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ACTIVE VIDEO DANCING GAME PROVIDES HIGH-INTENSITY EXERCISE FOR HIP-HOP DANCERS AND NON-DANCERS

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ABSTRACT

The purpose of this study was to investigate the effects of active video game dancing (AVG dancing) on physiological variables in hip-hop dancers. The AVG dancing was performed using the Xbox Kinect, and the physiological variables included oxygen consumption (VO_2), heart rate (HR), energy expenditure (EE), metabolic equivalent (MET), respiratory exchange ratio (RER), and the percentage of maximum oxygen consumption (VO_2max%). Thirteen hip-hop dancers (dance experience 5.4±3.2 years) and 16 recreationally active young non-dancers participated in the study. VO_2max was measured at baseline. A few days later, following 15 min of rest in a supine position, the participants performed the AVG dancing. The mean VO_2max values in the dancers and non-dancers were 47.7±1.8 mL/min/kg and 46.6±1.9 mL/min/kg, respectively. No significant difference in VO_2max was observed between the groups. However, the percentage (%) of VO_2max and percentage of HRmax values were significantly higher in the dancer group during the AVG dancing ($p<0.01$). Furthermore, the $VO_{2\ AVG\ Dance}$, $HR_{AVG\ Dance}$, EE_{AVG_Dance} and MET_{AVG_Dance} values were significantly higher in the dancer group ($p<0.01$). These findings demonstrate that while previous dance experience may affect the playability of the game, thus causing improved physiological responses, AVG dancing provides high-intensity exercise to both dancers and non-dancers (>6 MET).

Keywords**:** Exer-game; Dance experience; Oxygen consumption; Energy expenditure; Heart rate; Active video game.

INTRODUCTION

Physical activity is known to have many health benefits. Despite the known benefits of physical activity, most people do not meet the minimum recommendations for physical activity (Hallal *et al.*, 2012). Additionally, physical inactivity is claimed to be the fourth most important factor contributing to global mortality (WHO, 2010) and is listed among the causes of a number of chronic diseases, including diabetes, cardiovascular diseases and cancer (Barlow & Chang, 2007). Epidemiological studies have shown that for every increase of 1 metabolic equivalent (1 MET=3.5mL O_2 (kg/min)) in exercise performed, all-cause mortality rates are reduced by 8-17% (Myers *et al.*, 2002; Gulati *et al.*, 2003).

Rapid technological developments are the primary contributor to decreased physical activity levels. However, active video games (AVGs), which have recently become a point of interest, are considered a potential tool for preventing a sedentary lifestyle. As AVGs take the place of passive video games, it is believed that they can provide a fun and accessible way to participate in physical activity. AVGs are fairly easy to use at home, so their impact on exercise intensity and energy expenditure has attracted increasing attention. Variables such as the intensity of the activity and energy expenditure (EE) during AVGs are not only related to the brand of game console (Play station, Xbox, or Nintendo), but are also closely related to the characteristics of the preferred game. Among these game consoles, the Xbox Kinect (Microsoft Corporation, WA, USA) is one that can be controlled interactively without having to touch a physical object (Kamel Boulos, 2012).

Studies conducted on AVGs have investigated the physiological responses, the impact on physical activity level and whether these results fulfilled the healthy living criteria set forth by the American College of Sport Medicine (ACSM) for different groups (children, adults, the elderly, and the obese) (Guderian *et al.*, 2010; Seamon *et al.*, 2017; Staiano *et al.*, 2017). Previous studies have found that although the same level of perceived difficulty was reported, individuals consumed more energy while playing AVGs than during traditional exercise (Warburton *et al.*, 2009).

To our knowledge, none of the studies conducted with AVGs have provided information on the baseline physical activity level of the participant groups. In addition, no study has investigated whether EE and exercise intensity during AVGs meet the ACSM exercise intensity criteria for groups, who are already fit or who have different skill levels (dancers, cyclists, or boxers).

PURPOSE OF STUDY

The goals of the current study were: to determine the exercise intensity during the AVG, measured by various physiological responses; to test whether the AVG exercise intensity meets the ACSM criteria; and to compare hip-hop dancers and physically active but non-dancer youths in terms of their physiological responses.

METHODOLOGY

Participants

Thirteen professional hip-hop dancers (9 male and 4 female; mean age=22.7±2.4 years; dance experience=5.3±3.1 years) and sixteen non-dancers (11 male and 5 female; mean age=20.1±0.4 years) volunteered to participate in this study. The primary inclusion criteria were as follows: being healthy, having a body mass index (BMI) less than 25kg/m^2, and having a minimum of one year of continuous professional hip-hop dance performance experience for the dancer group or no dance experience for the non-dancer group. The non-dancer volunteers were recreationally active (football, running, fitness, etc.) but were not participating in any dance classes. Participants with medical, cardiovascular, metabolic and/or respiratory illnesses were not included in the study. Health status was determined using the Physical Activity Readiness Questionnaire (PAR-Q), (ACSM, 2014). Persons using drugs and/or ergogenic supplements were excluded. Participants were asked to avoid exhaustive exercise for 24 hours before testing and were told to refrain from eating or drinking for three hours before testing (Monedero *et al.*, 2015).

Ethical approval

All participants were informed at the beginning of the study about the experimental risks and their right to withdraw from the study at any time without negative consequences. Written consent forms were obtained. The study protocol conformed to the ethical guidelines of the 1975 Declaration of Helsinki. The study was approved by the University Institutional Review Board (Protocol number: 42404).

Data collection

Each participant completed two laboratory visits. A schematic design of the study is shown in Figure 1. Physiological variables measured included oxygen consumption (VO_2), maximum oxygen consumption (VO_2max), carbon dioxide production (VCO_2), respiratory exchange ratio (RER), MET, EE, heart rate (HR), and maximum heart rate (HRmax), which was defined as 220 minus the participant's age (in years). Oxygen consumption and carbon dioxide production were measured continuously using the computerised, breath-by-breath analysis system Master Screen-CPX (Care Fusion, Germany). The system was calibrated to local air conditions, gas volume, and gas contents before the testing sessions according to the manufacturer's instructions. HR was recorded continuously using a Polar chest band, fixed to the participant's chest, and a Polar brand S810i pulse watch (Polar Electro, Finland) (White *et al.*, 2011). The absolute and relative VO_2, VCO_2, and HR values for the participants were recorded for the three conditions explained below.

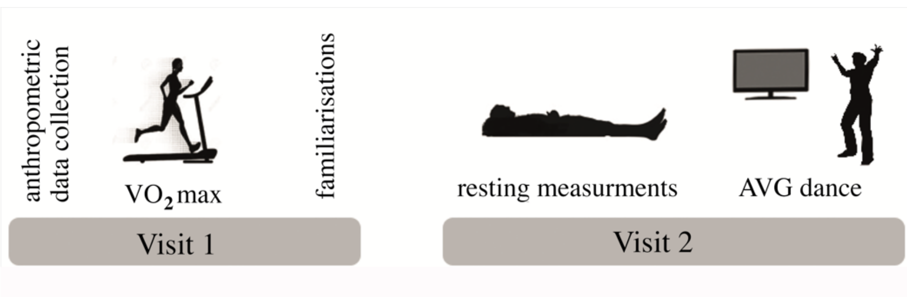

Figure 1. **SCHEMATIC REPRESENTATION OF EXPERIMENTAL PROTOCOL**

(1) In the first visit, following the collection of anthropometric data and body fat percentage (BFP) (Tanita MC^{-1}80-MA, Japan), each participant underwent a graded treadmill exercise test using the Bruce protocol to determine VO_2max (mL/kg/min) (Alberg, 2002; Dixon *et al.*, 2006).

(2) One week later, during the second visit, participants rested for 15 minutes in a supine position to evaluate physiological variables at rest. VO_2, VCO_2, and HR were recorded throughout the resting period, but only the mean value of the last 5 minutes was used for the analyses.

(3) Finally, the participants danced with the AVG for 15 minutes. An Xbox game console with the Kinect device was used for the AVG assessment. The participants danced (AVG dance performance) in the "Fitness-Cardio Groove" mode of the "Dance Central 3" game package. Oxygen consumption, VCO_2, and HR were measured throughout the 15-minute testing period. The participants were verbally motivated during the AVG dance test. EE,

MET and RER values were calculated for resting and dancing conditions using Equations 1, 2, and 3, respectively.

$$EE\ (kcal/min)=(1.1xVCO_2+3.9xVO_2)x1.44/1440 \quad (1)$$
(Weir, 1949)

$$Total\ MET=Total\ expenditure\ of\ the\ individual\ VO_2\ (kg/min)/3.5 \quad (2)$$
(Chow *et al.*, 2016)

$$RER=VCO_2/VO_2 \quad (3)$$

Analysis of data

All values are presented as the mean±standard deviation (SD). Independent sample t-test was performed to determine differences between the dancer and non-dancer groups for descriptive characteristics (age, height, weight, BMI, BFP, and VO_2max) and all physiological variables. Additionally, paired sample t-tests were performed to compare physiological responses recorded during resting and dancing conditions (VO_2, % of VO_2max, RER, MET, EE, HR, and % of HRmax). A power analysis (1-β) and test of effect size (Cohen's *d*) were performed using GPower software (3.1 version). The sample size of 13 and 16 participants (for the dancer and non-dancer groups, respectively) provided >83% statistical power (except RER_{dance}: 1-β=0.58 and $MET_{relative}$: 1-β=0.54) at α level of 0.05 (2-tailed). Statistical analyses were performed using SPSS 21.0 (Statistical Package for the Social Sciences, SPSS Inc.) for Windows. A p value <0.05 was accepted as statistically significant.

RESULTS

Descriptive characteristics of the dancers and non-dancers are presented in Table 1. Both groups were similar in terms of mean height, weight, BMI, BFP, and VO_2max ($p>0.05$), except for mean age. There was a significant difference in mean age values between the dancer and non-dancer groups ($p<0.05$).

Table 1. **DESCRIPTIVE CHARACTERISTICS OF PARTICIPANTS**

Variables	**Dancer group** M±SD	**Non-dancer group** M±SD	**p-Value**
Age (years)	22.77±2.45**	20.13±1.50	0.003
Height (cm)	172.08±11.14	169.88±11.06	0.599
Weight (kg)	64.02±11.21	62.71±13.01	0.777
BMI (kg/m^2)	21.48±2.18	21.49±2.25	0.991
BFP (%)	14.43±4.72	16.03±5.67	0.423
VO_2max (mL/kg/min)	47.66±6.37	46.61±7.42	0.689

**p<0.01 (Significantly different from non-dancer group)
BMI=Body Mass Index BFP=Body Fat Percentage
VO_2max=Maximum oxygen consumption

The physiological variables recorded during the rest period and AVG dancing are presented in Table 2. There were no statistically significant differences in the VO_2 rest, MET_{rest}, EE_{rest}, and HR_{rest} values between the two groups ($p>0.05$). Resting RER values were significantly different between groups, with the non-dancer group showing higher RER values ($p<0.01$; $1-\beta=0.87$). However, during AVG dancing, all physiological variables except for RER-dance were significantly higher in the dancer group than in the non-dancer group ($p<0.05$ and $p<0.01$; $1-\beta>0.83$).

During the AVG, VO_2 values increased six-fold (6.6) in the dancer group and five-fold (5.4) in the non-dancer group (compared with the resting values), and these increments were significantly different between the two groups ($p<0.05$; $1-\beta=0.99$). Additionally, although VO_2max values were similar for both groups, during the AVG, the dancer group reached a significantly higher percentage of VO_2max value than the non-dancer group ($p<0.01$; $1-\beta=0.99$; Table 2).

Table 2. **PHYSIOLOGICAL VARIABLES RECORDED DURING REST PERIOD AND ACTIVE VIDEO DANCING GAME**

Variables	**Dancer group** M±SD	**Non-dancer group** M±SD	**p-Value**	**1-β**	**Cohen's *d***
VO_2 rest (mL/min)	301.37±64.63	267.23±63.90	0.166	0.28	0.531
VO_2 dance (mL/min)	2008.50±545.10**#	1442.32±310.97#	0.002	0.92	1.313
VO_2 rest (mL/kg/min)	4.70±0.55	4.29±0.63	0.080	0.43	0.687
VO_2 dance (mL/kg/min)	30.95±4.12**#	23.20±3.56#	<0.001	0.99	2.029
% of VO_2 max	65.40±7.54**	50.53±8.84	<0.001	0.99	1.794
RER rest	0.90±0.07**	0.99±0.08	0.004	0.86	1.184
RER dance	0.98±0.06*#	1.03±0.06#	0.034	0.58	0.833
MET rest	1.34±0.16	1.23±0.18	0.080	0.38	0.643
MET dance	8.84±1.18**#	6.63±1.02#	<0.001	0.99	2.020
MET relative	6.66±1.14*	5.56±1.55	0.042	0.54	0.795
EE rest (kcal/min)	1.48±0.31	1.33±0.32	0.226	0.23	0.474
EE dance (kcal/min)	10.01±2.75**#	7.26±1.57#	0.002	0.90	1.264
EE rest (kcal/kg/min)	0.023±0.003	0.021±0.003	0.138	0.41	0.666
EE dance (kcal/kg/min)	0.154±0.021**#	0.116±0.019#	<0.001	0.99	1.900
HR rest (bpm)	71.08±7.49	67.86±8.85	0.309	0.17	0.389
HR dance (bpm)	157.92±15.77**#	138.38±18.29#	0.005	0.83	1.134
% of HRmax (bpm)	80.07±8.03**	69.23±9.20	0.002	0.90	1.246

* $p<0.05$ and ** $p<0.01$ (Significantly different from non-dancer group)
# $p<0.01$ (Significantly different from rest values within group)
VO_2=Oxygen consumption RER=Respiratory exchange ratio
MET=Metabolic equivalent MET relative=Relative metabolic equivalent
EE=Energy expenditure HR=Heart rate

When compared with the resting values, the results showed that EE increased six-fold (6.7) in the dancer group and five-fold (5.5) in the non-dancer group and these increments were significantly different between groups ($p<0.05$; $1-\beta=0.99$). HR values increased 2.2-fold among the dancers and 2.0-fold among the non-dancers, compared with the resting values. These results indicate that during the AVG, the dancer group reached a significantly higher percentage of their maximum HR ($p<0.01$; $1-\beta=0.89$; Table 2).

DISCUSSION

Early studies on this topic compared AVGs with passive video games and/or with resting and sedentary states (like watching television) (Graves *et al.*, 2010; White *et al.*, 2011; O'Donovan *et al.*, 2012; O'Donovan & Hussey, 2012; Scheer *et al.*, 2014; Clevenger & Howe, 2015; Marks *et al.*, 2015). Additionally, many studies have compared different AVGs with each other (Lanningham-Foster *et al.*, 2009; Noah *et al.*, 2011; O'Donovan & Hussey, 2012; Clevenger & Howe, 2015). Recently, different AVG consoles were compared (O'Donovan *et al.*, 2012; Scheer *et al.*, 2014; Marks *et al.*, 2015) and AVGs were compared to traditional exercises (Graves *et al.*, 2010; White *et al.*, 2011; Devereaux, 2012). Studies conducted on different participant groups generally involved the elderly, disabled and obese individuals (Seamon *et al.*, 2017; Staiano *et al.*, 2017). However, the number of studies that have examined the physiological effects of AVGs played with Xbox Kinect on special groups is considerably limited. Furthermore, to our knowledge, no study has been conducted using hip-hop dancers.

The physiological variables examined during AVGs have been limited to VO_2, HR and EE (Graves *et al.*, 2010; White *et al.*, 2011; Devereaux, 2012; O'Donovan *et al.*, 2012; Clevenger & Howe, 2015; Marks *et al.*, 2015). It has been reported that the VO_2 consumed during AVGs is significantly higher than the VO_2 consumed under sedentary conditions (such as while resting, watching television, playing passive games) (Graves *et al.*, 2010; White *et al.*, 2011; O'Donovan *et al.*, 2012; O'Donovan & Hussey, 2012; Scheer *et al.*, 2014; Clevenger & Howe, 2015). The findings of the current study are in agreement with the results of these previous studies.

In a study conducted with the Xbox Kinect, participants played AVGs with songs from different musical genres. It was found that decreasing the pauses between songs increased both the exercise intensity and VO_2 (Noah *et al.*, 2011). Noah *et al.* (2011) also reported that the mean VO_2 value was 28.45±5.06 mL/kg/min during an AVG played with different songs (song changes and pauses were not considered). In contrast, the pauses between songs in the AVG used in the present study were considered, but no differences were found for the VO_2 consumed by the dancer and non-dancer groups (30.95±4.12 mL/kg/min and 23.20±3.56 mL/kg/min, respectively). Additionally, the VO_2 values in the dancer group were higher than those in the Noah *et al.* study, whereas the VO_2 values in the non-dancer group were lower than those of the mentioned study. However, the oxygen consumption of both groups was between 21 and 31.5 mL/kg/min, a range that corresponds to high-intensity exercise. Therefore, these results confirm that AVGs can be recommended as a source of physical activity for healthy populations.

Similar to the VO_2 findings, it has been shown that AVGs require greater EE than sedentary conditions (Graves *et al.,* 2010; White *et al.,* 2011; O'Donovan *et al.,* 2012; O'Donovan & Hussey, 2012; Scheer *et al.,* 2014; Clevenger & Howe, 2015). Clevenger and Howe (2015) compared Xbox Kinect AVGs with passive video games and reported that playing AVGs for 6-10 minutes significantly increased EE in adolescents (n=58; range of age: 8-17 years). In agreement with previous literature, the present study found that EE recorded during an AVG was significantly higher than EE recorded under sedentary conditions ($p<0.01$). O'Donovan *et al.* (2012) compared EE levels produced during games played on different AVG consoles in varying conditions (single or multiplayer) and reported that games played on the Xbox Kinect console resulted in higher EE values (single-player=6.78kcal/min. vs. multiplayer=7.19 kcal/min.) than those obtained with the Nintendo Wii (single-player=4.96kcal/min. vs. multiplayer=6.15kcal/min.).

Additionally, higher EE was recorded for participants playing multiplayer games than for those playing single-player games (O'Donovan *et al.,* 2012). EE was higher in both the dancer and non-dancer groups in the present study than the EE reported by O'Donovan *et al.* (2012) for multiplayer and single-player games (dancers=10.01kcal/min., non-dancers=7.26kcal/min., multiplayer games=7.19kcal/min. and single-player games=6.78 kcal/min.). These findings further emphasise the importance of this genre of AVG.

The HR responses to AVGs have been examined in many studies (Graves *et al.,* 2010; Noah *et al.,* 2011; White *et al.,* 2011; O'Donovan *et al.,* 2012; Scheer *et al.,* 2014; Clevenger & Howe, 2015; Marks *et al.,* 2015). It was reported that the HR values of participants playing six different AVGs (Disney Rush, Skiing, Reflex Ridge, Zumba/Your Shape, Wipeout and Dance Central) were significantly higher than the HR values produced by four different passive video games (120–147 vs. 92 beats/minute, respectively) (Clevenger & Howe, 2015). With regard to song tempo, it was shown that a slow song (208-243 steps) produced a HR of 138 beats/minute, while a fast song (403 steps) produced an HR of 190 beats/minute (Noah *et al.,* 2011). O'Donovan *et al*. (2012) compared the HR values of single and multiplayer games played on different consoles and reported HR values of 114±21 and 104±28 beats/minute for single-player games and 118±20 and 119±28 beats/minute for multiplayer games.

Another study compared active video boxing and dancing games and demonstrated that HR values were significantly higher during the boxing game played on Xbox Kinect (Marks *et al.,* 2015). It has been shown that physiological responses to AVGs can be affected by a number of factors, such as the model of the game console, the number of players, the tempo of the music, and the characteristics of the game being played (Marks *et al.,* 2015). In the current study, the mean HR of the AVG dancing was much higher in the dancer group (158±16 beats/minute) than in the non-dancer group (138±18 beats/minute). The HR of the dancer group in the present study was also higher than the values reported in the aforementioned studies (Noah *et al.,* 2011; O'Donovan *et al.,* 2012; Clevenger & Howe, 2015; Marks *et al.,* 2015). Consequently, the physiological responses produced by the AVGs may depend not only on the characteristics of the AVG itself, but also on the existing skills of the players.

METs are a unit that calculates the VO_2 consumed during physical activities. This measure is a useful, practical and standardised way to describe the intensity of various physical activities (ACSM, 2014). According to the criteria established by the ACSM (2014), light physical activity is defined as <3 METs, moderate activity is defined as between 3 and 6 METs, and vigorous physical activity is defined as ≥6 METs. Several AVGs have been shown to require a moderate activity level based on the ACSM criteria (3-6 METs) (O'Donovan *et al.,* 2012; O'Donovan & Hussey, 2012; Clevenger & Howe, 2015). Graves *et al*. (2010) reported MET values of 1.9, 1.9, 2.4 and 3.6 during yoga, balance, muscle coordination and aerobic AVGs, respectively, played on the Nintendo Wii.

On the other hand, Noah *et al.* (2011) reported high MET values (>6 MET, ACSM) for an AVG dancing. The MET values of participants during the AVG dancing in the present study were 8.9 METs in the dancer group and 6.6 METs in the non-dancer group. These data show that the AVG used in this study produced MET levels that meet the criteria for high-intensity exercise, as determined by the ACSM. Although the METs were higher in the dancer group, the AVG in this study also generated high-intensity physical activity in the non-dancer group. Therefore, it is believed that AVG dancing can be recommended as an exercise method for maintaining a healthier lifestyle.

RER provides information about the physical effort exerted during exercise, with an individual exerting maximum effort as they approach an RER value ≥1.10 (ACSM, 2014). In the present study, the RER values during the AVG dance session were 0.98 in the dancer group and 1.03 in the non-dancer group. Additionally, the RER values at rest were lower in the dancer group, which suggests that the dancer group had a better physiological response than the non-dancer group. The findings of the current study are consistent with findings of previous studies, suggesting that RER values produced by short-term exercise, increase in individuals with a low resting RER, but are still lower than the RER values of individuals with higher resting RER values (Goedecke *et al.*, 2000). In the related literature, only one study reported an RER value of 1.07±0.1 (Noah *et al.*, 2011), which is higher than the RER values reported in the current study. Previous dance experience, physiological adaptations to physical activity and the age of the participants may explain the lower RER responses observed in the dancer group.

PRACTICAL APPLICATION

Based on these findings, AVG dancing can be recommended as a form of exercise. While this study recommends the use of AVGs, it is important to note that the physiological responses to AVGs depend on the participant's dancing ability. Instead of being sedentary at home, playing AVGs can contribute to a healthy lifestyle.

CONCLUSIONS

The findings of the current study clearly show that AVG dancing significantly increases VO_2, EE, HR and MET values and confirm that this game meets the criteria for high-intensity exercise determined by the ACSM. Of note, a recent review article verifies the recommendations and provides a summary of the existing literature (Aygun & Cakır-Atabek, 2018). Additionally, prior dance experience resulted in significantly higher physiological responses to the AVG dancing was observed. It can be concluded that one of the fundamental factors affecting the physiological responses produced by AVGs is a requirement for baseline skills that are unique to each game. These skills alter the physiological responses to the dancing game because they can affect game playability. It is recommended that the skill level of individuals be considered in relation to the characteristics of the AVG, when determining the exercise intensity if the game is to be used as a healthy lifestyle activity.

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