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THE EFFECTS OF EXERGAMING ON PHYSICAL ACTIVITY AMONG INACTIVE CHILDREN IN A PHYSICAL EDUCATION CLASSROOM

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Childhood obesity, which is due in part to lack of physical activity, is a serious concern that requires the attention of the behavioral community. Although excessive video game play has been noted in the literature as a contributor to childhood obesity, newer video gaming technology, called *exergaming*, has been designed to capitalize on the reinforcing effects of video games to increase physical activity in children. This study evaluated the effects of exergaming on physical activity among 4 inactive children in a physical education (PE) classroom. Results showed that exergaming produced substantially more minutes of physical activity and more minutes of opportunity to engage in physical activity than did the standard PE program. In addition, exergaming was socially acceptable to both the students and the PE teacher. Exergaming appears to hold promise as a method for increasing physical activity among inactive children and might be a possible intervention for childhood obesity.

Key words: childhood obesity, exergaming, physical education, social validity, video games

Seventeen percent of U.S. children are overweight (Centers for Disease Control and Prevention [CDC], 2007), which is double what it was 20 years ago (U.S. Department of Health and Human Services, 2001). The potential health and social consequences of childhood obesity include heart disease, Type 2 diabetes, sleep apnea, hypertension, increased chance of being an obese adolescent or adult, premature death, alienation from peers, and depression (U.S. Department of Health and Human Services, 2001). The literature indicates that children spend a large percentage of their time in sedentary behavior (e. g., McIver, Brown, Pfeiffer, Dowda, & Pate, 2009), which is one factor that contributes to childhood obesity (e.g., video game playing, television viewing, computer time; American Academy of Pediatrics, 2003; Anderson, Crespo, Barlett, Cheskin, & Pratt, 1998; CDC; Crawford, Jeffery, & French, 1999; Daniels et al., 2005; Pisacano, Lichter, Ritter, & Siegal, 1978; Reilly et al., 2005; Robinson, 1999; Spear et al., 2007). In addition, research shows that both physical activity and exercise are declining among children in the U.S. (American Academy of Pediatrics; Brownson, Boehmer, & Luke, 2005).

The U.S. Department of Health and Human Services and the U.S. Department of Agriculture (2005) recommend that children engage in daily physical activity for a minimum of 60 minutes at a moderate to vigorous intensity. Physical activity levels decrease as children get older, and data suggest that 75% of adolescents (Grades 9 through 12) do not meet the national recommendations for daily physical activity (CDC, 2007). A study by Sallis et al. (1997) found that physical education (PE) class provided only 18 min per week of physical activity that was of moderate to vigorous intensity.

Although excessive video game play has been noted in the literature as a contributor to

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childhood obesity, newer gaming technology, called *exergaming*, has been designed to capitalize on the reinforcing effects of video games to increase physical activity (Sanders & Hansen, 2008). Exergaming is a technology that uses interactive games to increase exercise behavior. Video games or various auditory or visual stimuli are paired with different types of exercise equipment and activities, and the individual must engage in physical activity to play the game or produce the auditory or visual stimulation (Sanders & Hansen). Exergaming holds promise as an intervention that is easy to implement with an entire class and, once trained, requires little effort from the PE teacher. Physical activity levels during PE may increase because children start to engage in physical activity right away. In addition, opportunities for physical activity may increase by implementing an exergaming lab in the school because these labs could also be available to students before and after school, providing them with a safe location to engage in physical activity.

Research has just begun to investigate the effects of exergaming on child behavior. Graves, Stratton, Ridgers, and Cable (2007) compared energy expended playing sedentary video games and interactive video games and found that interactive video games resulted in more energy expenditure. The intensity of the energy expended, however, was not high enough to contribute to the minimum daily level of recommended exercise. The limitation of this study is that they used lean children who were already very active in sports. Results may vary with inactive children. Lanningham-Foster et al. (2006) compared sedentary video games with interactive video games with 25 children and found that interactive video games doubled energy expenditure. In addition, their results showed similar effects for obese children, suggesting that interactive video games may be a possible intervention for childhood obesity.

The school is one environment that may be an ideal place for intervention for childhood obesity, because children spend the majority of their day at school and often spend additional time in this environment before and after school (U.S. Department of Health and Human Services, 2001). Although research has demonstrated increases in physical activity with school-based interventions, often these interventions are complex, difficult to implement, and require substantial time and effort from the change agents (Spear et al., 2007). Exergaming may provide a simple, alternative intervention. However, exergaming in a school setting has yet to be evaluated scientifically. Although implementing an exergaming lab in an elementary school could have substantial start-up costs, if it increases physical activity in children and develops exercising as a reinforcing activity, it could decrease the amount of money spent on obesity-related medical costs over the course of a child's life (Hansen & Sanders, 2007). Due to the potential health benefits of exergaming as an intervention for childhood obesity and the limited research in this area, it is clear that further research is needed to determine the effects of exergaming on physical activity in children. The purpose of this study was to evaluate the effects of exergaming implemented in a typical PE classroom with inactive children to determine whether children spent more time engaged in physical activity in an exergaming environment or in the traditional PE environment.

METHOD

Participants and Setting

Four 5th grade PE students from a southern public elementary school participated in this study (two girls and two boys with a mean age of 9 years). Participants were chosen because they were physically inactive in the PE classroom (defined as spending at least 30% of the time available to participate in physical activity either standing, sitting, or watching others), overweight (as defined by the PE teacher), had the lowest fitness scores in the

class, and had good attendance and behavior records.

We conducted the study during the regularly scheduled PE class. Due to the PE teacher testing the exergaming equipment with multiple classes, all 25 students in this 5th grade class engaged in both conditions of the study, but we collected data only on the four participants.

Dependent Variables

The dependent variables were the total minutes engaged in physical activity and the total minutes provided for physical activity during each condition (PE and exergaming classes). We collected duration data on each dependent variable during 30-min sessions using personal digital assistants programmed for collection of duration data. We used one duration key when a participant was engaging in physical activity and another duration key when an opportunity for physical activity was provided. These keys were immediately turned off when physical activity stopped or an opportunity was no longer provided.

We defined *physical activity* as moving a large muscle group (legs, arms, back, or abdominals) during an assigned task designated by the PE teacher (e.g., running, biking, throwing, catching, punching, swinging arms, squatting, kicking, walking, jumping, stepping, tapping, or any other physical activity that was part of the designated PE assignment). We did not count physical activity during any other time. For example, physical activity that occurred during transition time, waiting time, or any other time that was not part of the designated PE assignment or was used to gain class attention (e.g., teacher telling the class to hold their arms up to gain class attention) was not counted.

We defined *opportunities* to engage in physical activity as when the teacher instructed the student to engage in a PE or an exergaming task, and there was available equipment to engage in the task. The total time in the PE or exergaming conditions during which the student had an opportunity to engage in physical activity was calculated for each student per session. We did not count opportunities for a student while the PE teacher delivered instructions, if all exergaming activities were occupied, or if the teacher stopped the class to deal with problem behavior.

Interobserver Agreement

A second independent observer collected data to assess interobserver agreement on physical activity and opportunities across all conditions for 50% of the sessions. Interobserver agreement was assessed on a second-by-second basis throughout the observation session. An agreement was scored when both observers indicated that physical activity or opportunities were or were not occurring during each second of the observation. We calculated agreement by taking the total seconds of agreement divided by the total seconds of observation and then converting the ratio to a percentage. Mean agreement across all students was 96% (range, 92% to 98%) for physical activity and 95% (range, 92% to 97%) for opportunities.

Design and Procedure

We used an alternating treatments design to compare the effects of regular PE class and exergaming on the duration of physical activity.

Regular PE. During the regular PE condition, the teacher conducted class as usual in the standard format consistent with her regular lesson plan. The standard format included providing instructions on a skill or activity, modeling the skill or activity, providing an opportunity for the students to perform the skill or activity while providing prompts and encouragement, and repeating this cycle if teaching more than one skill or activity per class.

The school district provided the PE teacher with outcomes that each student must meet by the end of the year; however, the teacher was not required to follow a specific protocol or curriculum in order to teach these skills.

Exergaming. The exergaming condition was also conducted by the PE teacher. A classroom was converted into an exergaming lab in which nine stations had 11 activities with seven pieces of exergaming equipment available. During the first class, the teacher provided instructions and modeling on how to use each piece of equipment. A sign was posted on each piece of exergaming equipment listing the station number and simple instructions to assist the students in starting each activity. The teacher also provided instructions for station rotation and showed the class a schedule board that indicated to each student to which group he or she belonged and at which station each group would start for that class. She reviewed five rules for the exergaming room and had the class repeat the rules. Schedule boards were changed at the end of each class so that each group would start on the next station during their next class. Students rotated stations approximately every 10 min when the teacher turned the lights off and on. For all subsequent exergaming sessions, students were told to check the schedule board when they came into the room and then to go to the assigned station. Stations continued to rotate approximately every 10 min. The 10 types of exergaming included the following:

Kanomi Dance Dance Revolution (DDR) with Sony Play Station. This game consisted of a dance pad on which a player moves his or her feet to a set pattern that matches the general rhythm or beat of a song shown in front of the player on a TV screen.

Gamercize with Sony Play Station Batman and Robin. This is a form of gamercize in which a stair stepper machine interfaces with a video game's console, and motion from the stepper provides a signal to the interface module. The interface allows interaction between the game controller and game console only when the signal is present.

Three Rivers Game Cycle with Sony Play Station Monster 4 × 4. This exergame is a game cycle in which an upper body ergometer bike requires children to control on-screen actions by pedaling and steering the bike with their arms instead of their legs.

Electronic Sports Dog Fighter Simulator. Dog Fighter is a form of a virtual bike that resembles a traditional bike and allows children to control all on-screen actions, including steering, speed, turns, firing mechanisms, and other strategies. The faster the player pedals, the faster the objects on the screen move.

Cateye Virtual Bike with Sony Play Station. Dirt Biking is another form of a virtual bike that functions like the Dog Fighter.

Nintendo Wii Sports Baseball. This exergame is a virtual sport that allows children to participate in a baseball game inside a virtual world. After a swing or a throw, the screen provides a replay of the play; however, the player may choose to skip this option.

Nintendo Wii Sports Tennis. This is a virtual sport that allows children to participate in a tennis match inside a virtual world. After each play, the screen provides a replay of the play; however, the player may choose to skip this option.

Nintendo Wii Boxing. This exergame is a virtual sport that allows children to participate in a boxing match inside a virtual world.

iTech Fitness XrBoard. This game uses a balance board simulator that allows children to snowboard down a mountain or practice complicated skateboarding tricks.

Fit Interactive 3 Kick. This exergame is a martial arts simulator designed with resilient foam pads in three locations that that are punched or kicked in response to visual and auditory signals.

Social Validity

We used three social validity surveys to evaluate the students' and the PE teacher's views of the intervention.

Students' preference ranking survey. We administered the students' preference ranking survey at the end of the study during PE class.

The researcher met with each participant in the back of the exergaming room. The preference ranking survey consisted of 11 note cards with the name of one exergaming activity listed per card. Before ranking the exergaming activities, the students ranked five food items from most to least preferred to ensure that the students could follow the instructions.

Teacher's social validity survey. We administered the social validity survey at the completion of the study to measure the acceptability of exergaming as a form of PE. The survey consisted of eight statements (e.g., time spent in the exergaming lab was beneficial, the exergaming lab provided opportunities for students to work on skill development, and students followed directions in the exergaming lab) rated on a 1- to 5-point scale.

Teacher's scoring survey. We used the scoring survey to assess the teacher's perceptions of how much time was spent dealing with behavior problems, providing instructions, and practicing PE skills, and how much time the class followed directions across conditions. The survey consisted of four statements, and the teacher was asked to circle the percentage of time spent for each statement. We administered the survey prior to and at the completion of the study.

RESULTS

The exergaming condition resulted in higher levels of physical activity for all four participants (Drew, $M = 9.1$ min; Hannah, $M = 9.2$ min; Ryan, $M = 9.6$ min; Marley, $M = 9$ min) than the PE condition (Drew, $M = 1.8$ min; Hannah, $M = 1.4$ min; Ryan, $M = 1.7$ min; Marley, $M = 1.6$ min; see Figure 1). The exergaming condition resulted in a mean of 9.2 min of physical activity per session, and the PE condition resulted in a mean of 1.6 min of physical activity.

For all four students, the exergaming condition resulted in higher levels of opportunities (Drew, $M = 12.4$ min; Hannah, $M = 12$ min; Ryan, $M = 10.6$ min; Marley, $M = 11.7$ min) than the PE condition (Drew, $M = 3.1$ min; Hannah, $M = 3.4$ min; Ryan, $M = 3.6$ min; Marley, $M = 4.4$ min; see Figure 2). The exergaming condition produced a mean of 11.6 min of opportunities per session across participants, and the PE condition produced a mean of 3.8 min.

The physical activity and opportunities data allowed an analysis of the percentage of time the participants engaged in physical activity when given an opportunity. For the exergaming sessions, the mean percentage of time spent engaged in physical activity was 78% (Drew, $M = 79\%$, range, 46% to 90%; Hannah, $M = 80\%$, range, 52% to 97%; Ryan, $M = 75\%$, range, 61% to 92%; Marley, $M = 79\%$, range, 56% to 97%). In the PE condition, the percentage of time spent engaged in physical activity was more varied across sessions, with a mean of 60% (Drew, $M = 65\%$, range, 13% to 100%; Hannah, $M = 58\%$, range, 23% to 81%; Ryan, $M = 63\%$, range, 16% to 88%; Marley, $M = 53\%$, range, 21% to 90%).

An analysis of the percentage of time spent engaged in physical activity across exergaming activities was also conducted and showed that DDR and the 3 Kick produced the highest percentages across participants ($M = 94\%$, range, 88% to 100%). The Wii Tennis and Baseball had the lowest percentages of physical activity for Drew, Hannah, and Ryan ($M = 16\%$; range, 12% to 20%). The measurement of percentage of time engaged in physical activity by station began midway through the study; therefore, data were collected only once or twice for each activity across participants. Due to student absences, data were not collected on six stations for Marley and one station for Drew (see Table 1).

Exergaming appeared to be a socially acceptable intervention for both the PE teacher and the students. The students' preference ranking surveys indicated that the most preferred exergaming activities were Wii Boxing (Drew

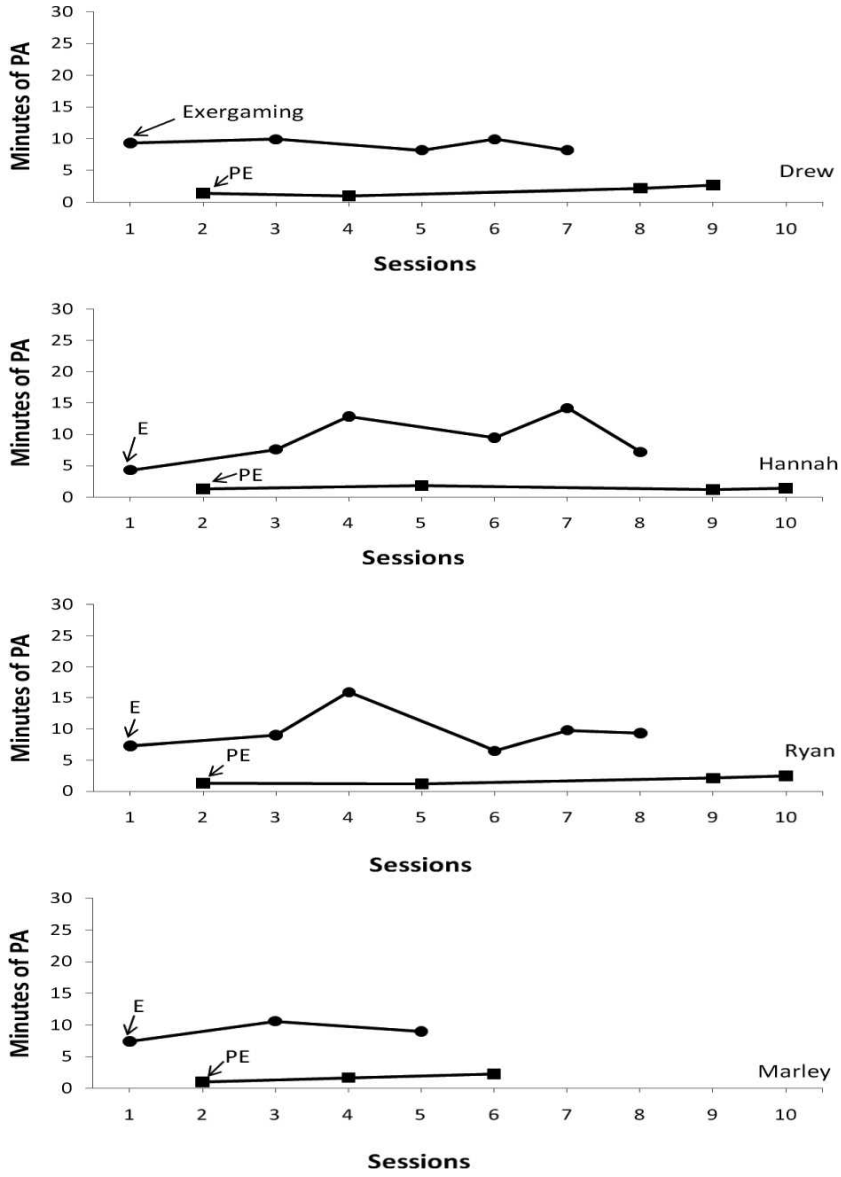

Figure 1. Minutes of physical activity (PA) per session for both the regular physical education (PE) and exergaming (E) conditions for each student.

and Marley), DDR (Hannah), and Wii Baseball (Ryan). The least preferred exergaming activities were Batman and Robin (Drew, Ryan, and Marley) and the Monster 4 × 4 (Hannah). Hannah and Marley reported a preference for exergaming, whereas Drew and Ryan reported a preference for both PE activities and exergaming activities.

On the social validity survey, the teacher strongly agreed (a score of 5) that exergaming was beneficial to the students, provided opportunities for students to work on skill development, and resulted in a reduction in behavior problems during class time. In addition, the teacher agreed (a score of 4) that time spent in exergaming increased skill acquisition and cardiovascular

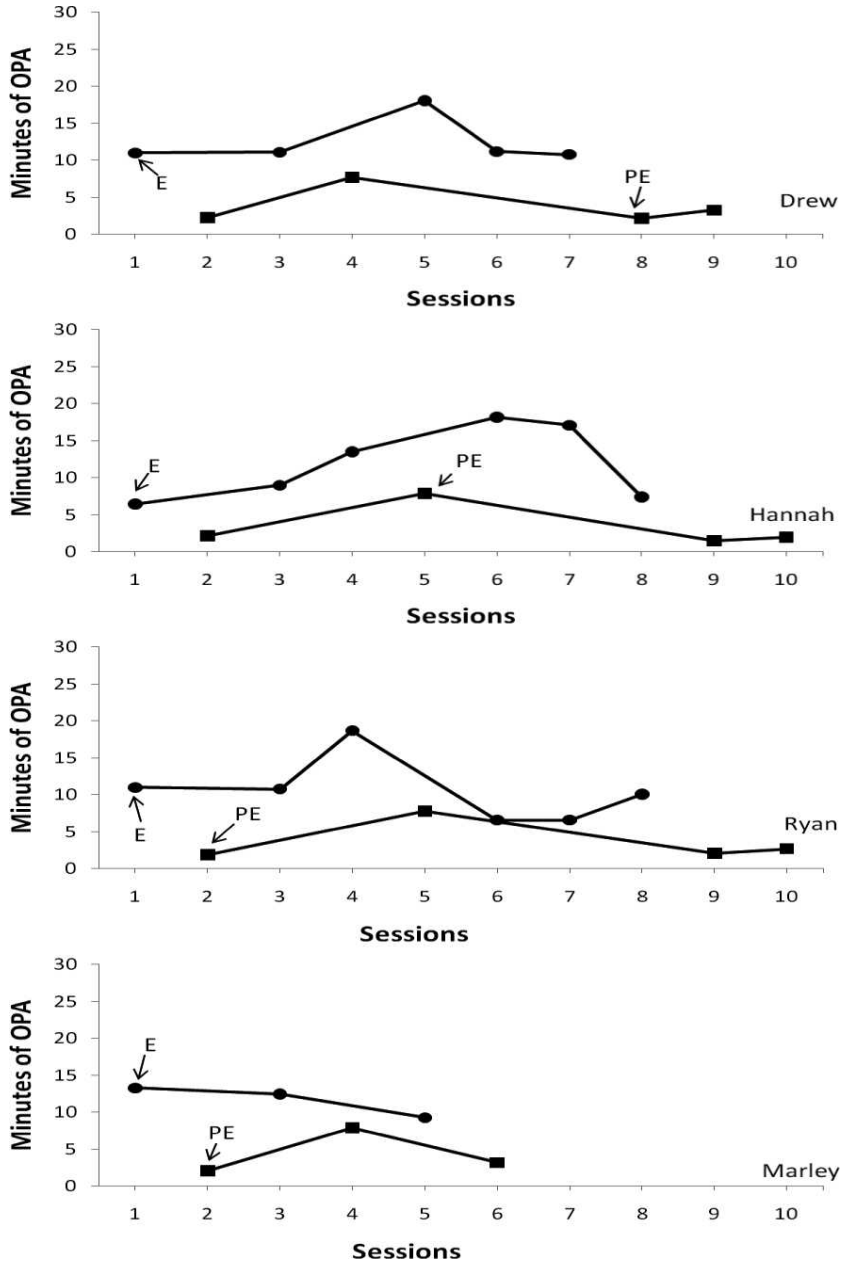

Figure 2. Number of minutes of opportunity to engage in physical activity (OPA) for both the regular physical education (PE) and exergaming (E) conditions for each student.

endurance and resulted in more student engagement in physical activity, and that students followed instructions during exergaming.

On the scoring survey, she reported a 30% reduction in time spent dealing with behavior problems, a 30% increase in students following directions, and a 50% increase in time spent having students practice a PE skill or activity per session across both conditions.

Table 1
Percentage of Time Engaged in Physical Activity by Station

Exergaming activity	Drew	Hannah	Ryan	Marley
Boxing/Monster[a]	83	83	99	
DDR 2	100	100, 95	98	93
3 Kick	97	96, 100	88	100
Dog Fighter		90, 95	85, 89	92
Batman and Robin	70	68	82, 95	
DDR 6	95	100	93, 96	
Wii Tennis and Baseball[a]	12	15	20	
XR Board	81	89	100	
Dirt Biking	47	72	51	

[a] Two games that made up one station; therefore, percentage of time engaged in physical activity was combined for these activities.

DISCUSSION

The current study was the first to evaluate the effects of exergaming on physical activity among four inactive 5th grade students in a physical education classroom. The results showed that exergaming produced substantially more minutes of physical activity for each participant than did PE. In addition, fewer minutes were available in PE for students to engage in physical activity than were available in exergaming. The PE class was scheduled for 30 min twice per week; however, after transition to PE, class management, instructions, and waiting for a turn, very little time was left for actual physical activity in the PE environment (a mean of 3.8 min). Even though both conditions required transition to PE, instructions, and waiting for a turn, time was saved in the exergaming condition. First, because children were engaged in more physical activity in the exergaming condition, there was less time to engage in off-task behaviors; therefore, time for class management was reduced. Second, minimal instructions were needed after the first session because the exergaming condition was the same every session, whereas in the PE condition, different activities were presented, thereby requiring more time devoted to instructions. Third, time to wait to engage in physical activity was reduced because there were only three people to a group in the exergaming condition; in the PE condition, children were often grouped into six or more. Fourth, although data were not collected on this observation, it appeared that the class arrived to the exergaming classes earlier than the PE classes. Often when children did not engage in appropriate transition behaviors (e.g., walking quietly in line), the teacher stopped to correct the behavior of these students, thereby lengthening the transition time. It is hypothesized that because of the reinforcing effects of exergaming, an establishing operation for appropriate transitioning behavior was in effect on the exergaming days, which resulted in shorter transition times. However, further research is needed to explore this hypothesis. Based on these data, exergaming produced six times the amount of physical activity than PE. Overall, these results indicate that exergaming is a simple, effective, and socially valid intervention for increasing physical activity among inactive 5th graders.

A benefit of this study is that it was conducted in the natural environment under typical school conditions. Another positive aspect of this study is that it included a measure of opportunity to engage in physical activity. This measure provided information on how much time students had available to engage in physical activity per session as well as the percentage of that time they actually engaged in activity. In PE, when provided with the opportunity to engage in physical activity, students engaged in physical activity, on

average, 60% of the time. However, the data showed that students were provided with very little time to engage in physical activity (M = 3.8 min per session). In the exergaming condition, students had a mean of 12 min of opportunities per session and engaged in physical activity, on average, 79% of the time.

A potential limitation of this study is the novelty of exergaming. It is possible that students engaged in more physical activity in the exergaming condition because the activities were new. Assessment of exergaming after children had been exposed to the equipment for several months would control for the potential confounding effect of novelty on the amount of physical activity.

For three of the four participants, the most preferred activities were ones in which they spent a high percentage of time engaged in physical activity. However, because there were only a few assessments per activity and no assessments on several activities for two participants (Drew and Marley), a more thorough evaluation of percentages of time engaged in physical activity by exergaming activity is needed. In addition, an evaluation of the factors that produce high percentages of time engaged in physical activity would be beneficial for increasing physical activity in the regular PE environment. Futher, identifying the exergaming activities that were least preferred and produced the lowest percentages of time engaged in physical activity would be valuable so that these stations could be modified or eliminated.

The U.S. Department of Health and Human Services and the U.S. Department of Agriculture (2005) recommend that children receive 60 min of moderate to vigorous physical activity per day. A limitation of this study is the absence of a measurement of the intensity of physical activity during exergaming and PE classes. Heart rate monitors were considered, but due to the time that would have been subtracted from the PE class by putting on and taking off the monitors, a decision was made to not assess the intensity of physical activity. Future studies should look at heart rate to determine whether exergaming or PE conditions provide moderate to vigorous levels of physical activity. In addition, the use of pre- and postfitness assessments for all exergaming and PE activities would help to determine the activities that produced the greatest improvements in fitness levels. Follow-up data could be collected to assess long-term effects on fitness levels and body mass index (BMI). Further, assessments of other benefits of physical activity (e.g., BMI, percentage of body fat, resting heart rate, recovery heart rate, blood pressure, muscular endurance, cardiovascular endurance) could also be measured in future studies.

In this study, the PE class was often shortened by a variety of events outside the control of the teacher. Future research should evaluate environmental changes that might increase the likelihood of providing more opportunity for physical activity in the classroom. In addition to evaluating environmental changes, it would be advantageous for researchers to assess the effects of teacher behavior on physical activity levels and opportunities for physical activity across conditions. Based on antedoctal data, teacher behavior appeared to be different across conditions. For example, researchers noted that the teacher appeared to engage in more smiling, positive comments, and specific feedback in the exergaming condition. Perhaps, because exergaming kept students actively engaged in physical activity, the teacher had more opportunity to give specific feedback and praise.

A final recommendation for future research is to evaluate the effects of exergaming on problem behavior. In the social validity and teacher scoring survey, the teacher reported a decrease in behavior problems across conditions as a result of exergaming. Although data were not collected on problem behavior to verify these reports, exergaming might serve as an effective intervention for reducing problem behavior among children in a school setting.

The present study demonstrated that exergaming produced more physical activity across all four participants than did regular PE activities. Futher, exergaming was socially acceptable to the PE teacher and students in this study. Based on the data collected during this study, exergaming could be a possible intervention choice for increasing physical activity among inactive 5th graders. Nonetheless, future research is needed to provide additional evaluation of the effects of exergaming on physical activity levels as well as health factors among inactive children.

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