Dance Dance Revolution: A Physiological Look at an Interactive Arcade Game

by Josh Trout and Karra Zamora

Abstract

The purpose of this study was to examine body composition (via Bodpod®), time in target heart rate zone, estimated caloric expenditure (via heart rate monitor), prior physical activity levels (via Baecke questionnaire), and enjoyment levels (via Physical Activity Enjoyment Scale) as a result of playing Dance Dance Revolution® (DDR) three times per week for 20 minutes over eight weeks. Participants were 14 female and 12 male participants aged 18-30. Participants showed a significant reduction in body fat from pre- to post-treatment. Males and females expended an estimated 276 and 176 calories respectively during each dance session. Results showed consistent high levels of enjoyment over the eight weeks. Exit interviews revealed that DDR was perceived as fun yet challenging and beneficial.

Key words: dance, exergaming, obesity

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Video games that require the gamer(s) to be physically active are growing in popularity. The animated virtual-reality excitement of these games may be a critical tool in increasing the amount of time people spend in daily moderate to vigorous physical activity (MVPA). Daily MVPA is a crucial component in the battle against hypokinetic diseases such as obesity and heart disease. The most recent data from the National Center for Health Statistics show that 19% of U.S. children aged 6-11 and 17% of adolescents aged 12-19 are overweight. Even worse, 32% of adults in the U.S. aged 20-74 are overweight and an additional 34% are obese (United Stated Department of Health and Human Services [USDHHS], 2006). Being overweight or obese increases the risk of hypertension, type II diabetes, coronary heart disease, stroke, osteoarthritis, and some cancers (Centers for Disease Control and Prevention [CDC], 2005; USDHHS, 2001). This chronic and worsening health trend requires immediate attention as obesity is currently the second leading cause of death in the U.S. owing to physical inactivity. In fact, physical inactivity and poor diet (the two most frequent cited causes of obesity) cause over 400,000 deaths per year in the United States (Mokdad, Marks, Stroup & Gerberding, 2004). This is more than the number of deaths caused by infectious diseases, firearms, motor vehicle crashes, illicit drug use, alcohol, and HIV combined; only tobacco use causes more deaths (Mokdad et al., 2004).

While the statistics are disturbing, technology may be a possible solution in the form of "exergaming" (exercise + gaming). Exergaming involves playing a video game using your body as the joystick. One of the most popular forms of exergaming is an interactive dancing arcade game (there are also home versions) known as Dance Dance Revolution® (DDR) (Konami of America, Inc., Redwood City, CA). This game provides opportunities for people who enjoy video games to engage in physical activity and possibly improve their health at the same time. Lanningham-Foster et al. (2006) found that energy expenditure more than doubled when participants played active video games such as DDR compared to playing sedentary video games. Furthermore, Unnithan, Houser, & Fernhall (2006) found that children who played DDR for 12 minutes exceeded the minimal American College of Sports Medicine (ACSM) recommended heart rate intensity for developing and maintaining cardiorespiratory fitness.

Although empirical evidence in this area is slim, anecdotal evidence in countless newspaper and magazine articles have provided personal testimonies of people losing weight ("Dance Dance Revolution", 2005; Barker, 2005; Doyle, 2004; Kreimer, 2004) and even managing diabetes (Twede, 2005) after a just few weeks of playing the game. Due to the overwhelming popularity of DDR since it was released in the U.S. in 2001, it has been featured on Fox News, CNN, ABC News, the Early Show on CBS and several other media outlets. In fact, the game has been so popular with children and teenagers that Konami (the company that manufactures DDR) recently announced plans to place DDR in all 753 public schools in West Virginia (Lash, 2006).

Although widely popular in physical education programs, arcade stores, and even living rooms, few studies have examined physiological variables during game play. Furthermore, no empirical evidence exists regarding enjoyment levels. The purpose of this study was to examine body fat percentage, time spent in target heart rate zone (THRZ), caloric expenditure, prior physical activity, and enjoyment levels in healthy young adults while playing DDR. Caloric expenditure estimates were collected for comparison to more traditional physical activities as well as to examine differences between genders. Gender comparison with regard to caloric expenditure and enjoyment was necessary since males receive more DDR media coverage, most of which focuses on enjoyment and weight loss. No explanation is available for this, however, if males enjoy the game more or expend more calories while playing (and thus lose more body fat), the media may focus more attention on them compared to females. Both genders were examined equally in this investigation.

Four hypotheses were determined prior to data collection: (a) participants would show a reduction in body fat and body weight, (b) participants with higher enjoyment scores would spend more time within or above their THRZ and show greater improvements in body composition compared to participants with lower enjoyment scores, (c) participants who were more physically active prior to the study would enjoy DDR more than less physically active participants and (d) participants would report high levels of enjoyment from playing DDR. Regarding the latter hypothesis, the relationship of enjoyment scores and the degree to which participants were physically active prior to the study was also examined. Participants were diverse in terms of their daily levels of physical activity, thus analyzing these variables allowed

investigators to determine if sedentary or highly active individuals enjoyed the game more.

Methods

This study was approved by the Human Subjects Review Committee at California State University-Chico. Informed consent was obtained prior to data collection from all participants.

Participants

Twenty six students (12 males and 14 females, aged 18-30) volunteered to participate. Twenty participants were white, two were Hispanic, two were Asian, one was Filipino, and one was American Indian. All but one were graduate or undergraduate students at a university in Northern California who represented 12 different majors across campus. Participants were recruited by posting advertisements about the study around campus and asking for volunteers. Participants were not compensated for participation in the study.

Procedure

After signing an informed consent, participants filled out the Baecke Questionnaire of Habitual Activity, which asks a series of questions on a 5-point Likert scale to quantify work activity, sports activity, and non-sports leisure activity (Baecke, Burema, & Frijters, 1982; Aadahl & Jorgensen, 2003). Participants also completed a Physical Activity Readiness Questionnaire to determine whether or not their health was at risk prior to participating in the study. Next, after sitting quietly for five minutes wearing a heart rate monitor, participants' resting heart rate was recorded. This information along with age and target exercise intensity zone (set at 60-80%), was used in the Karvonen formula [(220-age) - Resting HR * 0.6 or 0.8 + Resting HR] to determine THRZ during exercise. Upper and lower limits of exercise intensity were programmed into the heart rate monitor at 60% and 80% respectively. These limits are the generally accepted heart rate range for exercise and fall within ACSM's classification for "moderate" and "hard" exercise intensity (American College of Sports Medicine [ACSM], 2006, p.340).

Participants then underwent a BodPod® (Life Measurement, Inc., Concord, CA) assessment to determine their body fat percentage as well as their total pounds of lean and fat weight (Ball, 2005; Fields, Higgins, & Radley, 2005). The BodPod® was calibrated and tests were conducted according to the manufacturer's guidelines.

After baseline data were collected, participants reported to the lab three times per week for the next eight weeks to play DDR using a Sony Playstation 2® (Sony, Foster City, CA) and an electronic dance pad (Cobalt Flux, Inc., Salt Lake City, UT). Dance Dance Revolution® requires the player to step or "dance" on one of four arrows on a 3' X 3' touch-sensitive pad on the floor based on visual cues from the screen and the beat of a song.

Participants were not allowed to miss any sessions. Missed appointments were rescheduled as close to the originally scheduled date as possible. Each dance session, (24 in total over the 8-week period) lasted 20 minutes. While playing, participants wore an Ekho E300 heart rate monitor (Ekho, Minneapolis, MN) that was programmed with the individual participants' body weight, age, gender, and upper and lower limits of their THRZ. Heart rate monitors measured time spent within, above, and below the THRZ and estimated caloric expenditure. Although evidence suggests that a degree of error is involved in estimating caloric expenditure from heart rate (Hiilloskorpi et al., 1999), research suggests that heart rate data and activity type are acceptable methods for determining this variable (Treuth, Adolph, & Butte, 1998). For practicality, it was determined that estimates of caloric expenditure, as opposed to direct measures were acceptable for the scope of this investigation.

While dancing, participants were allowed to choose the songs they wanted to dance to. Participants were also allowed to dance at their own pace and select their own difficulty level as long as they remained active for the entire 20 minutes. The goal was to simulate a self-selected leisure level of play similar to playing the game at home or in an arcade. Data on which songs each participant chose were not collected.

After each dance session was completed, participants completed a modified Physical Activity Enjoyment Scale (PACES) (Motl, Dishman, Saunders, Dowda, Felton, & Pate, 2001; Kendzierski & DeCarlo, 1991) to determine their enjoyment level during game play. We chose the modified version because it was shorter and easier to understand and more appropriate for this study since participants would have to complete it 24 times during the 8-week treatment (three questionnaires per week for eight weeks). Participants were asked to rate 14 questions on a 5-point Likert scale (1 = "Disagree a lot" and 5 = "Agree a lot"). Positive statement scores such as "I enjoy it" were calculated at face value. The values of negative statement scores such as "It frustrates me" were reverse scored. This allowed every statement to have a numeric value so a score could be averaged.

Participants were asked at each session to write down any changes to their routine physical activity levels, nutritional consumption, and/or medications. Participants were also asked not to make any changes in these areas and to notify the investigators if they did. When the participants finished their 20-minute dance session in the lab, the investigators recorded the amount of time spent above, within, and below their THRZ, as well as, their estimated caloric expenditure from the heart rate monitor wrist strap.

After eight weeks of playing DDR three times per week, participants again underwent a BodPod® assessment to measure post-treatment body composition. Immediately after the Bodpod® assessment, participants were formally interviewed using the standardized open-ended interview approach (Patton, 2002) for approximately 30 minutes. These exit interviews were designed to obtain information regarding participants' feelings on dancing, playing video games, and overall perceptions of DDR. Participants were asked again about their food intake, physical activity outside the lab, and medications taken during the 8-week study since these variables could have had an impact on body composition. Exit interviews were tape-recorded and transcribed for analysis. Transcripts were coded by two researchers to identify and compare emergent themes.

Statistical Analysis

Paired sample *t* tests were used to compare body fat percentage as well as body weight before and after the 8-week treatment.

Scores for all 14 questions on the PACES were summed for each time playing DDR. Daily enjoyment scores were averaged every two weeks for the duration of the 8-week study. This allowed investigators to examine changes in enjoyment in four separate time periods. Repeated measures ANOVA examined enjoyment scores over each of four time periods (weeks 1-2, weeks 3-4, weeks 5-6, and weeks 7-8) and was used to compare the estimated calorie expenditure by gender each week. Simple linear regression was used to predict changes in body fat percentage from PACES scores. Simple linear regression was also used to predict the amount of time spent within and above THRZ from PACES scores. A third simple linear regression was used to predict PACES scores from the degree to which participants were physically active prior to the study. Alpha level was set at $p < .05$.

Results

Quantitative

Post-test bodyweight (M = 157 pounds, SD = 33.4 for females and M = 167.3 pounds, SD = 20.2 for males) was significantly less (see Table 1) than pre-test bodyweight (M = 158.6 pounds, SD = 34.3 for females and M = 168.8 pounds, SD = 21.8 for males), ($t(25) = 1.99$, $p < .05$). Among both genders, post-test body fat percentage (M = 25.6%, SD = 11.9%) was significantly less than pre-test body fat percentage (M = 26.8%, SD = 11.5%), ($t(25) = 3.33$, $p < .05$). Twenty-two of the 26 participants showed a reduction in body fat, while four gained body fat (see Figure 1).

Table 1. ***Demographic and Pre/post Tests Data***

ID#	Pre-Test Body weight	Post-Test Body weight	Pre-Test Body fat %	Post-Test Body fat %	Activity Level[a]	Age	Height[b]	PACES[c]
				Females				
1	183.5	175.3	38.9	37	4.0	23	68	67.5
2	177.4	175.2	36.4	35.9	5.	20	68	69.9
3	154.6	155.2	37.8	36.9	9.6	18	65	68.5
4	117.6	115.7	33.4	30.9	5.7	23	64	69.0
5	163.6	160.5	27.2	23.5	9.8	20	71	53.8
6	151.9	155.7	32.3	34.4	4.8	25	63	68.9
7	125.6	125.5	27.8	30.1	7.2	23	62	42.9
8	209.0	210.4	43.6	43.5	7.2	23	65	69.8
9	157.9	157.1	31.8	31.5	7.0	22	62	47.9
10	121.9	120.4	31.9	31	10.0	21	63	66.8
11	162.4	161.6	34.5	34.2	7.7	19	63	66.8
12	107.2	104.7	30.6	27.9	8.0	24	64	63.7
13	158.9	159.5	37.0	36.2	4.6	28	68	58.5
14	229.0	221.6	49.9	49.2	4.3	22	63	56.8
				Males				
15	169.3	169.8	18.9	18.8	10.8	21	74	60.8
16	165.8	158.1	14.5	9.3	8.6	21	74	69.1
17	203.8	196.2	20.6	20	4.5	29	74	68.3
18	198.1	190.2	22.2	17.6	9.2	22	72	66.0
19	169.1	164.1	26.7	24.5	8.6	18	68	69.6
20	185.0	185.3	28.3	26.6	8.7	20	69	53.5
21	124.8	126.2	9.5	9.0	10.8	22	68	69.2
22	154.5	157.3	9.2	7.7	8.7	20	70	64.6
23	156.5	156.7	6.0	5.4	10.8	22	68	56.3
24	153.2	157.0	9.3	7.5	10.8	20	69	62.3
25	184.7	190.7	25.3	25.7	8.8	20	67	49.9
26	160.7	155.7	12.0	12.3	10.1	20	75	66.3

[a] Measured using Baecke Questionnaire. [b] Measured in inches. [c] Average over eight weeks.

Although only a 1.2% reduction in body fat was observed, no other weight loss strategies such as caloric restriction or consuming fat-burning supplements were implemented. The intervention was only 60 minutes of physical activity per week.

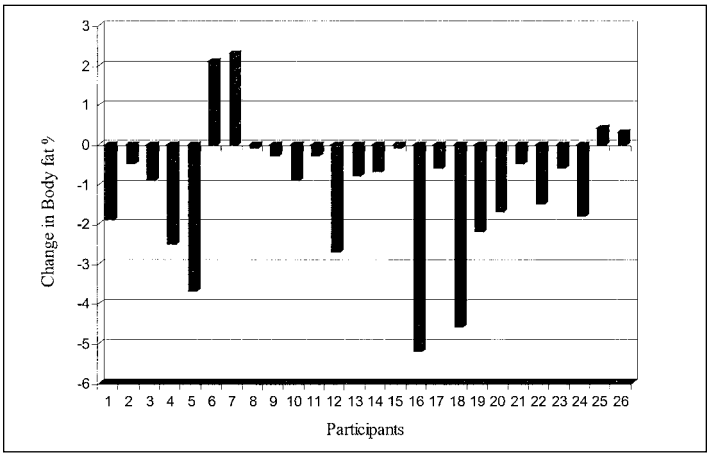

Figure 1. Change in body fat % for each participant after the 8-week treatment.

Although nutrition logs and daily caloric expenditures were not recorded throughout the eight weeks, it is likely that the reduction in body fat was due to participation in the study. Participants were asked prior to participating in the study not to make any changes to their diet, physical activity patterns, or medications. If any changes were made, participants were asked to list them each time they reported to the lab (questions about these lifestyle changes were added to the PACES questionnaire). Less than ten changes in total, mostly binge eating or drinking, were noted from all participants throughout the study. Only two participants became ineligible for participation due to these restrictions: One began using oral contraceptives and one was a student-athlete whose training season would have begun during the study.

Males burned significantly more calories ($F(1,24) = 26$, $p < .05$) per 20-minute session playing DDR (M = 276.3, SE =1 4.2), compared to females (M = 177.5, SE = 13.2). The number of calories burned per dance session did not significantly change over the 8 weeks.

Perhaps the most interesting finding from this study was the

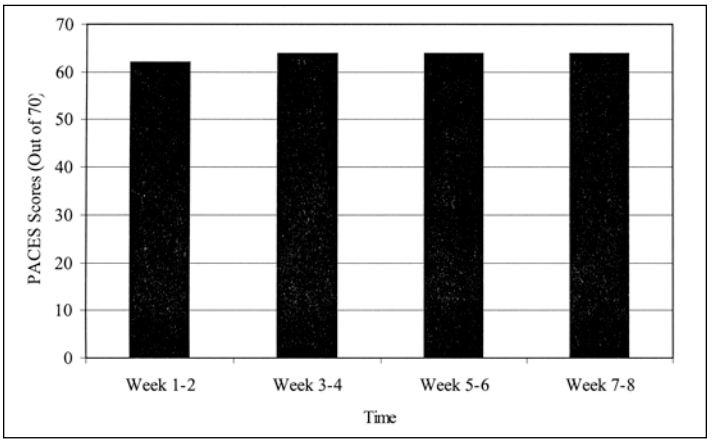

Figure 2. Mean enjoyment scores for all participants. The 8-week treatment was divided into four 2-week blocks.

extent to which participants enjoyed the game. When all 14 PACES statements were averaged, 81% of participants scored a 4 or higher out of 5 (5 being the highest level of enjoyment) on the PACES over the 8 weeks indicating consistent high levels of enjoyment (see Figure 2). No significant change in enjoyment scores was observed over time during the eight weeks and no significant relationship was observed between enjoyment scores and gender.

Participants who were more active prior to the study had significantly lower enjoyment scores in all four time blocks (see Table 2) except weeks 5-6 where it approached significance [weeks 1-2, $F(1,24) = 5.43$, $p < .05$; weeks 3-4, $F(1,24) = 6.39$, $p < .05$; weeks 5-6, $F(1,24) = 4.08$, $p = .06$; weeks 7-8, $F(1,24) = 4.75$, $p < .05$]. Prior physical activity scores from the Baecke questionnaire were divided into low, medium and high groups. The PACES comparisons among these groups do not differ greatly. The least active third of participants averaged 62.4, 65.5, 63.3, and 64.1 on the PACES in weeks 1-2, 3-4, 5-6, and 7-8, respectively. In the same four time blocks, the medium group scored 61.3, 63.2, 63.3, and 62.9. The high, or most active group scored 62, 62.2, 62.1, and 61.

Table 2. ***Enjoyment Scores from PACES in Four Separate Time Blocks***

ID #	Weeks 1-2	Weeks 3-4	Weeks 5-6	Weeks 7-8
		Females		
1	66.3	67.1	67.8	68.5
2	69.8	70.0	70.0	69.6
3	67.6	69.0	69.0	68.3
4	69.0	69.0	69.0	69.0
5	55.8	53.3	55.6	50.5
6	67.8	68.3	69.5	70.0
7	39.5	43.5	45.67	43.0
8	69.6	69.6	70.0	70.0
9	41.1	50.1	49.0	51.1
10	66.0	66.5	67.8	66.6
11	61.8	70.0	68.8	66.5
12	63.1	64.0	63.6	63.8
13	57.0	58.6	59.1	59.0
14	60.6	57.8	53.0	55.6
15	63.5	60.8	59.6	59.3
		Males		
16	69.0	70.0	67.3	70.0
17	67.1	67.0	69.1	69.6
18	65.6	65.8	66.8	65.6
19	68.6	70.0	69.8	70.0
20	53.1	52.6	54.1	53.8
21	67.0	69.8	70.0	70.0
22	61.8	65.5	67.0	64.0
23	55.5	57.0	56.0	56.5
24	62.5	62.0	62.0	62.8
25	56.9	51.7	46.4	44.4
26	63.7	66.8	67.8	67.0

There was no significant relationship between enjoyment scores and time spent within or above the THRZ and between enjoyment scores and changes in body fat percentage.

Qualitative

Exit interviews with each participant provided insight into what participants liked and disliked about DDR, if they perceived to have benefited from participation in the study, and their general feelings regarding dancing and video games. Overall, participants said they enjoyed playing DDR. In fact, all but one subject used the word "fun" to describe their experiences playing the game. Participants said they liked "combining physical activity with a video game", "being able to select the intensity level based on how I felt that day", and "feeling successful after learning [how to dance to] a song." With regard to the music played while dancing, eight participants stated that they enjoyed the music, while seven felt that the music was either "boring," "monotonous," or "inappropriate for real dancing."

Negative responses to DDR. Negative responses to the game included "it hurt my feet," "I had trouble staying on the dance pad," and "it was too repetitive." The most prominent negative response was that progressing to the next level (there are 5 levels in the game) was frustrating. Several participants noted that each time they attempted the next higher level; it was too fast and complex resulting in frustration. They expressed a desire for more "in between" levels with a more steady progression.

Another common negative response was that stepping on the arrows on the dance pad was too "constraining" compared to freestyle dancing (e.g., dancing at nightclubs, weddings, or other dance events). One participant stated "I guess I'm used to [dancing] differently and that was kind of frustrating for me to have to move the way [the game] showed me to move." Another participant said "It's like really unrealistic dancing. You would never actually dance that way." Another participant noted "the only problem with DDR is those stupid right, left, forward movements. It kind of gets a little hard to bust a move." Even though some participants felt constrained by playing DDR in comparison to freestyle dancing, they still said they enjoyed the game. Even more interesting is that the seven subjects who disliked dancing in general said they enjoyed playing DDR.

Perceived benefits of DDR. When asked "What, if anything, do you like about DDR?," the most common response was that it was challenging. When probed for further explanation, participants stated that the game implemented several strategies to keep them constantly challenged including "trying to keep the red bar [that indicates successful dance steps] full," "picking faster songs," "going for higher combinations [of perfect dance steps]," "trying to get a higher grade like an 'A' on every song," and "avoiding the 'boos' on the screen when you messed up."

Some participants described feeling so challenged by the game that it brought out the competitive spirit in them. For example, one participant stated "I enjoyed the competition the most, being able to go up against a video game and just keep improving myself. There's never a time when you can actually beat the game. You just keep progressing."

Twenty-four of the 26 participants said they felt like they benefited in some way from playing DDR. Perceived benefits included: (a) increased leg strength and endurance, (b) feeling less winded and more energized throughout the day, having better balance and eye-foot coordination, and (c) feeling healthier overall. Three participants actually mentioned that their performance in

other areas had improved. One participant mentioned "I do a lot of dancing…with the beat, you know, like if it's a four count…I [am enrolled in a] Beginning Ballroom [dance class] and I can just kind of keep on count without consciously making an effort which I didn't do [before participating in this study]." Another participant felt her cardiovascular endurance had increased. She said "Cardio-wise I have more endurance. Like when I ran the race on Saturday, the three miles, I felt good…I wasn't struggling to like run so I think [DDR] has helped."

Overall, participants described many reasons why they enjoyed playing DDR and how it challenged them. In fact, all but three indicated their intention to purchase a home version of DDR to play at their leisure.

Discussion

In addition to the positive effects on body composition, participants reported consistent high levels of enjoyment from playing DDR throughout the eight weeks. The objective measurement of enjoyment from the PACES parallels the subjective responses from exit interviews in that participants reported consistent high enjoyment levels throughout the eight weeks from both. Most participants discussed how the game constantly challenged them in a way that made them want to continue playing. This is encouraging since exercise adherence has been linked to exercise enjoyment (Ryan, Frederick, Lepes, Rubio, & Sheldon, 1997; Lindgren & Fridlund, 1999). Even satisfaction with the music being played during exercise is linked with exercise enjoyment (Wininger & Pargman, 2003). This is particularly interesting since several participants in this study said they enjoyed the self-selected music that accompanied the dance sequences. Thus, it is plausible to expect that individuals who enjoy DDR (or even the music associated with DDR) are likely to adhere to this form of exercise.

Although most participants enjoyed playing DDR based on PACES scores and exit interviews, those who were more physically active prior to the study reported significantly lower enjoyment scores compared to less physically active participants in weeks 1-2, weeks 3-4, and weeks 7-8. This relationship approached significance in weeks 5-6. Five subjects had a cumulative activity score (this includes a work, sport, and leisure-time index) that was 10 or higher. These were considered the most physically active participants prior to the study. These participants reported more highly active leisure time as well as regular participation in sports such as bowling, golf, running, motocross, soccer, basketball, lacrosse, cycling, and softball. The reason that participants who were more physically active did not enjoy playing DDR as much as those who were less physically active is not fully understood. Perhaps they were satisfied with their current level of daily physical activity and therefore received less enjoyment from the addition of DDR. It is also possible that, because they were already active in sports, they had already found the types of physical activity that they enjoyed, thus making DDR more of a "chore".

Regardless of the degree to which certain participants enjoyed playing DDR, most expended as many or more calories playing DDR than comparable physical activities. Not surprisingly, males expended significantly more calories than females, which were initially assumed to be a factor of males having greater body weight. However, males only weighed an average of 10 pounds more than females in this study. One variable that may explain this is to examine the amount of effort males put into playing the game. Exit interviews indicated that males competed with themselves or against the game more often than females. In addition, males reported more strategies to keep themselves challenged by the game compared to females. Reasons why participants produce varying levels of effort in exergaming needs to be examined further. It is reasonable; however, to predict that, like any game or sport, some individuals will enjoy and excel at the specified motor patterns, timing, and rhythm of DDR, while others will not. Exit interviews revealed that participants found DDR "challenging" yet "constraining." Perhaps the motor learning required to play DDR appeals to individuals who enjoy other sports/physical activities that are also challenging yet constraining.

Males and females burned as many or more calories as other MVPA's. For example, males in this study whose mean weight was 169 ± 34 pounds burned an average of 276 kcals per 20 minutes of playing DDR. Using a web-based interface (www.caloriecontrol.org) to estimate caloric expenditure, an individual weighing 169 pounds would burn approximately 253 kcals in 20 minutes jogging, 176 kcals weight lifting, 135 kcals performing yoga, and 226 kcals swimming. According to the same source, females in the study whose mean weight was 159 ± 34 pounds and burned an average of 177 kcals, would burn approximately 238 kcals in 20 minutes jogging, 166 kcals weightlifting, 127 kcals performing yoga, and 213 kcals swimming. Thus, playing DDR has implications for weight management since playing it requires as many calories as other popular physical activities. DDR, however, has an advantage over the more traditional physical activities such as jogging on a treadmill or swimming laps. It has exciting music, eye-catching animation, and offers an innovative way to have fun while exercising in a virtual environment. In addition, most participants who said they disliked dancing in general said they enjoyed playing DDR. Thus, DDR could be used as a tool for physical educators, personal trainers, or after school program directors to introduce concepts of dance to individuals who would otherwise be reluctant or too intimidated to even try.

Results from this study indicate that playing DDR is an enjoyable and challenging activity even after playing it three times per week for eight weeks. DDR also appears to have positive effects on body composition. Perhaps video games and technology devices that have contributed to sedentary lifestyles will, ironically, be the tools to get our nation moving again.

Dr. Trout is a faculty member at the California State University, Chico. Karra Zamora is a physical education teacher in California.

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