' Activities

Over 6 consecutive class days, students actively interacted with the game on six songs in the dance routine (see Table 1). The songs and dances remained the same for each class, and each student had the opportunity to be on-game for each of the six songs and dances.

Table 1

Sequence of Groups and Songs

	Song																																	
	Day 1						Day 2						Day 3						Day 4						Day 5						Day 6					
Group	1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6
1	■											■					■					■					■					■					
2		■					■											■					■					■					■				
3			■					■					■											■					■					■			
4				■					■					■					■											■					■		
5					■					■					■					■						■										■	
6						■					■					■					■						■					■					

Note. 1 = What Makes You Beautiful; 2 = Livin' La Vida Loca; 3 = Everybody Needs Somebody; 4 = Rock N' Roll; 5 = So What; 6 = We Speak No Americano. Gray boxes = on-game.

The songs selected and the length of each were "Everybody Needs Somebody" by Blues Brothers (3:15 min), "Livin' La Vida Loca" by Ricky Martin (3:37 min), "So What" by Pink (3:33 min), "Good Feeling" by Flo Rida (4:02 min), "Rock N' Roll" by Skrillex (3:50 min), and "We Speak No Americano" by Yolonda Be Cool (2:58 min). These songs were selected because of their upbeat tempo and the common length of time it takes to perform each. These songs and dances had been used previously in the PE class, so students were familiar with them and with the procedure for using the exergame system.

Data Collection and Analysis

Data were gathered after each class session and filed until all of the class sessions were complete. Once data were collected, steps, MVPA, and PA were entered into separate Excel spreadsheets. Data were organized for each participant by day, song, and on- or off-game. The mean was calculated for the number of steps taken and MVPA levels during each day of the study. The mean was determined by each participant's daily step count and MVPA divided by the number of days engaged in the study.

A *t* test determined the difference between on- and off-game steps and MVPA. Each participant's on- and off-game scores for steps and MVPA were averaged, which provided 27 data points. A *t* test was performed with these averages and determined the difference between on- and off-game steps and MVPA. Analyses were conducted in Excel, and a critical alpha level of $p < .05$ was adopted for all significance tests.

Results

Participants took a mean of 1,891.63 (SD = 435.3) steps/class, with a minimum of 1,347 steps and a maximum of 2,648 steps. Participants who were on-game took more steps per song (M = 346) than participants who were off-game (M = 314). However, the difference of total steps taken between on- (M = 345.61, SD = 78.8) and off-game (M = 313.82, SD = 78.6) was not statistically significant, $t(27) = 1.50$, $p = .1289$.

Participants were physically active for a mean of 15 min, 40 s (SD = 174.63 s). Only 9 min (SD = 210.39 s) were at MVPA. The amount of time spent in PA per song ranged from 96 to 218 s during

on-game play (M = 168.85, SD = 29.59). Off-game PA ranged from 83 to 203 s (M = 155.55, SD = 31.54). No significant difference was found between on- and off-game PA, $t(25) = 1.54$, $p = .1309$. The amount of time spent in MVPA per song ranged from 32 to 165 s during on-game play (M = 105.14, SD = 37.85). Off-game MVPA ranged from 25 to 145 s (M = 90.10, SD = 36.57). These differences were not statistically significant, $t(27) = 1.48$, $p = .1438$.

Discussion

The purpose of this study was to describe fifth grade students' PA by steps and MVPA while they played the dance-based video game *Just Dance 4* during PE classes. According to Stone, Faulkner, Zeglen-Hunt, and Bonne (2012), children are not meeting the daily recommended levels of PA. It has been recommended that children aged 6 to 12 should take more than 12,000 steps/day (Tudor-Locke et al., 2004). Cardon and De Bourdeaudhuij (2004) determined that 13,000 steps/day were needed to reach the equivalent of 60 min of MVPA. Griffiths et al. (2013) found that children only average 10,000 steps/day. Alderman et al. (2012) and Tudor-Locke et al. (2004) determined that PE could account for approximately 10% of the total steps children take each day. In this study, participants took an average of 1,900 steps/class session, which equates to nearly 16% of their daily recommended amount of steps per day.

Exergames can provide opportunities for children to be physically active in PE classes. The Centers for Disease Control and Prevention (2012) recommends that students should engage in MVPA for 50% of PE class time. From a review of 44 studies, Fairclough and Stratton (2006) reported that students were not meeting recommended levels of MVPA during PE and suggested interventions are needed to increase MVPA. In some studies wherein exergames were used (Fogel et al., 2010; Shayne, Fogel, Miltenberger, & Koehler, 2012), students spent as much as 90% of their class time in PA. Students in the current study were physically active approximately half of their time during PE. Although not meeting the 50% criterion proposed by the Centers for Disease Control and Prevention, students averaged 9 min of MVPA, or 30% of class time. Over 6 days of data collection, some students were very active, engaging in MVPA for 15 min (50% of PE), whereas others were less active (i.e., 2.3 min). These results

suggest that exergames such as *Just Dance 4* can be used as an effective intervention for increasing MVPA during PE.

Different methods of measuring PA have been used in exergame (Fogel et al., 2010; Maloney et al., 2008; Noah et al., 2011; Tan et al., 2002). In this study, pedometers were used to measure PA. On average, students were physically active for approximately half of the class time, spending one third of the class period in MVPA. Students in Gao, Podlog, and Huang's (2013) study used motion accelerometers while playing *DDR*. Gao et al. found that students were in MVPA for 30% of their class time. Yang and Foley (2008) used heart rate telemetry and reported students spending 80% of their class time in MVPA. Pedometers similar to the ones used in this study have been validated for estimating MVPA, but heart rate monitors could provide a more direct and accurate measure of PA intensity. PA estimates taken from pedometers are based on step count and may fail to account for increases in heart rate intensity associated with arm action and nonlocomotor movement. Future research should examine the consistency and validity of instruments used to measure PA during exergame play.

Exergames such as *Just Dance 4* provide students with instantaneous, positive feedback about their performance in the form of points and praise statements. According to Docheff (1990), the more positive and specific the feedback is, the more meaningful it will be to the participants and the more likely their PA will increase. Boyce, Markos, Jenkins, and Loftus (1996) posited that feedback should be immediate and related to the characteristics of the movement (i.e., direct, instantaneous, and congruent). Direct feedback did not seem to influence students' PA in the current study. The four on-game participants were the only ones to receive specific feedback from the game about their performance, yet off-game participants were as active as their on-game counterparts. Thus, children could be motivated to perform *Just Dance 4* because they enjoy playing the game and dancing to fun music, and enjoyment is more influential on their PA level than is the specific feedback they receive. Gao et al. (2013) reported that participants who enjoy the activity are motivated to participate to reach higher levels of PA. Thin, Brown, and Meenan (2013) found that Xbox Kinect, the system used in this study, provides high enjoyment ratings among participants. Further research

needs to examine how children's motivation and enjoyment affect their PA level while playing exergames such as *Just Dance 4*.

In summary, findings from this study suggest that elementary PE teachers may be able to use exergames such as *Just Dance 4* to increase students PA and MVPA. The small number of participants in this study limits the generalizability of these results; however, conducting additional research with a larger sample size is needed to ascertain if results can be replicated. One promising finding that needs to be explored further is the degree to which PA levels while children are playing exergames are dependent upon children receiving direct feedback about performance from the game. It is possible that enjoyment and motivation mediate the effect exergames have on children's PA.

References

Alderman, B., Benham-Deal, T., Beighle, A., Erwin, H., & Olsen, R. (2012). Contribution of physical education to young adolescents' daily physical activity. *Pediatric Exercise Science, 24,* 634–648. https://doi.org/10.1123/pes.24.4.634

Beets, M. W., Patton, M. M., & Edwards, S. (2005). The accuracy of pedometer steps and time during walking in children. *Medicine and Science in Sports and Exercise, 37,* 513–520. https://doi.org/10.1249/01.MSS.0000155395.49960.31

Beighle, A., & Pangrazi, R. P. (2006). Understanding children's physical activity level: Activity time and steps per minute. *Journal of Physical Activity and Health, 3,* 221–229. https://doi.org/10.1123/jpah.3.2.221

Boyce, B. A., Markos, N. J., Jenkins, D. W., & Loftus, J. R. (1996). How should feedback be delivered? *Journal of Physical Education, Recreation, & Dance, 67*(1), 18–22. https://doi.org/10.1080/07303084.1996.10607173

Cardon, G., & Bourdeaudhuij, I. (2007). Comparison of pedometer and accelerometer measures of physical activity in preschool children. *Pediatric Exercise Science, 19,* 205–214. https://doi.org/10.1123/pes.19.2.205

Centers for Disease Control and Prevention. (2013). *Results from the school health policies and practices study 2012.* Retrieved from http://www.cdc.gov/healthyyouth/data/shpps/pdf/shpps-results_2012.pdf#page=39

Colley, R. C., Janssen, I. A. N., & Tremblay, M. S. (2012). Daily step target to measure adherence to physical activity guidelines in children. *Medicine and Science in Sports and Exercise, 44,* 977–982. https://doi.org/10.1249/MSS.0b013e31823f23b1

Cox, M., Schofield, G., Greasley, N., & Kolt, G. S. (2005). Pedometer steps in primary school-aged children: A comparison of school-based and out-of school activity. *Journal of Science and Medicine in Sport, 9,* 1–97.

Cardon, G., & De Bourdeaudhuij, I. (2004). A pilot study comparing pedometer counts with reported physical activity in elementary schoolchildren. *Pediatric Exercise Science, 16,* 355–367. https://doi.org/10.1123/pes.16.4.355

Docheff, D. M. (1990). The feedback sandwich. *Journal of Physical Education, Recreation, & Dance, 61*(9), 17–18. https://doi.org/10.1080/07303084.1990.10604618

Fairclough, S. J., & Stratton, G. (2006). A review of physical activity levels during elementary school physical education. *Journal of Teaching in Physical Education, 25,* 239–257. https://doi.org/10.1123/jtpe.25.2.240

Fogel, V. A., Miltenberger, R. G., Graves, R., & Koehler, S. (2010). The effects of exergaming on physical activity among inactive children in a physical education classroom. *Journal of Applied Behavior Analysis, 43,* 591–600. https://doi.org/10.1901/jaba.2010.43-591

Gao, Z., Podlog, L., & Huang, C. (2013). Associations among children's situational motivation, physical activity participation, and enjoyment in an active dance video game. *Journal of Sport and Health Science, 2,* 122–128. https://doi.org/10.1016/j.jshs.2012.07.001

Gidlow, C. J., Cochrane, T., Davey, R., & Smith, H. (2008). In-school and out-of-school physical activity in primary and secondary school children. *Journal of Sports Sciences, 26,* 1411–1419. https://doi.org/10.1080/02640410802277445

Graser, S. V., Vincent, W. J., & Pangrazi, R. P. (2009). Step it up: activity intensity using pedometers. *Journal of Physical Education, Recreation, & Dance, 80*(1), 22–24. https://doi.org/10.1080/07303084.2009.10598263

Griffiths, L. J., Cortina-Borja, M., Sera, F., Pouliou, T., Geraci, M., Rich, C., & Dezateux, C. (2013). How active are our children? Findings from the Millennium Cohort Study. *BMJ Open*, *3*(8). https://doi.org/10.1136/bmjopen-2013-002893

Huang, S. Y., Hogg, J., Zandieh, S., & Bostwick, S. B. (2012). A ballroom dance classroom program promotes moderate to vigorous physical activity in elementary school children. *American Journal of Health Promotion, 26,* 160–165. https://doi.org/10.4278/ajhp.090625-QUAN-203

Janssen, I., & LeBlanc, A. G. (2010). Systematic review of the health benefits of physical activity and fitness in school-aged children and youth. *International Journal of Behavioral Nutrition and Physical Activity, 7(*40). https://doi.org/10.1186/1479-5868-7-40

Keays, J. J., & Allison, K. R. (1994). The effects of regular moderate to vigorous physical activity on student outcomes: A review. *Canadian Journal of Public Health/Revue Canadienne de Santé Publique, 86*(1), 62–65.

Maloney, A. E., Carter Bethea, T., Kelsey, K. S., Marks, J. T., Paez, S., Rosenberg, A. M., & Sikich, L. (2008). A pilot of a video game (*DDR*) to promote physical activity and decrease sedentary screen time. *Obesity, 16,* 2074–2080. https://doi.org/10.1038/oby.2008.295

Noah, J., Spierer, D. K., Tachibana, A., & Bronner, S. (2011). Vigorous energy expenditure with a dance exergame. *Journal of Exercise Physiology, 14*(4), 13–28.

Riddoch, C. J., Mattocks, C., Deere, K., Saunders, J., Kirkby, J., Tilling, K., . . . Ness, A. R. (2007) Objective measurement of levels and patterns of physical activity. *Archives of Disease in Childhood, 92,* 963–969. https://doi.org/10.1136/adc.2006.112136

Rowlands, A., & Eston, R. (2005). Comparison of accelerometer and pedometer measures of physical activity in boys and girls, ages 8–10 years. *Research Quarterly for Exercise and Sport, 76,* 251–257. https://doi.org/10.1080/02701367.2005.10599296

Schneider, P. L., Crouter, S. E., Lukajic, O., & Bassett, D. R. (2003). Accuracy and reliability of 10 pedometers for measuring steps over a 400-m walk. *Medicine and Science in Sports and Exercise, 35,* 1779–1784. https://doi.org/10.1249/01.MSS.0000089342.96098.C4

Shayne, R. K., Fogel, V. A., Miltenberger, R. G., & Koehler, S. (2012). The effects of exergaming on physical activity in a third-grade physical education class. *Journal of Applied Behavior Analysis, 45*(1), 211–215. https://doi.org/10.1901/jaba.2012.45-211

Stone, M. R., Faulkner, G. E., Zeglen-Hunt, L., & Bonne, J. C. (2012). The Daily Physical Activity (DPA) policy in Ontario: Is it working? An examination using accelerometry-measured physical activity data. *Canadian Journal of Public Health/Revue Canadienne de Santé Publique, 103,* 170–174.

Strong, W. B., Malina, R. M., Blimkie, C. J., Daniels, S. R., Dishman, R. K., Gutin, B., & Trudeau, F. (2005). Evidence based physical activity for school-age youth. *The Journal of Pediatrics, 146,* 732–737. https://doi.org/10.1016/j.jpeds.2005.01.055

Tan, B., Aziz, A. R., Chua, K., & Teh, K. C. (2002). Aerobic demands of the dance simulation game. *International Journal of Sports Medicine, 23,* 125–129. https://doi.org/10.1055/s-2002-20132

Thin, A. G., Brown, C., & Meenan, P. (2013). User experiences while playing dance-based exergames and the influence of different body motion sensing technologies. *International Journal of Computer Games Technology, 2013*. https://doi.org/10.1155/2013/603604

Troiano, R. P., Berrigan, D., Dodd, K. W., Masse, L. C., Tilert, T., & McDowell, M. (2008). Physical activity in the United States measured by accelerometer. *Medicine and Science in Sports and Exercise, 40*(1), 181–188. https://doi.org/10.1249/mss.0b013e318 15a51b3

Trost, S. G. (2006). Public health and physical education. In D. Kirk, D. MacDonald, & M. O'Sullivan (Eds.), *The handbook of physical education* (pp. 163–187). London, England: Sage. https://doi.org/10.4135/9781848608009.n10

Tudor-Locke, C. S., Lee, S. M., Morgan, C. F., Beighle, A., & Pangrazi, R. P. (2006). Children's pedometer-determined physical activity during the segmented school day. *Medicine and Science in Sports and Exercise, 38,* 1732–1738. https://doi.org/10.1249/01.mss.0000230212.55119.98

Tudor-Locke, C., Pangrazi, R. P., Corbin, C. B., Rutherford, W. J., Vincent, S. D., Raustorp, A., . . . Cuddihy, T. F. (2004). BMI-referenced standards for recommended pedometer-determined steps/day in children. *Preventive Medicine, 38,* 857–864. https://doi.org/10.1016/j.ypmed.2003.12.018

Yang, S. P., & Foley, J. T. (2008, April). Comparison of moderate to vigorous physical activity while playing *DDR* and EyeToy. *Research Quarterly for Exercise and Sport, 79,* A17–A18.