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Original article

Impact of active video games on the glycemic profile and nutritional status of adolescents

Impacto do videogame ativo sobre o perfil glicêmico e o estado nutricional de adolescentes com excesso de peso: um estudo de intervenção controlado

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ABSTRACT

Introduction: The interactive game is an intervention proposal, especially among young people, to promote physical activity. **Objective:** To test the hypothesis of the impact of physical activity using active video games on the glycemic profile of overweight adolescents. **Methods:** Controlled intervention study carried out in the second half of 2018. The sample consisted of 70 overweight adolescents, distributed in control and experimental groups, aged between 10 and 16 years old, enrolled between the 5th and 9th year of education elementary school II of public schools in the city of Campina Grande/ PB. Sociodemographic, lifestyle, nutritional status and biochemical variables were studied and a gamification strategy was adopted. The data were analyzed in SPSS 22.0 and the chi-square and paired t-test were performed, adopting a significance level of 5%. **Results:** The intervention improved BMI and reduced abdominal adiposity in adolescents, but did not cause significant changes in the glycemic profile. **Conclusion:** The use of active video games to increase physical activity in overweight adolescents in a school environment is an effective tool to improve the nutritional status of adolescents. Interventions with a longer duration need to be evaluated to verify possible effects on the glycemic profile. This is a viable, low-cost intervention that takes advantage of technological resources in line with the interests of the target population.

Keywords: obesity; adolescent; glycemic profile; physical activity.

RESUMO

Introdução: O jogo interativo é uma proposta de intervenção, sobretudo entre o público jovem, na promoção da atividade física. **Objetivo:** Testar a hipotese do impacto da atividade física com uso de videogame ativo sobre o perfil glicêmico de adolescentes com excesso de peso. **Métodos:** Estudo de intervenção controlado realizado no segundo semestre de 2018. A amostra foi composta por 70 adolescentes com excesso de peso, distribuídos nos grupos controle e experimental, com idade entre 10 e 16 anos, matriculados entre o 5º e o 9º ano do ensino fundamental II de escolas públicas do município de Campina Grande/ PB. Foram estudadas variáveis sociodemográficas, de estilo de vida, estado nutricional e bioquímicas e adotou-se uma estratégia de gamificação. Os dados foram analisados no SPSS 22.0 e foram realizados os teste qui-quadrado e t- pareado, adotando-se um nível de significância de 5%. **Resultados:** A intervenção melhorou o IMC e reduziu a adiposidade abdominal dos adolescentes, mas não causou alterações significativas sobre o perfil glicêmico. **Conclusão:** O uso do videogame ativo para aumentar a atividade física em adolescentes com excesso de peso em ambiente escolar é uma ferramenta eficaz para melhorar o estado nutricional de adolescentes. Intervenções com maior tempo de duração necessitam ser avaliadas para verificar os possíveis efeitos no perfil glicêmico. Esta é uma intervenção viável, de baixo custo e aproveita recursos tecnológicos em sintonia com interesse da população alvo.

Palavras-chave: obesidade; adolescente; perfil glicêmico; atividade física.

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Introduction

Due to the epidemiological changes that have occurred, it is believed that there will be a higher percentage of adolescents with high-adiposity than malnourished adolescents in the coming years [1].

Adolescence is considered the most critical period for obesity occurrence and, consequently, associated problems, as this phase is characterized by a low level of physical activity, the development and consolidation of sedentary behaviors, and changes in body composition. These facts make this period important for carrying out intervention and prevention measures [2].

Changes caused by physical exercise are already predicted in the lipid profile [3], blood glucose, blood pressure [4], and inflammation levels assessed by c-reactive protein (CRP) in obese individuals. In a randomized clinical trial [5], which evaluated the impact of one year of physical exercise on obese children and adolescents, beneficial changes were found in glycemic control (fasting blood glucose) in individuals undergoing the proposed intervention.

In this context, it is necessary to adopt strategies that motivate children and adolescents to practice physical activity, such as active games or exergames — technological games (video games) that require the participant's body movements to function [6].

This study was developed to test the hypothesis of the impact of a physical activity intervention using active video games (AVG) on the glycidic profile of overweight adolescents.

Methods

A controlled gamified intervention study, with two comparison groups: "control" - with no intervention, and "experimental" - active video game use, three times a week, for 50 minutes, for eight weeks. A hundred twenty-nine (129) eligible individuals with overweight/obesity were initially evaluated; after applying the exclusion criteria, 105 remained in the study. With the record of losses and dropouts (35), 70 adolescents made up the final sample. (Figure 1).

Two public schools in the top quartile of students in Campina Grande/PB were drawn. The intervention was allocated per school, one for the intervention and the other for the control, to avoid bias due to contact between the groups. In the urban area of the city, there are 20 municipal schools, of middle school, in the morning and/or afternoon shifts. The population of this study consists of adolescents aged between 10 and 16 years, 11 months and 29 days, overweight or obese, enrolled between the 5th and 9th year of middle school in the selected schools. In each school, all students who met these criteria were invited to participate in the study, respecting the minimum sample size according to the following parameters: average effect size of 0.75, alpha error of 0.05, and power of 80.0%, totaling a minimum of 29 individuals in each group.

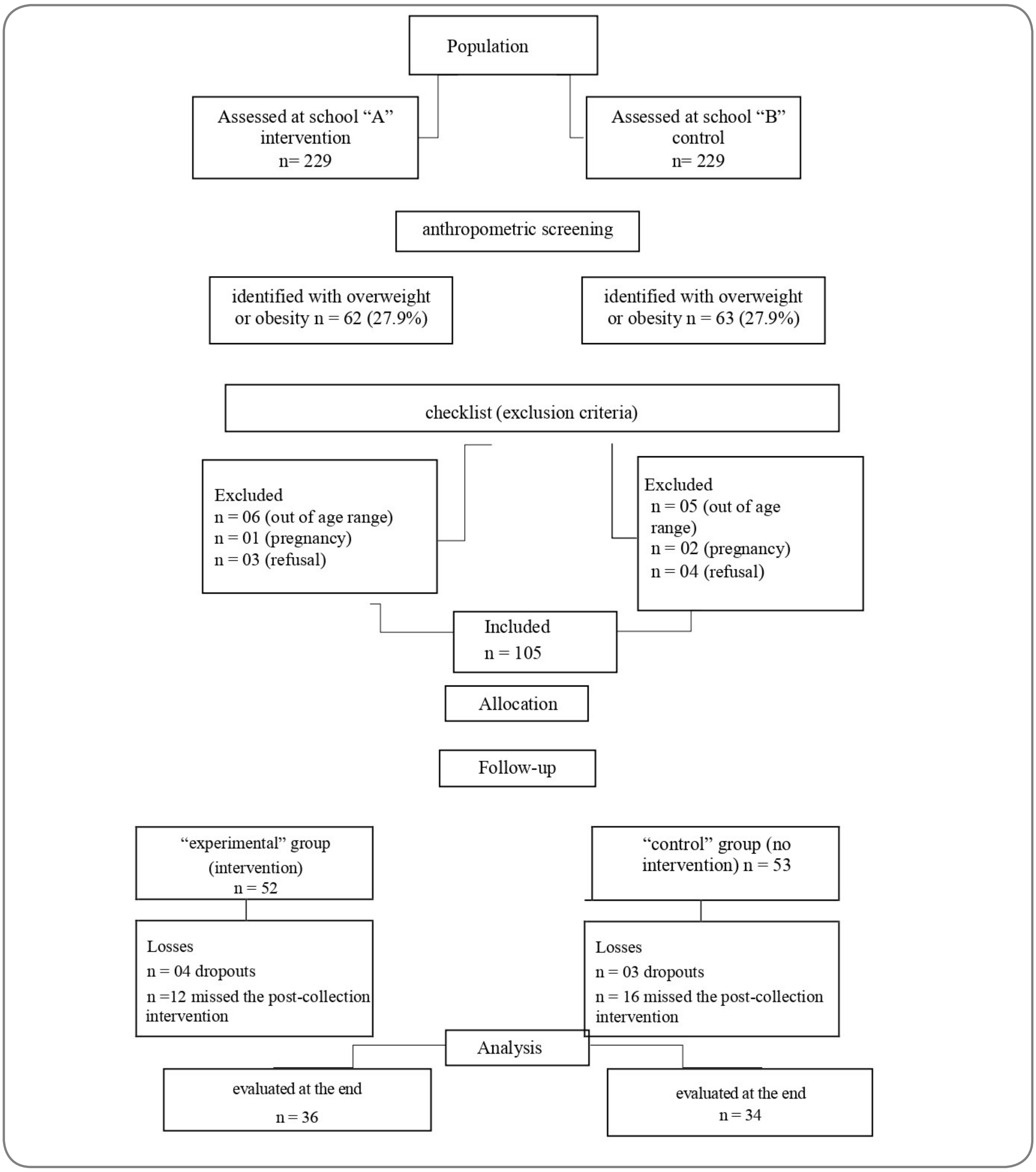

Figure 1 - Flowchart of participants involved in the study, Campina Grande, PB, 2018

The inclusion criteria used were: adolescents aged between 10 and 16 years, 11 months and 29 days; be a student enrolled between the 5th and 9th year of middle school in the selected schools of Campina Grande/PB; present a nutritional status characterized as overweight or obesity, according to age and gender, according to z-score.

Individuals who presented at least one of the following situations were excluded from the study: a condition that did not allow them to perform physical activity, such as motor or mental limitations, or diseases in which physical activity could be harmful, such as exercise-induced bronchospasm and cardiac arrhythmia; patients with hyperthyroidism, decompensated diabetes mellitus, genetic syndrome; being on some weight loss treatment; pregnancy, postpartum period or breastfeeding; active video game user. Cases of individuals who did not collect blood after the intervention or who gave up were considered losses.

Variables, procedures and data collection instruments

Sociodemographic variables (economic class, age, gender, and color), level of physical activity (active/inactive), nutritional status (overweight or obesity), and glycidic profile (fasting blood glucose, glycated hemoglobin, and insulin resistance, using the TyG index) were evaluated. Except for sociodemographic variables, all variables were evaluated in both groups (experimental and control) before and after the intervention. Emphasizing that the control group (without intervention) underwent only blood collections and questionnaires.

A form was applied to obtain sociodemographic and lifestyle information. The assessment of age, gender, and color was based on criteria from the Brazilian Institute of Geography and Statistics [7], the economic class was defined based on criteria from the Brazilian Association of Research Companies [8], and the level of physical activity was analyzed using the "International Physical Activity Questionnaire" (IPAQ), short version [9].

Nutritional status was assessed using the body mass index (BMI), constructed from the ratio of weight (in kg) to the square of height (in meters), following the recommendations of the World Health Organization (WHO, 2006), for the age group, considering: overweight when ≥ +1 BMI < +2 Z-Score and obesity when BMI ≥ +2 Z-Score.

Height and weight were measured in duplicate, considering the average values of the two measurements. To measure height, a portable stadiometer, Avanutri® brand, with an accuracy of 0.1 cm, was used; and to identify the weight, a Tonelli® digital scale was used, with a capacity of 150 kg and an accuracy of 0.1 kg. To obtain the measurements, the procedures recommended by the WHO were followed, and the adolescent had to be without shoes, accessories, or carrying objects.

Insulin resistance was assessed using the TyG index calculated from the equation: Tyg index=[log(fasting triglycerides (mg/dL) x fasting blood glucose (mg/dL)/2. Since there is no specific cutoff point for insulin resistance by the TyG index in this age group, the 90th percentile was adopted as a reference, with values equal to or greater than it being considered altered [10].

Waist circumference was measured with the adolescent in an upright position, with a relaxed abdomen, arms at their sides, feet together, weight equally supported by both legs, and breathing normally. The end of the last rib was located and marked; then, a measuring tape was positioned horizontally in the midline between the end of the last rib and the iliac crest and maintained so that it remained in position around the abdomen at the level of the umbilical scar, allowing the circumference to be read to the nearest millimeter. Values above the 90th percentile were considered increased according to the International Diabetes Federation (IDF), but with a maximum limit of 88 cm for girls and 102 for boys, according to the National Cholesterol Education Program Adult Treatment Panel III [11].

Abdominal adiposity was considered present when the waist circumference/height ratio was ≥ 0.5 [12].

Intervention and gamification

The intervention was carried out with adolescents in the experimental group. They used the active video game for fifty minutes, three times a week, for eight weeks.

To carry out the intervention, the XBox 360 platform was used, with the Kinect accessory (Microsoft®) to enable the user to control and interact only with the command of body movements, making them perform physical activity. Just Dance (2014 to 2018) was the game selected, as in addition to the fact that most dances can lead teenagers to achieve moderate intensity of physical activity, it is also reported in the literature [13] as the one that arouses the greatest interest among teenagers, in addition to allowing the intervention to be carried out in a group of four adolescents at the same time.

The intervention was carried out in reserved rooms at the selected school, at times available in the morning and afternoon shifts, and was supervised and controlled. To this end, the presence of adolescents on the day of the activity was recorded, and heart rate was monitored using a multilaser® Atrio frequency meter before (to calculate training frequency), during (to monitor exercise intensity) and after the activity (to assess hemodynamic stability). This equipment is a wireless transmitting heart strap to the wrist heart monitor.

Measurements were obtained during the intervention period to ensure that exercise was maintained at moderate intensity. The activities were carried out in sub-groups of up to four participants, guided and supervised by physical education professionals, physiotherapists, master's students, scientific initiation and/or extension students linked to the project, all previously trained.

The dances used for intervention were previously selected, including those that could lead to moderate intensity, and gathered in a block of 10 (GBLOCK). This selection was carried out by physical education students with experience in using this technology to promote physical activity.

To increase adolescents' engagement in the intervention activity, a gamification strategy was adopted, with the creation of new blocks of songs per week and the development of challenges measured by a properly calibrated team. The group earned points based on criteria created by the researchers, such as punctuality, group encouragement, posts about the intervention on social media, and individual and group performance (achieving a number of stars). There were weekly awards and a final award for the group that accumulated the most points at the end of the intervention.

Adolescent adherence was based on the frequency of attendance at physical activity sessions, as well as the performance of supervised activity.

In the control group, measurements were only taken in the same periods as in the experimental group.

Data analysis procedures and ethical aspects

The data were double-entered, initially submitted to Epi Info validation, and analyzed in SPSS 22.0. Normality distribution was assessed using the Kolmogorov-Sminorv test.

The chi-square test was applied to carry out a comparative analysis between sociodemographic characteristics (economic class: C, D, and E; A and B; gender: male and female; color: white and non-white); level of physical activity: (not active and active); nutritional status (overweight and obese); abdominal adiposity (WC/H ≥ 0.5 and WC/H < 0.5) and glycidic profile (fasting blood glucose ≥ 100.0 and < 100.0 mg/dL; glycated hemoglobin ≥ 5.7 and < 5.7 and insulin resistance ≥ P90 and <P90 of the TyG index) of adolescents in the two comparison groups at the beginning of the study. To evaluate the effect of the intervention on the measurement of waist circumference in each group, the paired t-test was used.

The study was developed in accordance with Resolution 466/2012 of the National Health Council and was approved by the Research Ethics Committee, CAAE: 84019518.3.0000.5187. In accordance with WHO recommendations, it was registered in Clinical Trials (NCT03532659) and REBEC (RBC-2xn3g6).

Results

Seventy (70) adolescents were evaluated, 36 in the experimental group and 34 in the control group. The two groups were similar in all characteristics, except gender, as there were more boys in the experimental group compared to the control. The majority of students were self-reported non-white (87%) and belonged to economic classes C, D, or E (68.6%).

Regarding lifestyle, 34.3% declared themselves as non-active, 40% were obese, and 61.4% had excess abdominal adiposity. None had changes in fasting blood glucose. However, 11.4% of the adolescents showed changes in glycated hemoglobin (Table I).

At the end of the intervention, it was found that the number of adolescents considered physically active increased to 56 (80.0%), although they were not associated with the group. Regarding nutritional status, of the total of 42 adolescents who were overweight, eight were classified as eutrophic, and cases of obesity were higher in the control school (n = 16; 55.8%). It was found that insulin resistance was no longer associated with the group (Table II).

Table I – Comparison of sociodemographic characteristics related to the practice of physical activity, nutritional status, and glycidic profile of adolescents from "experimental" and "control" schools at baseline. Campina Grande/PB, 2018

Variables	Total n = 70		Experimental school n = 36		Control school n = 34		P-value
	n	(%)	n	(%)	n	(%)	
Gender							
Female	37	52.9	24	66.7	13	38.2	0.017
Male	33	47.1	12	33.3	21	61.8	
Age (Years)							
10 – 12	23	32.9	15	41.7	08	23.5	0.106
≥ 12 Years	47	67.1	21	58.3	26	76.5	
Race/Color							
Black, Pardo, Indigenous	61	87.1	32	88.9	29	85.3	0.731*
White	09	12.9	04	11.1	05	14.7	
Economic class							
C, D and E	48	68.6	22	61.1	26	76.5	0.167
A and B	22	31.4	14	38.9	08	23.5	
Level of physical activity (prior to the study)							
Not active	24	34.3	11	30.6	13	38.2	0.499
Active	46	65.7	25	69.4	21	61.8	
Nutritional status							
Obesity	28	40.0	11	30.6	17	50.0	0.097
Overweight	42	60.0	25	69.4	17	50.0	
Abdominal adiposity							
Present (WC/H ≥ 0.05)	43	61.4	23	63.9	20	58.8	0.663
Absent (WC/H < 0.5)	27	38.6	13	36.1	14	41.2	
Fasting blood glucose (mg/dl)							
≥ 100	-	-	-	-	-	-	-
< 100	70	100.0	36	100.0	34	100.0	
Glycated hemoglobin hba1c (%)							
≥ 5.7	08	11.4	02	5.6	06	17.6	0.145*
< 5.7	62	88.6	34	94.4	28	82.4	
Insulin resistance (TyG index)							
≥ P90	07	10.0	02	5.6	05	14.7	0.253*
< P90	63	90.0	34	94.4	29	85.3	

WC/H = waist circumference/height ratio; *Fisher's exact test

Table II – Comparison of cardiometabolic risk factors among adolescents from schools randomized as "experimental" and control" after the intervention. Campina Grande/ PB, 2018

Variables	Total n = 70		Experimental school n = 36		Control school n = 34		P-value
	n	(%)	n	(%)	n	(%)	
Level of physical activity							
Not active	4	20.0	7	19.4	07	20.6	0.905
Active	56	80.0	29	80.6	27	79.4	
Nutritional status (n= 62)*							
Obesity	25	40.3	9	27.3	16	55.2	0.025
Overweight	37	59.7	24	72.7	13	44.8	
Abdominal adiposity							
Present (WC/H ≥ 0.05)	38	54.3	21	58.3	17	50.0	0.484
Absent (WC/H < 0.5)	32	45.7	15	41.7	7	50.0	
Fasting blood glucose (mg/dL)							
≥ 100	-	-	-	-	-	-	-
< 100	70	100.0	36	100.0	34	100.0	
Glycated hemoglobin HbA1c (%)							
≥ 5.7	08	11.4	02	5.6	06	17.6	0.145*
< 5.7	62	88.6	34	94.4	28	82.4	
Insulin resistance (TyG Index)							
≥ P90	06	8.6	04	11.1	02	5.9	0.674*
< P90	64	91.4	32	88.9	32	94.1	

WC/H = waist circumference/height ratio; *Eight adolescents reached the nutritional status of eutrophy; *Fisher's exact test

Discussion

In the present study, it was observed that obesity was present in 40.0% of them and abdominal adiposity in 61.4%. Although no change in fasting blood glucose was recorded (above 100 mg/dL), there was an increase in glycated hemoglobin in 11.4% and insulin resistance in 10.0%. Of the total, 34.3% were classified as non-active (inactive or irregularly active).

In a study carried out [13] with 54 obese and overweight adolescents aged between 15 and 19 years, in which a 20-week intervention was carried out to evaluate whether the exergame would produce weight loss. It was concluded that the use of active video games increased significantly caloric expenditure of these adolescents, in addition to promoting weight loss. Likewise, an active video game intervention was carried out in overweight children for 24 weeks, and a significant decrease in BMI was observed among participants [14]. A previous study also carried out with adolescents no positive effects of AVG on BMI had been found. The authors attributed the lack of change in nutritional status to the intervention time, which was considered short in the 2017 study (12 weeks); however, longer than that of the present study, which was eight weeks, and managed to record a reduction in BMI and of abdominal adiposity [15].

This reinforces the need to evaluate body composition since it is already known that when starting to practice physical exercise, muscles begin to develop, which can affect weight [16]. It also highlights the importance of checking the intensity of the exercise, in addition to the frequency and duration, as well as other aspects of the lifestyle, such as food consumption, aspects that can affect the outcomes in question [17].

Furthermore, unlike the studies mentioned, the present study was controlled and supervised so that the adolescents carried out the intervention in front of one of the researchers, who applied gamification techniques (collaboration, encouragement, and carrying out the activity in groups, for example) to ensure moderate exercise intensity throughout the execution time (50 minutes). In 2012, Staiano *et al*. [14] stated that cooperative games were capable of producing greater intrinsic motivation and are more often associated with greater energy expenditure during the game. A systematic review published in 2019 indicated that cooperative games involving exergames were more attractive to overweight children and adolescents compared to those with normal weight, generating greater satisfaction, self-efficacy, and positive expectations, which may favor adherence and commitment among young people [18].

The ability of exergame to promote an increase in energy expenditure has been described in the literature [19]. However, its effects on the metabolic profile require more attention.

Although diabetes mellitus (DM) mainly affects individuals from the fourth decade of life onwards, an increase in incidence has been noticed in children and young people [20]. A study carried out in some American states between 2002 and 2012, observed an increase of 7% per year in the prevalence of DM in this population [21].

Although the population in this study is young and considered normoglycemic, the changes observed in glycated hemoglobin and insulin resistance may already demonstrate changes in glucose metabolism. Furthermore, this is an overweight population and it is already well established that obesity is associated with a multitude of metabolic and clinical restrictions, which result in a greater risk of developing cardiovascular complications and metabolic diseases, particularly resistance to insulin and type 2 diabetes [21].

Methodological differences, especially regarding the method adopted and the cutoff points for diagnosing IR using the TyG index, make it difficult to compare previously published results. One of the possibilities for not having observed an impact of the intervention on the glycidic profile is that this is an initially normoglycemic population, and fasting blood glucose is used to calculate the TyG index, adopted to assess insulin resistance. The values of triglycerides are also included in the calculation of this index, which can be reduced during exercise but increase again immediately after the so-called “detraining” so that these possible fluctuations can end up interfering with the values of the TyG index [21].

After the intervention with AVG, it was observed that there was a reduction in AC. This result is similar to that found in a study [22] in Turkey, which analyzed 50 overweight or obese adolescents. After an exercise program using the AVG over 8 weeks, participants’ AC values decreased significantly.

Some studies have been carried out to evaluate the effectiveness of AVG in combating obesity in children and adolescents [23]. In an experimental study [24] carried out in New Zealand with 20 adolescents, the effects of AVG on the anthropometric profile and level of physical activity were evaluated over 12 weeks. After the intervention, the group showed higher levels of physical activity and decreased body weight and waist circumference, corroborating the results of the present study.

The use of AVG as an innovative tool for controlling childhood obesity has been observed by health professionals since the benefits include adherence and increased levels of physical activity, reduced consumption of low-nutrition foods, and increased energy expenditure, with direct repercussions on the main comorbidities associated with childhood obesity [25].

Conclusion

In this study, active video games did not cause a reduction in glycemic values in overweight and obese adolescents. However, we observed a reduction in body mass index and abdominal adiposity in the sample that played the active video game. Therefore, the use of active video games to increase physical activity in adolescents with obesity or overweight in a school environment can be an effective tool for a better lifestyle and changing sedentary habits. New studies with longer intervention time are suggested to better understand the impact of active video game use on the glycemic profile of overweight or obese adolescents in a school environment.

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Authors’ contributions
Conception and design of the research: Guimarães ALV, Carvalho DF; **Data collect:** Guimarães ALV, Carvalho D; **Data analysis and interpretation:** Guimarães ALV, Carvalho DF; **Manuscript writing:** Guimarães ALV, Carvalho DF, Oliceira RC; **Critical review of the manuscript for important intellectual content:** Guimarães ALV, Carvalho DF, Oliceira RC.

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