

Article

Classification of Exergames with Different Types: Perceptual and Physiological Responses in College Students

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Abstract: This study aimed to (i) investigate and compare the effects of five different types of active video games (AVGs) on physiological and perceptual variables, (ii) categorize the AVGs' physical activity (PA) intensity according to ACSM classification, and (iii) investigate the correlation between rating of perceived exertion (RPE) and enjoyment score within each AVG. Twelve college students participated in this study. Each AVG was played randomly for 15 min on non-consecutive days. The physiological variables were measured with a breath-by-breath system continuously during the AVGs and resting conditions. The AVGs significantly increased oxygen consumption, respiratory exchange ratio, energy expenditure, metabolic equivalent, and heart rate compared to rest conditions ($p < 0.001$). According to ACSM criteria, Fruit Ninja, Just Dance, and Shape-Up Muscle games were defined as moderate PA (MET = 4.07, 5.46, and 5.25; RPE = 10.33, 10.42, and 14.67 respectively) and Shape-Up Cardio, and Fighter Within games were defined as vigorous PA (MET = 6.83, and 7.03; RPE = 13.92, and 13.75 respectively). All games were enjoyable (>27). Young adults can get the recommended PA intensity with AVGs, burning 80–150 kcal in 15 min. The findings suggest that energy expenditure may be similar among different types of AVGs. However, skeletal muscle energy metabolism may differ according to the type of AVG.

Keywords: active video games; perceived exertion; enjoyment; energy expenditure; heart rate; respiratory exchange ratio



Citation: Aygün, C.; Çakır-Atabek, H. Classification of Exergames with Different Types: Perceptual and Physiological Responses in College Students. *Appl. Sci.* **2023**, *13*, 10769. <https://doi.org/10.3390/app131910769>

Academic Editors: Jacek Polechoński and Piotr Wodarski

Received: 26 August 2023

Revised: 23 September 2023

Accepted: 25 September 2023

Published: 27 September 2023



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1. Introduction

Physical inactivity is considered to be one of the biggest health problems of the 21st century [1]. In addition, it has been recognized as one of the major causes of numerous chronic maladies such as stroke, cardiovascular illness, type 2 diabetes, cancer, and obesity [2]. The World Health Organization recommends that individuals aged 18 and older engage in at least 150–300 min of moderate-intensity aerobic physical activity (PA) or at least 75–150 min of vigorous-intensity aerobic PA per week to achieve substantial health benefits [3]. However, a significant portion of the population in the USA does not engage in sufficient physical activity; most adolescents [4] and 38.4% of individuals aged between 18 and 24 do not meet the minimum recommended PA [5]. In this context, from 1999–2000 to 2015–2016, the age-adjusted obesity rates significantly increased from 27.4% to 38.1% in men, and from 33.3% to 41.2% in women [5]. In agreement with these findings, the worldwide prevalence of obesity has nearly tripled from 1975 to the present. More than 1.9 billion adults (39% of the population) have been reported as overweight, and over 650 million adults (13% of the population) have been reported as obese [6]. Besides the prevalence of physical inactivity, sedentary behavior, which can be defined independently of physical inactivity as large amounts of time spent sitting, reclining, or lying down, is rising [7]. Due to this fact, sedentary behavior (all activities' metabolic equivalents (METs) < 1.5) has been identified as a risk factor [8–10]. Changes in transportation forms, increasing urbanization, and increasing sedentary behaviors in work are shown as the main reasons for sedentary

behaviors [6]. In addition, especially recently, screen-based recreational activities such as watching TV series and passive video games have become widespread as sedentary behaviors [11]. It has been reported that over 90% of America's children and adolescents own a video gaming system, and over 60% play video games for at least 30 min a day. In addition, data show that 85% of male and 47% of female emerging adult college students reported playing video games, with almost 35% of males playing daily [12].

Recent research findings strongly provide evidence that active video games (AVGs) can be used as an alternative model for PA [13]. AVGs, also known as exergames, give an opportunity to exercise in isolated areas such as on-campus, in the dormitory, and at home by moving the whole body during the game. The foremost well-known gaming devices are Microsoft's Xbox 360 and Microsoft's Xbox ONE (Microsoft, Redmond, WA, USA), with 135 million units sold around the world from 2005 to 2020 [14,15]. Given the interest of young adults in console video games, AVGs with detected PA intensity can be an effective method to promote participation in the PA to meet the minimum requirements to be considered physically active; this can positively affect the physiological and psychological health of young adults. From this point of view, the AVGs can be used instead of passive video games, defined as sedentary behavior, and also create an alternative exercise model to classical exercises [16–18].

It has been stated that most of the studies conducted with AVGs are classified as light to moderate PA (2–6 METs), similar to that of brisk walking [19–22]. However, recent studies have reported that some AVGs are classified as vigorous to near maximal PA (METs > 6), similar to running [13,16]. These findings show that the characteristics of selected games affect physiological responses, consequently affecting the intensity of the PA. Hence, increasing the options of AVGs with known PA intensities is essential to achieve the recommended PA at target intensity.

A robust correlation between exercise enjoyment and exercise behavior has been reported [23]. It is well acknowledged that enjoyment is one of the most influential factors to increase participation in PA [24]. Especially recently, screen-based PA and AVGs have been suggested for enjoyable PA [13,23]. Exergames and AVGs are particularly noted for being more enjoyable than classic exercises [16,25]. However, the level of enjoyment may differ due to the technological infrastructure and the differences in the screenplay and music of AVGs [23,26]. As enjoyment increases during playing AVGs, the desire to participate in screen-based PA may increase instead of sedentary activities and passive video games [23]. At this point, it is considered that determining the enjoyment level of AVG alternatives is also essential for screen-based PA participation.

In exercise science, the rating of perceived exertion (RPE; Borg scale) scale is frequently used to evaluate exercise intensities and perception of effort during aerobic and resistance training [27]. Especially for these exercises, it has been shown that RPE is a reliable measurement of perceptual effort in terms of reflecting physiological variables. However, whether the RPE reflects the physiological effort in technology-based games still requires investigation [28]. During playing exergame, similar RPE scores have been elicited despite higher physiological responses [29]. A recent study reported that RPE may be lower than the actual exertion (measured via heart rate (HR)) during exergames [28]. This difference can be attributed to the type of exergames. This situation needs to be examined. The possibility of a lower RPE may be a positive side of the AVGs to prolong the duration of exercise [26]. It is crucial to determine RPE for AVG selection.

Although previous studies [25,30] have presented some evidence of physiological responses of AVGs, there is still a need to categorize the AVGs based on the PA intensity and to increase the options of games at a target intensity. Additionally, there are findings that show that the RPE and enjoyment may differ depending on the AVGs' structural differences [13,25]. For these reasons, the current study focused on RPE and enjoyment. Hence, the purposes of the current study were to (i) investigate and compare the effects of five different types of active video games (AVGs) on physiological and perceptual variables, (ii) evaluate and categorize the AVGs' PA intensity according to The American College

of Sports Medicine (ACSM) classification, and (iii) investigate the relationship between perceptual variables. The physiological variables were limited to oxygen consumption (VO_2), carbon dioxide production (VCO_2), respiratory exchange ratio (RER), energy expenditure (EE), MET, and HR, whereas the perceptual variables were limited to RPE and enjoyment level.

2. Materials and Methods

2.1. Participants

Healthy sports science undergraduate male students ($n = 12$; mean age = 20.50 ± 1.51 years; mean height = 173.50 ± 4.30 cm; mean body mass = 71.08 ± 8.72 kg; body mass index = 23.64 ± 2.99 kg/m²), volunteered to participate in this study. A priori sample size was calculated (G*Power, version 3.1.9.2, University of Kiel, Kiel, Germany) for one-way repeated measures analysis of variance (ANOVA), with a determined effect size = 0.35, power = 0.80, one group and six measurements (rest and five different active video games). According to these, at least 10 participants should be involved in the study. The primary inclusion criteria for participation in this study were being healthy without any medical, cardiovascular, metabolic, and/or respiratory disorders. Health status was determined using the Physical Activity Readiness Questionnaire (PAR-Q) [31]. Participants were asked to avoid performing exhaustive exercise for 24 h before measurements and were told to refrain from eating or drinking for 3 h before the measurements.

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, and written consent forms were obtained. The study protocol conformed to the ethical guidelines of the 1975 Declaration of Helsinki, and the study was approved by the Ethics Committee of Eskişehir Technical University (Protocol number 14411).

2.2. Active Video Games

Five different AVGs were played in random order on non-consecutive days, separated by at least 48 h. AVG trials were played using Xbox ONE (Microsoft). This device was used because it offers a large number of AVGs with different features, and there is no need to touch anything while playing the game. In this case, the participants allow physical freedom of movement. The following AVGs with different types were played for 15 min: (1) Fruit Ninja (Halfbrick Studios), (2) Just Dance 2017 (Ubisoft), (3) Shape Up Muscle Quest (Ubisoft), (4) Shape Up Cardio Quest (Ubisoft), and (5) Fighter Within (Ubisoft). There were two main reasons for choosing these games. First, martial arts and dance are popular among young people, and second, these games are different in terms of the game scenario, challenge situation, and aerobic or anaerobic exercise types, which allow the whole body to move [32–34]. All participants received standardized verbal encouragement while playing the games from the researcher. The physiological and perceptual variables were measured for each AVG.

2.3. Resting Condition

The physiological measurements of resting condition were taken before one of the AVGs randomly. The participants rested in a supine position. The physiological variables (VO_2 , VCO_2 , RER, HR) were measured continuously throughout the rest for 20 min, but the mean value of the last 5 min was used in the analyses.

2.4. Physiological Measurements

Physiological variables such as oxygen consumption (VO_2), carbon dioxide production (VCO_2), and respiratory exchange ratio (RER) were measured continuously using the computerized breath-by-breath analysis system Master Screen-CPX (Care Fusion, Höchberg, 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, Helsinki, Finland). HR data were downloaded from the watch using Polar software (v.4.01.029). MET, EE ($\text{kcal}\cdot\text{min}^{-1}$), EE ($\text{kcal}\cdot\text{kg}^{-1}\cdot\text{min}^{-1}$), HRmax and heart rate reserve (HRR) were calculated using Equation (1) [35], Equation (2) [36], Equation (3) [13], Equation (4) [35], and Equation (5) [35], respectively.

$$\text{MET} = \text{VO}_2 (\text{mL}\cdot\text{kg}^{-1}\cdot\text{min}^{-1}) / \text{Resting VO}_2 (\text{mL}\cdot\text{kg}^{-1}\cdot\text{min}^{-1}) \quad (1)$$

$$\text{EE} (\text{kcal}\cdot\text{min}^{-1}) = (3.9 \times \text{VO}_2 + 1.1 \times \text{VCO}_2) \quad (2)$$

$$\text{EE} (\text{kcal}\cdot\text{kg}^{-1}\cdot\text{min}^{-1}) = (3.9 \times \text{VO}_2 + 1.1 \times \text{VCO}_2) / \text{weight of the individual (kg)} \quad (3)$$

$$\text{HR max} = 220 - \text{age} \quad (4)$$

$$\text{HRR} = (220 - \text{age} - \text{HR rest}) \times \text{target intensity} + \text{HR rest} \quad (5)$$

2.5. Perceptual Measurements

Immediately after completing each AVG, participants sat down and filled in the perceptual questionnaires. A modified Physical Activity Enjoyment Scale (PACES) asks participants to rate “how you feel at the moment about the physical activity you have been doing” using a 5-item and 7-point Likert-type scale (1 = unpleasurable; 7 = pleasurable). Two items are reverse-coded. For each occasion, the sum of all the items, ranging from 5 to 35, constitutes a unidimensional measure of enjoyment. Higher values reflect greater levels of enjoyment. It has been reported that the PACES is both reliable and valid in PA environments [37,38]. Additionally, the RPE (Borg scale) is often used to assess the severity of physical exertion during effort and rest [39]. The 15-point Borg scale was used to determine participants’ levels of perceived exertion after each condition [39].

2.6. Statistical Analysis

Results are presented as the mean \pm standard deviation (SD). All the data were assessed for the normal distribution with the Shapiro-Wilk test. The effects of six different conditions on the examined physiological and perceptual variables were analyzed using a one-way repeated measures ANOVA. The sphericity was checked using Mauchly’s sphericity test. Additionally, the Bonferroni post-hoc methods were applied for multiple pairwise comparisons when the F-test statistic was significant ($p < 0.05$). Power analysis ($1 - \beta$) was performed and determined as 1.000 for all analyses (except enjoyment score = 0.804). Additionally, the effect sizes were calculated as the partial eta-squared (η_p^2). The correlation between RPE and enjoyment scores was evaluated using the Pearson Product Moment Correlation. A value of $p < 0.05$ was accepted as statistically significant. All statistical analyses were performed using SPSS version 24.0 for Windows (Statistical Package for the Social Sciences, SPSS Inc., Chicago, IL, USA).

3. Results

The findings demonstrate that all AVGs significantly increased the VO_2 , MET, EE, and HR above the rest condition ($p < 0.05$). The lowest physiological responses were recorded for Fruit Ninja AVG; however, the highest physiological responses were recorded for Fighter Within AVG. The VO_2 , EE, MET, and HR responses were not significantly different between Just Dance and Shape Up Muscle AVGs; also, they were not significantly different between Shape Up Cardio and Fighter Within AVGs. The physiological responses of participants for six different conditions are presented in Table 1. The values of total EE (kcal) for 15 min are presented in Figure 1. The perceptual responses of participants for different conditions are presented in Table 2. Percentage changes of VO_2 and HR according to resting values are shown in Figure 2. One of the objectives of the study was to categorize the AVGs’ physical activity (PA) intensity according to ACSM classification.

The Fruit Ninja, the Just Dance, and the Shape Up Muscle AVGs were defined as moderate PA (3–5.9 MET), and the Shape Up Cardio and the Fighter Within AVGs were defined as vigorous PA (6–8.7 MET). The categorization of the physical activity intensity of AVGs according to the ACSM classification is presented in Table 3.

Table 1. The mean \pm SD values of physiological responses of participants for different conditions.

Variables	Rest	Fruit Ninja AVG	Just Dance AVG	Shape Up Muscle AVG	Shape Up Cardio AVG	Fighter Within AVG	<i>p</i> Value	F	η_p^2
VO ₂ (mL·kg ⁻¹ ·min ⁻¹)	3.97 \pm 0.37	16.21 \pm 3.42 ^{acdef}	21.52 \pm 3.75 ^{abef}	20.76 \pm 2.83 ^{abef}	27.03 \pm 3.04 ^{abcd}	27.90 \pm 4.61 ^{abcd}	<0.001	127.20	0.92
RER	0.76 \pm 0.02	0.87 \pm 0.02 ^{acdef}	0.90 \pm 0.03 ^{acdef}	0.96 \pm 0.01 ^{abc}	0.95 \pm 0.02 ^{abc}	0.96 \pm 0.03 ^{abc}	<0.001	119.24	0.92
EE (kcal·min ⁻¹)	1.33 \pm 0.1	5.53 \pm 1.0 ^{acdef}	7.43 \pm 1.1 ^{abef}	7.29 \pm 0.8 ^{abef}	9.41 \pm 0.7 ^{abcd}	9.75 \pm 1.5 ^{abcd}	<0.001	127.62	0.92
EE (kcal·kg ⁻¹ ·min ⁻¹)	0.019 \pm 0.001	0.079 \pm 0.017 ^{acdef}	0.105 \pm 0.019 ^{abef}	0.104 \pm 0.015 ^{abef}	0.134 \pm 0.015 ^{abcd}	0.138 \pm 0.023 ^{abcd}	<0.001	120.01	0.92
MET	1.00 \pm 0.0	4.07 \pm 0.7 ^{acdef}	5.46 \pm 1.0 ^{abef}	5.25 \pm 0.7 ^{abef}	6.83 \pm 0.7 ^{abcd}	7.03 \pm 1.0 ^{abcd}	<0.001	124.78	0.92
HR (beat·min ⁻¹)	71.00 \pm 9.82	120.67 \pm 17.43 ^{acdef}	131.33 \pm 20.23 ^{acdef}	135.92 \pm 15.55 ^{abef}	152.33 \pm 17.76 ^{abcd}	153.58 \pm 18.04 ^{abcd}	<0.001	113.13	0.91
HR max%	-----	60.47 \pm 8.68 ^{def}	65.83 \pm 10.15 ^{ef}	68.11 \pm 7.63 ^{bef}	76.33 \pm 8.64 ^{bcd}	76.98 \pm 9.06 ^{bcd}	<0.001	26.36	0.70
HRR max%	-----	38.77 \pm 11.59 ^{def}	47.26 \pm 14.96 ^{ef}	50.84 \pm 9.51 ^{bef}	63.71 \pm 11.40 ^{bcd}	64.36 \pm 13.27 ^{bcd}	<0.001	25.00	0.69

AVG: active video game; VO₂: oxygen consumption; RER: respiratory exchange ratio; EE: energy expenditure; MET: metabolic equivalent; HR: heart rate; ^a $p \leq 0.01$: significantly different from rest condition; ^b $p < 0.05$: significantly different from Fruit Ninja AVG; ^c $p < 0.05$: significantly different from Just Dance AVG; ^d $p < 0.05$: significantly different from the Shape Up Muscle AVG; ^e $p < 0.05$: significantly different from the Shape Up Cardio AVG; ^f $p < 0.05$: significantly different from the Fighter Within AVG.

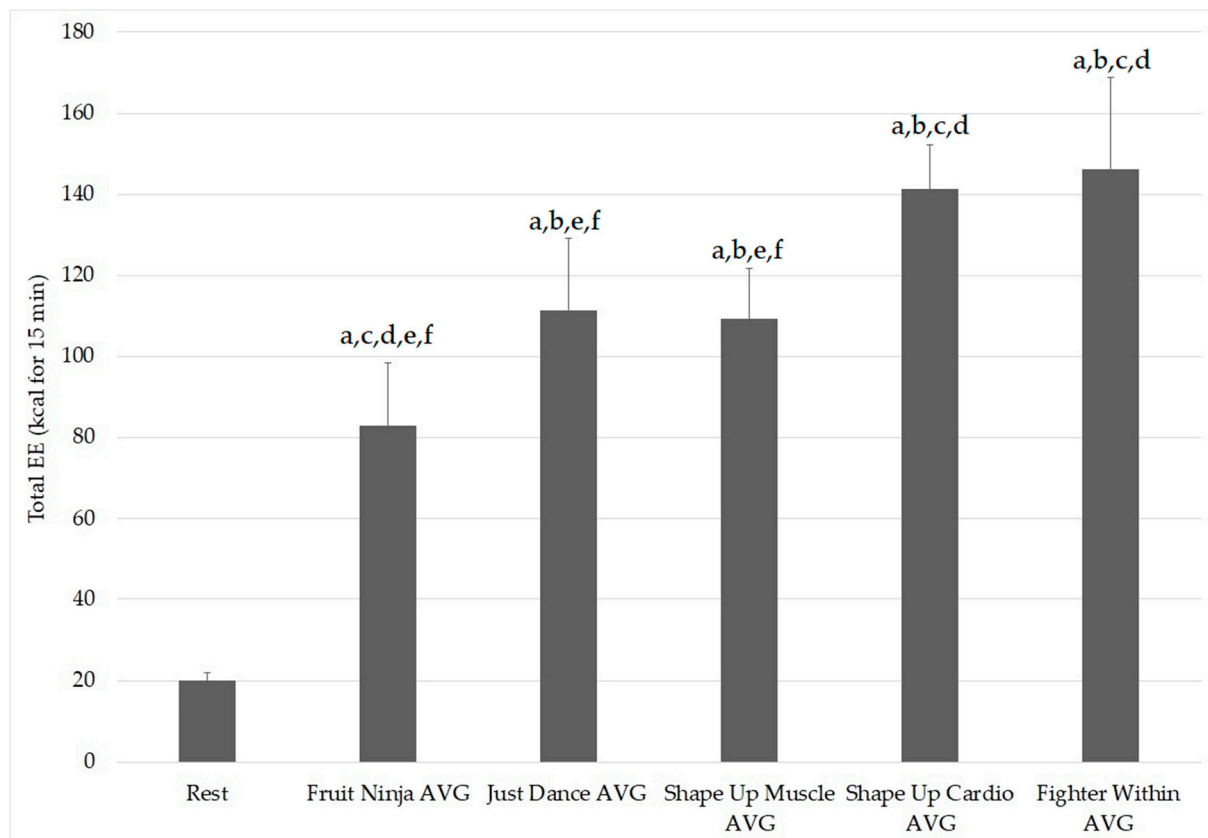


Figure 1. The total amount of energy expenditure (kcal) for 15 min of each experimental condition. AVG: active video game; ^a $p \leq 0.01$: significantly different from rest condition; ^b $p < 0.05$: significantly different from Fruit Ninja AVG; ^c $p < 0.05$: significantly different from Just Dance AVG; ^d $p < 0.05$: significantly different from the Shape Up Muscle AVG; ^e $p < 0.05$: significantly different from the Shape Up Cardio AVG; ^f $p < 0.05$: significantly different from the Fighter Within AVG.

Table 2. The mean \pm SD values of perceptual responses of participants for different conditions.

Variables	Fruit Ninja AVG	Just Dance AVG	Shape Up Muscle AVG	Shape Up Cardio AVG	Fighter Within AVG	<i>p</i> Value	F	η_p^2
RPE scores	10.33 \pm 2.57 ^{††π}	10.42 \pm 2.31 ^{††π}	14.67 \pm 1.23 ^{#†}	13.92 \pm 1.88 ^{#†}	13.75 \pm 1.48 ^{#†}	<0.001	17.28	0.61
Enjoyment scores	28.83 \pm 4.87	28.50 \pm 4.42	27.00 \pm 3.76 ^{π}	28.17 \pm 3.09 ^{π}	31.92 \pm 2.27 ^{††}	<0.05	3.35	0.23

AVG: active video game; RPE: Rating of perceived exertion; [#] $p < 0.05$: significantly different from Fruit Ninja AVG; [†] $p < 0.05$: significantly different from Just Dance AVG; ^{††} $p < 0.05$: significantly different from the Shape Up Muscle AVG; ^{†††} $p < 0.05$: significantly different from the Shape Up Cardio AVG. ^{π} $p < 0.05$: significantly different from the Fighter Within AVG.

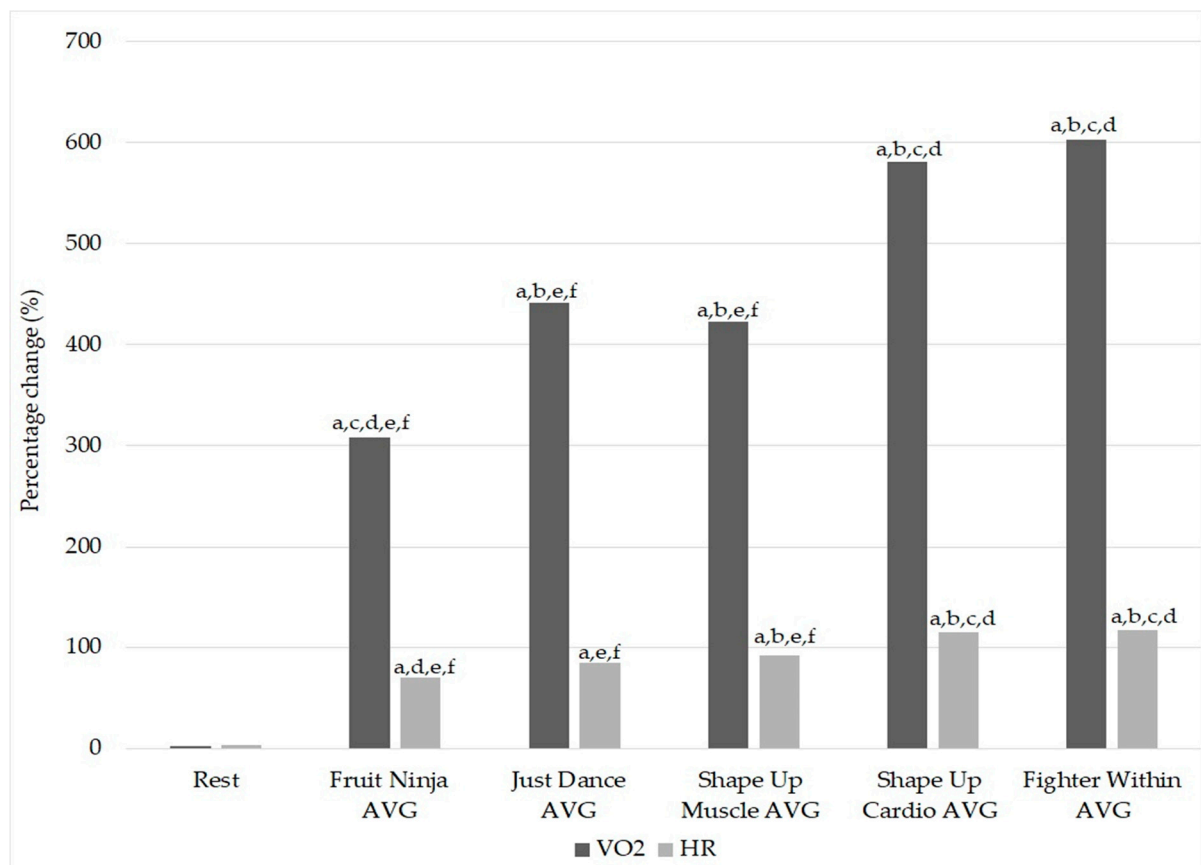


Figure 2. Percentage changes of VO₂ and HR according to resting values. AVG: active video game; VO₂: oxygen consumption; HR: heart rate; ^a $p \leq 0.01$: significantly different from rest condition; ^b $p < 0.05$: significantly different from Fruit Ninja AVG; ^c $p < 0.05$: significantly different from Just Dance AVG; ^d $p < 0.05$: significantly different from the Shape Up Muscle AVG; ^e $p < 0.05$: significantly different from the Shape Up Cardio AVG. ^f $p < 0.05$: significantly different from the Fighter Within AVG.

The findings show that the Shape Up Cardio and Fighter Within AVGs (141.23 \pm 10.9 and 146.30 \pm 22.6, respectively) induce significantly higher EE (kcal) than other AVGs (Fruit Ninja = 83.00 \pm 15.5; Just Dance = 111.47 \pm 17.7; Shape Up Muscle = 109.44 \pm 12.3) ($p < 0.05$) (Figure 1). As seen in Figure 2, VO₂ consumption and HR significantly increased above the rest condition. The results determine that the RPE scores of Shape Up Muscle, Shape Up Cardio, and Fighter Within AVGs are significantly higher than the RPE scores of Fruit Ninja and Just Dance AVGs ($p < 0.05$) (Table 2). On the other hand, the highest enjoyment score was determined for the Fighter Within AVG (31.92 \pm 2.27), which was significantly different from the Shape Up Muscle and Shape Up Cardio AVGs (27.00 \pm 3.76 and 28.17 \pm 3.09, respectively) ($p < 0.05$) (Table 2). One of the objectives of the study was

to investigate the correlation between RPE and enjoyment score within each AVG. When examining the correlation between RPE and enjoyment, no significant correlation was observed between RPE and enjoyment scores of AVGs ($p > 0.05$).

Table 3. The categorization of the physical activity intensity of AVGs according to the ACSM classification.

AVGs	ACSM Classification METs Light: 2.0–2.9 Moderate: 3.0–5.9 Vigorous: 6.0–8.7	ACSM Classification HR max% Light: 57–63 Moderate: 64–76 Vigorous: 77–95	ACSM Classification HRR max% Light: 30–39 Moderate: 40–59 Vigorous: 60–89	ACSM Classification RPE Light: 9–11 Moderate: 12–13 Vigorous: 14–17
Fruit Ninja AVG	Moderate	Light	Light	Light
Just Dance AVG	Moderate	Moderate	Moderate	Light
Shape Up Muscle AVG	Moderate	Moderate	Moderate	Vigorous
Shape Up Cardio AVG	Vigorous	Vigorous	Vigorous	Moderate
Fighter Within AVG	Vigorous	Vigorous	Vigorous	Moderate

4. Discussion

The current study aimed to investigate the physiological (VO_2 , RER, EE, MET, and HR) and perceptual (RPE and enjoyment) responses of five different AVGs, comparing them with each other and resting conditions. Another purpose of the current study was to evaluate and categorize the AVGs' PA intensities according to ACSM classification. The main findings demonstrated that AVGs examined in the present study significantly increased the VO_2 , RER, EE, MET, and HR values compared to the rest condition in healthy and physically active college males and differed between each other. The highest values of VO_2 , EE, MET, and HR were observed in Shape Up Cardio and Fighter Within AVGs. Based on the current study's findings and ACSM classification (light intensity PA is defined as requiring 2.0–2.9 METs, moderate as 3.0–5.9 METs, and vigorous as 6.0–8.7 METs) [35], the Fruit Ninja, the Just Dance, and the Shape Up Muscle AVGs were defined as moderate PA (3–6 MET), the Shape Up Cardio, and the Fighter Within AVGs were defined as vigorous PA (>6 MET). The highest enjoyment score was recorded for Fighter Within AVG. On the other hand, differently from the physiological findings of the current study, the highest RPE score was recorded for Shape Up Muscle AVG.

There is strong evidence that AVGs increased physiological variables such as VO_2 , MET, EE, and HR significantly, compared to the rest condition [20,22,30,38,40–43] and sedentary routines [13,43,44]. Findings indicated that many factors, such as the number of players [22], types of the selected game [16,25], features of the console used [42,45], or the individual's ability to perform the desired skill [30], affect the physiological responses of AVGs. Monedero et al. [25] compared AVGs with two different exercise types and reported that the physiological responses (EE, VO_2 , MET, and HR) of the "Your Shape Fitness Evolve" game were significantly higher than those the "Kinect Adventures" game. Consistent with these findings, AVGs played in the current study were found to be significantly different from each other.

The current study aimed to evaluate and categorize the AVGs' PA intensity according to ACSM classification. In many studies, the AVGs' PA intensity has generally been defined as low (<3 MET) and moderate (3–6 MET) intensity [18,40]. In the current study, based on the MET values, the Fruit Ninja, Just Dance, and Shape up Muscle AVGs can be defined as moderate PA, whereas the Shape up Cardio and Fighter within AVGs can be defined as vigorous PA. On the other hand, even though the AVGs with similar characteristics are compared (e.g., active video dancing games) in similar populations, the findings may differ because of the differences in game structure. Aygün and Çakir-Atabek [30] examined the

“Fitness–Cardio Groove” mode of the “Dance Central 3” and indicated that active video dancing games cause vigorous PA in young males. For this reason, it should be considered that the same type of games, for example, dance may have different effects in different modes: different dancing games or a dancing game with different structure settings may affect the findings.

Recently, it has become much more important to determine the AVGs’ PA intensity, especially in college students who do not meet the minimum PA requirements. It is considered that the determination of vigorous AVG is important for individuals to use in practice when the vigorous PA alternatives are limited at home. Few studies in the literature have qualified the AVGs as vigorous PA (>6 MET) [16,25,30]. Consistent with the findings of the current study, the AVGs in which a player has to fight against an opponent [$\text{MET} = 9.70 \pm 1.68$] [16] or dance like hip-hop [$\text{MET} = 6.63 \pm 1.02$] [30] have been determined as vigorous PA.

RER value shows the balance between oxygen consumption and carbon dioxide production. It is used to estimate the type and amount of nutrients (combination of carbohydrate, fat, protein) oxidized predominantly in energy production [46]. Muscles rely on glucose for energy during activity, which causes a higher RER value: the muscles’ glucose need increases as the intensity of the workout increases. The RER values approach 1.0 as more carbohydrate is used [46] and increase over the ≥ 1.10 during maximum effort [47]. In the present study, the RER values during the AVGs were between 0.87–0.96. Strikingly, the present study’s findings determined no differences between Just Dance and Shape Up Muscle AVGs in terms of VO_2 , EE, and MET, but the RER value was statistically higher in Shape Up Muscle AVG than in Just Dance AVG. This case shows that, even if the energy expenditure is similar among the AVGs, the energy source used by the muscles can vary depending on the game selection. Considering the RER values, it can be inferred that, even if a similar amount of calories is burned during these two games (Just Dance and Shape Up Muscle AVGs), more carbohydrates are burned in Shape Up Muscle AVG. It is important to be aware of these types of AVGs, especially for exercise prescription.

Studies demonstrated that the RPE scores of AVGs were lower than classical exercises even though the exercise intensities were the same or similar [13,25,48,49]. A study reported higher RPE scores for “Your Shape Fitness Evolve” AVG than “Kinect Adventures” AVG in young adults. However, there are no significant differences in RPE (determined with Omni-Scale) between Adventure, Boxing, and Dance AVGs in children [25]. In the current study, no significant differences were determined for RPE between Shape Up Muscle (14.67 ± 1.23), Shape Up Cardio (13.92 ± 1.88), and Fighter Within AVGs (13.75 ± 1.48). The RPE scores reported above were significantly higher than the RPE scores reported for Fruit Ninja (10.33 ± 2.57) and Just Dance (10.42 ± 2.31) AVGs. As seen in Table 2, although the RPE scores for the three AVGs were not statistically different, significant differences were determined for physiological responses; the lowest responses were recorded in Shape Up Muscle AVG, where the RPE score was recorded as the highest. These findings suggest that RPE may not reflect the actual effort (measured physiological responses) in AVGs.

Determining the level of enjoyment associated with performing PA is important for promoting and supporting an active lifestyle [50]. It is difficult to make a one-to-one comparison as different scales are used for enjoyment measurement in the literature. However, in general, studies have determined that playing AVGs is enjoyable for individuals [19,25,51] and showed that AVGs are more enjoyable than classical exercises [25,38,51]. In the present study, the Fighter Within AVG was observed as the most enjoyable game compared with others. In addition, the other games have been found to be quite entertaining (enjoyment score > 27 ; Table 2) and compatible with the literature.

A negative relationship has been stated between RPE and feeling states in some kinds of exercise, especially during the classical continuous exercise. A higher level of RPE has been correlated with feeling bad [24,52–54]. In contrast with these findings, this correlation was not determined for high-intensity interval training (HIIT) [24,53,55,56]. Monedero et al. [54] showed that there was a negative correlation between RPE and enjoy-

ment in classical bicycle training, but this relationship was not evident in the interactive cycling video game. In the current study, for the examined AVGs, no correlation was found between RPE and enjoyment scores. This can be explained by the structural types of AVGs, such as setting goals, listening to music, or engaging in competition [26,49], as well as by the medium and high-intensity intermittent exercise types of AVGs [16]. As the positive side of AVGs, these findings show that even if the exertion increases above 13 points (somewhat hard), the participants still feel good and enjoy the game. Additionally, findings show that the game with the highest intensity (Fighter within AVG: MET = 7.97 ± 1.3) is also the most entertaining event, which means it is possible both to enjoy and exercise vigorously.

Limitations

Several limitations of the current study should be noted in interpreting the results. Because of the variety of AVGs on the market, the results of the current study cannot be generalized to all active console video games. Furthermore, undergraduate students in our study did not vary widely in age. For this reason, it should be considered that these findings could not be generalized to different aged-group students. Additionally, the small sample size and the participants were also entirely male and lacked considerable variety in terms of ethnicity and race, so future research should strive for a more representative sample. Finally, although we used the gold standard measurement method, the breath-by-breath gas exchange analysis system, to analyze physiological measurements, this study was conducted in a laboratory environment by encouraging the participants. Therefore, it may not fully reflect the results of playing AVGs alone at home. However, this study may reflect the effects of similar AVGs on college students.

5. Conclusions

Consequently, all examined physiological variables were found to be higher for AVGs than the resting condition, and the AVGs played were shown to be enjoyable. According to ACSM criteria, three of AVGs (Fruit Ninja AVG, Just Dance AVG, and Shape Up Muscle AVG) were defined as moderate PA (MET 3.0–5.9; ACSM [35]), and two of them (Shape Up Cardio AVG, and Fighter Within AVG) were defined as vigorous PA (MET 6.0–8.7; ACSM [35]) for college students. Contrary to previous studies conducted with classical continuous exercise [54], no negative correlation was found between RPE and enjoyment, similar to the results of intermittent exercise [24,53]. The present study demonstrated that even if the energy consumption of different AVGs is similar, it can be different the relative contribution of carbohydrates and lipids to overall energy expenditure when evaluated in terms of RER.

Based on the current findings, young adults can choose a game by knowing the game's physiological responses and amount of burned calories, e.g., in the range of 80–150 kcal for 15 min. When AVGs are used as PA, it could be possible to exercise vigorously and have more fun. This could support ensuring the continuity of participation of PA. Using this knowledge, exergaming stations can be installed as recreational areas in any location where the AVG systems can be applied. Also, it can offer an attractive and effective opportunity to participate in PA with different game alternatives. Furthermore, young adults, especially college students, may choose to buy AVG equipment instead of sedentary-based video games, minimizing physical inactivity and increasing enjoyable PA.

Innovative approaches are needed to address the societal problem of sedentary behavior and physical inactivity, maintain public health, and prevent chronic diseases. Traditional forms of physical activities such as walking, running, and cycling have proven the physiological benefits. However, technology-based and funny exercise models can also play an effective role in participating and maintaining the PA.

Author Contributions: Conceptualization, C.A. and H.Ç.-A.; methodology, C.A. and H.Ç.-A.; software, C.A.; validation, C.A. and H.Ç.-A.; formal analysis, C.A.; investigation, C.A.; resources, C.A.; data curation, C.A.; writing—original draft preparation, C.A.; writing—review and editing, H.Ç.-A.; visualization, C.A. and H.Ç.-A.; supervision, H.Ç.-A.; project administration, C.A. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

Institutional Review Board Statement: The study was conducted in accordance with the Declaration of Helsinki and approved by the Institutional Review Board of Eskişehir Technical University (IRB protocol number 14411 and date of approval 27 May 2019).

Informed Consent Statement: Informed consent was obtained from all subjects involved in the study. Written informed consent has been obtained from the participants to publish this paper if applicable.

Data Availability Statement: The data are not publicly available due to the participants' privacy. The data presented in this study are available on request from the corresponding author.

Acknowledgments: We extend our gratitude to the students of Eskişehir Technical University for their participation in this research, which is based on the Scientific Research Project (19ADP184) of Eskişehir Technical University.

Conflicts of Interest: The authors declare no conflict of interest.

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