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ORIGINAL ARTICLE

A digital movement in the world of inactive children: favourable outcomes of playing active video games in a pilot randomized trial

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Abstract

This parallel randomized controlled trial was aimed to evaluate whether parameters as physical fitness, reaction times, self-perception and enjoyment levels, as well as parental and children perspectives, were affected by active video games in inactive and technologically preoccupied children. Data were collected in a laboratory setting from four randomly selected urban public schools. All 1300 children in grades 3–6 were surveyed for the study. Among the 918 responders, 106 children were determined to be inactive and preoccupied with technology. Children in 3 schools ($n = 53$) allocated to active video game and in one school ($n = 53$) allocated to control group were compared by univariate covariance analyses for primary outcomes such as weight, body mass index and fat ratios at the end of 12 weeks. Active video game group significantly showed favourable responses for weight, body mass index and corresponding z scores as well as reaction times and self-perception controlling for age and baseline scores. In addition, enjoyment of the children in the game group by qualitative analysis was high indicating a motivational aspect for the continuation of the games. Diverse contributions of games to physical, social, intellectual and personal development were revealed.

Conclusion: Active video games by promoting enjoyment levels and physical activity, as well as contributing to agility, alertness, socializing, and striving, led to a reduction in weight gain. They may be used as beneficial tools diverting children from inactivity and subsequent obesity.

Trial registration: This study called AVGAME is registered with the number NCT03720938 in Clinicaltrials.gov. The trial protocol can also be retrieved from the archives of Abant Izzet Baysal University.

What is Known:
- *Nowadays, children prefer sedentary video games that are known to induce weight gain and obesity-related comorbidities.*
- *Active video games were shown to decrease weight in overweight and obese children.*

What is New:
- *Active video games decrease weight increment and reaction times, thus could be used to prevent obesity in inactive non-obese children.*
- *Active video games raise self-esteem, induce enjoyment, improve the personal and intellectual development of children in addition to socializing and is a safe alternative to indoor sedentary video games*

Keywords Inactive children · Active video games · Physical fitness · Self-perception · Enjoyment · Obesity

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Abbreviations

AVG	Active video games
BMR	Basal metabolic rate
C	Control
CY-PSPP	Children and youth physical self-perception scale
DEC	Daily energy consumption
FMS	Fundamental movement skill
FR	Fat ratio
GSW	Global self-worth
PA	Physical activity
PACES-SF	Physical activity enjoyment scale-short form
PF	Physical fitness
PSW	Physical self-worth
RCT	Randomized controlled trial
RT	Reaction time
SES	Socioeconomic status
SP	Self-perception
ST	Skinfold thickness
SVG	Sedentary video games

Introduction

Inactivity was reported to be high in children and considered to be the fourth common cause of death for all ages [22]. A negative relationship between physical activity and self-esteem and obesity was reported recently in children [37]. Subnormal academic performance and obesity-related comorbidities like hypertension, diabetes, coronary heart diseases, depression and cancer might arise as a result of decreased physical activity [7]. The reason for decreased activity in children is usually the increased indoor use of sedentary screen time [12]. Children usually do not prefer to perform outdoor physical activity (PA) due to several causes including parental anxiety about the dangers of playing in outdoor environments, children's low sense of self-perception (SP) and enjoyment due to inactivity [20].

In addition to inactivity, increased nutritional intake accompanying screen time was reported to be the main causes of obesity and its subsequences. Thus, increasing activity and decreasing energy can attenuate the problem by decreasing the adiposity rebound in peripubertal years of childhood and adolescence. Targeting these two main causes at peripuberty games, as novel approaches for prevention of childhood and related adult obesity, was reported to be useful [35]. Games like board, card and seemingly sedentary video games were found to be effective as educational tools for healthy dietary activity to decrease caloric intake as well for healthy physical activity especially if combined with group sessions [29, 34]. Previously, these games have been demonstrated to encourage children and adolescents for healthy eating and exercising for prevention of excess weight [23, 29]. The games can also motivate children for longer periods, therefore providing them healthy life styles [14]. Among these games, active video games (AVG) have recently been introduced for decreasing the sedentary time for children and directing them to PA at home, thus increasing their caloric expenditure [3]. AVGs were regarded as a form of exercise and directly involved in physically exercising upper, lower extremities and whole body. Studies have shown that the expended energy through AVGs was more than the energy expended during sedentary video games (SVG) and equal to PA of moderate intensity which caused 3 to 6 times the amount of resting energy consumption [24]. Though there were studies in obese children, we did not encounter studies on the effects of AVG in children with inactivity and technology preoccupation. In addition, we observed the lack of clarity about how AVG influenced the enjoyment level in children and attitude of both children and their parents.

Thus, the aim of this study was to determine the quantitative effect of AVG on physical fitness (PF) parameters like weight, body mass index (BMI) and fat ratios (FR). The study also was aimed at factors for motivation or continuance of the games as SP and enjoyment levels together with qualitative effects of games on satisfaction and attitude changes in inactive children. Likewise, the study tried to reveal the feelings and perspectives of the participant children's parents about AVG for the maintenance of playing games during the study.

Material and methods

This study was a parallel randomized controlled trial (RCT) in which the randomly selected elementary urban public schools were the allocation units. Though we randomly selected the schools from the public ones, each student was ultimately assumed to act individually regardless of the attended school. The rationale for this particular randomization which focused on participant rather than cluster randomization was to avoid the interaction between two "independent" groups [32]. A sample size of 26 children per group was needed with the assumption of Cohen's d = 0.8, the alpha error of 0.05 and a power of 80%. We estimated an attrition rate of 85% due to the exclusion criteria. Four primary schools among 14 were allocated randomly to one of AVG and control (C) groups with a ratio of 3:1. Since C group would not play games and get to the laboratory environment, we preferred a smaller number of schools for the C group to achieve a children allocation ratio of 1:1. Number sequences were generated by the coordinator through a web-based true random number generator. In order to increase the number and power, all survey responders from classes III, IV, V and VI without sports participation were included in the study. Inclusion criteria of children were 8–13 years old, preoccupied with technology and physically inactive. This critical period of peripubertal adiposity was very important for developing future insulin resistance and obesity [9]. Besides, children in this age group had sufficient abilities for adapting the directions for the study as well as filling the questionnaire forms reliably. Exclusion criteria were the presence of at least one of the following conditions: circulatory, respiratory and musculoskeletal diseases, neuropsychiatric disease, exercise-induced anaphylaxis, morbid obesity and short stature.

Technological preoccupation was defined as using the computer for activities other than homework, for at least 7 h or more in a week, watching television for 3 h or more in a day, playing video games for 5 h or more in a week in addition to the parental definition of the children as preoccupied with technology [11]. Physical inactivity was defined as children with < 1.56 activity scores by Ekelund criteria. According to this criteria, children with activity scores between 1.56–1.81 and greater than 1.81 were classified as moderately and highly active, respectively [17]. Daily energy consumptions (DEC) were divided by basal metabolic rates (BMR) to calculate the activity scores. To do this, children recorded activities through a scale ranging from 1 to 9 for every 15-min period for 3 non-consecutive days, including a weekend day. Children were given directions not to perform intense activities the day before the recording was performed. DEC was calculated through the adding of each 15 min period energy consumptions of the corresponding activities in the recordings [27]. BMR was calculated by the Harris-Benedict formula.

Children in AVG group alternatively played Nintendo Wii® AVGs from sports (boxing, tennis, golf, baseball, and bowling), balance (ski slalom, heading ball, balance bubble, ski jumping and penguin playing), aerobics (rhythm boxing, hula-hoop, cycling, step, and run), resort (jet-skiing, water skiing, table tennis, basketball, swordplay, archery, canoeing and frisbee) and training (rhythm kung fu, snowball, turning ball, Segway circuit, perfect 10, skateboard, major, obstacle course and bicycle) categories for 50–60 min, 3 days a week, for 12 weeks in laboratory environment supervised by three experienced personnel between March and May 2013. Children in C group did not play games.

Primary and secondary outcomes were PF characteristics of children such as weight, BMI, FR and RTs, SP and enjoyment, respectively. All the outcomes except enjoyment were measured by researchers twice, one at the onset and the other at the end of the study. Weight and height were measured to the nearest 0.01 kg (Seca 767) and 0.1 cm (Seca 220), correspondingly. BMI was calculated according to the Quetelet index:

$$\text{Body mass index} = \frac{\text{Weight (kg)}}{\text{Height (m)}^2}$$

Weight, height and BMI age-adjusted z scores were calculated by a Windows®-based application using national data [26]. Children with BMI over 1 SD above mean were considered as having ‘excess weight’. Heights less than − 2 SD were accepted as short. Four site skinfold thicknesses (ST) were measured by Holtain caliper to calculate body FRs. Durnin-Womersley and Siri formula were used respectively to calculate body density and FRs after obtaining biceps, triceps, supra-iliac and subscapular ST;

$$\text{Body density} = 1.1533\text{–}0.0643\ \text{Log}\Sigma 4\text{ST}\quad \text{(Boys)}$$
$$\text{Body density} = 1.1369\text{–}0.0598\ \text{Log}\Sigma 4\text{ST}\quad \text{(Girls)}$$
$$\text{Percentage of fat (\%)} = \left[\frac{4.95}{\text{Body density}} - 4.5\right] \text{x}100$$

RTs were measured by Newtest 1000 timer as response times to visual and auditory stimuli. Ten RTs to both stimuli were recorded for both dominant and non-dominant hands of every child. Children were given direction to press the device button immediately after they receive the auditory or visual stimulus. The lowest and highest observed RTs were excluded and repeated. The arithmetic mean of the last 5 recordings was accepted as the final RT as seconds.

The groups’ SP profiles were evaluated by the Children and Youth Physical Self Perception Profile (CY-PSPP). The scale comprised 6 subscales of SP that are sports competence, physical condition competence, strength competence, body attractiveness, physical self-worth (PSW) and global self-worth (GSW). Each subscale was assessed by 6 questions with four ordinal levels of response [36]. Short form of physical activity enjoyment scale (PACES-SF) was used to determine the AVG group’s level of enjoyment from AVG after every game, 32 times in total. The responses from the 5 statements were recorded on the basis of the 7-point Likert scale. Mean of all five items resulted in a final score. The modified bipolar scale, a type of rating scale showing a range between two opposite values with a centre value, has been found to be reliable and valid for children between 9 and 14 years of age [25].

In order to reveal the perspectives of children and parents about the AVG in the AVG group, focus group sessions were held after weeks 6 and 12. Numbers ranged from 6 to 8 children or parents per mixed age groups. Eight semi-structured questions were asked to learn the feelings and perspectives of children and parents as well as to assess the contribution of games to attitude changes in children’s lives. Answers were both audio-recorded and transcribed verbatim by two independent interviewers.

Socioeconomic status (SES) of the schools and children was evaluated according to the schools that the children attended in addition to parental education levels.

Statistical analyses

Categorical and numeric data were presented as counts (%) and means (SD), respectively. In order to analyse the data, z-tests were used to compare the categorical variables. For numerical and normally distributed variables, independent samples t test was used for comparing the two groups' initial values. Multiple outcomes of PF, RT and SP variables were tested for any difference between groups by covariate analysis (ANCOVA) adjusted for the score at baseline and confounding variables. Eta squared (η2) values were used to calculate effect sizes for univariate analyses. Non-normally distributed numeric variables for subgroup analyses were evaluated by the Mann-Whitney U test. A p value < 0.05 was significant in SPSS version 21 (SPSS Inc., USA).

For the qualitative part, transcribed data with the help of recorded sound were processed and transferred to a Word® document. Two researchers read and discussed the transcripts to agree on descriptive codes. The coordinator assigned these codes to the data before the inductive analysis. Each code and corresponding collated data were used to identify the themes and subthemes by two interviewers which were the contribution of games and sustainability of games as ideas and feelings about the games. Major findings were outlined after refinement of aberrant cases by consensus of researchers. NVIVO version 10 for Windows ® (NVivo, 2012) was used for the analyses according to NVivo 10 for Windows user's guide.

Results

There was no difference between the schools in terms of SES due to their public nature. Therefore, each student was assumed to act individually regardless of the attended school [8]. Responders ($n = 918$) out of 1300 surveyed children (71%) were eligible for the study. Children whose parents were non-responsive to phone calls and declined to participate ($n = 132$) were discarded (consent rate 85.6%). Children who did not meet the criteria for low PA and high technology use ($n = 560$) via the questionnaire were excluded. Children who failed to respond to 3-day Bouchard report and had problems in detailed history and physical examination that could interfere with the PA were also dropped out ($n = 113$). Children with heights less than − 2 SD below the standard ($n = 7$) were excluded due to a short stature that has been previously shown to interfere with SP [10]. Recruitment was completed in February 2013. The number of participated children was 106 [46 boys (44%), 60 girls (56%)], AVG group ($n = 53$) and C group ($n = 53$) (Fig. 1). There were no children who have played AVGs at home. Ages of included children were between 8.2 and 13.1 years. Almost 11.5% of the 918 children participated in the games. All participated children completed the study schedule within originally assigned groups from March to May, 2013. Compliance to the study after group assignments was high due to multiple game options.

Baseline features of children were shown in Table 1. Children in the groups were gender-matched while the mean ages of AVG group were statistically lower than C group. There were 25, 20, 2 and 6 children in AVG versus 15, 12, 19 and 7 children in C groups, respectively in classes III, IV, V and VI. In accordance with the lower age in AVG than C group, numbers of children in higher grades from AVG group were significantly lower than C group and vice versa ($p < 0.05$). Mean parental education levels were similar in groups ($p > 0.05$) despite the significant differences for maternal high and paternal middle school educations. Age-adjusted height scores (z scores) were higher in AVG than C groups. There were 16 children (5 obese and 11 overweight) versus eight children (2 obese and 6 overweight) with BMIs greater than 1 SD in AVG and C groups, respectively. The proportion of children having BMI greater than 1 SD in AVG group was not different from C group [Pearson chi-square (1, $n = 53$) = 3.447, $p > 0.05$].

There were three children (5.6%) who were transferred from above 1 SD to within normal BMI z scores in the AVG group. However, no overweight child returned to normal in the C group. The proportion of children transferring from the overweight to normal during the study in AVG group was statistically similar to the C group ($p > 0.05$). On the contrary, there was only one child (1.8%) transferring from normal to overweight in AVG group, while there were 9 children (16.9%) transferring from normal BMI group to overweight group in C group. The proportion of children transferring from normal to overweight during the study in AVG group was significantly lower than the C group ($p < 0.01$). At the end of the intervention, there were 14 children (three obese and 11 overweight) versus seventeen children (three obese and 14 overweight) with BMI greater than 1SD in AVG and C groups, respectively.

Table 2 shows the results of the change of all PF and RT variables during the measurements and the difference of the relevant variables between the groups. At the beginning of this study, we did not observe any significant differences in absolute weight, BMI, age-adjusted correlates of these two variables and FRs between the groups (Table 1). At the end of our study, we found that all children in both groups gained some weight. Children in the AVG group gained significantly less weight than C children as regards to age-adjusted scores. At the end of intervention, BMI and BMI z score mean values decreased significantly in AVG group compared to increased values of C group. Reliability tests resulted in an excellent Cronbach's alpha score higher than 0.96 between all test-retest measures for weight and BMI z scores (ICC = 0.97, 95% CI 0.95–0.98). Statistically significant effects of games on weight, weight z score, BMI and BMI score when adjusted for baseline scores and confounding factor age [F (1,102) = 12.90, $p = 0.001$, η2 = 0.112; F (1,102) = 8.41, $p = 0.005$, η2 = 0.076; F (1,102) = 22.99, $p = 0.000$, η2 = 0.184 and F (1,102) = 13.97, $p = 0.000$, η2 = 0.120; respectively] were observed, while there was not a significant effect of games on body FRs when adjusted for age and baseline ratio [F (1,102) = 1.28, $p = 0.259$, η2 = 0.012].

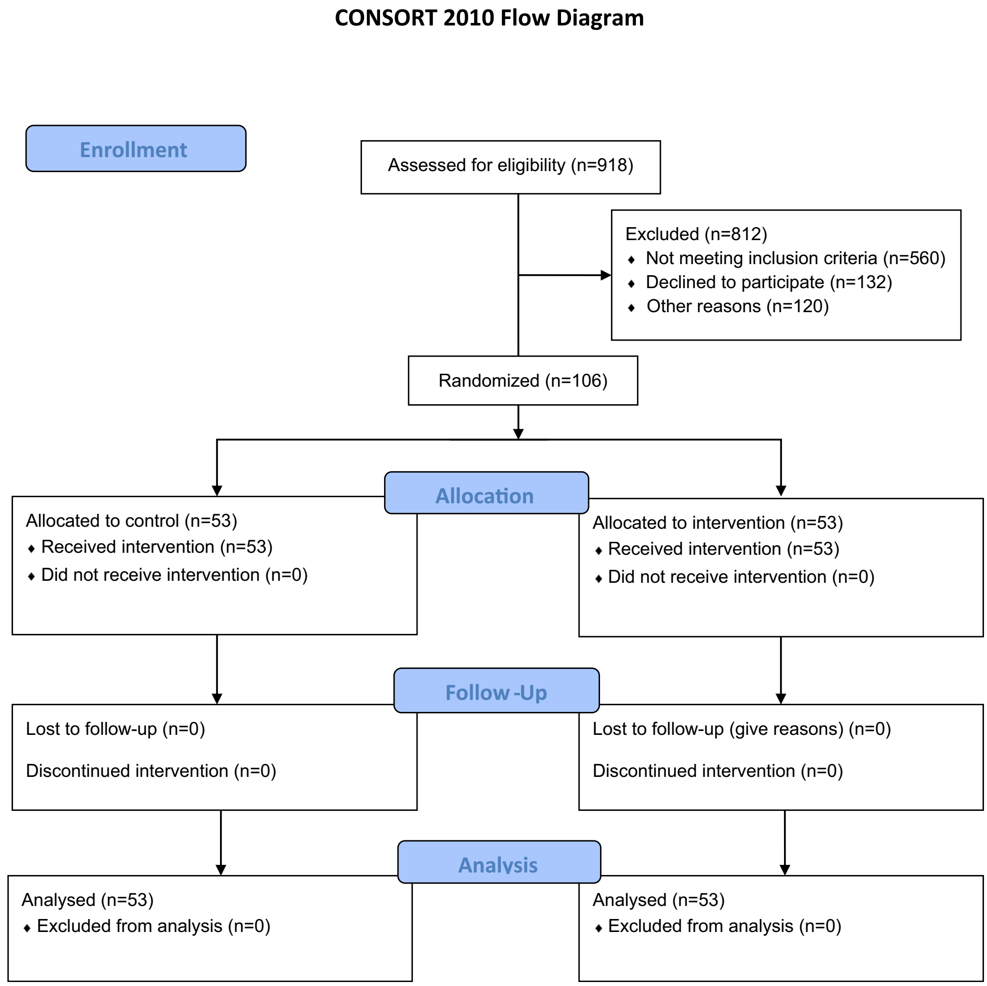

Fig. 1 Flowchart showing the design of the study

The most significant reduction in the RTs was observed for visual RTs in non-dominant hands [F (1,102) = 27.31, p = 0.000, η2 = 0.211]. The second most significant reduction was observed in the visual dominant hands' RTs [F (1,102) = 18.52, p = 0.000, η2 = 0.154]. Age and baseline adjusted auditory RTs did also differ significantly for dominant and non-dominant hands' RTs [F (1,102) = 17.91, p = 0.000, η2 = 0.149 and F (1,102) = 7.29, p = 0.008, η2 = 0.067; respectively].

There were increases in all subscales of physical SP at the end of the intervention. Increases in the subscales of PSW and GSW were most prominent and significant once the univariate analyses were controlled for the covariate age and baseline values [F (1,102) = 7.56, p = 0.007, η2 = 0.069 and F (1,102) = 9.32, p = 0.003, η2 = 0.084], respectively.

There were no significant differences for PA enjoyment scales of AVG categories in regard to gender in AVG children (Table 3).

Figure 2 depicts the results of qualitative analyses revealing the feelings and perspectives of children for the games. Usually, there were positive feelings of enjoyment, happiness, excitement and of being active and energetic. However, some children stated negative feelings of dislike for the games because they were boring and difficult. Some of them felt depressed and jealous when they lost the game. The themes that revealed the perspectives of children and parents about the contributions and experienced changes of AVG intervention were diverse. We observed the remarkable contribution of AVG to PA, as well as to physical change, socializing, relationship with screens, intellectual and personal development of children.

Discussion

In the present study, all children gained some weight during the 12-week study period. This result suggested the failed nature of games for reduction of weight in children and was in accordance with the results of Bochner et al., who conducted a meta-analysis about the game exercising [6]. In contrast to this prima facie inference, we observed a decreased rate of weight gain in children exercising with video games. This prominent finding was entirely dissimilar to the findings of the above meta-analysis and can be attributed to methodological differences.

Table 1 Demographic and physical characteristics of experimental and control group children

		Group		
		AVG *n* 53	Control *n* 53	*p* value
Physical activity level	Male	1.244 (0.37)	1.305 (0.79)	0.732
	Female	1.177(0.32)	1.183 (0.88)	0.972
Gender*	Male Female	24 (45.3) 29 (54.7)	22 (41.5) 31 (58.5)	0.845
Age (years)		9.62 (1.02)	10.31 (1.15)	0.002
Weight (kg)		33.65 (9.39)	34.29 (8.46)	0.716
Weight z score		0.13 (1.23)	− 0.22 (1.05)	0.112
Height (cm)		135.8 (8.5)	136.4 (7.7)	0.694
Height z score		0.00 (1.08)	− 0.57 (0.98)	0.005
Body mass index (kg/m^2)		17.97 (3.34)	18.20 (3.29)	0.723
Body mass index z score		0.13 (1.30)	0.06 (1.15)	0.745
Fat ratio %		24.54 (7.14)	25.43 (6.78)	0.511
Maternal education**	Illiterate	3 (5.7)	5 (9.4)	> 0.05
	Primary school	23 (43.4)	30 (56.6)	> 0.05
	Middle school	4 (7.5)	9 (17)	> 0.05
	High school	18 (34)	4 (7.5)	< 0.05
	University	5 (9.4)	5 (9.4)	> 0.05
Paternal education**	Illiterate	4 (7.5)	4 (7.5)	> 0.05
	Primary school	13 (24.5)	12 (22.6)	> 0.05
	Middle school	7 (13.2)	17 (32.1)	< 0.05
	High school	23 (43.4)	14 (26.4)	> 0.05
	University	6 (11.3)	6 (11.3)	> 0.05

Marked with asterisks are counts and percentages in parentheses

Other data are mean and standard deviation in parentheses

Z score standard deviation score

AVG active video games

*Z test with Bonferroni correction

**Chi-square test

The frequency and duration of games in our study could be perceived as high and long for such studies. The intensity of the games might also have played part for the difference in results. On the contrary to studies which reported AVG to be ineffective for the prevention of obesity in children, our findings suggest that adolescent obesity could be prevented by decreasing the rate of acquisition of prepubertal adiposity during the critical peripubertal years. Our study is unique in that the effects of AVG playing were studied in children with variable weights, unlike other studies which focused on overweight or obese children exclusively [31]. In an even more recent study, Sen et al. reported that board game Kaledo intervention was as effective as behaviour intervention in decreasing BMI and BMI z scores in obese children between 9 and 12 years old [29]. Through a similar design with our study, Viggiano et al. reported the Kaledo to be effective for reducing BMI z score and increasing physical activity in 7- to 11-year-old children with varying weights like our study [35]. In accordance with the results of the above trials, decrease in BMI and BMI z score in our study in contrasting to an increase in similar data of C group suggested an attenuating effect of games on children's adiposity levels. The last two studies used Kaledo game as an indirect tool via education for improving nutritional intake and physical activity whereas our study aimed to increase physical activity and used AVG as a tool via direct exercising. Our results with those of Sen et al. suggested that game intervention studies were as effective as family-based interventions to reduce adiposity and could be good alternatives to family-based intervention when parental group sessions were also incorporated into children's interventions. The presence of only one child in AVG group shifting from normal to excess weight compared to nine children in the sedentary group can show that AVGs could decrease the adiposity increase in even 12 weeks. Though we did not determine the pubertal stages of children in the study, we concluded that AVGs during these critical periods of peripuberty could decrease the previously defined 'adiposity

Table 2 Group differences in physical fitness parameters and reaction times

	AVG group			Control group			*p* value*
	At the beginning of the 1st week	At the end of the 12th week	Delta difference 1–12 weeks	At the beginning of the 1st week	At the end of the 12th week	Delta difference 1–12 weeks	
Weight (kg)	33.65 (9.39)	34.18 (9.58)	− 0.52 (1.12)	34.29 (8.46)	36.19 (9.04)	− 1.90 (1.87)	0.001
Weight z score	0.13 (1.23)	0.23 (1.23)	− 0.09 (0.21)	− 0.22 (1.05)	0.06 (1.02)	− 0.28 (0.30)	0.005
BMI (kg/m^2)	17.97 (3.34)	17.64 (3.36)	0.32 (0.69)	18.20 (3.29)	18.86 (3.57)	− 0.66 (1.06)	0.000
BMI z score	0.13 (1.30)	0.00 (1.31)	0.13 (0.32)	0.06 (1.15)	0.27 (1.17)	− 0.21 (0.45)	0.000
Fat ratio %	24.54 (7.14)	22.37 (6.68)	2.16 (2.05)	25.43 (6.78)	24.62 (7.83)	0.81 (4.43)	0.259
Visual reaction time Dominant hand (s)	0.263 (0.067)	0.233 (0.040)	0.030 (0.070)	0.269 (0.055)	0.269 (0.075)	0.00 (0.058)	0.000
Visual reaction time Non-dominant hand (s)	0.282 (0.083)	0.240 (0.045)	0.042 (0.075)	0.284 (0.058)	0.282 (0.076)	0.002 (0.065)	0.000
Auditory reaction time Dominant hand (s)	0.285 (0.079)	0.243 (0.053)	0.042 (0.076)	0.314 (0.071)	0.289 (0.079)	0.025 (0.075)	0.000
Auditory reaction time Non-dominant hand (s)	0.294 (0.086)	0.264 (0.049)	0.031 (0.085)	0.321 (0.074)	0.293 (0.080)	0.028 (0.078)	0.008

AVG active video games

BMI body mass index z score age adjusted scores or standard deviation scores

s seconds

*Denotes two-sided p values between groups, by univariate covariate analyses controlling for age and baseline values

Values expressed as mean and standard deviation in parentheses

rebound', which has already started from 5 years of age on [15]. The insignificant change between groups in regard to fat ratios did not support this idea. We concluded that the method used for quantification of fat tissue might not be as sensitive and appropriate as dual-energy X-ray absorptiometry or magnetic resonance imaging for such studies [30].

RTs to visual and auditory stimuli are considered to be relevant to fundamental movement skills (FMS) and analysed in this study [4]. Significant shortening of visual and auditory RTs of both dominant and non-dominant hands after games was observed in AVG children compared to sedentary children. By this finding, we can deduce that AVG children gained definitive agility and were not 'happy triggers', as suggested elsewhere. There seemed not to be a speed-accuracy trade-off issue since AVG group achieved valid faster RTs compared to C group [16]. The reason for agile visual responses was probably the increased excitability and diminished inhibition of motor neurons [1].

Table 3 The gender comparison of the results of physical activity enjoyment scale in AVG group children

Game category	Gender	Number	Mean (SD)	*p* value
Sports	Female	29	21.34 (2.59)	0.194
	Male	24	20.46 (4.08)	
Resort	Female	29	33.04 (3.36)	0.809
	Male	24	33.27 (3.30)	
Balance	Female	29	21.24 (2.32)	0.843
	Male	24	21.41 (2.49)	
Aerobic	Female	29	22.17 (1.41)	0.247
	Male	24	21.54 (2.39)	
Training	Female	29	38.50 (2.70)	0.543
	Male	24	37.95 (3.61)	

SD standard deviations

p probability of two-sided significance of the Mann-Whitney *U* test

The absence of difference for the category of sports competence in our study was in accordance with other well-controlled studies in which authors found no effect of sports AVG on perceived object control skill among other FMS. In those studies, weekly frequency and duration were less than our study. One of them used Xbox Kinect [21] and the other Nintendo Wii game [5] consoles. Versions of Pictorial Scale of Perceived Competence for Young Children (PMSC) instead of CY-PSPP were used as measurement scales. Though insignificant changes in subdomains of SP profile such as sports competence, physical conditioning, physical strength and body attractiveness, the significantly higher values in favour of AVG children for the variables of PSW and GSW suggested a favourable effect of playing AVGs on physical SP, particularly when considering the three-tier hierarchal model of the physical SP profile. This finding was unique in our study and in accordance with the well-known fact that PSW is one of the elements affected mostly by PA [19]. Improving SP of the experienced performance in such a low dose AVG might be the leading cause of motivation associated with a positive feedback for the continuation of sports activities [33].

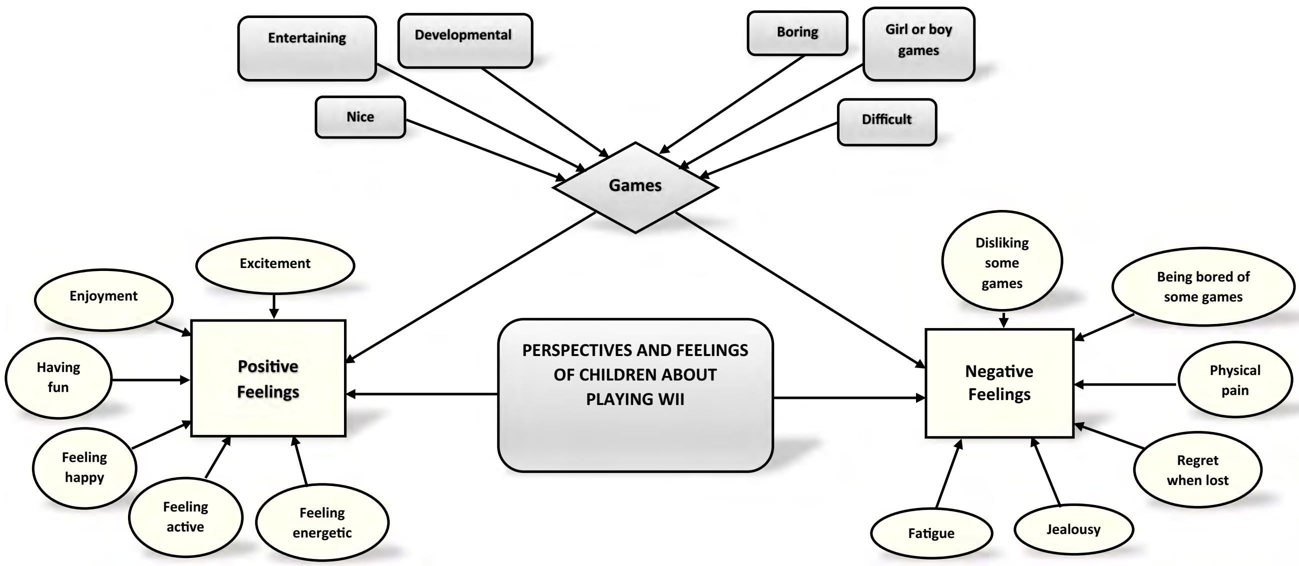

Fig. 2 Feelings and perspectives of children in the experimental group about active video games

The predominance of positive feelings in the qualitative part suggested that AVGs were as motivating as traditional physical education methods. The adherence of all children to the study protocol also added support to this observation. This motivation could be helpful for the engagement and continuation of the physical AVG activity due to the concepts of effectance and self-efficacy, suggested respectively by White and Bandura, separately [4]. The results suggested that PA analogous to FMS could be transferable to real life in accordance with the findings of Barnett et al. that children preferred AVGs for learning and transferring FMS to real life. In the qualitative part of the study, changes in PA for AVG children made us think that there was a good transferability of activities for AVG to real life [4]. Though authors have studied FMS in children who play AVG, the known association between FMS and PA suggested that skills gained thorough AVG can be transferred to real life. On the other hand, contrasting parental views from the present study about skill acquisition and transferability might be due to the diverse features of samples in the studies. The absence of children exposed previously to AVGs in our study may be accounting for the observed diversity since previously non-exposed children can benefit from games more than exposed children [4, 5]. The findings of trying novel games and practicing skills were similar to our study. The additional observations of intellectual, personal, social and physical changes could contribute to the continuation of games. Favourable outcome of a mitigating relationship with screens was in contrary to the findings by Forde et al. [18] that stated children in free-living conditions preferred to use AVG devices more frequently and longer as sedentary screen devices rather than their due active purposes. Though we did not study children at their homes, we could speculate that children's excitement and dedication to the use of AVG will decrease the sedentary screen time if sufficient dose and motivation by game variability besides supervision were provided.

The strong points of this study were its well-controlled design, use of national z scores [6], reliability and validity of the scales. We preferred a cluster-like randomization despite a participant-level analytic procedure in order not to increase type 1 statistical error due to the probable interference between AVG and C groups which might lead to the purchasing of AVG devices by C children. This might seem a limitation rather than a strong point. We opposed the idea of limitation since both groups were drawn from public schools and had similar parental education levels, thus did not differ in SES levels which might affect the outcomes [2, 28]. Internal validity was thought to be high due to the intervention implemented in a laboratory environment supervised by trained personnel. Owing to the strict exclusion criteria, we also speculated an acceptable external validity (generalisability with efficacy and effectiveness) of the results for the children at homes, particularly when supervised by parents [13]. Meanwhile, the qualitative part also allowed a phronetic approach to explore the perspectives in-depth as well as contributions and experienced changes of the participants by the AVG intervention. One of the flaws of the study was the observation of high dropouts in children of AVG group. We observed that parents did not wish their children's contribution to the study after school time due to an erroneous thought that it might affect their academic achievement. Another limitation was that we did not study the factors that might have influenced the outcome such as diet or other PA aside from AVG.

According to our results, AVGs might be used as an adjunctive tool in diverting children away from inactivity. By this means, children can overcome inactivity, obesity and related comorbidities, and also improve socializing, and intellectual and personal development.

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Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

Ethical approval The study was authorized by the local ethics committee for human research (protocol number 2012/15). All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards.

Informed consent All the parents received and signed the forms together with all children gave their oral assents prior to randomization in this research.

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