Serious game assessment in a child obesity tackling program
Avaliação de *serious game* em programa de enfrentamento da obesidade infantil
Evaluación de *serious game* en programa de combate a la obesidad infantil

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Abstract

Objective: To assess a serious game as an educational strategy for children in a program to tackle overweight and obesity.

Methods: This is methodological, quantitative and cross-sectional research. Children from a physical conditioning program with interactive games for obese and/or overweight children participated in the study (n=13). Participants' profile was made through anthropometric data, questionnaires about their eating habits and physical activity. Subsequently, the serious game DigesTower was presented as an additional strategy to the program and the game was assessed by the target audience.

Results: Children aged seven to 11 years with overweight and obesity participated. DigesTower was well received by the participants, who claimed to have immersion, motivation and encouragement to improve their knowledge. The final version of the game was developed and made available online for free and publicly

Conclusion: The study sought to encourage the use of innovative tools to assist as educational interventions in the field of childhood obesity and the serious game was assessed as a potential educational strategy for children. It is hoped that this study will inspire future research in which its objects of study are the development of digital games for children.

Resumo

Objetivo: Avaliar um *serious game* enquanto estratégia educativa para crianças em um programa de enfrentamento de sobrepeso e obesidade.

Métodos: Pesquisa metodológica, com abordagem quantitativa e de corte transversal. Participaram do estudo as crianças pertencentes a um programa de condicionamento físico com *games* interativos para crianças obesas e/ou sobrepeso (n=13). Foi feito o perfil dos participantes por meio de dados antropométricos, questionários sobre seus hábitos alimentares e de atividade física. Posteriormente, o *serious game DigesTower* foi apresentado como uma estratégia adicional ao programa e realizada a avaliação do jogo pelo público-alvo.

Resultados: Participaram crianças de sete a 11 anos com sobrepeso e obesidade. O *DigesTower* foi bem recebido pelos participantes, que afirmaram ter imersão, motivação e estímulo para melhoria do seu conhecimento. A versão final do jogo foi desenvolvida e disponibilizada *online* de forma gratuita e pública.

Conclusão: O estudo buscou incentivar o uso de ferramentas inovadoras para auxiliar como intervenções educativas no âmbito da obesidade infantil e o *serious game* foi avaliado como uma potencial estratégia educativa para crianças. Almeja-se que este estudo inspire futuras pesquisas em que seus objetos de estudo sejam o desenvolvimento de jogos digitais para o público infantil.

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Resumen

Objetivo: Evaluar un *serious game* como estrategia educativa para niños en un programa de combate al sobrepeso y a la obesidad.

Métodos: Investigación metodológica, con enfoque cuantitativo y de corte transversal. Participaron en el estudio niños que forman parte de un programa de acondicionamiento físico con *games* interactivos para niños obesos o con sobrepeso (n=13). El perfil de los participantes fue elaborado mediante datos antropométricos, cuestionarios sobre sus hábitos alimentarios y de actividad física. Luego se presentó el *serious game DigesTower* como una estrategia adicional del programa, y el público destinatario realizó la evaluación del juego.

Resultados: Participaron niños de 7 a 11 años con sobrepeso y obesidad. El *DigesTower* fue bien recibido por los participantes, que afirmaron tener inmersión, motivación y estímulo para mejorar sus conocimientos. La versión final del juego fue desarrollada y se puso a disposición en línea de forma gratuita y pública.

Conclusión: El estudio buscó incentivar el uso de herramientas innovadoras para ayudar con intervenciones educativas en el ámbito de la obesidad infantil, y el *serious game* fue evaluado como una posible estrategia educativa para niños. Se espera que este estudio inspire futuras investigaciones que tengan como objeto de estudio el desarrollo de juegos digitales para el público infantil.

Introduction

Currently, childhood obesity has reached worrying proportions in several countries and portrays a problem to be faced. This is a complex condition, related to genetic, nutritional, socioeconomic and environmental factors and can be defined as the accumulation of fatty tissue both in a localized and generalized way.[1]

In the past few decades, childhood obesity rates have increased worldwide and continue to rise, especially in low- and middle-income countries. The number of overweight and obese children and adolescents grew more than tenfold, from 11 million in 1975 to 124 million in 2016.[2] Worldwide, it is predicted that, by 2025, approximately 268 million children and adolescents between five and 17 years of age will be overweight and of this total it is estimated that 91 million will be obese.[3]

Studies carried out in South America have shown a prevalence of overweight of approximately 7% in children under five years of age, while in children of school age the prevalence of overweight and obesity ranged from 15% to 36.9%, and among adolescents, it varied from 16.6% to 38%.[4,5]

The high prevalence rates of overweight and obesity together with its risks make the disease a public health problem. To combat obesity, health organizations in Brazil and around the world have established goals to promote health and encourage healthier habits. The countries of the Americas took an important step in the fight against the growing obesity epidemic by signing a "Five-year Action Plan for the prevention of obesity in children and adolescents". Among other measures, the plan provides for the improvement of school nutrition and physical activity and the promotion of healthy eating. One of the proposed solutions is health education actions aimed at children.[4,6,7]

Health education is a way of improving users' understanding of the disease, which, in turn, can improve their general condition and reduce the use of health resources.[8] From this, educational interventions have been created, with innovative attributes and more appropriate to the target audience. One of these approaches is based on the use of serious games as a means of improving knowledge and as an additional tool in education and health promotion programs.[9]

According to one of the forerunners of this terminology, a serious game is a game in which there is a learning objective to be achieved. However, this does not mean that this type of game is uninteresting or less fun, it just reinforces that there is a purpose beyond the fun.[10]

Programs to combat and treat childhood obesity focus mostly on improving eating behaviors and increasing physical activity;[11] however, approaching the child audience in their family environment with new strategies and media, such as serious games, can bring an important differential for better adherence of these programs.

Games can offer the chance to teach children to face overweight and obesity, as these are highly inviting to this audience, which facilitates the reach and interest of children.[12] Its elements increase interest, motivation and pleasure, thus improving their engagement within programs.[13]

Within this scope, this article presents the game DigesTower, a serious game aimed at children, with a view to encouraging healthy eating and physical exercise. The main objective of this study was to

assess the serious game as an educational strategy for children in a program to tackle overweight and obesity.

Methods

This is a research with a quantitative, methodological and cross-sectional approach. Methodological research carries out the development, validation, or assessment of research tools and methods.[14]

The serious game DigesTower was developed and assessed by health and computing experts at an earlier stage, in 2014. Subsequently, the game underwent a reformulation to adapt it and present it to the target audience in the future.[15] Its development relied on the collaboration of a multidisciplinary team and was based on the studies of Novak[16] and Schell[17] as well as on theories of behavior change in health.[18]

The main themes of the game are healthy eating and physical exercise and seeks to encourage better eating habits. The human digestive system, its main organs and digestive enzymes are presented in a playful way and the serious game explores the digestion process of each food class (carbohydrates, proteins and fats).

DigesTower is classified as Tower Defense, that is, a subtype of strategy games that, as the name already suggests, is focused on defending an element of the game.[19] In the case of this specific game, food will come in waves and need to be digested by digestive enzymes.

From this, the serious game DigesTower was presented to school children in order to be assessed as an educational strategy. Since January 2017, participants have been accompanied in a physical conditioning program with interactive games for obese and/or overweight children developed at a State University in the countryside of São Paulo State. The program has three fronts: medical and nutritional monitoring, psychological monitoring and physical activities. The children participating in the program did not have other comorbidities associated with overweight and obesity and practiced physical activity exclusively during the school period.

The study was sent and approved by a Research Ethics Committee (REC). Parents and children were invited to participate in the research through face-to-face contact and were asked to sign the Informed Consent Form (ICF) and the Term of Assent. Then, the children received the serious game as an additional strategy, in addition to the usual strategies already used by the program.

The first stage of the research consisted of children's anthropometric assessment and their measurements, weight, height and body mass index (BMI) and classification by Z-score were measured, according to procedures and charts provided and recommended by the World Health Organization (WHO).[20] This was followed by the application of instruments for data collection with the Previous Day Food Questionnaire (QUADA)[21] and the Previous Day Physical Activity Questionnaire (QUAFDA)[22] to assess food consumption and the practice of physical exercises, the Child Eating Behaviour Questionnaire (CEBQ)[23] to verify the eating behavior of students, and finally EGameFlow[24] to assess the proposed serious game.

A survey of the profile of children belonging to the program was carried out. After measuring anthropometric data, questionnaires were applied directly to the children regarding their eating habits and physical activity in the last 24 hours, always considering the application on weekdays when there is a common diet and physical activities in the family's routine, i.e., avoiding collections in a week with holidays or days after the weekend, such as Monday.

In the QUADA instrument there is a provision of meals, arranged chronologically in coffee, morning snack, lunch, afternoon snack, dinner and evening snack. Each meal is illustrated with 21 different foods.[21] Such foods were selected considering the dietary patterns of children in the school age group, the availability of food, the menu offered in schools and the Food Guide for the Brazilian Population.[25]

QUAFDA checks children's attitude towards physical activity, the means of transportation used to go to school, and the physical activities practiced. The general score of children's physical activity in this questionnaire is determined by adding the

scores of activities that children reported performing the previous day, based on the drawings of 11 predefined activities and with three different intensities. The level of physical activity was assessed by the tertiles of distribution of the score generated by the instrument. The distribution values of the QUAFDA score in tertiles were 35, 58 and 141, respectively, for the 1st, 2nd and 3rd tertiles. To characterize the pattern of physical activity presented in the questionnaire, participants were classified as less active, intermediate and more active.[22]

Only the CEBQ was intended for family members to assess eating behavior as instructed by the instrument's own authors. The CEBQ contains 35 items and aims to assess eight dimensions of eating behavior: Food responsiveness; Emotional over-eating; Enjoyment of food; Desire to drink; Satiety responsiveness; Slowness in eating; Emotional under-eating; Food fussiness. Each item is assessed on a five-point Likert scale ranging from 1, which is uncommon, to 5, which is very frequent. The scores of the questions belonging to the same dimension are added, so that each one of them will present an average value and standard deviation.[23]

Subsequently, the serious game DigesTower was presented at the end of the activities of the fitness program, individually. Two sessions were held, on different days, both with 30 minutes. At the end, children answered the EgameFlow questionnaire to assess the game.[24]

This instrument seeks to create a scale of user satisfaction with the educational game. The evaluator assigns a score from one to seven for each item present in the eight categories (Concentration; Challenges; Autonomy; Goal Clarity; Feedback; Immersion; Knowledge Improvement), the value being one considered "weak" and the seven is considered "strong".[24]

The data obtained in the research were organized on Excel and analyzed quantitatively by means of descriptive statistics, such as simple frequency, mean, median, standard deviation.[26] Data were organized in tables, graphs and percentages according to their items and categories as well as assessed and analyzed in the light of the theory on the subject of study.[21-25]

Results

All children in the fitness program with interactive games for obese and/or overweight children were invited and agreed to participate in the study, totaling 13 children. Data collection took place from January to July 2017. The anthropometric data of the participating children are presented in Table 1.

Table 1. Characterization of children participating in the study (n*=13)

Child	Sex	Idade (years)	Body mass (Kilogram)	Stature (meters)	IMC† (Kilogram/ meters^2)	Score Z‡
C1	F	9 years	74.5	1.54	30.6	>+3 (severe obesity)
C2	M	8 years	47.9	1.39	24.8	>+3 (severe obesity)
C3	M	8 years	63.6	1.37	33.9	>+3 (severe obesity)
C4	M	9 years	52.1	1.39	26.9	>+3 (severe obesity)
C5	M	10 years	92.9	1.55	38.6	>+3 (severe obesity)
C6	M	10 years	70.2	1.56	29.2	>+3 (severe obesity)
C7	M	11 years	111.5	1.66	40.4	>+3 (severe obesity)
C8	F	8 years	53.8	1.43	26.3	>+3 (severe obesity)
C9	M	11 years	58.1	1.44	28	>+2<+3 (obesity)
C10	M	8 years	40.6	1.39	21.1	>+2<+3 (obesity)
C11	M	8 years	45.2	1.4	23	>+2<+3 (obesity)
C12	M	7 years	41	1.34	22.8	>+2<+3 (obesity)
C13	M	7 years	39.9	1.32	22.9	>+2<+3 (obesity)

*n - number of participants (absolute frequency); †BMI - Body Mass Index; ‡Z score - Standard score.

The QUADA was applied to assess food consumption in the last 24 hours. The proportions of children who met the recommendations are presented in Figure 1.

There is the consumption of cereals, breads and pasta by children; however, the consumption of all children was much lower than recommended. The same happened with the consumption of vegetables, none of participants achieved what was recommended by the guide. However, a positive fact was that although they do not eat many vegetables, most children consume legumes (69.23%), especially beans in main meals, such as lunch and dinner.
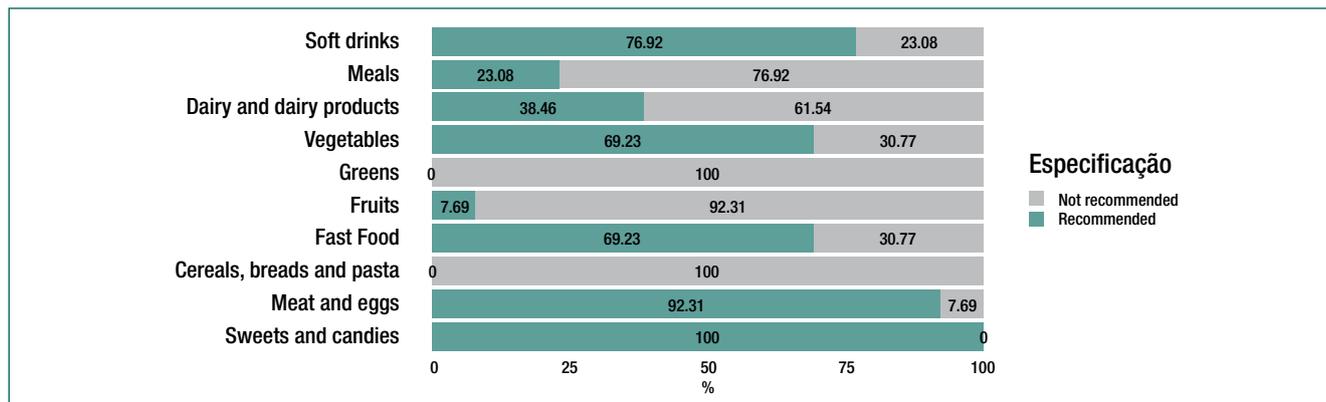
Figure 1. Percentage of children who eat the daily portions recommended by the Food Guide for the Brazilian Population (n=13)

Of the total of 13 children, 10 participants reported not consuming snacks with a high fat content (fries, pizza and hamburger) as well as soft drinks the day before the questionnaire was administered. Children also did not abuse the recommended sugars and sweets, even eating a portion of this food group. However, fruit consumption was much lower than desired, the majority did not consume any portion of fruit and only one child reached the recommended values of three servings a day (7.1%).

Afterwards, the QUAFDA was applied to assess the physical activities practiced in the last 24 hours. Of the total participants, 10 children were classified as less active (76.92%), three as intermediate (23.08%) and there was no child who reached the high level of physical activity score according to the questionnaire, considered more active.

Regarding children's eating behaviors, these were analyzed using the CEBQ. Figure 2 illustrates the averages of children's responses participating in the CEBQ.

The highest averages are present in the dimension "Food responsiveness" and "Pleasure in eating", while the lowest refer to the dimensions "Satiety responsiveness" and "Slowness in eating". Another low average was seen in the dimension "Emotional under-eating". After answering all the instruments for the children's profile, the serious game DigesTower was presented to them. After finishing the game, the children were invited to answer a questionnaire to assess it. An adapted version of EGameFlow was used, a specific questionnaire for assessing educational games. The assessments made by the children were grouped by category and are described in Table 2.
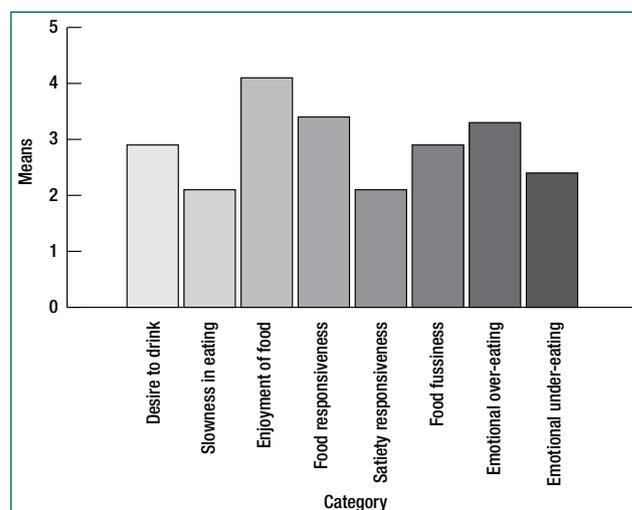
Figure 2. Mean responses in each CBEQ dimension (n=13)

Table 2. Descriptive statistics for EGameFlow categories (n*=13)

EGameFlow categories	Minimum-Maximum	Median	Mean	Standard deviation
Concentration	4.00-7.00	7.00	6.38	0.89
Challenges	5.75-7.00	6.50	6.54	0.50
Autonomy	3.75-7.00	6.75	6.08	1.20
Goal Clarity	4.00-7.00	7.00	6.46	1.01
Feedback	4.00-7.00	7.00	6.38	1.02
Immersion	5.50-7.00	7.00	6.71	0.49
Knowledge Improvement	4.33-7.00	6.67	6.13	1.03

n* - number of participants (absolute frequency)

The game was well received by the children, who claimed to have had immersion, motivation and encouragement to improve their knowledge. This could be seen through the high average responses in the various categories. It was possible to notice that "Challenges" and "Immersion" categories, in addition to having the highest averag-

es of the questionnaire, were those that had the smallest standard deviations, i.e., most children scored these themes similarly, with grades six and seven. In the "Challenges" category, the highest score given by children stands out, referring to the game skills and how much they increase throughout the game. However, question four had to be revised. The question addressed the difficulty of the game and there was a variation in the answers, some children found the difficulty adequate and others considered the game difficult. However, all children were able to overcome the difficulties imposed on DigesTower and consequently complete it. "Immersion" was the category best assessed by the children. It was noted that children were quite immersed in the game and demonstrated a great involvement with the activity. "Autonomy" and "Improvement Knowledge" obtained the lowest averages when compared to the others and had the highest standard deviations, indicating that probably some children gave low scores while others gave high scores. Regarding the items assessed in "Autonomy", children reported not having much control over the menu (question seven), evidenced by the proportion of grades below six (23%). Despite this, there was a positive assessment of recovery from mistakes made during the game.

Another difficulty raised by the children was seen in the answers to question 10 ("I know the next step in the game?"), belonging to the "Autonomy" category, which obtained four grades below six and had to be revised for the final version of DigesTower. It was necessary to have a clearer explanation in the interface about what would happen in the next stages of the game. Most of children positively assessed the "Feedback" category, but in this category, question 13 ("I receive feedback on my progress in the game?") Obtained lower scores (23%) and it was also necessary to rethink the feedback dynamics, the in order to improve it. An example used for this purpose was the addition of more audiovisual effects to alert the player to some actions during the game. The analysis of data from EgameFlow contributed to the need for adjustments to be pointed out and addressed in the final version of the serious game.

Discussion

In this study, the serious game DigesTower was inserted in an interdisciplinary program to confront childhood obesity. Children's BMI showed values of Z scores for obesity and severe obesity. However, these values were expected, since it was a prerequisite for children to be above normal weight for their participation in the fitness program with interactive games for obese and/or overweight children. Furthermore, literature also reinforces that there is a significant trend towards an increase in the prevalence of obesity in children and adolescents today. [27]

For the discussion about the previous day food, the results of this study illustrate that there was a low percentage of children who consumed snacks and soft drinks the previous day (about 30%); this information is in disagreement with the data reported in literature for children and adolescents in Brazil and other countries, since they are higher percentages. [28,29]

It is believed that the data found in this study are lower due to the inclusion of children in the university's fitness program, which provides consultations with pediatric doctors and nutritionists aimed at changing eating habits and all children in the group were already being monitored and maintained a specific diet for metabolic diseases.

Regarding the data found on the children's physical activity on the previous day, the results also disagree with what was exposed in the literature, as there is a more balanced distribution in another study that used the same instrument, presenting as data 23.8% of children less active, 36.7% intermediate and 39.5% more active, differently from what was found, which are only less active (76.92%) and intermediate (23.08%). [22]

Moreover, the CEBQ was used in this study to obtain data regarding the participants' eating habits and higher averages were noted in "Food responsiveness" (FR) and "Enjoyment of food" (EF), while the lowest averages refer to "Satiety responsiveness" (SR) and "Slowness in eating" (SE), which goes according to literature. Some authors comment that overweight children had lower scores on the

"Slowness in eating" subscale, which demonstrates a faster feeding pattern.[30]

Still, the results of these subscales are generally high in obese children and tend to be low in children with low weight.[23] The highest values in "Food responsiveness" and "Enjoyment of food" are in line with what is expected in the literature, since they were assessed only with overweight or obese children.

Another low average was seen in "Satiety responsiveness". According to the authors of the scale, this dimension assesses the ability to regulate appetite in order to compensate for a previous meal. A low response to satiety is ranked among the likely behavioral causes of obesity.[23]

In this context, due to the rapid advancement of technology in recent decades, literature points out that the current generation has differentiated learning needs, when compared to past generations. They learn much more easily when learning relates to technology.[31]

Regarding the assessment of serious games, some authors claim that it is essential to obtain Feedback from the target audience. Their comments are very pertinent to refine the components of the game and improve its suitability.[32]

Some studies have observed that serious games have positive effects for the development of healthy lifestyles, but what stands out the most in studies is the improvement in knowledge. Effects on clinical outcomes were significant, but much less. In general, these games have increased the adoption of a healthy lifestyle, although the effect sizes are small.[33]

Another important fact highlighted by the literature is that players are more willing to spend time learning in games than learning through traditional methods, as long as the challenge in the game is viable. Therefore, serious games can be a better means than other computer-based interventions to reach the target audience in a large-scale implementation.[33]

Regarding DigesTower assessment, the children reported not having much control over the menu, evidenced by the proportion of grades below six (23%). Such notes may have occurred because it is a tower defense game and this type of game has moments of just watching the actions taken, which

may have generated this feeling of little control of the game itself. Despite this, they positively assessed the recovery from errors mentioned during the game and felt that they could use several strategies.

Another difficulty encountered by the children was in the Autonomy category evidenced in the answers to question 10 ("I know the next step in the game?"), Which obtained 31% of marks below six and a revision was necessary for the final version of the game. It was necessary to make it clearer in the interface what would happen in the next stage, such as, for instance, adding on the screen the "next food" box, which illustrated the food that would appear shortly thereafter, aiming to alert the player to prepare better to face it.

Finally, as a limitation of this study, there is the fact that data collection was carried out with a limited number of children, since only the population that was participating in the "physical conditioning program with interactive games for obese and/or overweight children" was considered and that they were children who were already overweight or obese.

Obtaining assessments from children who do not belong to this group may reveal needs or suggestions different from those identified in this research and further enrich the assessment of the serious game in question.

Conclusion

At the end of the study, it was possible to achieve the proposed objectives, outline the profile of the children participating in an obesity tackling program, as well as assess the serious game DigesTower as an educational strategy with this audience. DigesTower was considered adequate and stood out as an innovative technological tool. In the future, we seek to use the serious game as a possible intervention tool for childhood obesity. It was identified, through the assessments of the target audience, that DigesTower presented potential as an educational tool, seeking to encourage children to better habits and motivate their adherence to the obesity treatment program. Also, this study was developed in order to contribute to the area of technologies for health, more specif-

ically for the development of new strategies for education and health promotion, demonstrating that this type of tool can be not only pleasurable but also effective. Finally, the research corroborates area literature by launching something of interest to this generation of children, bringing technological innovation and seeking to use technologies and devices that are already part of the daily life of this audience.

Acknowledgments

Collaborations

Dias JD, Tibes-Cherman CM, Aragão RB, Tourinho Filho H, Zem-Mascarenhas SH, Fonseca LMM contributed to the study design, data analysis and interpretation, article writing, relevant critical review of intellectual content and approval of the final version to be published.

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