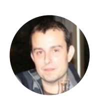
Competitive active video games: Physiological and psychological responses in children and adolescents

Article *in* Paediatrics & Child Health · October 2015


Ausiàs Cebolla
University of Valencia


Jaime Guixeres
Universitat Politècnica de València


Mariano Alcañiz
Universitat Politècnica de València


Rosa M Baños
University of Valencia

Competitive active video games: Physiological and psychological responses in children and adolescents

Juan F Lisón MD PhD[1], Ausias Cebolla PhD[2,3], Jaime Guixeres PhD[3,4],
Julio Álvarez-Pitti MD PhD[3,5], Patricia Escobar MSc[6], Alejandro Bruñó MSc[1],
Empar Lurbe MD PhD FAHA[3,5], Mariano Alcañiz PhD[3,4], Rosa Baños PhD [3,6]

JF Lisón, A Cebolla, J Guixeres, et al. Competitive active video games: Physiological and psychological responses in children and adolescents. Paediatr Child Health 2015;20(X):1-4.

BACKGROUND: Recent strategies to reduce sedentary behaviour in children include replacing sedentary screen time for active video games. Active video game studies have focused principally on the metabolic consumption of a single player, with physiological and psychological responses of opponent-based multiplayer games to be further evaluated.
OBJECTIVE: To determine whether adding a competitive component to playing active video games impacts physiological and psychological responses in players.
METHODS: Sixty-two healthy Caucasian children and adolescents, nine to 14 years years of age, completed three conditions (8 min each) in random order: treadmill walking, and single and opponent-based Kinect (Microsoft Corporation, USA) active video games. Affect, arousal, rate of perceived exertion, heart rate and percentage of heart rate reserve were measured for each participant and condition.
RESULTS: Kinect conditions revealed significantly higher heart rate, percentage of heart rate reserve, rate of perceived exertion and arousal when compared with treadmill walking (P<0.001). Opponent-based condition revealed lower values for the rate of perceived exertion (P=0.02) and higher affect (P=0.022) when compared with single play.
CONCLUSION: Competitive active video games improved children's psychological responses (affect and rate of perceived exertion) compared with single play, providing a solution that may contribute toward improved adherence to physical activity.

Key Words: *Children; Physical activity; Sedentarism; Sport psychology; Video games*

Physical inactivity has been increasingly recognized as a major problem in global health (1). Children have become less physically active in recent decades, expending approximately 600 calories less per day than their counterparts 50 years ago (2). In the past, children spent much of their spare time practicing active outdoor games; however, the advent of technology has meant that children are now devoting a significantly larger part of their free time to sedentary activities, such as watching television, using computers and playing video games (3). Recent research has examined different strategies to reduce sedentary hours in children. One such approach includes replacing sedentary screen time for active video games (AVGs) or exergames, which are electronic games that allow players to physically interact by using body movements with images on a screen, in a variety of activities such as sports, dancing or fitness games. Preliminary evidence has revealed that energy expended by children playing AVGs over short periods of time is comparable with the energy expended in other light- to moderate-intensity physical activities (4). However, recent randomized clinical trials have revealed that AVGs are unlikely to significantly increase habitual physical activity (PA) levels in children and youth (5,6), questioning its usefulness as an intervention tool in the fight against childhood inactivity and obesity (7,8). To date, AVG studies have focused principally on physiological responses (PA intensity, energy expenditure), both in single- and multiplayer modes (9-13), while the psychological responses have received little attention, particularly with multiplayer modes. There is evidence that the sustained use of AVGs is difficult, but is more likely to be achieved when children play in the company of others (14) and, the competition may promote group cohesion during a game play experience, increasing the adherence to exercise interventions (15). On the other hand, studies examining acute affective responses to exercise have led to a mounting literature proposing that affective responses are the first link in the hypothesized exercise intensity-affect-adherence chain

[1]Faculty of Health Sciences, University CEU-Cardenal Herrera, Valencia; [2]Department of basic and clinical psychology and psychobiology, Universitat Jaume I, Castelló; [3]CIBER Fisiopatología de la Obesidad y Nutrición, Instituto de Salud Carlos III; [4]I3BH Innovation & Research Institute on Bioengineering for Humans-Universidad Politécnica de Valencia; [5]Obesity and Cardiovascular Risk Unit, Pediatric Department, Consorcio Hospital General Universitario, University of Valencia; [6]Department of Personality, Evaluation and Psychological Treatment, University of Valencia, Spain
Correspondence: Dr JF Lisón, Facultad Ciencias de la Salud, Universidad CEU-Cardenal Herrera, Edificio Seminario, s/n. 46113 Moncada, Valencia (España). Telephone 0034 96 13690 00 ext 1370, fax 0034 96 139 52 72, e-mail juanfran@uch.ceu.es
Accepted for publication August 14, 2015

(16,17). However, to our knowledge, no previous AVG studies have investigated psychological responses (affect, arousal and rate of perceived exertion [RPE]) when playing AVG against another opponent. Therefore, the aim of the present study was to determine whether adding a competitive component when playing AVGs would impact psychological responses.

METHODS

Participants

Sixty-two healthy children and adolescents (28 boys, 34 girls) nine to 14 years of age (mean 11.8±1.3 years), were recruited from a summer school at the Polytechnic University (Valencia, Spain). Exclusion criteria for participants included experiencing medical problems or physical impediments interfering with their ability to participate in PA and, having previously played Kinect Adventures (Microsoft Corporation, USA) AVG. The research protocol was approved by the Ethics Committee of the University of Valencia (Valencia, Spain). Child assent and written parental informed consent were obtained before participation.

Anthropometric measurements

Each participant's height and weight were measured using a calibrated electronic stadiometer (Scale-Tronix, USA) and a digital body fat analyzer (SC 330 MA, Tanita, Wales), to the nearest 0.5 cm and 0.1 kg, respectively. Standardized body mass index (BMI-*z*) was calculated according to Cole et al's lambda-mu-sigma method (18).

Physiological measurements

Heart rate (HR) was measured using a new-generation wireless remote monitoring platform (NUUBO, Spain), which has been validated as a cardiological monitoring tool (19,20). This platfrom consists of two elements: a biomedical shirt that captures electrocardiographic (ECG) signals through adherence of textile electrodes to the skin; and an electronic device that transmits the ECG signal via Bluetooth (Bluetooth, USA) to a computer, which stores the information in memory cards. In the present study, a peak detection algorithm from ECG signal was used to detect continuous HR during the tests. Mean HR and percentage of HR reserve (%HRR) were calculated for each participant and each test. HRR is defined as the difference between resting HR and maximum HR. Seated resting HR was calculated as the mean HR during the 5 min resting period. For calculating maximum HR, the age prediction equation of Tanaka et al (21) was used. %HRR has been validated as a good marker of relative levels of PA in adults and children (22).

Psychological measurements

Emotional state was assessed from the perspective of the circumplex model (23). According to this model, the domain of affect can be defined by the orthogonal and bipolar dimensions of affective valence (pleasure and displeasure) and perceived activation (low to high). For the present research, three scales were used. The Feeling Scale (24): a single-item measure of affective valence. It is composed of 11 items, and the scale ranges from −5 to +5. Anchors are provided at 0 (neutral) and at all odd integers, ranging from very bad (−5) to very good (+5). The Felt Arousal Scale (25): a 6-point, single-item measure of perceived activation. The scale ranges from 1 to 6, with anchors at 1 (low arousal) and 6 (high arousal). Pictorials were added in both scales to make them more understandable for children. Eston-Parfitt RPE scale (26): this scale was specifically designed to evaluate RPE in children. It depicts an ambulatory figure at various stages of exertion on a concave slope, with a progressively increasing gradient at the higher intensities. The scale ranges from 0 (very, very easy) to 10 (so hard, I'm going to stop).

Experimental procedure

A repeated-measures design was used to compare physiological and psychological measurements among three different conditions: treadmill walking (TR), single-player (KS) and opponent-based (KO) Kinect Adventures Game (KAG). Children were randomly assigned to start one of the three conditions, and the subsequent condition order was counterbalanced. All of the tests were conducted during a single laboratory session, and were separated by 5 min so that the participants would not experience leftover fatigue from the previous test; HR was monitored to ensure return to resting HR between the tests. HR was recorded during the tests and psychological (arousal, affect and RPE) variables were measured immediately after each condition. In the TR condition, participants walked on a motor-driven treadmill (Mercury Max, BH Fitness, Spain) for 8 min at two speeds (first 4 min at 4.2 km/h and last 4 min at 5.7 km/h), which corresponds to light intensity (first velocity) and moderate intensity (second velocity). Both intensities were in agreement with the energy expenditure reported in children while playing AVG (4,8). In the two KAG conditions, participants played for 8 min each, at two increasing difficulty levels (2×4 min without rest). In the KO condition, the children competed against other participants. Before the KAG conditions, an explanation was given about how to use the video-console, and the participants were asked to practice for approximately 5 min to familiarize themselves with the game. All participants played with the same game settings, and were encouraged to play to the best of their ability, desire or both. The "Reflex Ridge" game, which is included in the Xbox Kinect Adventures pack (Microsoft Corporation, USA), was the game selected. This game is a "track-and-field" inspired activity and was chosen because of its easy playability and its ability to predominantly elicit lower body muscles in the same manner as TR. Although the TR condition cannot exactly be matched to the KAG conditions in terms of intensity or energy expenditure, it was essentially used to compare psychological KAG responses against a reference traditional exercise. After the familiarization stage and before data collection, participants remained seated for 5 min while watching relaxing videos and music to stabilize their HR, which was monitored to ensure return to resting HR. All tests were performed in a private room so that only the participants and researchers were present. The protocol lasted approximately 45 min per participant. During the rest periods, water was provided. All participants were informed at the beginning of the study that they could choose to stop at any time.

Statistical analysis

To achieve a statistically significant 1 point affect increase between the estimated mean and the sampling mean with a statistical power equal to 90% and an alpha risk of 0.05, a sample size of 61 participants per condition was necessary. ANCOVA tests were used to study HR, %HRR, RPE and psychological responses (affect and arousal) of children for the three different conditions (TR, KS, KO). Bonferroni's post-hoc test was used for statistical comparisons among conditions. Due to the dispersion in the BMI *z*-score in children, and its possible interaction with physiological and psychological responses to exercise, it was taken into account as a covariable. Similarly, sex was considered as a covariate. Data are presented as mean ± SD. Statistical analyses were performed using SPSS version 18.0 (IBM Corporation, USA) for Windows (Microsoft Corporation, USA); $P<0.05$ was considered to be statistically significant.

RESULTS

A total of 62 Caucasian children and adolescents were included in the study; 87.1% (n=54) of the children were of a normal weight and 12.9% (n=8) were overweight. The BMI *z*-score was 0.27±0.82. No statistically significant differences between weight groups (P>0.05) or between sexes (P>0.05) was observed for any of the studied variables; therefore, data were pooled.

Results of the ANCOVA revealed significant differences for HR, %HRR, RPE, affect and arousal among the conditions (TR, KS, KO) (Table 1). The results of the Bonferroni test revealed significantly higher HR values in the KAG conditions compared with TR (KO and KS; P<0.001), although there were no significant differences between KS and KO (P=0.183). Similar results were observed for %HRR. Therefore, both KAG conditions revealed significantly higher values when compared with the TR condition (KO and KS, P<0.001); however, there were no differences between KAG conditions (P=0.654). Regarding psychological responses, KAG conditions revealed significantly higher rates of RPE when compared with TR (KO and KS, P<0.001). Interestingly, KO revealed lower rates of RPE compared with KS (P=0.02). Furthermore, results revealed that children reported higher positive affect in KO when compared with KS (P=0.022), although there were no significant differences observed between KAG conditions and TR (KO P=0.869; KS P=0.154). Regarding arousal, children exhibited higher arousal during KAG conditions, compared with TR (KS and KO, P<0.001), although there were no differences among KAG conditions (P=0.9).

TABLE 1
ANCOVA test among conditions

	TR	KS	KO	F	μ^2
HR, bpm	123±16	137±20	139±18	56.645†	0.66
%HRR	31.1±11.6	44.3±15.3	47.8±13.6	55.815†	0.66
RPE	3.1±1.3	4.5±1.3	4±1.2	33.648†	0.38
Affect	2.9±1.6	2.5±1.7	3.1±1.5	4.182*	0.11
Arousal	2.8±0.8	3.4±0.9	3.4±0.9	11.959†	0.31

*Data presented as mean ± SD. HR Heart rate; KO Kinect opponent-based condition; KS Kinect single condition; RPE Rating of perceived exertion; TR Treadmill condition; %HRR Percentage of heart rate reserve. *P<0.05; †P<0.01*

DISCUSSION

The present study examined the physiological and psychological effects of KAGs in children and adolescents. Our results revealed significantly higher HR and %HRR values in both KAG conditions compared with TR. These data are consistent with previous exergaming literature (10), and the values were higher than those recently reported by Smallwood et al (12), who evaluated the physiological responses in other Kinect AVGs and reported lower HR values (Dance Central, 118 beats/min; and Kinect Sports Boxing, 131 beats/min). When comparing KAG conditions, our results coincide with those obtained by Peng and Crouse (13), who investigated the effects of different AVG playing modes on PA intensity, and reported no differences. Similarly, Bonetti et al (11) analyzed AVG playing against another player and reported no differences in energy expenditure compared with solo play. In the present study, both KAG conditions revealed higher rates of perceived exertion compared with TR. This result could, in part, be explained as a result of the higher HR values in the KAG conditions versus TR. However, the most notable finding was that the competitive play (KO) did, in fact, show significantly lower RPE when compared with single-play (KS). RPE represents a subjective estimate of strain, that reflects both physiological and psychological variables. According to Eston et al (26),

> "RPE involves the interplay of afferent feedback from cardio respiratory, metabolic and thermal stimuli and efferent feed-forward mechanisms to enable an individual to evaluate how hard or easy an exercise task feels".

Nonetheless, it is also related to psychological experience, such as affect, self-efficacy, pleasure activity or perceived ability (27). Therefore, it is reasonable to assume that the decrease of RPE in the KO condition could be related to an increase on the affect (2.5 [KS] versus 3.1 [KO]). Certainly, it is well known that AVG may be a starting point to engage sedentary children to a more active lifestyle by overcoming fatigue (28-30). Our results provide further evidence to support to this because they suggest that during competitive AVG play, children perceive the activity as being any more fatiguing than conventional single AVG play (11). Other usual barriers, apart from fatigue, reported by children regarding PA include lack of pleasure (31). Playing AVG with other children may increase the experience of pleasure and positive emotions (affect and arousal), which should facilitate adherence to physical activity. Accordingly, there is evidence that the sustained use of AVG is difficult; however, it is more likely to be achieved when children play in the company of others (15). Similarly, Williams et al (17) reported that acute affective responses to a moderate-intensity exercise stimulus predicts PA participation six and 12 months later in adults. On the other hand, competitive experiences have been perceived to be healthy for children because they teach them to deal with a competitive society, (32) and a competitive PA atmosphere can produce better performance gains (33). Moreover, competition may promote group cohesion during a game play experience, increasing the adherence to exercise interventions (16).

It also needs to be noted that only relying on AVGs as a tool for PA among children and adolescents is not enough to ensure the recommended daily amount of exercise for this population. Nevertheless, we are proposing that PA, as a result of competitive AVG engagement, can contribute to, rather than replace, daily PA recommendations. There are components of free play and sports (benefits of fresh air, vitamin D, connection with nature) (7) that are beneficial beyond the increased energy expenditure associated with AVGs. In addition, potential disadvantages of AVGs (learning to manipulate the games, resulting in much less actual naturalistic and energetic movement; financial cost of the consoles, accessories and new games), should also be taken into account. On the other hand, with indoor time increasingly dedicated to inactive pastimes, expansion of home-based opportunities for PA is essential. AVGs are not constrained by typical reported barriers to participation such as time, unsafe neighborhoods or seasonal conditions (31).

The results of the present study are subject to limitations. First, the sample was one of convenience; therefore, the findings cannot be generalized to all children and adolescents. However, the results of the present study may be applicable to similar populations. Second, there were limitations due to the cross-sectional nature of the data. While these results may have implications for PA accumulation, long-term randomized controlled trials will be necessary to investigate the relationship between psychological responses and competition over time in AVGs, and to determine whether opponent-based AVGs can be implemented and maintained as effective PA and/or sedentary behaviour interventions. Additionally, KAG was only played for 8 min, with a 5 min training period. It was decided to shorten the time of the exercises (8 min × 3 conditions) to reduce fatigue in participants. Although these time periods are standard in the AVG literature to date, a longer play period may be more generalizable to typical play/competition, therefore, reflecting a more realistic scenario. It appears to be likely that as the duration of the competition increases, the effect of the competitive component may decrease. On the other hand, the fact that the TR intensity was fixed, while the AVG sessions were not, renders the comparisons with physiological responses meaningless. Therefore, further studies comparing longer AVG play against a matched non-AVG outdoor physical activity are warranted. Finally, another possible limitation to the present research was the method used to evaluate the physiological response. The gold standard by which cardiorespiratory fitness is measured requires indirect calorimetry under laboratory controlled settings with sophisticated equipment, including a special mask. Instead, we used a multiparameter wireless electronic shirt. The decision was founded on its ergonomic and noninvasive method, compared with the mask system. We were analyzing the psychological response during PA in children and, therefore, a noninvasive and easy-to-use system that would not interfere with the emotional experience was needed.

Despite these limitations, the present study had several strengths: it was the first to examine the effects of KAG (Reflex Ridge) in children and adolescents, and included a sample sufficiently large to explore physiological and psychological responses. The incorporation of %HRR provides a relative intensity measure that allows the comparision of children of different conditions (age, weight, fitness level). In addition, besides the measurement of HR, %HRR and RPE, affect and arousal were also measured, providing insight into differences in motivating characteristics across competitive AVGs.

CONCLUSION

The findings in the present study suggest that competitive AVGs appeared to improve children's perception of exertion and affect, compared with single play.

ACKNOWLEDGEMENTS: The authors acknowledge Anne Teresa Scharfenecke (Language Service, Universidad CEU-Cardenal Herrera, Valencia, Spain) and Eilish Slowey for their contributions in reviewing the English in the manuscript. CIBEROBN is an initiate of the Instituto de Salud Carlos III (ISCIII).

DISCLOSURES: The authors have no financial relationships or conflicts of interest to declare.

REFERENCES

1. World Health Organization. Global health risks: Mortality and burden of disease attributable to selected major risks. 2009. <www.who.int/healthinfo/global_burden_disease/GlobalHealthRisks_report_full.pdf> (Accessed May 10, 2015).
2. Boreham C, Riddoch C. The physical activity, fitness and health of children. J Sports Sci 2001;19:915-29.
3. Cummings HM, Vandewater EA. Relation of adolescent video game play to time spent in other activities. Arch Pediatr Adolesc Med 2007;161:684-9.
4. Daley AJ. Can exergaming contribute to improving physical activity levels and health outcomes in children? Pediatrics 2009;124:763-71.
5. Maddison R, Foley L, Ni Mhurchu C, et al. Effects of active video games on body composition: A randomized controlled trial. Am J Clin Nutr 2011;94:156-63.
6. Baranowski T, Abdelsamad D, Baranowski J, et al. Impact of an active video game on healthy children's physical activity. Pediatrics 2012;129:e636-e642.
7. Chaput JP, LeBlanc AG, Goldfield GS, Tremblay MS. Are active video games useful in increasing physical activity and addressing obesity in children? JAMA Pediatr 2013;167:677-8.
8. LeBlanc AG, Chaput JP, McFarlane A, et al. Active video games and health indicators in children and youth: A systematic review. PLoS One 2013;8:e65351.
9. Peng W, Crouse JC, Lin JH. Using active video games for physical activity promotion: A systematic review of the current state of research. Health Educ Behav 2013;40:171-92.
10. Biddiss E, Irwin J. Active video games to promote physical activity in children and youth: A systematic review. Arch Pediatr Adolesc Med 2010;164:664-72.
11. Bonetti AJ, Drury DG, Danoff JV, Miller TA. Comparison of acute exercise responses between conventional video gaming and isometric resistance exergaming. J Strength Cond Res 2010;24:1799-1803.
12. Smallwood SR, Morris MM, Fallows SJ, Buckley JP. Physiologic responses and energy expenditure of kinect active video game play in schoolchildren. Arch Pediatr Adolesc Med 2012;166:1005-9.
13. Peng W, Crouse J. Playing in parallel: The effects of multiplayer modes in active video game on motivation and physical exertion. Cyberpsychol Behav Soc Netw 2013;16:423-7.
14. Chin A, Paw MJ, Jacobs WM, Vaessen EP, Titze S, van Mechelen W. The motivation of children to play an active video game. J Sci Med Sport 2008;11:163-6.
15. Estabrooks PA. Sustaining exercise participation through group cohesion. Exerc Sport Sci Rev 2000;28:63-7.
16. Williams DM, Dunsiger S, Ciccolo JT, Lewis BA, Albrecht AE, Marcus BH. Acute affective response to a moderate-intensity exercise stimulus predicts physical activity participation 6 and 12 months later. Psychol Sport Exerc 2008;9:231-45.
17. Williams DM, Dunsiger S, Jennings EG, Marcus BH. Does affective valence during and immediately following a 10-min walk predict concurrent and future physical activity? Ann Behav Med 2012;44:43-51.
18. Cole TJ, Bellizzi MC, Flegal KM, Dietz WH. Establishing a standard definition for child overweight and obesity worldwide: International survey. BMJ 2000;320:1240-3.
19. Guixeres J, Zaragozá I, Alcañiz M, Gomistena J, Cebolla A. A new protocol test for physical activity research in obese children (Etiobe Project). Annu Rev CyberTherapy Telemed 2009;7:281-3.
20. Rodriguez A, Guixeres J, Rey B, Alcaniz M. Reliability and validity of TIPS wireless ECG prototypes. Stud Health Technol Inform 2012;181:83-7.
21. Tanaka H, Monahan KD, Seals DR. Age-predicted maximal heart rate revisited. J Am Coll Cardiol 2001;37:153-6.
22. Gavarry O, Bernard T, Giacomoni M, Seymat M, Euzet JP, Falgairette G. Continuous heart rate monitoring over 1 week in teenagers aged 11-16 years. Eur J Appl Physiol Occup Physiol 1998;77:125-32.
23. Ekkekakis P, Hall EE, Petruzzello SJ. The relationship between exercise intensity and affective responses demystified: To crack the 40-year-old nut, replace the 40-year-old nutcracker! Ann Behav Med 2008;35:136-49.
24. Hardy CJ, Rejeski WJ. Not what, but how one feels: The measurement of affect during exercise. J Sport Exerc Psychol 1989;11:304-17.
25. Svebak S, Murgatroyd S. Metamotivational dominance: A multimethod validation of reversal theory constructs. J Pers Soc Psychol 1985;48:107-16.
26. Eston RG, Lambrick DM, Rowlands AV. The perceptual response to exercise of progressively increasing intensity in children aged 7-8 years: Validation of a pictorial curvilinear ratings of perceived exertion scale. Psychophysiology 2009 Jul;46:843-51.
27. Robbins LB, Pis MB, Pender NJ, Kazanis AS. Exercise self-efficacy, enjoyment, and feeling states among adolescents. West J Nurs Res 2004;26:699-715; discussion 716-21.
28. Haddock BL, Siegel SR, Wikin LD. The addition of a video game to stationary cycling: The impact on energy expenditure in overweight children. Open Sports Sci J 2009;2:42-6.
29. Guixeres J, Saiz J, Alzañiz M, et al. Effects of virtual reality during exercise in children. J Univers Comput Sci 2013;19:1199-1218.
30. Devereaux J. Comparison of rates of perceived exertion between active video games and traditional exercise. Int Sport Med J 2012;13:133-40.
31. Zabinski MF, Saelens BE, Stein RI, Hayden-Wade HA, Wilfley DE. Overweight children's barriers to and support for physical activity. Obes Res 2003;11:238-46.
32. Sallis JF, Hovell MF, Hofstetter CR. Predictors of adoption and maintenance of vigorous physical activity in men and women. Prev Med 1992;21:237-51.
33. Tauer JM, Harackiewicz JM. The effects of cooperation and competition on intrinsic motivation and performance. J Pers Soc Psychol 2004;86:849-61.