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Choice of Interactive Dance and Bicycle Games in Overweight and Nonoverweight Youth

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Abstract

Background: Interactive video games are a popular alternative to physical activity in youth. One advancement in computer games are interactive games that use physical activity as a game playing controller, combining exercise and entertainment, or exertainment.

Purpose: This study tested the reinforcing value and activity levels of interactive dance and bicycle race games in 18 overweight and 17 nonoverweight 8- to 12-year-old youth.

Methods: Reinforcing value was studied using a behavioral choice paradigm that provided children the opportunity to respond on progressive ratio schedules of reinforcement for a choice of either playing the video dance or bicycle game using a handheld video game controller or one of three options: dancing or bicycling alone, dancing or bicycling while watching a video, or playing the interactive dance or bicycle game. Reinforcing value was defined in relationship to the amount of responding children engaged in for either choice.

Results: Results showed the interactive dance game was more reinforcing than dancing alone or dancing while watching the video ($p = .003$), but there was no difference across bicycling conditions. Nonoverweight youth were more active when given the opportunity to play the interactive dance game than overweight children ($p = .05$).

Conclusions: These results suggest that children may be motivated to be active when given the opportunity to play an interactive dance game.

INTRODUCTION

One of the major factors that influence the choice of how children allocate time among physically active or sedentary leisure time activities is their level of enjoyment derived from the activity (1,2). Many children have a wide variety of options among their leisure time activities, which range from a variety of physically active and sedentary alternatives. When given equal access to enjoyable sedentary and physically active alternatives, many youth choose to be sedentary (3,4), although the choice can be influenced by reducing access to sedentary behaviors (3,4) or by using sedentary behaviors to reinforce youth for being more physically active (5,6). Popular sedentary activities among children are interactive computer games, many of which adapt the level of play based on the improving skills of the child (7,8). The interactive nature of the games provides a continual challenge to the youth, which is individualized based on the skill level of the child.

One advancement in computer games are interactive games that use physical activity as the game playing controller, combining exercise and video game entertainment, or exertainment. These games begin at an easy level, provide feedback on performance and increase the level

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of difficulty based on child progress. These games may have a place in intervention programs designed to increase youth physical activity if children choose to allocate time they would have been sedentary to playing these exertainment computer games.

The primary goal of this study is to compare child choice of two different exertainment interactive physical activity games, an interactive dance video game and an interactive bicycle video game in boys and girls, and for overweight and nonoverweight youth. A consistent body of research has shown that girls are less active than boys (9,10), and overweight youth are more sedentary than thinner peers (11,12), and it is critical to evaluate whether exertainment works equally well for both genders and youth at varying degrees of overweight. To evaluate the reinforcing value of exertainment, children were given a choice of playing the interactive game using a handheld video game controller, or one of three different activity experiences, doing the activity alone, doing the activity while watching a video, and playing the interactive game. The condition in which participants played either the dance or bicycle video games using the handheld game controller are sedentary activities, providing comparisons of choice of active versus sedentary alternatives. The experimental conditions provide assessment of the influence of controls for having a sedentary alternative to the exercise experience, and for having a multimedia experience that is not interactive. Research has shown that attending to alternative stimuli while engaged in exercise increases the amount of exercise in obese youth (13), and it may be that the multimedia experience is more critical than the interactive nature of the dance and bicycle games.

The behavioral choice task varied the behavioral cost of playing the interactive video games or the alternatives, which provides the opportunity to measure the relative reinforcing value of the choices. Relative reinforcing value refers to how much responding the youth engages in to gain access to either of the alternatives.

METHODS

Participants

Participants for this study included 17 nonoverweight (at or below the 85th body mass index [BMI = kg/m^2] percentile) and 18 overweight children (>95th BMI percentile) between 8 and 12 years of age. Youth who were at risk for overweight, between the 85th and 95th BMI percentile were not included to provide separation between the overweight and nonoverweight groups. Participant characteristics, grouped by gender and BMI, are presented in Table 1. Participants were recruited from a newspaper advertisement, a direct mailing, and from our child database of families who have volunteered for previous laboratory studies. Inclusion criteria included at least a moderate liking (4 on a 7-point Likert-type scale) of all of the activities, no activity restrictions, including asthma, upper respiratory diseases/illnesses, or any physical limitations that can affect participation, did not own either the interactive dance game or the bicycle race game and a height requirement of 55 in. or greater, which was needed to ensure the child could pedal the cycle ergometer easily. Fifty-six children were screened for participation. Nine children were excluded because they were too short to pedal the cycle ergometer. Forty-four children met all criteria, and 9 children chose not to participate. Thirty-five families participated in the full study. The 9 children who chose not to participate averaged 10.6 ± 1.3 years of age, with 55% (5/9) male, all were non-Hispanic Whites, and they had *z*-BMI values of 23.3 ± 6.1 and *z*-BMI values of 1.1 ± 2.0. There were no significant differences between any of these characteristics in the children who chose to be in the study versus the children who met criteria but did not choose to be in the study.

Procedures

Parents were screened by phone for their child's height, weight, activity restrictions, a brief medical history, ethnic background and whether their child owned either the interactive dance or bike game. If eligible, the child was scheduled for two 60-min visits to the Behavioral Medicine Laboratory at the University at Buffalo. Parents were informed that their child should not eat within 2 hr and not exercise the day of their scheduled session (other than the child's scheduled physical education class). On arrival to the laboratory, written informed consent was obtained from the parents and assent from the child. The children completed a same day recall for food and activity to make sure they followed the food and activity recommendations. The experimenter then measured their height and weight. Next, the children sampled each activity for approximately 2 min, according to what condition they were assigned to that day. They rated each activity on a 7-point Likert scale, anchored from 1 (*do not like*) to 7 (*like very much*). The children then engaged in the behavioral choice task for dancing or bicycling based on the condition for that day. Children were given $20.00 for their participation in the experiment.

Experimental Conditions

The interactive dance game is Dance Dance Revolution (Konami, Redwood City, CA) a Sony Playstation® 2 game with a dance mat that attaches to the Playstation 2 console. As shown in the top graphic of Figure 1, each child participated in three choice conditions. In each comparison one of the alternatives was playing the dance video game with the game controller (in bold italics). The alternatives across the three comparisons were: (a) dance along with dance music from an instructional dance video (Dance + Music), (b) dance along with an instructional dance video (Dance + Video), or (c) play the interactive dance video game by dancing on the mat to music according to dance steps given by the game (Interactive Dance Game).

The interactive bicycle game used a Cateye™ stationary cycle (Cateye, Boulder, CO) that connected to a Sony Playstation® and Playstation 2 video game console (Sony, San Mateo, CA). The bicycle is unique in that it connects to a video game console, and the handlebars move for steering the bicycle. Children played a game called Freekstyle™ (Electronic Arts, Redwood City, CA), in which a character appeared on the screen riding a motorized bike. As the child began pedaling the bicycle, the animated bicycle on the screen began to move forward, and the youth could manipulate speed, braking or steering. The same functions could be performed using the video game controller or riding the bicycle. As shown in the bottom graphic of Figure 1, children had a choice between playing the bicycle game using the video game controller or: (a) riding the bicycle (Bicycle Alone), (b) riding the bicycle while watching a video they choose from a large selection of child videos (Bicycle + Video Comparison), or (c) playing the interactive game by riding the stationary bicycle (Interactive Bicycle Game). The order of tasks (dance/bicycle) was counterbalanced across participants, and the order of presentation of the three choice comparisons was also counterbalanced.

Measures

Behavioral Choice Task—A computer-generated choice procedure was used to assess the relative reinforcing value or motivated responding for the active and sedentary alternatives. Reinforcing value refers to the amount of work the participant will do to gain access to one of the two alternatives (3), such as the dance video game played with the video game controller or the dance video game played by dancing (comparison 3 in the top of Figure 1). We have used similar paradigms to assess the reinforcing value of physical activity in children (3). The computer screen consisted of two sets of three boxes in which different shapes and colors rotated every time a mouse button was pressed. The task began with participants having to respond on concurrent variable ratio (VR) VR8/VR8 schedules. When the child earned one point when the shapes matched in color and shape on either schedule, the schedule in both components doubled to VR16, VR32, VR64, and VR128. Variable ratio schedules refer to how the points that the child earns are provided. In a variable ratio 8 schedule, the child earns a point for every 8 mouse button presses, on the average, in a variable ratio 16 schedule, the child earns a point for every 16 mouse button presses, on the average. The number of points required to gain access to points progressively increase to provide data on how hard the child is willing to work to gain access to either of the alternatives. The computer recorded the participant's points earned throughout the session, and point totals were displayed at the top of the screen. An example of a computer screen that the participant would see is shown in Figure 2. After completing the task for the three conditions for each type of exertainment, the child exchanged their points earned for up to 30 min of time to be distributed among the alternatives based on points earned. Each point was worth 2 min. The experimenter monitored each participant through an intercom and video camera positioned in each test room.

Liking of Activities—Liking of physical activities used in the study was assessed by 7-point Likert-type scales, anchored from 1 (*do not like*) to 7 (*like very much*).

Same-day Food and Activity Recall—This measure was used to ensure that the child adhered to not consuming food at least 2hr prior to scheduled appointment and did not engage in physical activity the day of their scheduled session (other than the child's scheduled physical education class). The recall was assessed in an interview format in which the interviewer asked the child to recall their eating or physical activity that day, and provided time and examples of activities as prompts to facilitate recall.

Demographics—Socioeconomic status, race, ethnicity, and income were assessed using a demographics questionnaire (14). Socioeconomic status was based on parental education and occupation, and assigned numeric values that correspond to five socioeconomic classes which are Class I = 11–17 (lower class), Class II = 18–31 (lower to middle class), Class III = 32–47 (middle class), Class IV = 48–63 (middle to upper class), and Class V = 64–77 (upper class).

Anthropometrics—Height was measured using a Heightronic 235 digital stadiometer and weight was measured using a TANITA digital weight scale. BMI (kg/m^2) was converted to z-BMI based on the a nationally representative database to provide normative percentiles for a specific child's gender and age (15).

Assessment of Physical Activity—During the dance game condition activity was assessed using a BioTrainer Pro biaxial accelerometer (Individual Monitoring Systems, Baltimore, MD). Data were collected at a sample rate of 10 Hz with an epoch of 15 sec. When downloaded to a computer each epoch provides an intensity (*g*) by time measure. This accelerometer has been validated for use with adults (16,17), and we have completed laboratory-based validation for 62 children who wore the BioTrainer Pro during a multistage treadmill test (18). Oxygen consumption ($mL \cdot kg^{-1} \cdot min^{-1}$; Vmax 29 metabolic cart, Sensormedics, Yorba Linda, CA) was measured during the last 30 sec of 3 min at treadmill speeds of 56.4 $m \cdot min^{-1}$, 69.6 $m \cdot min^{-1}$, and 85.8 $m \cdot min^{-1}$. Individual correlations between *g* values and oxygen consumption were calculated for each child. The average (±*SD*) *r* for the 62 correlations was 0.96 ± 0.07 (18). The accelerometer was worn on an adjustable belt which held the accelerometer securely between the navel and hip. During the bike game condition the mileage that the participant biked served as the measure of physical activity.

Analytic Plan

Two-way analyses of variance (ANOVAs) were used to assess differences in baseline characteristics of the children as a function of child gender and overweight status. Differences in relative reinforcing value was accomplished using mixed analyses of covariance

(ANCOVAs) for each type of exertainment, with child gender and overweight status as between-subject variables and condition, alternatives and schedules of reinforcement as within-subject variables. Candidate variables considered as covariates included age, socioeconomic status and activity liking ratings. Variables that were different between genders or between conditions were used as a covariate. Differences in child activity levels and liking of the different activities was assessed using a mixed ANOVA, with child gender and overweight status as between subject variables and type of activity as the within variable. Effect sizes for the *F* ratios (ES^F) for interactions with gender or overweight status were calculated based on formulas provided by Power Analysis Statistic Software (19). The relationship between liking ratings and reinforcing value of each activity was assessed by correlating total amount of responding for each activity with liking ratings. Analyses were completed using SYSTAT software (19).

RESULTS

Participant characteristics are shown in Table 1. The overweight youth weighed more, had greater BMI and *z*-BMI than nonoverweight youth. Boys had higher socioeconomic levels than the girls, and socioeconomic level was used as a covariate in the ANCOVA for reinforcing value, activity and liking measures. Twenty-six percent of the youth were minority.

The relative reinforcing value for the active or sedentary alternatives for each condition in the dance (top graphs) and bicycle (bottom graphs) video games are shown in Figure 3. Analysis of the responding for dance showed a significant interaction of type of activity × sedentary/active alternative × schedule of reinforcement, $F(8, 240) = 3.66$, $p = .0005$. Linear contrasts showed that as the schedules of reinforcement increased, the children chose the interactive dance game over the sedentary alternative, while children in the Dance + Video or Dance alone comparisons generally chose to be sedentary and play the dance game using the video game controller, $F(3, 50) = 4.68$, $p = .003$. The ANCOVA showed no differences in motivated responding for the sedentary or active bicycle choices for the three conditions over the different schedules of reinforcement, $F(8, 240) = 0.71$, $p > .05$. There were no interactions of motivated responding with child gender or overweight status.

Child activity levels in the period when the children were engaging in the dance activities they had earned showed an interaction of overweight status by condition, $F(2, 60) = 3.15$, $p = .05$, $ES^F = .245$). The nonoverweight children showed an increase in activity counts when playing the Interactive Dance Video Game versus the Dance + Music or Dance + Video conditions, $F(1, 30) = 11.67$, $p = .002$, whereas the overweight youth did not increase their activity counts across conditions, $F(1, 30) = 0.71$, $p > .05$; Figure 4. There were no significant group differences in miles biked across the three conditions, although post hoc contrasts showed greater miles biked in the Bicycle + Video (1.15 ± .99) and Interactive Bicycle Video Game (1.15 ± .87) conditions than in the Bicycle alone (.85 ± .81) condition, $F(5, 30) = 2.57$, $p < .05$. In addition, there was a main effect of gender, as girls biked more than the boys across the conditions, $F(1, 30) = 11.38$, $p = .006$.

As shown in Table 1, there was a significant difference in liking of the dance activities, $F(3, 90) = 5.44$, $p = .002$, as the Interactive Dance Video Game and Interactive Dance Video Game played with a video controller were significantly more liked than the Dance + Music or Dance + Video conditions, $F(5, 30) = 19.68$, $p < .001$. There were no significant overall differences in liking for any of the bicycle game conditions, $F(3, 90) = 2.28$, $p = .23$, although post hoc contrasts showed that liking Bicycle alone was significantly less than the Bicycle + Video, Interactive Bicycle Video Game or playing the Interactive Bicycle Video Game using the video controller, $F(5, 30) = 2.53$, $p = .05$. The correlations showed liking predicted responding to gain access to bicycling while watching a video ($r = .46$, $p = .005$) but was not significant

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predictors of bicycling alone (r = .30, p = .08) or the interactive bicycling game (r = .07, p = .66). Liking predicted responding to gain access to dancing alone (r = .60, p = .0001) and dancing while watching a video (r = .55, p = .0007) but did not predict choice of the interactive dance game (r = .23, p = .18).

DISCUSSION

Results show that youth are motivated to play the interactive dance video game but are less motivated to play the interactive bicycle video game. The increased motivation to play the interactive dance game was not a function of having video paired with the dancing but rather from the interactive nature of the dance game. The motivation to use the interactive dance game did not depend on child gender or degree of overweight, as all children were more motivated to dance to play the game than to play the game using the video controller. When the children exchanged their points for access to that activity, there was an interaction of activity with overweight status, as only the nonoverweight youth showed significant increases in activity when playing the interactive dance game. The overweight youth had nonsignificant increases in activity when playing the dance game, and the activity counts for the nonoverweight youth were almost 2.4 times that of the overweight youth while playing the interactive dance game.

Liking for the interactive dance video game was significantly greater than liking for dancing with the instructional dance music or video. Liking of the interactive dance video game using dance or using the video controller were equal, but children were more motivated to gain access to the interactive dance video game than playing the dance game using the video game controller. Correlational analysis did not show liking predicted choice of playing the interactive dance or bicycle games. Basic research with animals (20) and humans (21) suggests that there is a separation between liking food reward, which is consistent with basic theoretical differences between wanting and liking natural reinforcers (22). The idea that liking and wanting may differentially influence behavior was first discussed in relationship to drug self-administration, with the idea that initially animals self-administered drugs that they liked, or that produced pleasurable sensations. After repeated self-administrations the rewarding characteristics of the drugs mediated by the dopaminergic activity became more important, and animals craved the drugs even if liking was reduced. The idea that wanting may become more important than liking has also been extended to food and natural reinforcers (20-22). This study suggests that this distinction may also be extended to some physical activities.

The interactive bicycle game was not more motivating than riding the bicycle alone or the bicycle plus concurrent video. This may be due to one of several reasons. First, it may be that riding the bicycle to play the video game was not very reinforcing, in part because it was too much like usual exercise. It is also possible that the alternative to playing the interactive game by using the video controller was very similar to usual video games, and was a more reinforcing alternative. Because the relative reinforcing value of a behavior depends on the alternatives that are available (23), the choice of the bicycle game versus a less reinforcing alternative may have shifted the choice to be more physically active. It is possible that the workload set on the cycle ergometer may have been too high, limiting the children's motivation to choose the cycle.

The use of the behavioral choice paradigm with progressive ratio schedules of reinforcement (24) provides a sensitive assessment of the relative reinforcing value of video game and physical activity alternatives. Although the interactive dance was more reinforcing than the same game played with a video controller, the responses for these two alternatives were equal throughout most of the schedule comparisons, with differences being enhanced only at the greatest work requirement of 128 responses. When the amount of work required to gain access to the alternatives was low, there was no difference in the responses for either alternative. Thus, in a typical choice situation, in which participants have equal access to the alternatives without any constraints on the behaviors, the choice may be very similar. This suggests that a choice paradigm based on progressive ratio schedules of reinforcement is a more sensitive test of motivation than a choice situation that provides equal access but does not vary the work to gain access to the alternatives.

This study provides support for the use of interactive dance games in intervention programs to prevent or treat pediatric obesity. The potential for the use of dance as an exercise program in children is consistent with research using ethnic dance to prevent weight gain in African American youth (25). Interactive dance video games take advantage of youth positive experiences with video games and are designed to be enjoyable and match the challenges in the game to the skill level of the youth (7,8). Basic research has shown increases in dopaminergic activity during the playing of video games activity (26). Changes in dopaminergic activity are involved in reinforcing activities (27,28), which may in part be responsible for the increases in motivation to play the interactive game using physical activity.

This study assessed the motivation to play the interactive dance game only on one occasion. It is possible that the reinforcing effects of the interactive game will change over time. It would be advantageous if the reinforcing value increased or sensitized over time, and children would be more motivated to play the game with more experience. The changes in the game with feedback for performance, increasing skills and the variety of games may keep the reinforcing value of the activity elevated versus a game that is static over time. It is also possible that the effects would habituate over time. The interactive dance game is relatively novel, and the reinforcing value may decrease as the novelty wears off.

Similarities in the relative reinforcing value of the interactive dance game was not associated with equivalent amount of time in physical activity while playing the game for overweight and nonoverweight youth. There may be several reasons why overweight youth may engage in less activity than leaner youth. These include such psychological constructs as self efficacy in ability (29), perceptions of competence (30), and enjoyment of physical activity (31). An additional reason may be individual differences in motor proficiency and motor skills. Overweight youth may be less coordinated than leaner youth (32,33), and motor skills have been related to physical activity in youth (33-35). Problems with motor coordination also can influence self-efficacy and activity levels (35).

Future research should provide more direct measures of energy expenditure to assess whether overweight or nonoverweight differences in activity are associated with differences in energy expenditure. Energy expenditure depends both on the amount of activity and the body weight of the youth, and an overweight child may expend similar calories to a less overweight youth even if they are less active. The results of this study are limited to the two interactive games that were studied. As new forms of exertainment are developed, the motivation to play these games and be physically active should be studied. We hope that general principles of interactive game design can be developed that would provide a guide to the development of new exertainment games that youth want to play. It is possible that understanding why interactive computer games are reinforcing may also provide ideas about how to make typical youth activities more reinforcing for more youth.

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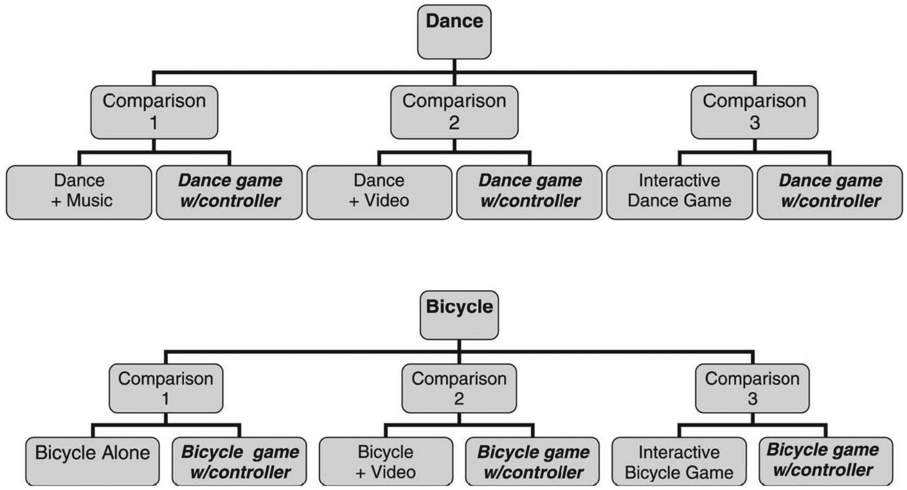

FIGURE 1.
Choices for the dance (top diagrams) and bicycle (bottom diagrams) conditions.

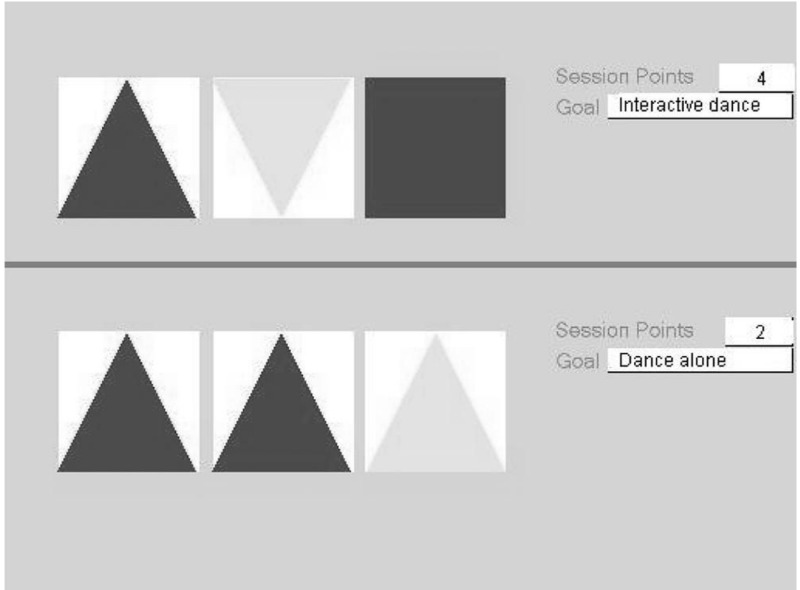

FIGURE 2.
An example of a screen from the computer task that represents a choice between the interactive dance game or dancing to music. The session points represents the number of points for each alternative that were earned. After a button press for either choice was made, the shapes revolved, and when all three shapes matched the children earned a point. The number of responses required to earn a point was determined by the schedule of reinforcement.

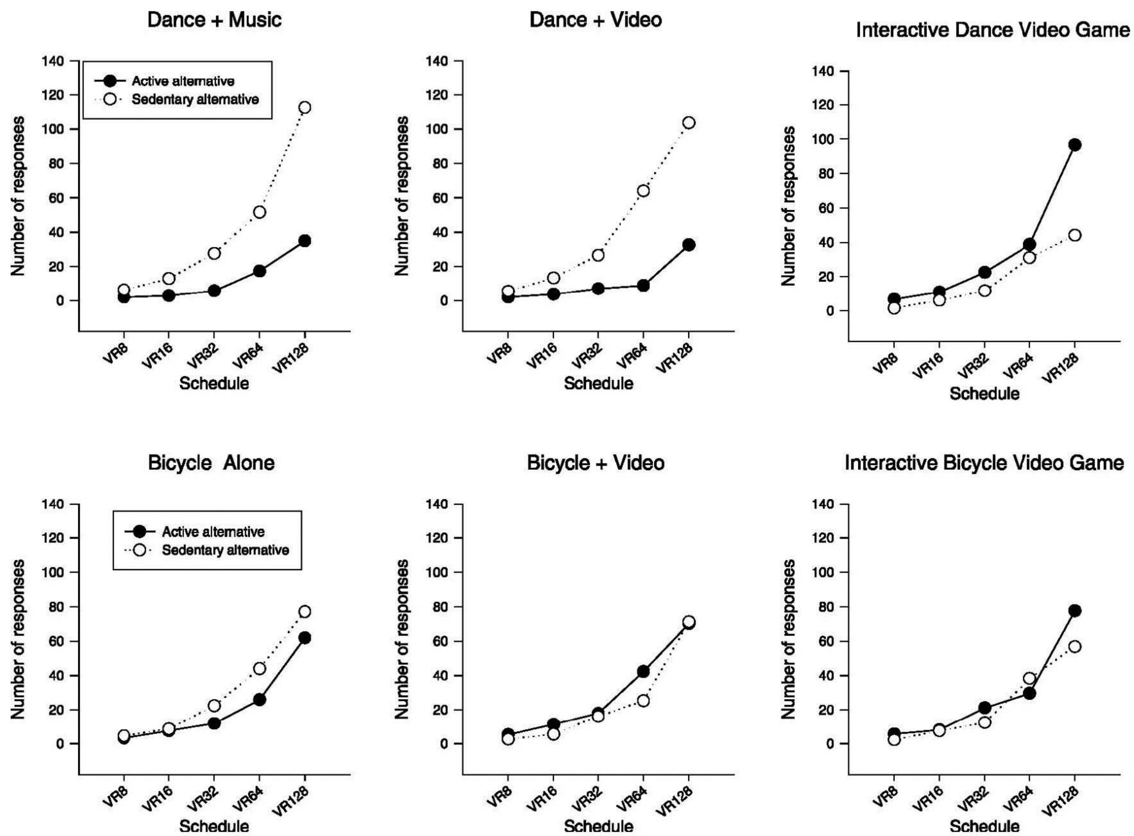

FIGURE 3.
Responses across the different schedules of reinforcement for the dance (top graph) and bicycle games (bottom graphs) as a function of the experimental condition and the schedules of reinforcement. The schedules refer to the average number of responses on either schedule to earn a point toward either choice. The schedules progressed to the next schedule when a participant met the schedule requirements.

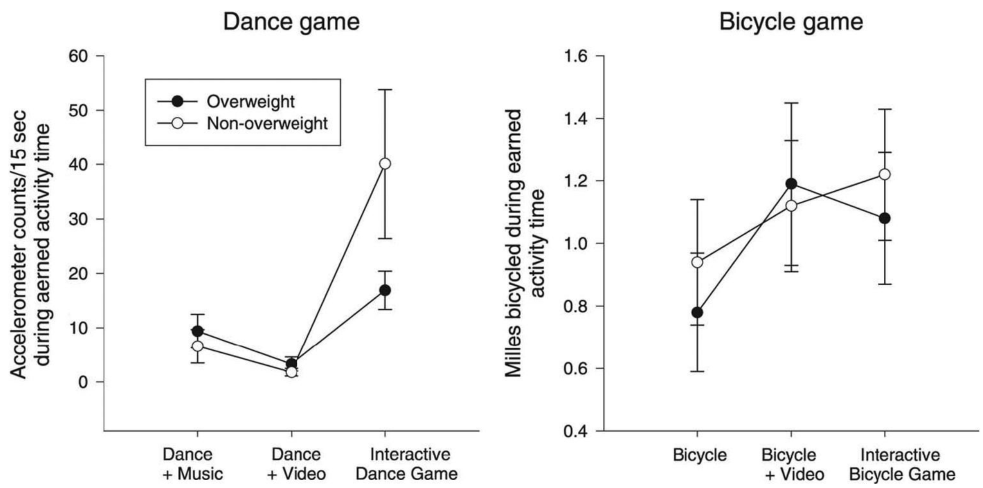

FIGURE 4.
Accelerometer counts during the time earned for the dance games and miles ridden during time earned for the bicycle games for overweight and nonoverweight youth (*M* ± SEM).

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TABLE 1

Characteristics of Participants

	Boys		*Girls*		
N	***Nonoverweight* 9**	***Overweight* 9**	***Nonoverweight* 8**	***Overweight* 9**	***Total* 35**
Age (y)	10.7 ± 1.3	10.9 ± 1.1	11 ± 1.1	10.6 ± 1.1	10.8 ± 1.4
Height (in.)	56.7 ± 3.3	57.8 ± 5.0	58.1 ± 2.5	57.3 ± 4.1	57.4 ± 3.8
Weight (lb)[a]	79.4 ± 13.0	135.6 ± 33.9	79.8 ± 13.5	118.8 ± 19.3	104.1 ± 32.5
BMI[a]	17.3 ± 1.7	28.5 ± 6.3	16.6 ± 1.9	25.4 ± 1.9	22.1 ± 6.2
z-BMI[a]	0.0 ± .8	2.1 ± 0.4	− 0.5 ± .8	1.9 ± 0.2	0.9 ± 1.3
SES[b]	55.6 ± 12.7	54.4 ± 17.3	39.6 ± 14.3	47.2 ± 14.8	49.5 ± 15.6
Minority Liking ratings	3/9 (33%)	3/9 (33%)	2/8 (25%)	1/9 (11%)	9/35 (26%)
Bike alone	4.0 ± 2.2	5.6 ± 1.6	5.3 ± 0.9	5.0 ± 1.2	4.9 ± 1.6
Bike with video	4.8 ± 1.6	5.6 ± 1.2	6.6 ± 0.5	6.1 ± 0.8	5.7 ± 1.3
Interactive bike	5.6 ± 1.5	5.9 ± 1.6	5.5 ± 1.7	6.3 ± 0.7	5.8 ± 1.4
Bike video game	5.8 ± 1.6	6.3 ± 1.4	5.1 ± 1.8	6.1 ± 0.8	5.9 ± 1.4
Dance alone	2.6 ± 1.4	3.6 ± 2.0	3.3 ± 1.5	4.0 ± 2.1	3.3 ± 1.8
Dance video	2.3 ± 1.4	3.3 ± 1.7	4.3 ± 2.2	3.2 ± 2.2	3.3 ± 1.9
Interactive dance	5.2 ± 2.0	6.4 ± 0.5	6.2 ± 2.1	6.5 ± 1.0	6.1 ± 1.6
Dance video game	5.3 ± 1.6	5.4 ± 2.1	6.1 ± 1.1	5.6 ± 1.2	5.6 ± 1.5

Note. Overweight youth were greater 95th body mass index (BMI) percentile, whereas nonoverweight youth were below the 85th BMI percentile. Socioeconomic status (SES) is based on parental occupation and education (14), minority status include Hispanic, African American, Native American, and multiple race families.

[a]Differences between overweight and nonoverweight youth ($p < .001$).

[b]Differences between genders ($p < .05$).