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# Influence of the exercise intensity during EA Sport Active 2 on physiology and psychology variables



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ABSTRACT

**Purpose.** Exergames purportedly aim to gamify physical activity, achieving both the high engagement rates found in video games and the health benefits derived from regular exercise. Therefore, this study sought to verify the influence of the EA® Active Sport 2® game level on heart rate, perceived exertion and future intention to play, affection, and fun.
**Methods.** 28 individuals (19 men and 9 women) aged between 19 and 25 years, students, participated in the study. The volunteers had their body composition measured and completed an exercise preference and tolerance questionnaire. On the second visit, the participants had their resting heart rate measured and, subsequently, underwent a maximum incremental test to determine the ventilatory thresholds. The third and fifth visits tested different exercise intensities (light, moderate and strong) determined by EA Active Sport, for PlayStation 3. To minimise the risk of bias, the sessions were randomised. Heart rate, affection, perceived exertion, motivation and future intention to play were measured in game sessions.
**Results.** During exercise, the mean heart rate (HR) at rest was below the heart rate reserve ($HR_{res}$) and the ventilatory threshold 1 (LV1) in low-intensity exercise and in the lower limit of the heavy domain for moderate and Active Game High. The assessment of perceived exertion (RPE) and affection did not show differences between the different intensities of the game.
**Conclusions.** The EA Active Sport 2 differentiates light from moderate and high-intensity exercise, but not between moderate and high game intensities. Affection, RPE, intention to play, and enjoyment did not differ between game intensities.
**Key words:** exergaming, video games, psychological adjustment, exercise

## Introduction

Video games became famous for bringing entertainment and fun to users. However, their uncontrolled use contributes to an increase in sitting hours (sedentary behaviour) and consequently impacts the prevalence of physical inactivity among young people and adults [1]. In an attempt to reduce the impact of video games on physical inactivity [1, 2], the most popular video game manufacturers (Nintendo, Sony, and Microsoft) introduced active video games (AVGs) in 2006, also known as exergames.

These exergames aim to gamify physical activity, obtaining both the high engagement rates found in video games and the health benefits derived from regular exercising. Furthermore, the use of exergames can address several access barriers around transport and leaving the home, while also providing enjoyable activities which may improve ongoing participation in physical activities [3, 4]. The development of new devices such as Microsoft Kinect and PlayStation Eye, which are able to detect body motion and incorporate it into the gameplay, has brought a new perspective to video games and their users. Kinect was first announced

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in 2009 during the Electronic Entertainment Expo (E3), and on November 2010, Microsoft announced that the device would be officially sold. A total of 8 million units were sold in just over 60 days [5].

Due to the potential of these new devices to rewrite the gaming and exercising industry, several studies have already assessed this novel technology. Research has usually focused on the way of playing (single or dual player; offline or online) [6, 7], type of games (e.g., sport, dance, balance, and strength) [8, 9], psychological variables (e.g., anxiety, self-efficacy, pleasure, competence, presence, flow, fun, engagement, enjoyment, usability, motivation, future intention to play) [6–15], and/or physiological aspects (e.g., heart rate, energy expenditure, and oxygen consumption) [6, 7, 9, 10, 13, 15, 16].

The possible interference of psychological variables (entertainment, pleasure) on the physiological response to exercise is identified in several studies. A recent investigation assessed an immersive virtual reality (IVR) device that integrated cable resistance training and not only found a substantial metabolic demand which meets the ACSM vigorous exercise requirements, but also high ratings of enjoyment that seemed to distract users from perceived exertion [17]. Gomez, Browne, Almalouhi et al. [17] found results which suggest similar muscle activation responses compared to traditional resistance exercises, as demonstrated by prior evidence, and reinforce the ability of an IVR exergaming system to make practitioners exercise at a high intensity while distracting them from the high demands of the exertion. Our hypothesis is that exercise performed during a video game (exergame) can promote distraction for support.

In mid-2010, large companies such as Nike and Adidas developed AVG games with the aim of practicing calisthenic physical exercise. One study observed that two weeks of AVG gaming (Your Shape: Fitness Evolved) increased vigour compared to the control group [11], while another study [9] observed a higher perception of effort in AVG with greater pleasure when compared to walking. Following the trend, the Electronic Arts company, with the support of the American College of Sports Medicine, developed the game EA Active Sport 2. This game is a virtual personal trainer which, based on a physical evaluation performed on the game platform, determines the level of intensity of the exercise to be performed.

Studies have indicated that AVG might be useful for exercise training since it presents higher affect response (increasing adherence) with higher intensity when compared to walking [9, 11]. Therefore, it is essential to evaluate whether AVGs (EA Active Sport 2) are capable of increasing exercise intensity (as proposed by the EA game) to ensure exercise progression through training, considering different exercise intensity domains (i.e. three zones based on ventilatory thresholds and ACSM intensities zones). Given these factors, this study aims to verify the influence of the EA Active Sport 2 game level on heart rate, perceived exertion, future intention to play, affect, and fun, since the latter is essential to increase adherence. Our hypothesis was that the game levels of EA Active Sport 2 would increase HR and perceived exertion without changing future intention to play, affection, and fun.

## Material and methods

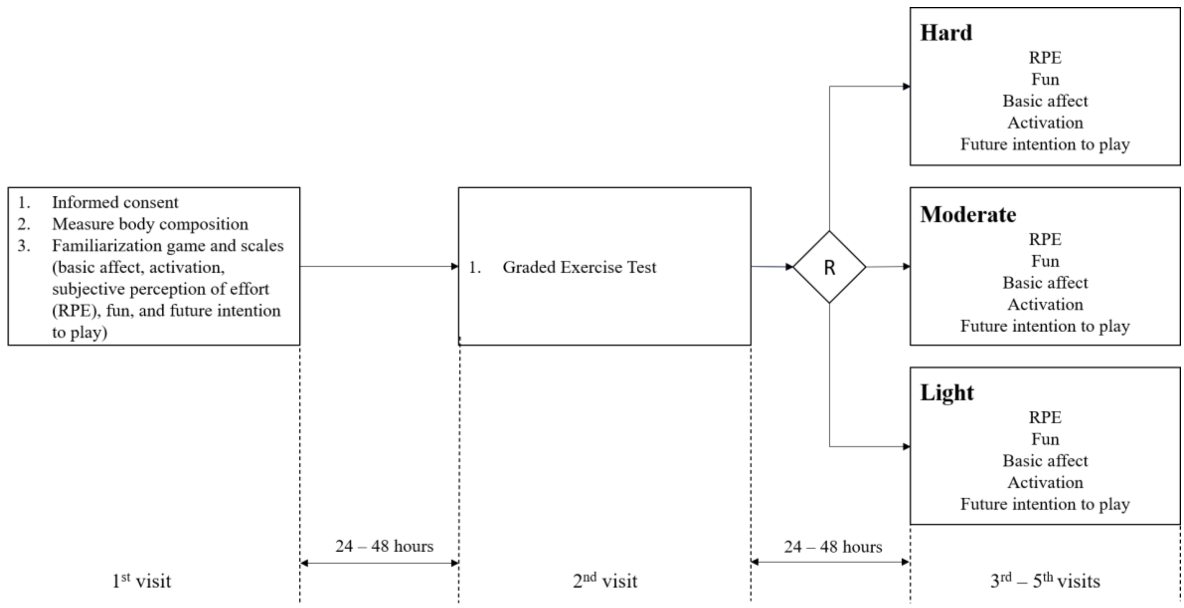
### Participants

The study included 28 individuals (19 men and 9 women) between the ages of 19 and 25 who were students at a university in Brazil. The recruitment of participants took place through invitations made via social medias (WhatsApp and Instagram) aimed at the target audience. Next, a sample calculation was performed to determine the sample size using the G-Power 3.0.10 software for two-way ANOVA, ANOVA *a priori* analysis of repeated measures (within-between interaction) with three groups (Intensities) and four measures (Moments). The following parameters were used: effect size of 0.30; an α error of 0.05; a power (1 – β) of 0.90; a correlation between repeated measures of 0.50; and a non-sphericity correction of 1.0, suggesting an estimated sample size of 27 volunteers.

The inclusion criteria for participation were apparently healthy and physically active participants who were engaged in physical exercise (aerobic or resistance training) at least 30 minutes, five times per week. The exclusion criteria included those who regularly used medications or treatments that would alter the cardiovascular (beta-blockers and calcium channel inhibitors), metabolic (antihyperglycemic and insulin), or mood (antidepressant and anxiolytic) responses. All participants performed the same interventions in the Physical Activity, Health, and Performance Laboratories.

### Study design

The study design was experimental with a crossover design, carried out in a total of five visits and with a mean interval of 48 h between them (Figure 1). The present study followed the CONSORT recommendations (Consolidated Standards of Reporting Trials), and




R – randomisation, RPE – rating of perceived exertion

Figure 1. Experimental design

there were no changes in the experimental design after starting the data collection.

During the first visit, the volunteers had their body composition measured and completed an exercise preference and tolerance questionnaire (PRETIE-Q). Then, the volunteers were introduced to the EA Active Sport Game and a familiarisation session was held. The volunteers' data were entered into the console, and the game determined the individual profile of the participants and created three sessions based on the intensities (light, moderate and heavy) of the activities that each of the volunteers would perform. The participants were also familiarised with the perceptual scales used in the study (affect, activation, rate of perceived exertion (RPE), fun, and future intention to play).

On the second visit, the participants had their resting heart rate measured, and later underwent a maximal incremental test to determine the ventilatory thresholds. They then performed three sessions across the third to fifth visit with different intensities (light, moderate and hard) determined by the game (Table 1). The sessions were randomised to minimise the risk of bias. Volunteers were not informed about exercise intensity.

Procedures

*Body composition*

Body mass, height, and skinfolds (triceps, subscapularis, suprailiac, thoracic, abdomen, and thigh) were collected to assess body composition. Body mass was measured using an electronic scale (Welmy Class III Scale – Brazil), height using a stadiometer (Sanny, Brazil), circumferences using a measuring tape (Sanny, Brazil) and skin folds with a Lange brand caliper (USA). All measurements followed the International Society for the Advancement of Kinanthropometry (ISAK) standard. The equations proposed by Jackson and Pollock [18] and Jackson, Pollock and Ward [19] were used to calculate body density for men and women, respectively. The fat percentage was calculated using the equation of Siri [20].

*Resting reserve heart rate*

The volunteers remained lying down for 10 minutes to assess the resting heart rate ($HR_{rest}$). We used the following equation to calculate the heart rate reserve ($HR_{res}$): $HR_{res}$ = *maximum HR* – $HR_{rest}$.

*Heart rate monitoring*

During the sessions, the heart rate (HR) was monitored by a Polar V800 watch and plethysmography sensors attached to the right and left forearm and left thigh, according to the EA Active Sport 2 Game manual.

*Preference for and Tolerance of the Intensity of Exercise*

The Preference for and Tolerance of the Intensity of Exercise Questionnaire (PRETIE-Q) was used to assess Preference and exercise tolerance. This instru-

Table 1. Session training model

| Phase | Activity | Description |
|---|---|---|
| Warm up | Heel lifts | Movement of standing on tiptoe and returning the heel to the floor |
| | Rainbow squats | Single-sided squat movement left and right with arms extended forward |
| | Windmills | With arms extended laterally, perform the movement of touching the foot with the opposite hand |
| | Good mornings | Start with a squat with the hands holding the feet, lift the hips, and extend the change by bringing the arms above the head |
| Main event | Soccer – high knees | Simulation of running movement on a soccer field by lifting the knees (static running) |
| | Soccer – kickups | Simulation of running movement on a soccer field (static running) |
| | Foot fires | In semi-squat, perform the movement of lifting the foot quickly |
| | Split squats | With an elastic, perform the deep squat movement |
| | Soccer running | Simulation of the running movement on a soccer field (static running) |
| | Push ups from knees | Kneeling, perform the elbow flexion movement |
| | Skipping | Simulation of the jump rope movement |
| | Triceps kickbacks | With the elastic band, perform the semi-squat movement and pull the elastic back |
| | Soccer – goalkeeper | Simulation of the movement of ‘grabbing’ the ball in the goal |
| | Mountain biking | Mountain biking movement simulation, with jumps and squats |
| | Alternating lunges | Perform the movement of step forward and crouch, alternating the forward leg |
| | Shoulder presses | With an elastic band, lift the arms above the head |
| | Lateral shoulder raises | With the elastic, perform the abduction and adduction movement of the arms |
| | Crunch with punches | Trunk lifting movement combined with punching |
| | Reverse crunches | Lifting movement of both legs in a lying position with bent knees |
| Cool down | Arm across and pulls | Sitting with outstretched legs, cross your arms over your chest and hold it with the opposite hand |
| | Chest opener | In a seated position with bent knees and arms extended behind the body, perform the movement of ‘opening’ the chest |
| | Leg over | Lying down, perform the movement of crossing the knee to the opposite side of the body |
| | Leg up | Lying down with your knees bent, perform the lifting movement of one of your legs |

ment contains 16 items, and a five-point Likert scale of responses accompanies each item ranging from ‘1’ (strongly disagree) to ‘5’ (strongly agree) [21].

*Perceptions during or after exercise sessions*

Different subjective scales were used to assess individual perceptions of affect, activation, RPE, fun, and future intention to play. All of them were continuously measured during the sessions and recorded in the final 15 s, in periods of 2 min.

The sensation scale (ES) [22] was used to assess the pleasure and displeasure levels in the activity, consisting of 11 items with a variation of +5 (very good) and –5 (very bad), where 0 represents a neutral condition.

Activation was measured using the scale (EA) suggested by Svebak and Murgatroyd [23], which has six points and ranges from ‘1’ (little activated) to ‘6’ (very activated).

Rating of perceived effort was measured during the sessions according to the CR10 scale [24], which presents a range of perceived exertion ranging from ‘0’ (absolutely nothing) to ‘10’ (extremely strong). The respective classifications followed the American College Sport of Medicine (ACSM) guidelines for adults.

The PACES Scale [25] was used to assess fun, which contains 18 items and two columns. One column includes positive responses (Likert scale from 1 to 7) and the other includes negative responses (Likert scale from –1 to –7).

Finally, an instrument adapted from [26] was used to assess the future intention to play. This instrument contains three items and has a Likert response scale from '1' (totally disagree) to '7' (totally agree).

Graded exercise test

A maximal incremental test on a treadmill (Super ATL, Inbramed, Porto Alegre, Brazil) was performed on the second visit to identify metabolic thresholds with analysis of oxygen consumption ($\dot{V}O_2$) during the incremental test (VO2000, Inbramed, Porto Alegre, Brazil). A walking test was performed after a five-minute rest in the lying position and continuous HR monitoring, which consisted of a warm-up lasting five minutes and a self-selected speed between 3.2 and 6.0 km $\cdot$ $h^{-1}$ and a fixed inclination of 0%. Participants were instructed on the possibility of changing the intensity at any time. The incremental test started with the participant's self-selected speed during warm-up. From that moment on, increments of 1.3% in the slope every minute were implemented, while the speed remained unchanged. The test was completed when the participants reached their maximum voluntary fatigue. The perceptual variables were monitored immediately before and during the test in the final 15 s of each stage.

*Ventilatory threshold determination and intensity domain*

Ventilatory threshold 1 ($\dot{V}T_1$) was assumed as the linearity breakpoint between $\dot{V}CO_2$ vs. $\dot{V}O_2$, the first inflection of the $\dot{V}_E$ vs. time [27]. Ventilatory threshold 2 ($\dot{V}T_2$) was measured by the second inflection of $\dot{V}e$ *vs.* $\dot{V}O_2$ and/or non-linear increase of carbon dioxide equivalent ($\dot{V}e \cdot \dot{V}CO_2^{-1}$) vs. workload with exercise intensity [28]. Two experienced evaluators analysed the data, and the model was used as the ventilatory threshold value. In the case of disagreement, a third experienced evaluator performed the evaluation. For future analysis, the HR related to $\dot{V}T_1$ and $\dot{V}T_2$ was identified. The intensity domains were calculated based on ventilatory thresholds: zone 1 – HR below $HR_{res}$ related to $\dot{V}T1$, zone 2 – HR between $HR_{res}$ related to $\dot{V}T_1$ and $\dot{V}T_2$, and zone 3 – HR above $HR_{res}$ related to $\dot{V}T_2$.

*Exercise sessions*

The exercise sessions consisted of exercises suggested by the game itself, which varied the type of exercise and the number of repetitions according to the intensity (light, moderate and hard). The HR was continuously monitored in all sessions through the Polar V800 and the game itself. Subjective perceptions were also evaluated through the sensations (FS), activation (EA), and CR10 (RPE) scales, asked immediately before, during, and immediately afterwards, at two-minute intervals.

For anchoring purposes, we used the following sentence: 'How is your…' followed by the variable to be measured (subjective perception of effort, activation or deactivation and pleasure or displeasure), to question the volunteers about their perceptions. The participants submitted the fun questionnaires (PACES) and future intentions to play at the end of each training session.

Statistical analysis

All initial assumptions were considered before carrying out the analyses, and the appropriate corrections were made when necessary. Normality was analysed using the Shapiro–Wilk test, and data were descriptively represented using means and standard deviations.

In addition, two-way repeated-measures ANOVAs were performed between the three game exercise intensities (light, moderate and intense) and four moments of the session (25, 50, 75 and 100%) to compare the effects of intensities on the perceptual responses (affect, activation, and RPE) and HR of the participants. One-way repeated measures ANOVAs were also performed between the three game exercise intensities tested (light, moderate, and hard) to verify the effect on fun and future intention to play.

Data tabulation was performed in Excel software spreadsheets (v. 365, Microsoft, Washington, United States). Data analysis and production of figures were conducted using the Statistica v.12 and GraphPad Prism software programs, respectively (v. 6, GraphPad Software, San Diego, USA).

**Ethical approval**

The research related to human use has complied with all the relevant national regulations and institutional policies, has followed the tenets of the Declaration of Helsinki, and, as integrated into an institutional project, has been approved by the Ethics Committee of the Federal University of Pernambuco (approval No.: 2.075.063).

**Informed consent**

Informed consent has been obtained from all individuals included in this study.

**Results**

Table 2 presents the descriptive characteristics of the 28 participants, with a mean age of 22 ± 1.4 years; of these, 19 men and 9 women with mean ages of 22 ± 1.1 and 22 ± 1. 9 years, respectively.

Table 2 also shows the $\dot{V}O_2$ values for ventilatory thresholds 1 and 2 and the respective %$HR_{res}$ at which the thresholds occurred. During exercise, the mean $HR_{rest}$ was below the $HR_{res}$ $\dot{V}T1$ (moderate) in the low-intensity exercise and at the lower limit of the heavy domain for the moderate and high intensities of the Active Game. The average $HR_{res}$ (main exercise) of the moderate and hard intensity of the Active Game did not differ, and both remained in the heavy domain (between $HR_{res}$ $\dot{V}T1$ and $HR_{res}$ $\dot{V}T2$).

Figure 2A shows the percentage of HR reserve in the three investigated intensities of EA Sport Active 2 according to the ACSM. A significant effect was found in the analysis of the main effects for intensity ($F_{(2, 81)} = 3.43$; $p = 0.037$), with high intensity presenting a higher mean $HR_{res}$ than light intensity. A significant

Table 2. Descriptive characteristics of volunteers

| Variables | All (*n* = 28) | | Men (*n* = 19) | | Women (*n* = 9) | |
|---|---|---|---|---|---|---|
| | Mean | *SD* | Mean | *SD* | Mean | *SD* |
| Age (year) | 22 | 1.4 | 22 | 1.1 | 22 | 1.9 |
| Height (cm) | 1.70 | 0.1 | 1.75* | 0.1 | 1.6* | 0.1 |
| Body mass (kg) | 69.0 | 13.2 | 75.1* | 9.2 | 55.9* | 10.7 |
| BMI ($kg \cdot m^{-2}$) | 23.7 | 3.5 | 24.6* | 2.9 | 21.8* | 4.1 |
| Fat percentage (%G) | 18.4 | 8.6 | 15.6* | 6.3 | 23.6* | 5.9 |
| Intensity Preference† | 3.1 | 0.3 | 3.2 | 1.1 | 3.3 | 1.5 |
| Peak of exercise | | | | | | |
| $HR_{Peak}$ (bpm) | 186 | 8.6 | 187 | 9.1 | 183 | 7.8 |
| $\dot{V}O_{2Peak}$ ($ml \cdot kg^{-1} \cdot min^{-1}$) | 39 | 6.5 | 38.9 | 6.7 | 39.1 | 6.7 |
| Ventilatory threshold** | | | | | | |
| $\dot{V}O_2\,LV_1$ ($ml \cdot kg^{-1} \cdot min^{-1}$) | 22.5 | 5.3 | 23.9 | 5.6 | 19.2 | 2.7 |
| Intensity LV1 (%) | 58.1 | 9.9 | 58.1 | 10.2 | 58.1 | 10.2 |
| %$HR_{res}$ $\dot{V}T1$ | 54.1 | 14.4 | 55.3 | 11.0 | 53.7 | 15.9 |
| $\dot{V}O_2\,LV_2$ ($ml \cdot kg^{-1} \cdot min^{-1}$) | 31.3 | 5.4 | 33.0 | 5.3 | 27.3 | 3.6 |
| Intensity LV2 (%) | 81.2 | 6.7 | 80.8 | 6.9 | 82.0 | 6.6 |
| %$HR_{res}\dot{V}T2$ | 80.6 | 14.0 | 83.7 | 10.1 | 79.4 | 15.4 |
| Exercise description (% $HR_{res}$) | | | | | | |
| Light | | | | | | |
| Warm up | 28.1 | 12.8 | 27.4 | 11.1 | 29.5 | 13.9 |
| Main exercise | 47.1 | 13.5 | 45.7 | 13.2 | 49.8 | 14.6 |
| Cool down | 32.2 | 13.7 | 32.2 | 9.6 | 32.2 | 16.7 |
| Moderate | | | | | | |
| Warm up | 34.1 | 12.1 | 32.3 | 9.6 | 37.4 | 15.9 |
| Main exercise | 56.0 | 14.5 | 54.1 | 12.7 | 59.6 | 17.7 |
| Cool down | 34.1 | 12.1 | 35.0 | 12.6 | 32.4 | 12.5 |
| Hard | | | | | | |
| Warm up | 33.9 | 12.1 | 30.6 | 11.0 | 40.1 | 12.2 |
| Main exercise | 57.8 | 17.0 | 54.1 | 17.7 | 64.7 | 15.9 |
| Cool down | 41.2 | 14.5 | 38.1 | 13.9 | 46.9 | 14.5 |
| Average session (min) | | | | | | |
| Light | 31.9†† | 4.2 | 32.4 | 4.4 | 30.7 | 4.0 |
| Moderate | 33.4# | 3.1 | 33.2 | 3.6 | 34.0 | 1.7 |
| Hard | 36.1††# | 3.8 | 35.9 | 3.6 | 36.4 | 4.2 |

* significant difference between men and women ($p < 0.05$), †† significant difference between time session (Light vs Hard) ($p < 0.05$), # significant difference between time session (Moderate vs Hard) ($p < 0.05$),
† Exercise Intensity Preference and Tolerance Questionnaire

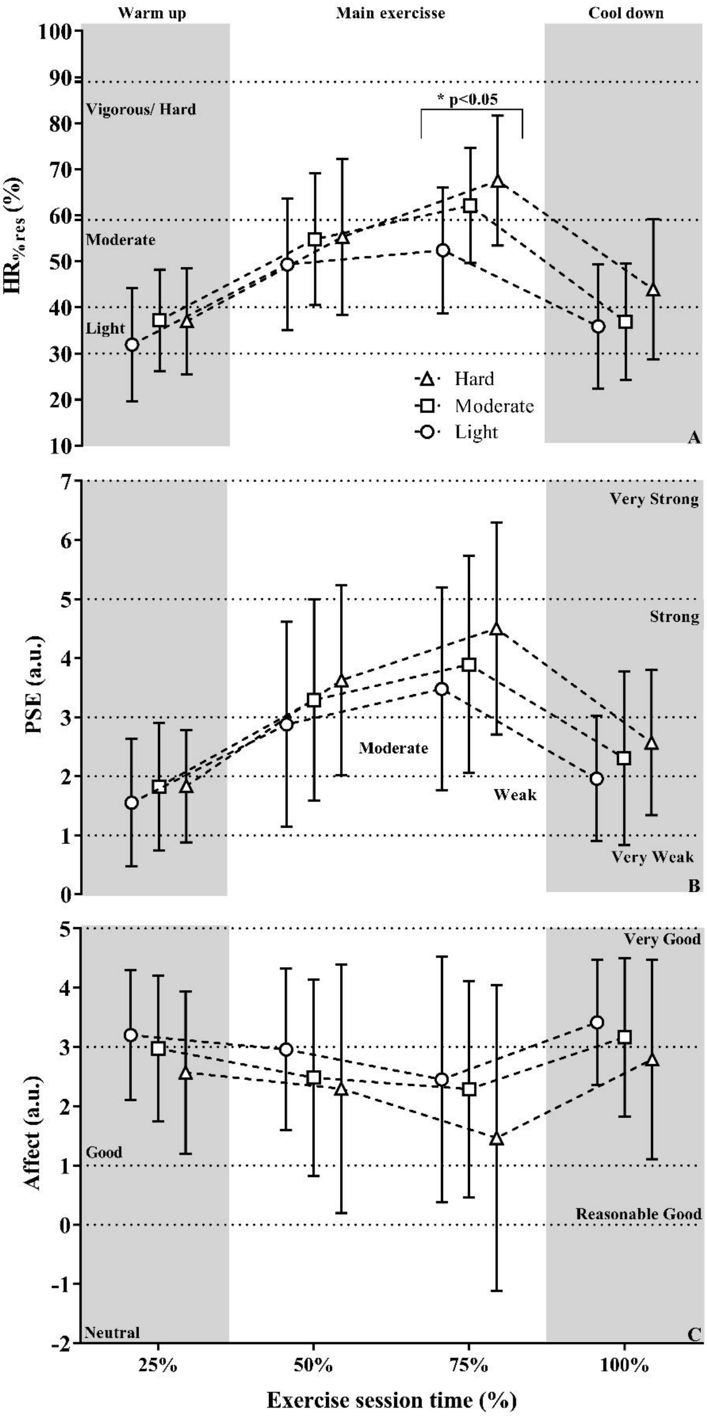



Figure 2. Heart Rate Response (A), RPE (B) and Affect (C) in the EA® Sport Active® 2 sessions as a function of the selected intensity

moment effect was found ($F_{(3, 243)}$ = 284.41; $p$ = 0.001), with a difference in $HR_{res}$ within all exercise session percentages (e.g., 25%, 50%, 75%, and 100%). A significant interaction intensity vs. moment was found ($F_{(6, 243)}$ = 5.10; $p$ = 0.001), with a difference being observed between light with moderate and high for 75% of the exercise time, and between light and high for 100% of the exercise time.

Figure 2B shows the average perceived exertion grouped by the investigated intensity. A significant effect was found for the moment ($F_{(3, 243)}$ = 136.17, $p$ = 0.001), with a difference between all moments independent of exercise intensity. No effect was identified for the intensities ($F_{(2, 81)}$ = 1.8114, $p$ = 0.170) or intensity vs. moment interaction ($F_{(6, 243)}$ = 0.601, $p$ = 0.733). The mean affect grouped by the intensity of the EA Sport Active 2 game is shown in Figure 2C. A main effect for moment was found ($F_{(3, 243)}$ = 18,896, $p$ = 0.001), with a lower affect for 50% and 75% of the exercise time (main exercise) over warm-up (25% of exercise time) and cool down (100% of exercise time), and lower affect for 75% compared to 50% of exercise time. No effect was identified for intensities ($F_{(2, 81)}$ = 1.7962, $p$ = 0.173) or intensity vs. moment interaction ($F_{(6, 243)}$ = 0.601, $p$ = 0.733).

Figure 3 shows the positions of the three intensities investigated in the circumplex model, which integrates affect and activation responses. The three conditions were located in the upper right quadrant, indicating that the intensities were perceived as highly activated and pleasurable.

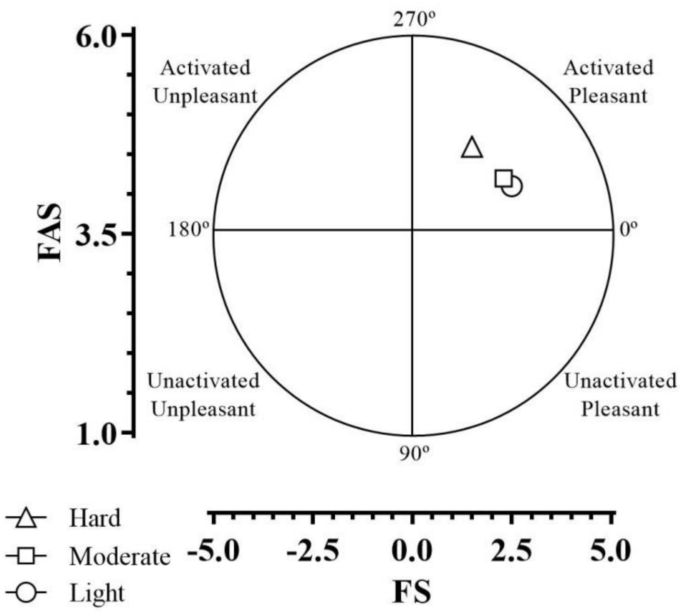



Figure 3. Representation by the circumplex model of affective and activation responses in the three investigated intensities

Table 3 shows the mean data of future intention to play and fun for the three investigated intensities of the EA Sport Active 2 game. No significant differences were found for future intention to play ($F_{(2, 81)}$ = 0.60; $p$ = 0.50), nor for entertainment ($F_{(2, 81)}$ = 0.63; $p$ = 0.530) between the game intensities.

Table 3. Enjoyment and future intention to play by intensity level

| Game intensity | Enjoyment | | Play by intention to play | | | |
|---|---|---|---|---|---|---|
| | Mean | *SD* | Mean | *SD* | Median | Mode |
| Light | 3.59 | 0.23 | 5.37 | 1.76 | 6.0 | 7.0 |
| Moderate | 3.67 | 0.33 | 5.70 | 1.62 | 6.0 | 7.0 |
| High | 3.62 | 0.27 | 5.63 | 1.37 | 6.0 | 6.3 |

## Discussion

The present study aimed to verify the ability to differentiate the intensities of the EA Sport Active 2 game according to the intensity domains based on ventilatory thresholds and to compare HRe and perceptual responses (affect, activation, and RPE), the future intention of playing, and the fun in the different intensities proposed by the EA Sport Active 2 game. Our hypothesis was partially confirmed because: (i) the EA Sport Active 2 game only differentiates light vs. high intensity (group effect of $HR_{res}$), without differentiating moderate and high intensity; (ii) no difference was found in RPE, affect, future intention to play or fun. Therefore, practitioners can use the high-intensity game mode to improve exercise intensity without changing the psychometric variables.

The light intensity of the game corresponded to the moderate domain according to the threshold zones. The intensity in moderate and high game intensity remained in the heavy domain according to the thresholds, suggesting the exercise intensity levelled off at moderate intensity. The hypothesis that the game would differentiate exercise intensity is partially supported by the $\%HR_{res}$ response. Although we found an effect of the interaction, we only found significant differences between light intensity with moderate and high intensity in the final part of the main session (75%). No difference was found between moderate and high game intensity. One possible explanation for this is that the game is limited in increasing the exercise intensity; however, the game suggests that the participant use equipment to overload the imposed exercise. As the present study subjects were young, the absence of an implement may have limited the increase in HR at a moderate and high intensity of play. Older and more sedentary subjects might present different HR responses in the exercises. This fact should be investigated in future studies. Finally, considering that the HR corresponding to the intensity domains was determined in the incremental test and the game is performed with different whole-body exercises (Figure 1), the HR corresponding to the intensity domains may not represent the intensity domain related to the exercise with the entire body. Thus, other studies should evaluate other markers (lactate and $VO_2$) during the game.

The subjective effort perception response and affective responses are modulated as a function of intensity [29, 30]. No response showed a significant difference at any time between the intensities proposed by the game (light, moderate and intense) in our study, despite an increase in HR between light vs. moderate and high intensity. We raised two hypotheses that could explain this result. The first hypothesis is related to a small difference in the proposed exercise dose between the intensities, a fact observed in the maintenance of the intensity domain by increasing the intensity of the game from moderate to high. The game differentiates intensity by one longer running time for some exercises. As presented, the game instructs the participant to use implements if the exercise is too easy or to slow down if the exercise is too hard. Therefore, adding an implement to improve intensity could present an increase in RPE and modify the affect between intensities. Our second hypothesis is related to the 'competition' that involves the video game. The theory of gamification may support the second hypothesis. The fact that you are playing a video game and competing with an avatar can impact the enjoyment regardless of the intensity. According to the theory of gamification, there is a reward system which makes playing video games more attractive when the difficulty gradually increases, making it possible to adapt to the game. Klimt et al. [31] found that players liked the game better when they were given a specific condition, with many successful events and a few failures; consequently, when the number of successes decreased and the failures increased, there was a decrease in satisfaction with their performance and the pleasure of playing.

The affect results of the sessions were classified as good on average. According to the Dual-Mode Theory (confirmed by the 'good' affect and HR values within the heavy domain – below LV2), the volunteers have a strong chance of having experienced good moments of pleasure, and therefore they might want to return to this activity. Limperos and Schmierbach [12] found that pleasure was one of the most vital indicators of future intention to use AVG. Furthermore, the player's performance and feelings of autonomy also contributed to enjoyment of the game. Taken together, practitioners could opt to use high intensity in the game to induce higher HR response without significant changes in the affect/pleasure, which could induce improvements in physical fitness with pleasure, which might increase adherence [17].

The results for enjoyment and future intention to play showed no influence from the exercise intensity in the proposed session for the game EA Active Sport 2. It is possible that as the game intensity did not show a significant difference between the proposed game sessions, this may have impacted the enjoyment and future intention to play. In addition, Rhodes and Kates [32] argue that PACES has low sensitivity to measure enjoyment.

This study has some limitations, including: (i) faults in capturing the movements on many exercises; (ii) the use of a threshold intensity domain being evaluated on a treadmill which is not the movement pattern used in the game; (iii) the sample characteristic (physically active young adults) might mitigate changes in HR at different game exercise intensities; and (iv) other participant characteristics such as being obese, overweight, and/or sedentary may present different HR responses. Future studies should try to apply the same study in games which allow changing intensities and even make a comparison between virtual or real activities and chronic and longitudinal studies.

## Conclusions

The results show that the exercises proposed by EA Active Sport 2 were not different between the intensities (light, moderate and high), except for the $HR_{res}$ between the light intensity compared to the moderate and high intensity game (75% of the session time). Likewise, affection, RPE, intention to play, play and pleasure did not differ between intensities. $HR_{res}$ remained in the heavy domain based on threshold zones during game sessions, despite the game exercise intensity being defined as moderate and high.

Finally, we suggest that new studies evaluate the possibility of using assistive devices to improve exercise intensity with the aim of improving adherence, and consequently promoting physical fitness and keeping fun and affection high during play sessions. In addition, it is important to emphasise that companies like EA must improve the process of testing games before making them available on the market.

## Disclosure statement

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## Conflict of interest

The authors state no conflict of interest.

## References

1. Stockdale L, Coyne SM. Video game addiction in emerging adulthood: cross-sectional evidence of pathology in video game addicts as compared to matched healthy controls. J Affect Disord. 2018;225:265–272; doi: 10.1016/j.jad.2017.08.045.
2. Brockmyer JF. Playing violent video games and desensitization to violence. Child Adolesc Psychiatr Clin N Am. 2015;24:(1):65–77; doi: 10.1016/j.chc.2014.08.001.
3. Lyons EJ, Tate DF, Komoski SE, Carr PM, Ward DS. Novel approaches to obesity prevention: effects of game enjoyment and game type on energy expenditure in active video games. J Diabetes Sci Technol. 2012;6(4): 839–848; doi: 10.1177/193229681200600415.
4. Street TD, Lacey SJ, Langdon RR. Gaming your way to health: a systematic review of exergaming programs to increase health and exercise behaviors in adults. Games Health J. 2017;6(3):136–146; doi: 10.1089/g4h.2016.0102.
5. Avancini M. Using Kinect to emulate an Interactive Whiteboard [Master Science]. University of Trento; 2011.
6. Mackintosh KA, Standage M, Staiano AE, Lester L, McNarry MA. Investigating the Physiological and Psychosocial Responses of Single- and Dual-Player Exergaming in Young Adults. Games Health J. 2016;5(6): 375–381; doi: 10.1089/g4h.2016.0015.
7. Verhoeven K, Abeele VV, Gers B, Seghers J. Energy expenditure during Xbox Kinect play in early adolescents: the relationship with player mode and game enjoyment. Games Health J. 2015;4(6):444–451; doi: 10.1089/g4h.2014.0106.
8. Soltani P, Figueiredo P, Vilas-Boas JP. Does exergaming drive future physical activity and sport intentions? J Health Psychol. 2020;26(12):2173–2185; doi: 10.1177/1359105320909866.
9. Perron RM, Graham CA, Hall EE. Comparison of physiological and psychological responses to exergaming and treadmill walking in healthy adults. Games Health J. 2012;1(6):411–415; doi: 10.1089/g4h.2012.0050.
10. Garn AC, Baker BL, Beasley EK, Solmon MA. What are the benefits of a commercial exergaming platform for college students? Examining physical activity, enjoyment, and future intentions. J Phys Act Health. 2012;9(2): 311–318; doi: 10.1123/jpah.9.2.311.
11. Huang HC, Wong MK, Yang YH, Chiu HY, Teng CI. Impact of playing exergames on mood states: a randomized controlled trial. Cyberpsychol Behav Soc Netw. 2017; 20(4):246–250; doi: 10.1089/cyber.2016.0322.
12. Limperos AM, Schmierbach M. Understanding the relationship between exergame play experiences, enjoyment, and intentions for continued play. J Games Health J. 2016;5(2):100–107; doi: 10.1089/g4h.2015.0042.
13. Lin Z, Zhang J, Chen Y, Zhang Q. Heart rate estimation using wrist-acquired photoplethysmography under different types of daily life motion artifact. In: 2015 IEEE International Conference on Communications (ICC). 2015:489–494; doi: 10.1109/ICC.2015.7248369.

14. Shafer DM, Carbonara CP. Examining Enjoyment of casual videogames. Games Health J. 2015;4(6):452–9; doi: 10.1089/g4h.2015.0012.
15. Viana RB, Alves CL, Vieira CA, Vancini RL, Campos MH, Gentil P. Anxiolytic effects of a single session of the exergame Zumba® fitness on healthy young women. Games Health J. 2017;6(6):365–70; doi: 10.1089/g4h.2017.0085.
16. Bronner S, Pinsker R, Naik R, Noah JA. Physiological and psychophysiological responses to an exer-game training protocol. J Sci Med Sport. 2016;19(3):267–271; doi: 10.1016/j.jsams.2015.03.003.
17. Gomez D, Browne JD, Neufeld EV, Pandit B, Dolezal BA. Muscle activity and user-perceived exertion during immersive virtual reality exergaming incorporating adaptive cable resistance system. Med Sci Sports Exerc. 2022;54(9S):217; doi: 10.1249/01.mss.0000877732.42096.e6.
18. Jackson AS, Pollock ML. Generalized equations for predicting body density of men. Br J Nutr. 1978;40(3):497–504; doi: 10.1079/bjn19780152.
19. Jackson AS, Pollock ML, Ward A. Generalized equations for predicting body density of women. Med Sci Sports Exerc. 1980;12(3):175–181.
20. Siri WE. The gross composition of the body. Adv Biol Medi Phys. 1956;4:239–280; doi: 10.1016/b978-1-4832-3110-5.50011-x.
21. Ekkekakis P, Hall EE, Petruzzello SJ. Some like it vigorous: measuring individual differences in the preference for and tolerance of exercise intensity. J Sport Exerc Psychol. 2005;27(3):350–374; doi: 10.1123/jsep.27.3.350 10.1123/jsep.27.3.350.
22. Hardy CJ, Rejeski WJ. Not what, but how one feels: the measurement of affect during exercise. J Sport Exerc Psychol. 1989;11(3):304–317; doi: 10.1123/jsep.11.3.304.
23. Svebak S, Murgatroyd S. Metamotivational dominance: a multimethod validation of reversal theory constructs. J Pers Soc Psychol. 1985;48(1):107–116; doi: 10.1037/0022-3514.48.1.107.
24. Borg GA. Psychophysical bases of perceived exertion. Med Sci Sports Exerc. 1982;14(5):377–381.
25. Monteiro D, Nunes G, Marinho DA, Couto N, Antunes R, Moutao J et al. Translation and adaptation of the physical activity enjoyment scale (PACES) in a sample of Portuguese athletes, invariance across genders nature sports and swimming. Rev Bras Cineantropom Desempenho Hum. 2017;19(6):631–643; doi: 10.5007/1980-0037.2017v19n6p631.
26. Venkatesh V, Davis FD. A Theoretical extension of the technology acceptance model: four longitudinal field studies. Manag Sci. 2000;46(2):186–204; doi: 10.1287/mnsc.46.2.186.11926.
27. Brubaker PH, Berry MJ, Brozena SC, Morley DL, Walter JD, Paolone AM et al. Relationship of lactate and ventilatory thresholds in cardiac transplant patients. Med Sci Sports Exerc. 1993;25(2):191–196.
28. Ekkekakis P, Parfitt G, Petruzzello SJ. The pleasure and displeasure people feel when they exercise at different intensities: decennial update and progress towards a tripartite rationale for exercise intensity prescription. Sports Med. 2011;41(8):641–671; doi: 10.2165/11590680-000000000-00000.
29. Camacho JM, Oliveira BRR, Neto GAM, Deslandes AC, Santos TM. Effect of two types of aerobic exercise prescription on variables related to adherence [in Portuguese]. Rev Bras Cien Mov. 2014;22(1):22–29; doi: 10.18511/0103-1716/rbcm.v22n1p22-29.
30. Rhodes RE, Kates A. Can the affective response to exercise predict future motives and physical activity behavior? a systematic review of published evidence. Ann Behav Med. 2015;49(5):715–731; doi: 10.1007/s12160-015-9704-5.