

Can active video games be part of the solution to promote physical activity in youth? A systematic review

Carmo JLF, Palmeira AL

Universidade Lusófona de Humanidades e Tecnologias – Faculdade de Educação Física e Desporto

To develop more efficient programs for promoting physical activity it is important to consider this new generation of video games. **Objective:** The aim of this systematic review is to identify interventions with the use of Active Video Games (AVG) to promote physical activity. **Methods:** We conducted a search in the PubMed database, using the starting question “can the use of AVG contribute to the increase of PA?” using the keywords and alternative terms, to be placed in the search strategies, to reduce bias in results. We’ve included papers published between 1st January 2008 and 11th June 2012, in English language. Titles and abstracts of identified papers were examined against inclusion and exclusion criteria. **Results:** Eight studies met the inclusion and exclusion criteria and we included 2 more papers from a systematic review found in this search. Ten papers are presented in this systematic review, 8 of which are independent samples (n= 623). From these studies, 7 were home-based interventions, 2 were laboratory-based and 1 was developed with the combination of home-based and multiplayer class. **Conclusion:** This new generation of computer games appears to arouse great interest in children and young people, so it seems we should consider these AVG as an additional “tool” to promote PA and reduce sedentary behavior.

Arch Exerc Health Dis 4 (1): 216-226, 2014

Key Words: Physical Activity; Exergames; Active Video Games; Youth; Randomized Controlled Trials

INTRODUCTION

The health benefits of regular physical activity have been extensively studied and there is irrefutable evidence of its role in the prevention of chronic diseases (e.g. cardiovascular disease, diabetes, cancer, hypertension, obesity, depression and osteoporosis) and premature death (1). However, despite all the efforts to promote PA, this declines across age between childhood and adolescence and continues to decline with age (2). Physical inactivity is, therefore, a contributing factor to the obesity epidemic, and it is necessary to change patterns of inactivity (3), because it seems that childhood sedentary lifestyles often become a lifelong habit (4).

Socio-economic problems, neighborhood safety, and lack of playground places are some of the related barriers to children’s inactivity (5). Therefore, children are spending 5.5. to 8.5 hours in sedentary activities (6). Another sedentary activity, seated video game play, is highly attractive to children and considered by

families as safe and less expensive ways of spending leisure time (7, 8).

According to the Entertainment Software Association, 72% of American households play computer or video games (9), showing that this sedentary behavior is widespread. However, technological advances have led to the development of a new generation of video console games, frequently known as “exergames” or “active video games”, requiring physical exertion to be played.

A recent meta-analysis of energy expenditure while playing AVG has showed that exergaming can provide light to moderate physical activity among players (10). A recent systematic review has referred higher energy expenditure when games involved both upper and lower body (11). However more experiential studies have been developed with this new generation of video games.

The goal of this systematic review was to provide information about the randomized controlled trials recently made with the use of AVG in the promotion

Copyright

©2012 CIAFEL. This is an Open Access article distributed under the terms of the Creative Commons Attribution License (<http://creativecommons.org/licenses/by-nc-nd/3.0/deed.en>). You are free: to share, to copy, distribute and transmit the work, provided the original author and source are credited.

Corresponding author:

João Luis Fernandes do Carmo, Universidade Lusófona de Humanidades e Tecnologias – Faculdade de Educação Física e Desporto • e-mail: joaolfcarmo@gmail.com

Table 1. PICOS Model used according to the starting question: “Can active video games improve physical activity in children and adolescents?”

Population	Intervention	Control	Outcomes	Study
Children and Adolescents	Active Video Games	No intervention	Physical Activity	Randomized Controlled Trials

of PA in youth. We also intend to provide directions to future trials, with the use of AVG to improve PA.

METHODS

Data sources, search strategy and study selection

We conducted a research strategy in which one author searched in PubMed data base, on 11th June 2012, using terms according to the PICOS model (12), with support of the starting question: “can the use of AVG contribute to the increase of PA?” (Table 1). Alternative terms were defined to the keywords (Table 2), to be placed in the research strategies, to reduce bias in results. All terms were determined after examining literature.

The search was restricted to English-language communications in peer-reviewed journals, published between 1st January 2008, and 11th June 2012. We’ve chosen this data because it seems that AVG are widespread worldwide in the last years.

Based on title and abstract we selected only experimental studies reporting on: i) the use of AVG to promote PA; ii) energy expenditure during AVG play; iii) benefits and risks of AVG play.

We excluded all articles: i) that were focused on virtual rehabilitation, cognitive and behavioral therapies, or health education promoted via video games and computers; ii) that used traditional video games or television during exercise; iii) did not use commercially available AVG; iv) whose results did not involve children and adolescents; v) whose study did not present a randomized controlled trial design.

We excluded the systematic reviews found. However, they were examined to find relevant references. Study authors have been contacted to clarify doubts.

Data extraction and synthesis

One reviewer examined titles and abstracts, in a non-blind review to the journal and names of the authors. Relevant papers were obtained in full and accessed the inclusion and study criteria described. The reviewer was responsible for data extraction, as well as its interpretation. Data extraction included: i) methodological details (e.g. sample size, participant

age, outcome measures); ii) key findings (principal results).

Study quality assessment

The quality of all Randomized Controlled Trials (RCT) was further assessed using PEDro evaluation scale (13). This checklist is used to describe the internal and statistical validity of study designs, mostly with respect to allocation, blinding and dropout rates. The evaluation was particularized by study and placed in Table 5. The first item (specified eligibility criteria) was not considered for this 11 item scale because it did not influence the internal validity and statistical results of the study.

RESULTS

Our search identified 8 randomized trials meeting the inclusion and exclusion criteria. We also included 2 studies (14, 15), after reading a systematic review found in the search. These studies were included because they are experimental studies, meeting also the inclusion and exclusion criteria. Figure 1 provides a flowchart, which demonstrates the results of the papers selection process. Studies that were excluded and its reasons are summarized in Table 3. A meta-analysis of studies was not made because of the methodological differences identified. Studies methodological aspects and key findings are presented in Table 4.

Ten papers are presented in this systematic review, 8 of which are independent samples (n= 623). From these studies, 7 were home-based interventions, 2 were laboratory-based and 1 was developed with the combination of home-based and multiplayer class.

Summary of results and studies limitations

In a 12 week pilot study Ni Murchu and colleagues suggest that using an AVG can engage children in more PA, reducing video game overall play and results in a decrease in children’s waist circumference (14). However this study was made with a small sample, so the findings should be interpreted with caution. Chin and colleagues, in a 12 week RCT, aimed to study children’s motivation to play an interactive

Table 2. Search conducted in PubMed database at 11th June 2012

#	Search conducted (11th June 2012)	Results
Phase I		
1	child*	1784282
2	adolescen*	1500675
3	young*	657319
4	kid*	2736
5	teen*	19536
6	girl* OR boy*	201442
7	((((#1) OR #2) OR #3) OR #4) OR #5) OR #6)	2972179
Phase II		
8	active video games	142
9	exergam*	45
10	new generation computer game	12
11	exertainment	3
12	video gam*	2032
13	Interactive video game	142
14	(((((#8) OR #9) OR #10) OR #11) OR #12) OR #13	2081
Phase III		
15	physical activity	264534
16	fitness	46108
17	exercise	240767
18	motor activit*	73856
19	energy expenditure	350012
20	sedentar*	15282
21	(((((#15) OR #16) OR #17) OR #18) OR #19) OR #20	757648
Phase IV		
22	randomized controlled trial as topic/	109637
23	randomized controlled trial.tw	434639
24	randomized controlled trial	406847
25	controlled clinical trial as topic/	102313
26	controlled clinical trial.tw	439832
27	controlled clinical trial	173230
28	random* allocat*	99493
29	((random*) AND controlled) AND trial*	437564
30	(((((singl*) OR doubl*) OR treb*) OR tripl*) ADJ blind*) OR mask*	56369
31	(((((((((#22) OR #23) OR #24) OR #25) OR #26) OR #27) OR #28) OR #29) OR #30	673085
Phase V		
32	((((#6) AND #12) AND #19) AND #29	53
33	((#32) AND ("2007-01-01"[Date - Publication] : "2012-07-09"[Date - Publication])) AND english[Language]	44

dance video game and found that multiplayer group played more than a home based group (non significant) (15). This study found that multiplayers increased playing time during the 12 weeks.

Nevertheless, this study included a small sample and there was a 41% dropout rate.

Maloney and colleagues found that Dance Dance Revolution video game (DDR) significantly reduced the sedentary screen time in 7 – 8 years olds, despite

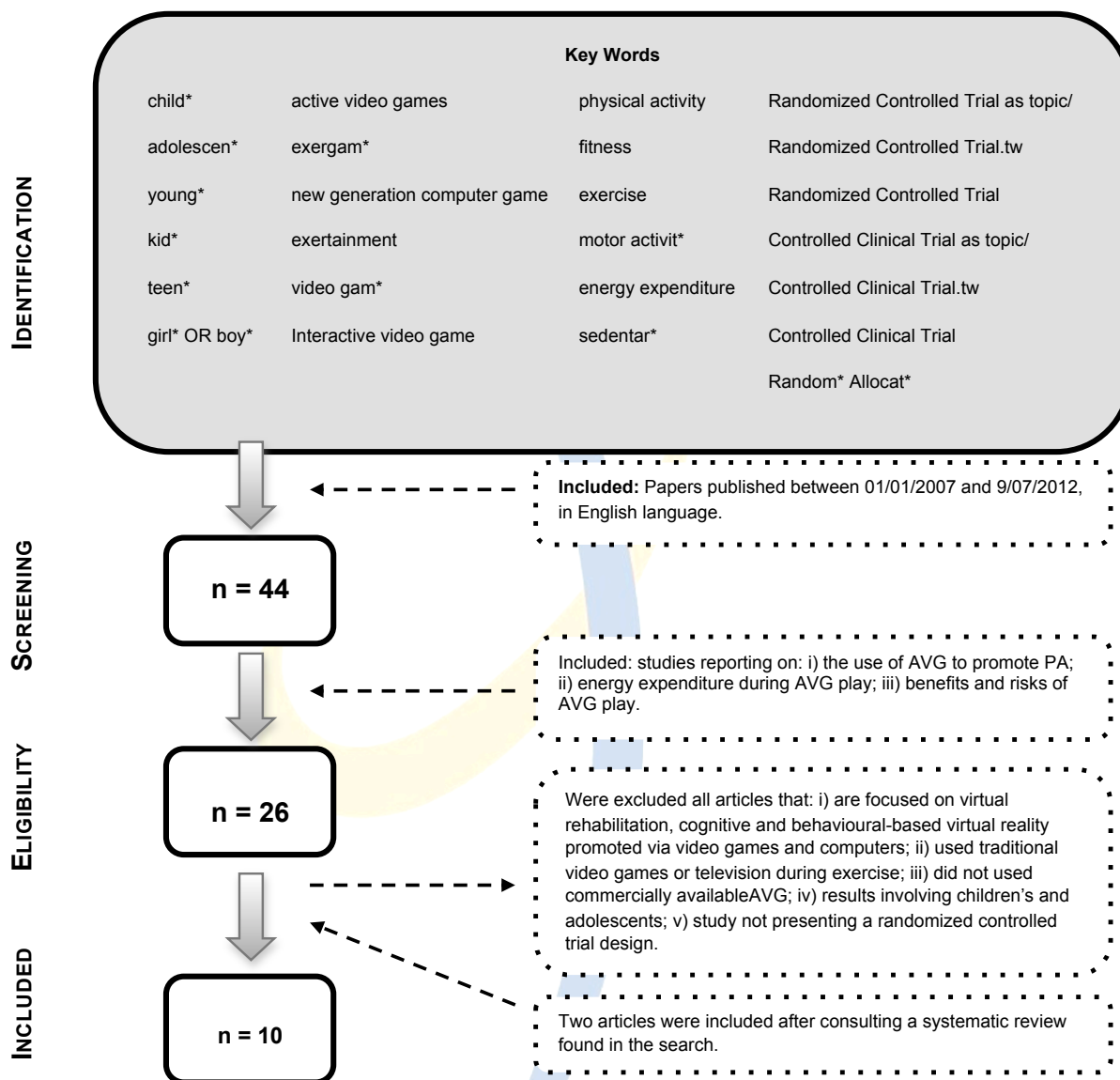


Figure 1. Flowchart of the conducted search (adapted from PRISMA Statement (12).

no changes were observed in MVPA between experimental and control groups (16). This RCT also found that most of the children and parents liked the most of the participants were from upper middle socioeconomic status.

Paez et al.'s findings suggest that parental and peer participation in DDR could play an important role in initial and continuous participation in this AVG(17). In the first week, the absence of other video games and parents participation was associated with children's use of DDR. Nonetheless, the consistency of the questionnaire used was not well known.

DDR and would recommend it to others. However this study had some technical problems with data collection tools. Other limitation of this study was that Adamo and colleagues examined the efficacy of an interactive cycling video game GameBike in comparison with stationary cycling to overweight or obese children over 10 weeks (18). This RCT found that both exercise conditions increased aerobic fitness and reduced body fat and total cholesterol in overweight and obese children. Yet, this study presented a small sample (n=26) and could not be generalized to other populations.

Table 3. Excluded papers for this systematic review according to the predefined criteria.

Article	Reason for exclusion
Energy intake and expenditure during sedentary screen time and motion-controlled video gaming. Lyons EJ, Tate DF, Ward DS, Wang X. <i>Am J Clin Nutr</i> . 2012 Jul 3	D
The effect of simulated ostracism on physical activity behavior in children. Barkley JE, Salvy SJ, Roemmich JN. <i>Pediatrics</i> . 2012 Mar;129(3):e659-66. Epub 2012 Feb 6.	A
Improving lower limb weight distribution asymmetry during the squat using Nintendo Wii Balance Boards and real time feedback McGough R., Paterson K., Bradshaw EJ, Bryant AL, Clark RA. <i>J Strength Cond Res</i> . 2012 Jan;26(1): 47-52.	D
Exergaming for health: a community-based pediatric weight management program using active video gaming. Christison A, Khan HA. <i>Clin Pediatr (Phila)</i> . 2012 Apr;51(4):382-8. Epub 2011 Dec 8.	F
Changes in physical activity and fitness after 3 months of home Wii Fit™ use. Owens SG, Garner JC 3rd, Loftin JM, van Blerk N, Ermin K. <i>J Strength Cond Res</i> . 2011 Nov;25(11):3191-7.	F
Virtual reality for stroke rehabilitation. Laver KE, George S, Thomas S, Deutsch JE, Crotty M. <i>Cochrane Database Syst Rev</i> . 2011 Sep 7;(9):CD008349. Review.	A
Rationale, design and methods for a randomised and controlled trial of the impact of virtual reality games on motor competence, physical activity, and mental health in children with developmental coordination disorder. Straker LM, Campbell AC, Jensen LM, Metcalf DR, Smith AJ, Abbott RA, Pollock CM, Piek JP. <i>BMC Public Health</i> . 2011 Aug 18;11:654	B
Effectiveness of interventions aimed at reducing screen time in children: a systematic review and meta-analysis of randomized controlled trials. Wahi G, Parkin PC, Beyene J, Uleryk EM, Birken CS. <i>Arch Pediatr Adolesc Med</i> . 2011 Nov;165(11):979-86. Epub 2011 Jul 4. Review. PMID: 21727260 [PubMed - indexed for MEDLINE]	A
Video game playing increases food intake in adolescents: a randomized crossover study. Chaput JP, Visby T, Nyby S, Klingenberg L, Gregersen NT, Tremblay A, Astrup A, Sjödin A. <i>Am J Clin Nutr</i> . 2011 Jun;93(6):1196-203. Epub 2011 Apr 13. PMID: 21490141 [PubMed - indexed for MEDLINE] Free Article	A
In-home tele-rehabilitation improves tetraplegic hand function. Kowalczewski J, Chong SL, Galea M, Prochazka A. <i>Neurorehabil Neural Repair</i> . 2011 Jun;25(5):412-22. Epub 2011 Mar 3. PMID: 21372246 [PubMed - indexed for MEDLINE]	A
Effects of high aerobic intensity training in patients with schizophrenia: a controlled trial. Heggelund J, Nilsberg GE, Hoff J, Morken G, Helgerud J. <i>Nord J Psychiatry</i> . 2011 Sep;65(4):269-75. doi: 10.3109/08039488.2011.560278. Epub 2011 Feb 18. PMID: 21332297 [PubMed - indexed for MEDLINE] Free PMC Article	B
Video game play, child diet, and physical activity behavior change a randomized clinical trial. Baranowski T, Baranowski J, Thompson D, Buday R, Jago R, Griffith MJ, Islam N, Nguyen N, Watson KB. <i>Am J Prev Med</i> . 2011 Jan;40(1):33-8.	C
Outcomes of a school-based intervention (RESCATE) to improve physical activity patterns in Mexican children aged 8-10 years. Colin-Ramírez E, Castillo-Martínez L, Orea-Tejeda A, Vergara-Castañeda A, Keirns-Davis C, Villa-Romero A. <i>Health Educ Res</i> . 2010 Dec;25(6):1042-9. Epub 2010 Sep 24.	A
Serious gaming technology in major incident triage training: a pragmatic controlled trial. Knight JF, Carley S, Tregunna B, Jarvis S, Smithies R, de Freitas S, Dunwell I, Mackway-Jones K. <i>Resuscitation</i> . 2010 Sep;81(9):1175-9.	A
"I can be happy even when I lose the game": the influence of chronic regulatory focus and primed self-construal on exergamers' mood. Jin SA. <i>Cyberpsychol Behav Soc Netw</i> . 2010 Aug;13(4):467-71.	A
Physical training in boys with Duchenne Muscular Dystrophy: the protocol of the No Use is Disuse study. Jansen M, de Groot IJ, van Alfen N, Geurts ACh. <i>BMC Pediatr</i> . 2010 Aug 6;10:55.	A
Ultradian rhythmicity and induced changes in salivary testosterone. Beaven CM, Ingram JR, Gill ND, Hopkins WG. <i>Eur J Appl Physiol</i> . 2010 Sep;110(2):405-13. Epub 2010 May 29.	A
Putting brain training to the test. Owen AM, Hampshire A, Grahn JA, Stenton R, Dajani S, Burns AS, Howard RJ, Ballard CG. <i>Nature</i> . 2010 Jun 10;465(7299):775-8.	A
Weight status, modes of travel to school and screen time: a cross-sectional survey of children aged 10-13 years in Sydney. Wen LM, Merom D, Rissel C, Simpson JM. <i>Health Promot J Austr</i> . 2010 Apr;21(1):57-63.	A
Predicting the effect of interactive video bikes on exercise adherence: An efficacy trial. Rhodes RE, Warburton DE, Bredin SS. <i>Psychol Health Med</i> . 2009 Dec;14(6):631-40.	D
The Fun Families Study: intervention to reduce children's TV viewing. Escobar-Chaves SL, Markham CM, Addy RC, Greisinger A, Murray NG, Brehm B. <i>Obesity (Silver Spring)</i> . 2010 Feb;18 Suppl 1:S99-101.	A
Effects of a wobble board-based therapeutic exergaming system for balance training on dynamic postural stability and intrinsic motivation levels. Fitzgerald D, Trakarnratanakul N, Smyth B, Caulfield B. <i>J Orthop Sports Phys Ther</i> . 2010 Jan;40(1):11-9.	B
Comparison of acute exercise responses between conventional video gaming and isometric resistance exergaming. Bonetti AJ, Drury DG, Danoff JV, Miller TA. <i>J Strength Cond Res</i> . 2010 Jul;24(7):1799-803.	D
Effects of an exercise intervention using Dance Dance Revolution on endothelial function and other risk factors in overweight children. Murphy EC, Carson L, Neal W, Baylis C, Donley D, Yeater R. <i>Int J Pediatr Obes</i> . 2009;4(4):205-14.	B
Physical activity and abdominal obesity in youth. Kim Y, Lee S. <i>Appl Physiol Nutr Metab</i> . 2009 Aug;34(4):571-81. Review.	A
Can exergaming contribute to improving physical activity levels and health outcomes in children? Daley AJ. <i>Pediatrics</i> . 2009 Aug;124(2):763-71. Epub 2009 Jul 13.	E
Rationale, design and methods for a randomised and controlled trial to investigate whether home access to electronic games decreases children's physical activity. Straker LM, Abbott RA, Piek JP, Pollock CM, Davies PS, Smith AJ. <i>BMC Public Health</i> . 2009 Jun 29;9:212.	E
Feasibility, design and conduct of a pragmatic randomized controlled trial to reduce overweight and obesity in children: The electronic games to aid motivation to exercise (eGAME) study. Maddison R, Foley L, Mhurchu CN, Jull A, Jiang Y, Prapavessis H, Rodgers A, Vander Hoorn S, Hohepa M, Schaaf D. <i>BMC Public Health</i> . 2009 May 19;9:146.	E

(continues)

Childhood obesity study: a pilot study of the effect of the nutrition education program Color My Pyramid. Moore JB, Pawloski LR, Goldberg P, Kyeung MO, Stoehr A, Baghi H. J Sch Nurs. 2009 Jun;25(3):230-9. Epub 2009 Apr 10.	B
The Sony PlayStation II EyeToy: low-cost virtual reality for use in rehabilitation. Rand D, Kizony R, Weiss PT. J Neurol Phys Ther. 2008 Dec;32(4):155-63.	B
Total energy intake, adolescent discretionary behaviors and the energy gap. Sonnevile KR, Gortmaker SL. Int J Obes (Lond). 2008 Dec;32 Suppl 6:S19-27.	A
Effect of a family-based intervention on electronic media use and body composition among boys aged 8--11 years: a pilot study. Todd MK, Reis-Bergan MJ, Sidman CL, Flohr JA, Jameson-Walker K, Spicer-Bartolau T, Wildeman K. J Child Health Care. 2008 Dec;12(4):344-58.	A
Virtual rehabilitation in an activity centre for community-dwelling persons with stroke. The possibilities of 3-dimensional computer games. Broeren J, Claesson L, Goude D, Rydmark M, Sunnerhagen KS. Cerebrovasc Dis. 2008;26(3):289-96. Epub 2008 Jul 31.	B
SWITCH: rationale, design, and implementation of a community, school, and family-based intervention to modify behaviors related to childhood obesity. Eisenmann JC, Gentile DA, Welk GJ, Callahan R, Strickland S, Walsh M, Walsh DA. BMC Public Health. 2008 Jun 29;8:223.	A
Energy expended playing video console games: an opportunity to increase children's physical activity? Maddison R, Mhurchu CN, Jull A, Jiang Y, Prapavessis H, Rodgers A. Pediatr Exerc Sci. 2007 Aug;19(3):334-43.	E
Virtual reality as a leisure activity for young adults with physical and intellectual disabilities. Yalon-Chamovitz S, Weiss PL. Res Dev Disabil. 2008 May-Jun;29(3):273-87. Epub 2007 Jun 21.	A

Legend: A – RCT not reporting the use of AVG to promote PA; B – articles are focused on virtual rehabilitation, cognitive and behavioral therapies, or health education promoted via video games and/or computers; C – using traditional video games or computers during exercise; D – did not present results with children and/or adolescents; E – not a randomized controlled trial;
Note: Articles were placed in table according to their publication date.

Another 12 week home based intervention using a peripheral device in a video game, concluded that there were no significant differences in PA between intervention and control group (19). Despite this result, Graves and colleagues reported that the use of this peripheral device led to the increase of active gaming and the reduction of sedentary video gaming. However, the sample of this study was small (n=42). An additional limitation of this study was that only 29 of 42 participants provided valid PA data.

A two-arm parallel trial was conducted by Maddison and colleagues in New Zealand, to evaluate the effect of an AVG over a 24 week period on body composition, PA and physical fitness, demonstrated that this new generation video games had a small but positive effect on BMI and body composition in overweight children (20). This research showed a reduction of daily time spent in playing sedentary video games. However this study didn't show change in average time spent in MVPA. A further limitation was that the snack food and video games diaries were not validated against other measures.

In a laboratory setting, Reommich and colleagues concluded that girls and boys could be equally involved in PA when provided their autonomy (21). These authors found that although children play exergames 87% longer than traditional games, the energy expenditure is lower for exergames compared to indoor versions of the same games. Despite these results, children were tested alone and played in an artificial environment, which could misinterpret some outcomes.

Table 4. Methodological details and key findings of the articles included in this review.

In a 13 week RCT, Baranowski and colleagues found that there was no evidence that using AVG, children were more active than children who played a sedentary video game (22). These authors reported that the outcomes were not moderated by parental perceived neighborhood, demographic characteristics or children BMI z score. Nevertheless, this study presented difficulties in corresponding accelerometer data and the console information.

Maddison and colleagues in a 24 week RCT concluded that AVG play can have a positive effect on body composition in overweight or obese children, being probably mediated through improved aerobic fitness (23).

Looking towards the future

A recent paper shows that exergaming can provide light to moderate PA among players (10). It seems that cycling or upper and inferior limb movements showed more energy expenditure, than upper limb movements (11, 18). However, most of the common and commercially available AVG are not designed to demand vigorous PA to win the game (24).

Although many studies reported higher energy expenditure when using AVG in clinical setting, it is not well established that it happens in home context. Most of the commonly commercially available AVG are made for home use, and most of home-based RCT have been short in duration (i.e. < 28 weeks (16)), so a longer period research seems necessary to understand the impact of this technology in PA.

Ref.	Sample	AVG used	Study Design	Measures	Results/Key Findings	PEDro Score
(23)	Same Ref. (20)	PS Eye Toy	Type: Two arm RCT Duration: 24 Week (12 week follow up) Aim: to identify mediators of the effect of an AVG intervention on Body Composition. Description: Users of sedentary VG were randomly assigned either to receive an AVG or no intervention. Context: Home	Anthropometry BMI Aerobic Fitness (shuttle test) PA (accelerometry) Snack Food consumption (self reported) AVG play (self reported)	AVG play can have a positive effect on body composition in overweight or obese children. This effect is predominantly mediated through enhanced aerobic fitness.	6
(22)	Size: 78 (49%F) Age: 9 - 12 $50 \leq \text{BMI} \leq 99$ Location: USA	Wii	Type: Two arm RCT Duration: 13 weeks Aim: to test whether children receiving an AVG engage children in PA than those who receive a sedentary VG. Description: Children receive 2 active (experimental group) or 2 inactive (control group), a console and the peripherals to run the games. Context: Home	Anthropometry Body Composition Demographics (self reported) Neighborhood safety (questionnaire) PA (accelerometry) AVG play (self reported) Children Interviews	There were no significant differences between treatment and control group regarding the variables. A significant time-related difference in sedentary behavior at week 6.	6
(21)	Size: 44 (50% F) Age: 8 - 12 BMI < 95 Location: USA	Wii	Type: Two arm RCT Duration: 3 days Aim: to determine if the basic factors of choice and mastery promote an increase in PA time and intensity, and to compare EE rate while playing exergames and home versions of traditional games. Description: Children were randomly assigned into two groups (experimental and control). The experimental group was given their 3 most highly ranked traditional toy or exergames counterpart. The control group only had access to one toy (traditional toy or exergames) Context: Laboratory	Anthropometry Body composition PA (accelerometry) PA attitudes (questionnaire) Ergospirometry Heart Rate Liking the activity (scale) Time engaged in active play (observation)	Experimental group played more AVG than control group ($p < 0.05$). Girls of experimental group had greater PA levels and intensity than girls in control group ($p < 0.05$). Both groups played more AVG than traditional indoor games ($p < 0.05$). Playing traditional games was more intense than AVG ($p < 0.05$).	7
(20)	Size: 322 Age: 10 - 14 BMI ≥ 85 Location: Australia	PS Eye Toy	Type: Two arm RCT Duration: 24 Weeks (12 week follow up) Aim: to evaluate the effect of AVG over a 6 month period on weight, body composition, PA and physical fitness. Description: Users of sedentary VG were randomly assigned either to receive an AVG or no intervention. Context: Home	Anthropometry BMI Aerobic Fitness (shuttle test) PA (accelerometry) Snack Food consumption (self reported) AVG play (self reported)	There was statistically significant treatment effect on BMI and zBMI from baseline to 24 week period, in the intervention group. Statistically significant treatment effect on %body fat and body fat from baseline to 24 week period. No significant treatment effect on MVPA and physical fitness.	6

(Continues)

(19)	Size: 42 (14F) Age: 8 - 10 Location: United Kingdom	PS2 or PS3 plus jOG device	Type: Two arm RCT Duration: 12 weeks Aim: to evaluate the effect of a peripheral device (jOG) on PA, self-reported behaviors, and body fat Description: children, owners of a PS2 or PS3 consoles, allocated in intervention group by receiving 2 jOG and control group asked to play sedentary games Context: Home	Anthropometry Maturation assessment Body Composition PA (accelerometry)	No significant difference in PA between intervention and control group At week 6, sedentary video gaming decreased and active video gaming significantly increased in intervention group in relation to controls.	6
(18)	Size: 30 Age: 8 - 10 BMI: ≥ 85 Location: Canada	PS2 plus GameBke	Type: Two arm RCT Duration: 10 weeks Aim: to compare the effects of an interactive video game cycling program (experimental) with stationary cycling using music (control), on adherence, duration, exercise intensity, submaximal aerobic fitness, metabolic parameters and body composition Description: Adolescent were stratified in control or experimental condition, with 4 participants (2 per group), failing to complete twice weekly 60 min sessions. Context: Laboratory	Anthropometry Body composition Submaximal aerobic fitness Exercise adherence Metabolic profile Diet (self reported)	The control group had attended more to sessions than experimental group ($p < 0.05$) Control group spent more time exercising in vigorous intensity than experimental ($p < 0.05$) The average distance pedaled per session was higher in control group than in experimental ($p < 0.05$)	5
(17)	Same as Maloney et al. (2008)	PS2 + 2 dance mats	Type: Two arm RCT Duration: 12 week Aim: to evaluate the effect of a peripheral device (jOG) on PA, self-reported behaviors, and body fat Description: children, owners of a PS2 or PS3 consoles, allocated in intervention group by receiving 2 jOG and control group asked to play sedentary games Context: Home	Demographic information Anthropometry Body composition PA (accelerometry) Parental support (questionnaire) Home environment	In the 1st week, the absence of other video game and participation of parents in DDR play was related to child DDR participation. At week 10, peers where associated with child participation in DDR.	6
(16)	Size: 60 (50% F) Age: 7 - 8 BMI: 17.6 ± 2.7 Location: USA	PS2 + 2 dance mats + DDR	Type: 2:1 RCT Duration: 28 Weeks (10-24th follow-up). Aim: to determine a feasibility of a home based dance video game (DDR), to increase PA and decrease SST Description: Children randomized in a 2:1 ration to DDR or wait list control (10 weeks delay) Context: Home	Anthropometry PA (accelerometry and pedometry) Body composition Seated blood pressure and pulse DDR use (self reported) STT (self reported) Satisfaction survey	Use of DDR was higher in the 1st weak and decreased along the study No significant changes observed in PA Significant reduction in SST in experimental group	6
(15)	Size: 27 Age: 9-12 BMI: not reported Location: Netherlands	PS2 + DDR	Type: Two arm RCT Duration: 12 weeks Aim: to evaluate the effect of weekly multiplayer class on motivation of children to play a AVG at home. Description: Children were randomized in two groups. Both group received interactive vide game to use at home. Experimental group were invited to participate in 60'	Anthropometry Aerobic Fitness (shuttle test) Body composition PA and sedentary behavior (self reported) DDR use (self reported) Perceived	Dropout was significantly lower in multi-player group compared to home group Multiplayer group played more (non significant) than the control group	4

(Continues)

		multiplayer class at sports center. Context: Home and Multiplayer class	Perceived competence in sport (questionnaire) Focus group discussions	Multiplayer group played more (901 min.) than home group (376 min.)
(14)	Size: 20 (8F) Age: 10 -14 BMI 19.7 [3.6] Location: New Zealand Eye-toy camera Eye-toy video games Dance mat	Type: Two arm RCT Duration: 12 weeks Aim: to evaluate the effect of active video games on children's PA. Description: children were randomized in two groups to receive a AVG upgrade package or no intervention. Context: Home	Anthropometry Body composition PA (accelerometry and self report questionnaire) Self reported activity log Estimate of energy based on activity compendium	No significant group differences in time spent in MVPA. PA measured with accelerometer was higher in intervention group compared with control group. There was a reduction in waist circumference and weight in intervention group at 12 th week.

In the home setting, the use of AVG's appears to be related to peer participation (17). It is therefore, important to study how peer and sibling participation affects exertion during home active video game play. Therefore group play seems to encourage PA, so the use of Internet and connections between remote consoles may also provide also an opportunity for exploring nonlocal play. Many barriers have been related to children's physical inactivity (5). Children prefer playing AVG than other leisure activities (21), because it seems this technology promotes an immersive activity (25), stimulating a psychosocial experience of competence and achievement (26). Thus, research is needed to identify

how this active video play influences children's behavior.

To better understand the AVG influence on PA and sedentary behavior, its important to identify a method of synchronizing times of exergaming with accelerometer data.

The active video games commercially available have different ways to be played, most of them with a remote controls ((e.g. Wii controls (Nintendo – Japan) or Playstation Move (Sony - Japan)) or through user interface using gestures captured by a webcam ((e.g. XBOX 360 plus Kinetic option – Microsoft - USA). It's imperative to compare these types of game play and compare their impact on PA.

Table 5 - PEDro Score for selected studies.

Ref.	PEDro Scale											Total Score
	1	2	3	4	5	6	7	8	9	10	11	
(23)	Yes page 3	Yes page 3	yes	Yes page 3	No	No	No	No	Yes page 3	Yes page 4-5	Yes page 4-5	6
(22)	Yes page e637	Yes page e637	Yes	Yes page e640	No	No	No	Yes page e639	No	Yes page e604	Yes page e604	6
(21)	Yes page 3	Yes page 3	Yes	Yes page 3	No	No	No	Yes	Yes	Yes page 6-9	Yes page 6-9	7
(20)	Yes page 157	Yes page 157	Yes	Yes page 157	No	No	No	No page 159	Yes page 158	Yes page 159-60	Yes page 159-60	6
(19)	Yes page 536	Yes page 536	Yes page 536	Yes page 540, 542-3	No	No	No	No	Yes page 539	Yes page 539-40	Yes page 540, 542-3	6
(18)	Yes e 806	Yes e 807	Yes	Noage 806	No	No	No	ge 807	No	Yes page 809-11	Yes page 810-11	5

(Continues)

(17)	Yes page 246	Yes page 247	Yes	Yes page 248	No	No	No	Yes page 248	No	Yes page 248-50	Yes page 249-50	6
(16)	Yes page 2075	Yes page 2075	Yes	Yes page 2076	No	No	No	Yes page 2076	No	Yes page 2077	Yes page 2077	6
(15)	Yes page 164	Yes page 164	Yes page 164	No Page 164	No	No	No	No page 164	No page 164	Yes page 165	Yes page 165	4
(14)	Yes page 2	Yes page 2	Yes	Yes page 4	No	No	No	Yes page 4	No	Yes page 4	Yes page 4	6

1- eligibility criteria were specified; 2 - subjects were randomly allocated to groups (in a crossover study, subjects were randomly allocated an order in which treatments were received); 3 - allocation was concealed; 4 - the groups were similar at baseline regarding the most important prognostic indicators; 5 - there was blinding of all subjects; 6 - there was blinding of all therapists who administered the therapy; 7 - there was blinding of all assessors who measured at least one key outcome; 8 - measures of at least one key outcome were obtained from more than 85% of the subjects initially allocated to groups; 9 - all subjects for whom outcome measures were available received the treatment or control condition as allocated or, where this was not the case, data for at least one key outcome was analyzed by "intention to treat"; 10 - the results of between-group statistical comparisons are reported for at least one key outcome; 11 - the study provides both point measures and measures of variability for at least one key.

Merits and strengths

This is, to our knowledge, the first systematic review of randomized controlled trials using AVG to promote PA. So, this review provides important information for future research, trying to contribute to the improvement of knowledge, searching for more ways to promote health and welfare in youth.

This systematic review focused mostly on PA-related outcomes. It should be noted, however, that other health outcomes could be considered in future studies that analyze the effects of AVGs, namely its possible effects on BMI, metabolic health, or psychosocial outcomes.

Methodological differences between studies did not allow us to state whether the use of these new generation video games can improve PA in children and adolescents. Another limitation to this review is that some studies included have relatively small samples.

CONCLUSIONS

The potential of active video game play to promote the increase of daily physical activity is arousing a great interest and discussion. Although there is some evidence that this technology promotes light to moderate physical activity, it is important to develop long-term interventions to verify whether AVG can motivate youth to increase PA and decrease sedentary activities. Home use of video games should be studied because it is here that these are most played.

It seems we should consider AVG as an additional "tool" to promote PA and reduce sedentary behavior.

This study provides some directions for futures studies in this research area.

REFERENCES

1. Warburton DE, Nicol CW, Bredin SS. Health benefits of physical activity: the evidence. *CMAJ*. 2006;174:801-9. Epub 2006/03/15.
2. Troiano RP, Berrigan D, Dodd KW, Masse LC, Tilert T, McDowell M. Physical activity in the United States measured by accelerometer. *Med Sci Sports Exerc*. 2008;40(1):181-8. Epub 2007/12/20.
3. Lobstein T, Baur L, Uauy R, TaskForce IIO. Obesity in children and young people: a crisis in public health. *Obes Rev*. 2004;5 Suppl 1:4-104. Epub 2004/04/21.
4. Lambourne K, Donnelly JE. The role of physical activity in pediatric obesity. *Pediatr Clin North Am*. 2011;58(6):1481-91, xi-xii. Epub 2011/11/19.
5. Gordon-Larsen P, Griffiths P, Bentley ME, Ward DS, Kelsey K, Shields K, et al. Barriers to physical activity: qualitative data on caregiver-daughter perceptions and practices. *Am J Prev Med*. 2004;27(3):218-23. Epub 2004/09/29.
6. Whitt-Glover MC, Taylor WC, Floyd MF, Yore MM, Yancey AK, Matthews CE. Disparities in physical activity and sedentary behaviors among US children and adolescents: prevalence, correlates, and intervention implications. *J Public Health Policy*. 2009;30 Suppl 1:S309-34. Epub 2009/05/16.
7. Gordon-Larsen P, McMurray RG, Popkin BM. Determinants of adolescent physical activity and inactivity patterns. *Pediatrics*. 2000;105(6):E83. Epub 2000/06/02.
8. Biddle SJ, O'Connell S, Braithwaite RE. Sedentary behaviour interventions in young people: a meta-analysis. *Br J Sports Med*. 2011;45(11):937-42. Epub 2011/08/03.
9. ESA. The essential facts about the computer and video game industry. Entertainment Software Association, 2011.
10. Peng W, Lin JH, Crouse J. Is playing exergames really exercising? A meta-analysis of energy expenditure in active video games. *Cyberpsychol Behav Soc Netw*. 2011;14(11):681-8. Epub 2011/06/15.
11. Biddiss E, Irwin J. Active video games to promote physical activity in children and youth: a systematic review. *Arch Pediatr Adolesc Med*. 2010;164(7):664-72. Epub 2010/07/07.

12. Liberati A, Altman DG, Tetzlaff J, Mulrow C, Gotzsche PC, Ioannidis JP, et al. The PRISMA statement for reporting systematic reviews and meta-analyses of studies that evaluate health care interventions: explanation and elaboration. *PLoS Med.* 2009;6(7):e1000100. Epub 2009/07/22.
13. Maher CG, Sherrington C, Herbert RD, Moseley AM, Elkins M. Reliability of the PEDro scale for rating quality of randomized controlled trials. *Phys Ther.* 2003;83(8):713-21. Epub 2003/07/29.
14. Ni Mhurchu C, Maddison R, Jiang Y, Jull A, Prapavessis H, Rodgers A. Couch potatoes to jumping beans: a pilot study of the effect of active video games on physical activity in children. *Int J Behav Nutr Phys Act.* 2008;5:8. Epub 2008/02/09.
15. Chin APMJ, 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(2):163-6. Epub 2007/08/21.
16. Maloney AE, Bethea TC, Kelsey KS, Marks JT, Paez S, Rosenberg AM, et al. A pilot of a video game (DDR) to promote physical activity and decrease sedentary screen time. *Obesity (Silver Spring).* 2008;16(9):2074-80. Epub 2009/02/03.
17. Paez S, Maloney A, Kelsey K, Wiesen C, Rosenberg A. Parental and environmental factors associated with physical activity among children participating in an active video game. *Pediatr Phys Ther.* 2009;21(3):245-53. Epub 2009/08/15.
18. Adamo KB, Rutherford JA, Goldfield GS. Effects of interactive video game cycling on overweight and obese adolescent health. *Appl Physiol Nutr Metab.* 2010;35(6):805-15. Epub 2010/12/18.
19. Graves LE, Ridgers ND, Atkinson G, Stratton G. The effect of active video gaming on children's physical activity, behavior preferences and body composition. *Pediatr Exerc Sci.* 2010;22(4):535-46. Epub 2011/01/19.
20. Maddison R, Foley L, Ni Mhurchu C, Jiang Y, Jull A, Prapavessis H, et al. Effects of active video games on body composition: a randomized controlled trial. *Am J Clin Nutr.* 2011;94(1):156-63. Epub 2011/05/13.
21. Roemmich JN, Lambiase Ms MJ, McCarthy TF, Feda DM, Kozlowski KF. Autonomy supportive environments and mastery as basic factors to motivate physical activity in children: a controlled laboratory study. *Int J Behav Nutr Phys Act.* 2012;9:16. Epub 2012/02/23.
22. Baranowski T, Abdelsamad D, Baranowski J, O'Connor TM, Thompson D, Barnett A, et al. Impact of an active video game on healthy children's physical activity. *Pediatrics.* 2012;129(3):e636-42. Epub 2012/03/01.
23. Maddison R, Ni Mhurchu C, Jull A, Prapavessis H, Foley LS, Jiang Y. Active video games: the mediating effect of aerobic fitness on body composition. *Int J Behav Nutr Phys Act.* 2012;9(1):54. Epub 2012/05/05.
24. Lieberman DA, Chamberlin B, Medina E, Jr., Franklin BA, Sanner BM, Vafiadis DK, et al. The power of play: Innovations in Getting Active Summit 2011: a science panel proceedings report from the American Heart Association. *Circulation.* 2011;123(21):2507-16. Epub 2011/04/27.
25. Ryan R, Rigby CS, Przybylski A. The Motivational Pull of Video Games: A Self-Determination Theory Approach. *Motivation and emotion.* 2006;30(4):344-60.
26. Baranowski T, Baranowski J, O'Connor T, Lu AS, Thompson D. Is Enhanced Physical Activity Possible Using Active Videogames? *Games for Health Journal.* 2012;1(3):228-32.

Copyright of Archives of Exercise in Health & Disease is the property of Archives of Exercise in Health & Disease and its content may not be copied or emailed to multiple sites or posted to a listserv without the copyright holder's express written permission. However, users may print, download, or email articles for individual use.