A Preliminary Exploration of the Effects of a 6-week Interactive Video Dance Exercise Program in an Adult Population

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ABSTRACT

Purpose: The purpose of this study was to determine the effects of a 6-week interactive video dance game (IVDG) program on adult participants' cardiorespiratory status and body mass index (BMI). **Methods**: Twenty-seven healthy adult participants attended IVDG sessions over a 6-week period. Participants completed pre- and post-testing consisting of a submaximal VO_2 treadmill test, assessment of resting heart rate (RHR) and blood pressure (BP), BMI, and general health questionnaires. Data were analyzed using descriptives, paired t-tests to assess pre-to post-testing differences, and one-way ANOVAs to analyze variables among select groups of participants. Questionnaire data was manually coded and assessed. **Results:** Twenty participants attended at least 75% of available sessions and were used in data analysis. Mean BMI decreased significantly (from 26.96 kg/m^2 to 26.21 kg/m^2; 2.87%) and cardiorespiratory fitness measured by peak VO_2 increased significantly (from 20.63 ml/kg/min to 21.69 ml/kg/min; 5.14%). Most participants reported that the IVDG program was a good workout, and that they were encouraged to continue or start an exercise routine. Forty percent reported improvements in sleep, and nearly half stated they had or were considering purchasing a home version of a video dance game. **Conclusions:** Interactive video dance game is an effective and enjoyable exercise program for adults who wish to decrease their BMI and improve components of cardiorespiratory fitness.

Key Words: cardiorespiratory fitness, video dance game, exercise

INTRODUCTION AND PURPOSE

Physical activity levels of most children and adults in the United States (US) are insufficient. The recent guidelines from the US Department of Health and Human Services[1] recommend that children engage in 60 minutes of moderate- to vigorous-intensity physical activity each day. In 2010 the Centers for Disease Control and Prevention (CDC) reported that 82% of high school students were not physically active for the recommended 60 minutes per day and the percentage of students attending daily physical education classes was only 33%.[2] In addition, 28% were considered to be overweight or obese. The recommendation for adults is a minimum of 150 minutes of moderate-intensity physical activity each week.[1] Forty percent of adults in the US do not participate in regular leisure-time activity and 60% are overweight or obese.[3] Adults are more likely to have additional risks factors for chronic diseases, such as cardiovascular disease, type II diabetes, and certain forms of cancer, which may be diminished by increased physical activity.[4]

Interactive video dance games (IVDGs) provide individuals with more options to participate in physical activity than in the past. Dance Dance Revolution®, better known as DDR®, was created by Konami Digital Entertainment Co., Ltd. in 1998 and was one of the first games to incorporate physical activity into a video game.[5,6] The system was originally developed for arcades in Japan but was adapted to work on various home video game systems available in the US, such as PlayStation®, Xbox®, and Nintendo Wii®.[7] These games incorporate dancing on an electronic controller pad and the player can compete with him/herself or against another person.

Several studies have been conducted on IVDGs to determine if they can increase daily physical activity in children.[8-10] A study by Lanningham-Foster et al[8] showed an increase in energy expenditure while children were participating in IVDGs compared to both sedentary video game playing and walking on a treadmill. While this study showed promise for the use of IVDGs as a means to burn calories, it only demonstrated a short (15 minute) single-session effect and did not address long-term changes in health.[8]

Similar studies using children or adolescents have shown that during single sessions of IVDG, HR can reach the level recommended by the ACSM for maintaining or increasing cardiorespiratory fitness levels.[9,10] However, the extent to which oxygen consumption (VO_2) is increased during these sessions remains in question.

Motivation is an important factor in adherence to any physical activity. Incorporating IVDGs into physical activ-

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ity programs may promote adherence to a regular exercise program and could provide many health benefits. An international survey of 556 DDR players (mean age: 18.7 years; range 12-50) found that 66% began playing IVDGs because they are "fun, amusing, and cool."[6] Reasons given for continuing to play after the novelty wore off included weight loss, improved physical condition, social connectivity, improved quality of sleep, and stress relief. This survey demonstrated promising benefits for adults interested in this novel form of exercise.

Active video gaming may also be an avenue for sedentary or less active individuals to incorporate more regular or intense physical activity into their lives. Recently, the American Heart Association brought health care providers, researchers, and representatives from the video game industry together to discuss the effects of active video games on health.[11] One of the panels at this summit examined the potential for active video games, including dance games, to provide a "gateway" to increase the amount of physical activity performed by individuals. They highlighted several ways that playing active video games may lead to improved health, including improved self-esteem gained from success at playing the games, increased confidence in the ability to perform physical activity, improved physical skills and overall well-being, and the social support offered by other players.[11]

Interactive video dance games may have the potential to increase fitness levels and have a positive impact on children and adolescents' health.[8-10] However, it is unknown if this is also true in the adult population. It is also undetermined if significant health benefits can be attained with regular, long-term play of IVDGs in any age group. Therefore the purpose of this study was to determine the effects of a 6-week IVDG program on adult cardiorespiratory status and body mass index (BMI). Our hypotheses were that (1) participants would gain cardiorespiratory benefits over this 6-week period, including increased estimated VO_{2max}, and decreased resting heart rate (RHR), BMI, and blood pressure (BP); and (2) participants would find the IVDG program to be enjoyable and challenging.

METHODS

Participants

Participants were recruited from the University of Indianapolis (UIndy), Indianapolis, IN, through campus flyers and E-mails sent to faculty and staff. Friends and family members of faculty and staff were also welcome to participate. Individuals were excluded for any of the following: history of cardiorespiratory disease (except controlled hypertension or asthma), failure to pass the Physical Activity Readiness Questionnaire (PAR-Q),[12] presence of a lower extremity fracture or musculoskeletal injury within 3 months of study commencement, or greater than 3 months pregnant at study commencement. All study procedures were approved by the UIndy Institutional Review Board.

Procedure

Pretesting began with participants completing the PAR-Q[12] to determine study eligibility, followed by the informed consent process. Each participant completed a general health and physical activity pretest questionnaire created by the researchers, which included questions regarding previous video dance game or dance experience. Participants were given a demonstration of the version of IVDG used in the study (Red Octane's *In the Groove 2*™) and were asked to practice for approximately 5 minutes. This information was used to determine each participant's aptitude and initial level of play for the study.

Participants were then scheduled for a submaximal treadmill exercise test. Immediately prior to this test, height, weight, resting BP, and RHR were measured. A ParvoMedics True One® 2400 Metabolic Measurement System (ParvoMedics; Sandy, UT) was used for the submaximal exercise test. Each morning prior to testing the system's air flowmeter was calibrated according to manufacturer's specification. Data recorded during each test included highest relative VO_2 achieved (peak VO_2; ml/kg/min), estimated VO_{2max} (ml/kg/min), metabolic equivalents (METs), and HR. The system collected data every 15 seconds during testing. Estimated VO_{2max} was calculated by the ParvoMedics system using the ACSM VO_{2max} equation [0.1 x speed (m/min) + 1.8 x speed (m/min) x grade + 3.5].[13]

Participants were fitted with a head support, mouthpiece, and noseclip, as well as a Polar® chest strap HR monitor (Polar Electro; Oy, Finland) that was electronically linked to the ParvoMedics system. The Balke-Ware submaximal treadmill protocol was used.[13,14] Participants were given a one-minute warm-up at 1.5 mph at 0% incline. Consistent with the Balke-Ware protocol, the treadmill maintained a constant speed of 3.3 mph, and the grade of the treadmill increased 1% per minute until the participant reached 85% of predicted maximum HR (220 – participant age),[13] completed 6 stages of the test, or requested to stop. Participants were encouraged to complete testing to predicted maximum HR, but had the option to stop prior to completing all 6 stages to avoid adverse events. At the conclusion of the treadmill test, participants completed a two-minute cool-down at 1.5 mph and 0% grade. Following the cool-down period, HR was measured manually and reassessed every 2.5 minutes until the participant was within 10% of his or her initial RHR to ensure adequate return to baseline.

The study intervention consisted of a 6-week IVDG program. Participants were expected to attend IVDG sessions on Monday, Wednesday, and Friday of each week at one of two times offered during the day. Six weeks was chosen because the researchers felt this length of time would be reasonable to demonstrate a change in cardiorespiratory status. Each session lasted 50 minutes (10 minute stretching warm-up, 30 minute IVDG exercise, 10 minute stretching cool-down). Resting heart rate was taken prior to the warm-up period. Participants were taught to take their own 30-second carotid or radial pulse during the first exercise session. If a participant was unable to locate his or her pulse, a researcher would monitor the pulse and determine the participant's HR.

The exercise room was divided into two sides based on the participants' abilities to perform the IVDG as introduced during pre-testing. To play the game, individuals

stood on a platform that was electronically linked to the gaming system. Two active platforms were used at one time with a split video screen (Figure 1). Arrows ascended from the bottom of the screen to the top and when they passed a stationary cue on the screen, the player attempted to touch the corresponding arrow on the platform with his or her foot. The speed at which these arrows moved determined the difficulty of the game. The dance steps were choreographed to the beat of music and visual feedback was provided on the screen including motivational messages, step accuracy, overall score. Participants who were more adept at learning step accuracy during the pretesting were placed on the side of the room with arrows appearing more quickly (decreased time to react). Participants were allowed to switch sides within or between sessions if they felt it would improve their performance.

At the mid-point (15 minutes) of the exercise session, participants were instructed to stop exercising and to count their HR for 30 seconds. This number was recorded and the session continued for the remaining 15 minutes. Immediately following the 30-minute IVDG session, HR was again recorded.

When the participants showed a plateau in exercise HR and as the researchers perceived improvement in participants' skill level, the level of difficulty was increased using preset levels on the video game. A change in level of difficulty added steps to each song and required more difficult transitions from one arrow to the next. This was done twice during the 6-week intervention and was intended to increase participants' HRs and degree of challenge during the 30-minute sessions.

Each participant was scheduled for a posttesting session within one week of concluding the 6-week IVDG program. In this session, each participant's weight, RHR, and resting BP were recorded. A submaximal treadmill exercise test, identical to that performed at pretesting, was conducted. Participants also completed a general health and physical activity posttest questionnaire that included questions about changes in health or exercise habits during the 6-week program and requested feedback about the IVDG program.

Data Analysis

SPSS version 15.0 was used for all data analysis. Descriptive statistics were used to examine the participants' demographics. All dependent variables (RHR, SBP, DBP, BMI, peak $VO_{2,}$ treadmill stages, estimated VO_{2max}, and METs) were found to be normally distributed using the Shapiro Wilk test ($p = 0.05$). Paired t-tests were used to determine if significant pre- to posttest differences existed. A one-way analysis of variance (ANOVA) was performed to determine if significant group differences existed between participants who (1) were involved in any type of regular exercise program outside the study (yes/no) and (2) considered his/her prestudy activity levels as vigorous, moderate, or minimal. Alpha was set at 0.05 for all data analyses.

RESULTS

Thirty-one participants initially enrolled in the study and 27 completed all pre- and posttesting. Data analysis was performed on the 20 participants whose average attendance was at least 75% (14 of 18 sessions). Attendance for the remaining 7 participants ranged from 28% to 67%. Data are presented for both men and women, but due to the low number of men (n=3), analyses focused primarily on the group as a whole. Demographics and baseline values for the 27 participants who completed all pre- and posttesting, and the 20 participants whose attendance was at least 75% can be found in Table 1. The 20 participants who attended at least 75% of sessions did not differ from the 27 who completed all pre- and posttesting on any variable.

Figure 1. Screen shot of video display for the IVDG (Red Octane's In the Groove 2™).

Results of the paired t-tests are shown in Table 2. Significant pre- to posttest differences were found for the BMI ($p = 0.005$), RHR ($p = 0.040$), peak VO_2 ($p = 0.026$), treadmill stages (0.030), estimated VO_{2max} ($p = 0.031$), and METs ($p = 0.021$). When female and male data were analyzed separately, the females also demonstrated a significant difference for BMI ($p = 0.012$), peak VO_2 ($p = 0.018$) and METs ($p = 0.013$). While the males did demonstrate notable changes in all variables except BP, the small sample size did not reveal statistical differences. No significant differences were found for systolic or diastolic BP. There were also no significant differences between any of the groups based on prior or concurrent activity level for the dependent variables.

During the pre- and post-submaximal treadmill test, most participants requested to stop the test due to fatigue prior to reaching 85% of their predicted maximal HR. One participant reached 85% of maximal predicted HR on both the pre-and posttest (pretest at the end of stage 2 and posttest at the end of stage 3). Two other participants reached 85% of their maximal HR during the pretest (one at the end of stage 3 and one at the end of stage 4) but both then requested to stop during the posttest (identical stages compared to pretest). No participant completed all 6 stages. Participants did show a significant difference in stages completed from pre- to posttesting, suggesting a greater tolerance for the workload as the treadmill incline increased.

Posttesting questionnaires revealed that 93% of the participants enjoyed the IVDG program and described it as

Table 1. Participant Demographics and Baseline Data

	All participants completing pre- and posttesting (N=27) Mean ±SD (range)	Participants with 75% or > attendance (N=20) Mean ± SD (range)
Age (years)	49.52 ± 6.55 (30.0-62.0)	50.50 ± 4.76 (41.0-62.0)
Sex	M = 4 (15%) F = 23 (85%)	M = 3 (15%) F = 17 (85%)
Weight (kg)	72.89 ± 14.35 (52.70-105.90)	71.41 ± 14.49 (52.70-105.90)
Height (cm)	163.26 ± 8.92 (150.0-184.0)	162.40 ± 8.41 (150.0-178.0)
BMI (kg/m^2)	27.27 ± 4.30 (20.51-34.53)	26.96 ± 4.19 (20.51-34.18)
RHR (bpm)	73.00 ± 9.27 (60.0-88.0)	72.05 ± 8.23 (60.0-87.0)
SBP (mmHg)	126.42 ± 8.07 (110.0-148.0)	125.26 ± 7.42 (110.0-139.0)
DBP (mmHg)	79.50 ± 5.06 (71.0-88.0)	79.26 ± 7.42 (71.0-88.0)
Peak VO_2 (ml/kg/min)	20.28 ± 2.91 (14.20-25.80)	20.63 ± 2.81 (14.50-25.80)
Treadmill Stages Completed	3.41 ± 0.75 (2.0 – 4.0)	3.60 ± 0.60 (2.0 – 4.0)
Estimated VO_{2max} (ml/kg/min)	25.30 ± 4.95 (16.20 – 39.70)	25.76 ± 3.55 (18.90 – 33.60)
METs	5.80 ± 0.84 (4.10-7.40)	5.90 ± 0.81 (4.10-7.40)

BMI = body mass index; RHR = resting heart rate; SBP = systolic blood pressure; DBP = diastolic blood pressure; VO_2 = oxygen consumption; METs = Metabolic equivalents

Table 2. Results of Paired t-tests for Participants Attending at Least 75% of IVDG Sessions

	Mean Pretest Value (SD)	Mean Posttest Value (SD)	Percent Change	95% Confidence Interval		Significance (2-tailed) p=0.05
				Lower	Upper	
BMI (kg/m^2)^^	26.96 (4.19)	26.21 (3.73)	-2.87%	0.26	1.24	0.005**
Females	26.65 (4.15)	26.10 (3.89)	-2.21%	0.13	0.96	0.012**
Males	28.67 (4.85)	26.76 (3.22)	-7.14%	-2.33	6.14	1.938
RHR (bpm)^^	72.05 (8.23)	68.40 (6.73)	-5.33%	0.18	7.12	0.040**
Females	71.88 (7.87)	68.94 (5.66)	-4.26%	-0.07	5.95	0.055
Males	73.00 (12.12)	65.33 (8.08)	-11.04%	-17.22	32.55	0.316
SBP (mm Hg)^^	125.26 (7.41)	125.89 (5.27)	0.50%	-6.13	4.87	0.812
Females	125.56 (8.02)	124.25 (10.27)	-1.05%	-4.57	7.19	0.641
Males	123.67 (2.89)	134.67 (8.08)	8.89%	-31.34	9.34	0.145
DBP (mm Hg)^^	79.26 (5.27)	78.63 (5.66)	-0.80%	-2.66	3.92	0.691
Females	79.00 (5.52)	77.88 (5.58)	-1.44%	-2.72	4.97	0.542
Males	80.67 (4.16)	82.67 (50.3)	2.48%	-11.94	7.94	0.478
Peak VO_2^^ (ml/kg/min)						
Females	20.63 (2.81)	21.69 (2.23)	5.14%	-1.99	-0.14	0.026**
Males	20.40 (2.89)	21.48 (2.30)	5.30%	-1.95	-0.22	0.018**
	21.93 (2.19)	22.90 (1.57)	4.42%	-10.31	8.38	0.700
Treadmill Stages Completed^^						
Females	3.60 (0.60)	3.90 (0.20)	8.33%	-0.57	-0.03	0.030**
Males	3.59 (0.62)	3.82 (0.39)	6.4%	-0.54	0.05	0.104
	3.67 (0.58)	4.33 (0.58)	17.98%	-2.10	0.77	0.184
Estimated VO_{2max} (ml/kg/min)^^						
Females	25.76 (3.54)	27.31 (4.57)	6.02%	-3.06	-0.04	0.031**
Males	25.26 (3.29)	26.52 (4.47)	4.99%	-1.26	3.27	0.130
	28.57 (4.36)	31.73 (1.90)	11.06%	-10.38	4.04	0.199
METs^^	5.90 (0.81)	6.22 (0.66)	5.42%	-0.60	-0.05	0.021**
Females	5.83 (0.84)	6.17 (0.68)	5.83%	-0.59	-0.08	0.013**
Males	6.27 (0.64)	6.53 (0.47)	4.15%	-3.04	2.50	0.719

^^Combined female and male data
**significant pre- to posttest difference ($p < 0.05$)
BMI = body mass index; RHR = resting heart rate; SBP = systolic blood pressure; DBP = diastolic blood pressure; VO_2 = oxygen consumption; METs = Metabolic equivalents

"a good workout." Nearly 90% were encouraged to start a workout program and 43% reported that they had or were considering purchasing a home version of the IVDG. While 40% reported an improvement in quality or quantity of sleep, there were no reported differences in smoking behaviors from pre- to posttesting.

DISCUSSION

Over half of the adult US population is overweight or obese[15] and more than half do not meet the 2008 US physical activity guidelines.[16] The present study showed that participation in a 6-week IVDG program led to a significant increase in estimated VO_{2max} and peak VO_2 during a submaximal treadmill test, and a significant decrease in BMI and RHR.

There are few studies that examine the effects of playing IVDG more than a single session, and the use of adults as participants is rare. Warburton et al[17] studied the effects of a 6-week IVDG program compared to stationary cycling in a cohort of college-age males. Their results showed a significant increase in VO_{2max} for the group playing the video dance game (11.0%) versus the stationary cycling group (3.4%). This is similar to our results in that estimated VO_{2max} increased by 6.02% (females: 4.99%; males 11.06%), which was significant. The males in our study showed a similar increase in estimated VO_{2max} compared to the males in the Warburton et al[17] study and an overall greater increase than the females in our study. Because of a greater proportion of muscle mass, men typically show a more rapid improvement in oxygen consumption as compared to females.[18,19]

Hordern et al[20] studied the effects of a 4-week aerobic-based training program in otherwise healthy individuals with type II diabetes. Their results showed a significant decrease in BMI (0.94%), and a significant increase in VO_{2max} (6.76%) in the exercise group compared to the control group. These findings are similar to the current study. Our mean decrease in BMI was 2.87% (females: 2.21%; males: 7.14%). As with VO_{2max}, men typically lose weight more rapidly than women due to a higher metabolism and higher proportion of muscle mass.[18,19] This may explain why the men in our study demonstrated a greater decrease in BMI than the women. Even so, when only the data from the women were considered, there was still a significant decrease in BMI. The amount of improvement in VO_{2max} was similar in both the Horndern et al[20] and our study. Of note, neither the Hordern et al study[20] nor the present study found a difference in resting BP following the exercise program.

A meta-analysis performed by Biddiss and Irwin[21] reported that active video games increase energy expenditure and HR. The average increase in energy expenditure reported for subjects 21 years of age or younger was 222% during active video play and HR increased an average of 64%. A similar study was conducted by Graves et al[22] who found a significantly greater energy expenditure in adolescents who played active video games versus those who played sedentary video games. Likewise, a study by Graf et al[23] found that playing DDR increased energy expenditure more than three-fold and demanded greater energy use compared to video boxing or video bowling. Increased energy expenditure is the basis of exercise programs with the goal of weight loss. Höysniemi [6] surveyed DDR players about their primary motivation to continue playing. Results showed that 87.5% of self-identified overweight players reported losing weight due to playing. Our study supports this effect with an average weight loss of 2.10 kg (4.62 lbs); hence the significant decrease in BMI.

Traditional cardiovascular and weight loss programs for adults often include activities such as walking, running, cycling, and swimming.[24,25] These activities can be monotonous. In addition, when adults do begin a new exercise program, there is a 50% chance that they will stop within six months.[26] IVDGs may provide an enjoyable alternative method for adults to meet activity requirements as recommended by the ACSM guidelines.[13] Similar to the results of the Höysniemi[6] study, which reported that 65% of DDR players continued to play for the entertainment factor, subjective reports from the present study showed that 93% of our participants found the video dance game enjoyable, with one participant stating, "the experience was wonderful."

The convenience of home use, or the camaraderie of a group, allows a variety of exercise options with IVDG. A study by King et al[27] found that the best predictor of long-term adherence to an exercise program in adults was the ability to exercise at home. Interactive video dance games can be purchased for home use, suggesting the possibility of increased exercise adherence. In our study, 43% of participants stated that they had purchased or were contemplating buying a home version of the video game. One participant reported that video dance gaming was "a nice way to begin an exercise program in the middle of winter when you are confined indoors." On the other hand, a meta-analysis by Burke et al,[28] found that group exercise showed increased benefits of adherence and social interaction when compared to exercising at home alone. This positive social aspect was also evident in our study, with one participant stating, "I really liked the group activity." Throughout the present study the researchers made observations regarding the group dynamics during the exercise sessions, noting that the group setting fostered friendly competition, encouragement, and attendance accountability. While the studies reporting benefits of exercising 'home alone' versus in a 'group' appear contradictory, this is likely reflective of the influence of individual personality. This is borne out by Song et al[29] who describe differences in motivation in individuals playing active video games. The individuals who were more competitive were more motivated by the presence of others, while those who were not competitive found the presence of others to be detrimental.

This study had several limitations including the relatively small sample size, substantially greater proportion of women, and lack of a control group. The fact that the cohort was limited to UIndy faculty, staff, and family affects the ability to generalize the results to a larger population. Specifics of additional diet and exercise of the participants were not recorded for this study, but comparisons were made between participants who were and were not involved in an additional exercise program, and no differences were found.

According to the CDC, benefits of regular physical activity include decreased risk for obesity, heart disease, hyper-

tension, and diabetes.[4] Our study demonstrated improvements in cardiorespiratory status and BMI among healthy adults. Therefore, future studies should include participants with various co-morbidities to determine if similar effects can be shown in adults often seen in rehabilitative settings. Additional research should include a larger sample size, a control group, and comparison of video dance games versus other forms of exercise. Future studies are also needed to examine the effects of IVDGs on coordination, balance, and fall risk.

CONCLUSION

This study sought to expand the current research on the effects of IVDGs as a viable fitness program by exploring the physiological effects and level of enjoyment for healthy adults. Results of this study show that adults can achieve improvements in cardiorespiratory status and BMI through participation in an IVDG exercise program. Interactive video dance games can be an enjoyable form of exercise performed within the home or as part of a group fitness program. This study questions the traditional assumption that video dance gaming is more appropriate for children by showing that this form of exercise is fun, challenging, and beneficial for adults.

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