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IMPACT OF SOFTWARE FOR MOBILE DEVICES ON THE BEHAVIOR OF ADOLESCENTS IN OBESITY PREVENTION

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ABSTRACT

Objective: to analyze the impact of educational software on the behavior of adolescents about obesity prevention in two public schools of Divinópolis-MG.
Method: uncontrolled clinical trial involving 238 adolescents, in the city of Divinópolis, MG, Brazil. Between June and October 2018, weight and height were measured, 24-hour dietary recall was performed, physical activity level was verified, socioeconomic classification and the stage of readiness for behavioral change was evaluated. The McNemar test was used to compare the qualitative variables. For the effect of the intervention on the quantitative variables, the Generalized Estimating Equations model was used. In the intervention, the educational game Healthy Running was used, developed for this study. Data were collected before and two months after the intervention.
Results: among the participants, 62.6% are female, with a median age of 16.7 years, ranging from 15 to 19 years. Regarding the nutritional situation before the intervention, 18.5% had excess weight. As to the level of physical activity is concerned, 50.4% were classified as active. After the intervention, the z-score of body mass index for males showed a significant improvement ($p<0.000$), as well as the level of physical activity ($p<0.001$).
Conclusion: the use of the educational game was valid and presented relevant results in improving the adolescents' behavior regarding food and physical activity. The use of the educational game can be considered appropriate to support education in the health area.

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DESCRIPTORS: Obesity. Software. Adolescent. Experimental games. Nutrition Therapy.

IMPACTO DE UM *SOFTWARE* PARA DISPOSITIVOS MÓVEIS NO COMPORTAMENTO DOS ADOLESCENTES NA PREVENÇÃO DA OBESIDADE

RESUMO

Objetivo: analisar o impacto de um *software* educativo no comportamento dos adolescentes acerca da prevenção da obesidade em duas escolas públicas de Divinópolis-MG.
Método: ensaio clínico não controlado com 238 adolescentes, no Município de Divinópolis, MG, Brasil. Entre os meses de junho e outubro de 2018, foram aferidos peso e altura, realizado recordatório alimentar 24 horas, verificados nível de atividade física, classificação socioeconômica e avaliado o estágio de prontidão para mudança de comportamento. Para comparação das variáveis qualitativas, utilizou-se o teste de McNemar. Para o efeito da intervenção sobre as variáveis quantitativas utilizou-se o modelo de Equações de Estimativas Generalizadas. Na intervenção, foi utilizado o jogo educacional *Healthy Running*, desenvolvido para este estudo. Os dados foram coletados antes da intervenção e dois meses após.
Resultados: entre os participantes,62,6% são do sexo feminino, com uma mediana de 16,7 anos de idade que variou de 15 a 19 anos. Sobre a situação nutricional antes da intervenção,18,5% apresentou excesso de peso. Quanto ao nível de atividade física,50,4% foram classificados como ativos. Após a intervenção o escore-z de Índice de Massa Corporal para o sexo masculino apresentou uma melhora significativa (p<0,000), assim como o nível de atividade física (p<0,001).
Conclusão: o uso do jogo educacional foi válido e apresentou resultados relevantes na melhora do comportamento dos adolescentes a respeito da alimentação e atividade física. O uso do jogo educacional pode ser considerado adequado no apoio à educação na área da saúde.

DESCRITORES: Obesidade. *Software*. Adolescente. Jogos experimentais. Terapia Nutricional.

IMPACTO DE UN *SOFTWARE* PARA DISPOSITIVOS MÓVILES EN EL COMPORTAMIENTO DE LOS ADOLESCENTES EN LA PREVENCIÓN DE LA OBESIDAD

RESUMEN

Objetivo: analizar el impacto de un *software* educativo en el comportamiento de los adolescentes acerca de la prevención de la obesidad en dos escuelas públicas de Divinópolis-MG.
Método: ensayo clínico no controlado con 238 adolescentes, en el municipio de Divinópolis, MG, Brasil. Entre los meses de junio y octubre de 2018, se evaluaron peso y altura, se realizó recordatorio alimentario 24 horas, se verificaron nivel de actividad física, clasificación socioeconómica y se evaluó la etapa de preparación para cambio de comportamiento. Para comparación de las variables cualitativas, se utilizó la prueba de McNemar. Para el efecto de la intervención sobre las variables cuantitativas se utilizó el modelo de Ecuaciones de Estimativas Generalizadas. En la intervención, se utilizó el juego educativo *Healthy Running*, desarrollado para este estudio. Los datos fueron recolectados antes de la intervención y dos meses después.
Resultados: entre los participantes,62,6% es del sexo femenino, con una mediana de 16,7 años de edad, que varió de 15 a 19 años. Sobre la situación nutricional antes de la intervención,18,5% presentó exceso de peso. Respecto al nivel de actividad física,50,4% fue clasificado como activo. Después de la intervención, el score-z de Índice de Masa Corporal para el sexo masculino presentó una mejora significativa (p<0,000), así como el nivel de actividad física (p<0,001).
Conclusión: el uso del juego educacional fue válido y presentó resultados relevantes en la mejora del comportamiento de los adolescentes respecto a la alimentación y actividad física. El uso del juego educativo puede considerarse adecuado para apoyar la educación en el área de la salud.

DESCRIPTORES: Obesidad. *Software*. Adolescente. Juegos experimentales Terapia Nutricional.

INTRODUCTION

The World Health Organization defines obesity and overweight as excessive fat accumulation that presents a risk to individuals' health and wellbeing, presenting alarming data and increased prevalence at an accelerated rate around the world.[1]

Genetic inheritance contributes to the development of obesity, but its etiology is complex and multifactorial, also including metabolic, environmental, behavioral, and emotional factors.[2] The decrease in the level of physical activity, the modernization of societies, and the increased consumption of high-calorie foods were some of the behavioral changes that have occurred in recent decades and have contributed to the worsening of obesity.[3]

In Brazil, the problem also presents worrying results. Data from the 2008-2009 Family Budget Survey (POF) showed a prevalence of excess weight in adolescents corresponding to 21.7% for males and 19.4% for females.[4] More and more children and adolescents have chronic and metabolic diseases due to obesity. This syndrome is responsible for 7% of global deaths. The prevalence of metabolic syndrome among Brazilian adolescents corresponds to 2.6%, mainly caused by inappropriate diet and physical inactivity.[5]

To generate healthy adults, prevention and health promotion measures are necessary while still in childhood, as well as an appropriate infrastructure for recreational and physical exercise and an evolution in nutritional education.[6] In education, like in all areas of work, technology is increasingly present, which turns the educational landscape more and more dynamic and challenging. Known as the digital generation, adolescents yearn for new techniques and technologies for the health area, especially when it comes to digital education, to serve as a differential in gaining their attention, as it demonstrates preference for new technologies when compared to a traditional strategy aimed at education and health promotion.[7]

Knowledge promotion needs to happen in an attractive and efficient manner, which is possible when using educational games as a tool in health education for adolescents. Educational games can be considered tools that are fun, but are also capable of facilitating and assisting learning, and can facilitate behavioral changes by promoting a rearrangement of educational contingencies.[8]

Thus, this study aimed to analyze the impact of using an educational game for mobile devices on the behavior of adolescents regarding obesity.

METHOD

This is a non-controlled clinical trial with a before and after design. The research was conducted at two public schools in the city of Divinópolis, state of Minas Gerais, from June to October 2018.

At those school, 2025 students are regularly enrolled in the age group between 15 and 19 years, which are the population eligible for this study. Considering a 23.7% prevalence of excess weight,[9] 95% confidence level and 5% sampling error, a sample of 238 adolescents was calculated. For the calculations, Open Epi version 3.01[1] was used. To participate in the research, being enrolled in high school, being present in the classroom on the days of data collection, having a smartphone with the *Android* operating system and being 15 to 19 years old were defined as inclusion criteria. The exclusion criterion of being a pregnant adolescent was adopted. The age range set is justified because it fits into the chronological limit of adolescence defined by the World Health Organization (WHO), which is between 10 and 19 years old.

[1] Available from: http://www.openepi.com

The study design consisted of three stages: 1) presentation of the research project, recruitment of participants, and assessment of nutritional status, socioeconomic level, level of physical activity, and stage of readiness for behavioral change; 2) intervention using the educational game; 3) at two months after the intervention, reassessment of nutritional status, socioeconomic and physical activity levels and stage of readiness.

The data from the 24-hour food recall were converted into grams with the help of the table for evaluation of food consumption in home measurements.[10] The International Physical Activity Questionnaire (IPAQ) was used to measure physical activity.[11] The families' socioeconomic class was assessed through the questionnaire and classification criteria of the Brazilian Association of Research Companies (ABEP).[12] To measure the stage of readiness for change in eating behavior and physical activity, a standardized and validated questionnaire was used for the Brazilian population and the study participants' age group.[13]

To develop the Healthy Running game, the serious game concept was used. This is a type of game in which education is the main goal, besides being interesting, enjoyable and fun, and having purposes beyond fun.[14]

Teachers and students in graduate students helped to produce the Healthy Running game, including nurses, nutritionists, and computer scientists. The teachers and students in the health area discussed the theme and the content to be presented in the game with a view to addressing didactic content, while the programmer developed the necessary mechanics for the game.

The development of the game was iterative and incremental. The scope of the game was defined in the first stage and then divided into stages for delivery, in which the parts of the process are repeated until all functions have been developed. This facilitates the validation of each proposed goal and the gradual evolution of the game.[15]

Iterative development is based on the idea of providing an initial version of the software for users to be able to test it and present their point of view on the product, through new requirements, until the desired version is obtained.[15] In summary, iterative development uses four important steps in the software development process: requirements survey/ analysis, design, development and testing. With this division, the software is developed in stages and, at the end of each stage, a testable version is delivered.

Healthy Running combines a platform game and a running game. It allows the participant to go through a teenager's main daily meals, such as breakfast, snack, lunch, afternoon snack, dinner, and late-night snack. First, the rules of the game are shown, as well as some definitions of food types presented during the game. For each meal, types of food and drinks are suggested that can be consumed, at the participant' discretion. There are items in the game that, when collected, show a question about natural, processed, and ultra-processed foods and about behavioral choices of physical activity and eating. At the end, the participant's score is calculated according to the food choices, along with the answers to the questions answered during the game. For each stage, a minimum number of questions to be answered was set in order to proceed to the next meal (stage).

The content of the game was based on the literature and sources produced by the Federal Health Department. To define the food schedule, the Food Guide for the Brazilian Population was consulted,[16] as well as the definition of the types of foods: natural, processed, and ultra-processed.

To show the amount of sugar in some sweets and drinks and provide notions of weight gain in the short and long term, based on the daily consumption of these foods; compare complete meals and usually consumed foods with other foods and preparations of high caloric value and low nutritional value; to stimulate the consumption of fruits and vegetables, the Imaging tool of dietary and nutritional education was used to promote healthy eating.[17] To work with behavioral nutrition, the concept of

hunger and satiety is presented to the participants through the odometer of hunger.[18] Finally, for the health report card, which is the result of the participant's choices during the game, the pocket version of the Food Guide for the Brazilian population was used,[16] where 18 questions are presented to check the diet and, based on the answers, a classification is presented.

Throughout the development, various tests were applied to the content developed until reaching a stable version that permitted the assessment of the game by external people. Ten experts participated in the assessment of the game, three from the computer area and seven from the health area.

The evaluators from the computer area had a degree in computer science, information systems and computer engineering. All were male, between 27 and 35 years of age, with a mean age of 27.7 years. The evaluators from the health area had a degree in nutrition, physical education and physiotherapy, being four women and three men. The ages ranged from 28 to 35 years, with a mean age of 31.7 years. The tool used to assess the game is a semistructured questionnaire for educational games called *EGameFlow,*[19] which, according to the authors, is a version of the *GameFlow* tool for educational games. Its main function is to assess the level of satisfaction the users experience during the game accurately and precisely.

The final version of the instrument contains 42 items allocated in eight dimensions: Concentration (6 items); Goal clarity (4 items); Feedback (5 items); Challenge (6 items); Control (7 items); Immersion (7 items); Social interaction (6 items); Knowledge improvement (7 items).[19] The categories with the highest averages were Goal clarity and Knowledge improvement, while the lowest averages were for Challenges and Autonomy.

The intervention began by installing the educational game on the adolescents' smartphone using the USB cable, without the need for internet. Then, the game was presented to the teenagers, who kept the game installed for 15 days, after which it was uninstalled from the devices.

To formulate the database, EPIDATA was used, together with all questions on the forms. This software made it possible to validate the information and prepare the data for statistical analysis.

For the statistical analysis of the data, Statistical Package for Social Sciences (SPSS) version 20.0 was used. The data analysis started by calculating the frequency distributions and central trend and dispersion measures. The Shapiro Wilk normality test, as well as the normal quantile graphs, indicated the asymmetric distribution of the data. The McNemar test was used to compare the qualitative variables. The effect of the intervention on the quantitative variables was obtained by comparing the median values before and after the nutritional intervention, using the Generalized Estimated Equations (GEE) model. To analyze the variable z-score of the Body Mass Index (BMI), only adolescents with excess weight (overweight or obesity) before the intervention were considered. The variables were treated as gamma distribution, with the log link function. The work correlation matrix used was the covariance matrix of the robust and unstructured estimator. Non-standardized coefficients and their respective confidence intervals (95% CI) were calculated.

All ethical and legal principles for research involving human beings were complied with, after obtaining approval from the Ethics Committee for Research involving Human Beings at the Federal University of São João del-Rei, Central-West Campus Dona Lindu.

RESULTS

The study included 238 adolescents, 62.6% of whom were female, with a median age of 16.7 years, ranging from 15 to 19 years. Regarding the socioeconomic level, 52.1% are in classes B1 and B2, that is, with an average household income between R$ 4427.36 and R$ 8695.88, with 18.5% and 33.6% respectively. As for the adolescents' nutritional status before the intervention, 18.5% of the studied population presented excess weight (overweight and obesity). What the level of physical activity is concerned, 50.4% were classified as active (Table 1)

Table 1 – Distribution of adolescents regularly enrolled, according to sociodemographic and health characteristics before the intervention. Divinópolis, MG, Brazil, 2018. (n=238)

Characteristics		n	%
Gender	Female	149	62.6
	Male	89	37.4
Age range	Up to 15 years	21	8.8
	16 to 16 years	166	69.8
	18 to 19 years	51	21.4
Socioeconomic Class	A	25	10.5
	B1 – B2	124	52.1
	C1 – C2	82	34.4
	D - E	7	2.9
Nutritional Status	Normal Weight	188	78.6
	Overweight	39	16.4
	Obesity	5	2.1
	Low Weight	7	2.9
	Very Low Weight	2	0.8
Level of Physical Activity	Very active	47	19.7
	Active	120	50.4
	Irregularly active	50	21.0
	Sedentary	21	8.8

At the end of the intervention, the prevalence of excess weight among the adolescents evaluated was 16.0%, representing a significant reduction of 2.5% (p=0.031) according to the McNemar test. When evaluating the effect of the intervention on the BMI z-score by age of adolescents with excess weight before the intervention, a significant reduction in median values (β=-0.05; p<0.001) was found, thus representing an improvement in the adolescents' nutritional status. When evaluating the effect of the intervention stratified by sex, however, the reduction in the BMI z-scores was significant only for males (β=-0.09; p<0.001) (Table 2).

Table 2 – Comparison of BMI z-scores for adolescents with excess weight before the intervention, total and stratified by sex. Divinópolis, MG, Brazil, 2018. (n=44)

Variables	Before Intervention	After Intervention	β (95% CI)*	p†
	Median (min-max.)	Median (min-max.)		
Total BMI z-score	1.43 (1.01-2.93)	1.36 (0.66-2.92)	-0.05 (-0.07--0.03)	**0.000**
BMI z-score by gender				
Female	1.29 (1.01-2.81)	1.29 (0.88-2.69)	-0.02 (-0.04-0.00)	0.083
Male	1.53 (1.06-2.93)	1.40 (0.66-2.92)	-0.09 (-0.13--0.44)	**0.000**

***β =** non-standard Beta for post-intervention comparison between variables, adjusted by socioeconomic level; †Generalized Estimating Equations.

With regard to the stage of readiness for behavioral change before the intervention, it is important to highlight that, for the domain corresponding to portions, most of the adolescents (43.3%) were in contemplation stage while, for the other domains evaluated, most of the adolescents were in the stage of preparation for behavioral change (Table 3).

Table 3 – Adolescents' stage of readiness for behavioral change before the intervention. Divinópolis, MG, Brazil, 2018. (n=238)

	Stage of Readiness				
	Pre-contemplation n (%)	**Contemplation n (%)**	**Preparation n (%)**	**Action n (%)**	**Maintenance n (%)**
Portions	53 (22.3)	103 (43.3)	61 (25.6)	21 (8.8)	0 (0.0)
Fat	27 (11.3)	77 (32.4)	86 (36.1)	33 (13.9)	15 (6.3)
Fruits and Vegetables	26 (10.9)	55 (23.1)	99 (41.6)	50 (21.0)	8 (3.4)
Physical Activity	22 (9.2)	69 (29.0)	100 (42.0)	42 (17.6)	5 (2.1)

Regarding the adolescents' level of physical activity, there was a significant difference after the intervention (p< 0.001). Despite the reduction in the number of active adolescents, an increase can be observed in the proportion of adolescents classified as very active, as well as a decrease in the proportion of insufficiently active and sedentary adolescents (Table 4).

Table 4 – Level of physical activity before and after the intervention. Divinópolis, MG, Brazil, 2018. (n=238)

Level of Physical Activity	**Before**	**After**	**p†**
	n (%)	**n (%)**	
Very active	47 (19.7)	83 (34.9)	< 0.001
Active	120 (50.4)	92 (38.7)	
Insufficiently active	50 (21.0)	45 (18.9)	
Sedentary	21 (8.8)	18 (7.6)	

† McNemar test

When evaluating the effect of the intervention on the food habits and consumption, a significant increase was found in the median number of daily meals (β = 0.06; p = 0.006), which represents a greater fractionation of meals the adolescents consumed throughout the day. In addition, there was a significant increase in the amount of water consumed daily (β=0.32; p<0.001) and in the median zinc intake (β=0.194; p< 0.05) (Table 5).

Table 5 – Effect of the intervention on the number of daily meals, water and nutrient intake after the intervention. Divinópolis, MG, Brazil, 2018. (n=238).

Variables	Intervention		β (95% CI)*	P-value†
	Before	After		
	Median (Min-Max)	Median (Min-Max)		
Daily meals	3 (3-5)	4 (3-5)	0.06 (0.02-0.11)	**0.006**
Daily water intake (liters)	2.0 (1.0-2.0)	2,0 (2,0-3,0)	0.32 (-0.18-0.83)	**0.000**
Nutrients				
Energy (kcal)	1531.9 (1150.7-2184.2)	1655.9 (1219.6-2424.9)	-0.03 (-0.16-0.10)	0.671
Cholesterol (mg)	169.0 (94.2-285.4)	180.1 (106.3-324.9)	0.18 (-0.04-0.20)	0.184
Fibres (g)	10.2 (5.8-14.9)	8.2 (4.7-13.9)	0.38 (-0.23-0.08)	0.382
Vitamin A (mcg)	205.3 (65.0-413.5)	212.9 (74.4-404.7)	-0.05 (-0.28-0.18)	0.661
Vitamin D (mg)	0.8 (0.3-2.4)	1.1 (0.5-2.8)	0.26 (-0.53-1.06)	0.512
Calcium (mg)	328.7 (169.4-569.6)	337.8 (186.7-597.6)	0.07 (-0.08-0.22)	0.374
Iron (mg)	9.8 (6.9-14.4)	9.6 (6.9-16.1)	0.09 (-0.48-0.67)	0.746
Zinc (mg)	6.5 (3.6-9.9)	6.7 (3.4-12.0)	0.194 (0.01-0.37)	**0.037**

*** β =** non-standard Beta for post-intervention comparison between variables;
†Generalized Estimating Equations

DISCUSSION

The results found in this study indicate that the educational game was effective to reduce the prevalence of excess weight among the adolescents participating in the study. In addition, it was relevant in changing some behavioral aspects in the adolescents, regarding eating habits and physical activity. In line with the study, recent research states that despite the good results when using health applications on mobile devices, not all studies were able to stimulate behavioral change in the participants.[8]

A significant reduction of (β=0.09; p<0.001) was found in the z-score of BMI by age, especially for males. These findings but reinforce the need to consider biological differences between genders when proposing interventions aimed at reducing the prevalence of overweight and obesity. In a multiprofessional intervention study, however, better results were found for females (β = 0.29; p<0.001).[20]

Regarding the level of physical activity, significant differences were found after the intervention, reducing the proportions of adolescents classified as insufficiently active or sedentary (p < 0.001), which reflects the lifestyle improvements. The participation of individuals in physical activities is recognized as a healthy lifestyle. Among adolescents, participation in physical activity programs is an item to prevent physical and organic disorders.[21]

Although the results showed a significant improvement for zinc intake only, there is an increase in median values for most of the micronutrients evaluated, such as calcium, vitamins A and D, which

should be considered positively, as the adolescents are vulnerable to nutritional deficiencies due to the demand resulting from the intense growth characteristic of this phase.[22]

Reinforcing the benefit achieved in this investigation regarding the significant increase in the number of daily meals, a study shows that adolescents who eat four or more meals a day are 50% less likely to have excess weight when compared to those who eat up to three meals a day. The same study reports that obesity was predominant among the students who ate less meals per day.[23]

One limitation in the study was that the stage of sexual maturation was not evaluated, which did not permit showing the adolescents' individual energy needs for comparisons with the calorie intake estimated by the Food Survey. This would possibly justify the increase in median energy values found after the intervention, as the increased energy demand coincides with the growth peak in this age group, increasing the appetite and nutritional needs, which are influenced by the normal events of puberty and the stage of sexual maturation.[24]

Readiness for change is defined as the importance the individual grants to his problem, along with his ability to change.[25] In this study, before the intervention, it could be observed that only for the domain regarding the number and size of portions, a large part of the adolescents (43%) were in the contemplation stage. This indicates that the adolescents recognize the problem, are willing to overcome it, but do not yet show a decisive commitment in their knowledge of the benefits of change (such as the adoption of habits to achieve healthy weight), but several barriers prevent the desired action (for example, price, lack of time, unpleasant taste of foods considered healthy).[25]

As noticed in this study, the objectives were achieved and the impact of using an educational game on the prevention of obesity in adolescents could be analyzed. According to the reviewers, the game has a pedagogical and amusing value regarding the topic.

Regarding the use of the serious game, the results proved its importance, as it adapted through the evaluation involving computer and health experts. This strengthens the importance of validating an educational game/software/program and is in line with the results of other studies that used a serious game for educational support.[19]

The study could have presented more significant values if the intervention period had been longer. It is worth noting that certain behavior patterns are key points for intervention programs.[28] Some cultural characteristics can have a relevant impact on the behaviour of young people and their prospects for change over time. These profiles should be investigated separately, and strategies and actions need to be tested that respect these populations' way of life.[26]

Educational games are tools that, in addition to providing fun, are also able to assist students with learning and can facilitate behavioral changes by providing new educational contingencies.[8]

Thus, interventions involving educational games/software to support dietary and nutritional education and physical activity are important for the sake of motivation for healthy living, increasing people's knowledge on the prevention of obesity, considering the importance of awareness raising and consequent lifestyle changes.

CONCLUSION

In view of the data presented, the intervention using a technological tool aimed at the awareness raising of young people regarding healthy eating practices and physical activity is paramount in this age group, being effective to expand the adolescents' knowledge and promote important changes related to students' healthy living behaviors.

The proposal to develop educational games as an educational support tool was very relevant. The game can be a differential in the prevention of obesity in adolescents and will enable future studies that explore new health promotion strategies.

The game will be available free of charge as an open educational resource, thus benefiting the academic community and society in general.

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NOTES

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APPROVAL OF ETHICS COMMITTEE IN RESEARCH

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CONFLICT OF INTEREST

There is no conflict of interest.

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