REVIEW ARTICLE

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Serious Games as tools for food and nutrition education: a systematic review

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ABSTRACT

Serious games emerge as teaching tools with a purpose beyond entertainment, aiming to improve some aspect of the teaching-learning process. Given the high prevalence of chronic noncommunicable diseases in the Brazilian population, this study aimed to evaluate, through a systematic literature review, the potential of serious games as a tool for Food and Nutrition Education. To this end, we searched the PubMed, Biblioteca Virtual de Saúde, and SciELO databases for articles published in the last five years in english and portuguese. A total of 63 studies were identified, of which only 10 met the inclusion and exclusion criteria established for this review. Most studies reported positive outcomes with the use of serious games as an educational tool, finding positive effects on the retention of knowledge learned about food and nutrition, and their use showed promise as an alternative to traditional teaching methodologies. Despite this, the studies had limitations regarding the duration of the interventions and the representativeness of their sample sizes, indicating the need for future studies with methodological designs that fill such gaps. This review shows that gamified approaches to nutrition education seem promising in the context of the teaching-learning process but still lack methodological standardization for interventions based on serious games to be validated as a tool for Food and Nutrition Education.

Keywords: food and nutrition education; health promotion; diet, healthy; Software; video games; experimental games.

INTRODUCTION

The prevalence of overweight and obesity is growing alarmingly worldwide, affecting both developed and developing countries, such as Brazil, indiscriminately[1,2]. This increase goes hand in hand with the epidemiological transition that began in the 1970s[3] when the prevalence of chronic non-communicable diseases became more prevalent than infectious diseases in the population[4]. According to the findings of the Non-communicable Diseases Risk Factor Collaboration[5] the prevalence of overweight and obesity among children and adolescents in the world doubled between 1975 and 2016. In Brazilian adolescents, the prevalence of overweight and obesity was 17.1% and 8.4%, respectively, between 2013 and 2014[6].

To understand obesity as a disease with a multifactorial etiology, it is necessary to take a broader look at the risk factors associated with it, such as genetic predisposition, the quality of sleep and wakefulness, the use of medication, and environmental pollution. In the context of lifestyle and eating behavior, factors such as a reduction in physical activity, the adoption of a sedentary lifestyle, social pressures, stress, difficulty in accessing quality food, and the palatability of more energy-dense foods have been highlighted as important factors in the prevalence of this disease[7,8].

Adolescents are the biggest consumers of highly processed, energy-dense products and have a dietary pattern that puts them at risk of developing chronic non-communicable diseases. Although there is a tendency for consumption of this type of food to decrease with adulthood, adults still consume more ultra-processed foods outside the home, consume more salt and sugar in their diets, and drink more alcohol, according to the Brazilian Institute of Geography and Statistics (IBGE)[9]. Faced with this scenario, the World Health Organization (WHO) recommends changes in the population's eating habits

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to prioritize the consumption of fruit and vegetables and reduce the consumption of energy-dense foods[10,11].

Changing eating behaviors is fostered through health promotion, which is done through strategies that deal with understanding the different causal relationships that affect diet, including income, education, access to health services, and the social and environmental determinants of health. In this way, healthy eating habits are promoted by creating a supportive environment for individuals, promoting individual and collective knowledge about health and food[12].

In Brazil, Food and Nutrition Education is one of the strategies promoted by the Promoting Adequate and Healthy Food (*Promoção da Alimentação Adequada e Saudável - PAAS*) guideline of the National Food and Nutrition Policy (*Política Nacional de Alimentação e Nutrição - PNAN*). The principle of this strategy is to promote self-care and autonomy in healthy eating habits. To this end, it uses educational resources that foster critical thinking and dialogue between individuals and groups, linking this teaching to the different stages of life, food systems, and the complexities of eating behavior[13,14].

Gamification is a teaching tool that combines the ideals of games with real-world situations to promote engagement through rewards, problem-solving, and the development of skills, processes, and environments[15,16]. In this way, gamification can become a motivating strategy for promoting self-care and changing eating behaviors when applied to Food and Nutrition Education.

In this context, serious games have emerged, which are games designed with a purpose beyond pure entertainment, with the main aim of improving some aspect of the teaching-learning process[17,18]. Serious games have been gaining ground in the health field as an educational tool over the years. Publications on this topic between 2015 and 2020 almost tripled compared to the first decade of the 21st century. The development of serious

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games is currently undergoing a gradual transition, moving away from themes focused on specific diseases and assisted learning, and towards broader health topics such as healthcare and nutrition[19,20].

Therefore, this systematic review aimed to evaluate the potential of serious games as an Food and Nutrition Education tool. To this end, interventions based on serious games were evaluated under the following outcomes: (a) knowledge acquired (b) changes in eating behavior (c) adherence to nutritional management (d) changes in biochemical markers related to Chronic Non-Communicable Diseases.

METHODS

Search strategy

This review was conducted using the protocol recommended by the Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) guideline[21]. Searches were carried out in the Pubmed, Virtual Health Library, and Scielo databases for articles on nutrition education and serious games, published in the last five years (January 2017 to March 2022), without delimiting population criteria (any age and gender). The descriptors used for this search were "nutrition education" and "serious games". The results obtained were pre-selected by reading the titles and abstracts and, whenever doubts arose as to their content, they were separated to be later analyzed in full.

Inclusion and exclusion criteria

Among the articles selected in the screening, those that met the following criteria were included: (1) they had been published in an English or Portuguese-language journal; (2) they were intervention studies; (3) studies that presented the evaluation of the applied

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game as the outcome. Articles were excluded if (1) they only evaluated the game's development; and (2) they were not available in full.

Qualitative assessment

Each article was given a positive, negative, or neutral quality rating according to the checklist of quality criteria in the Evidence Analysis Manual formulated by the Academy of Nutrition and Dietetics[22] (Table 1). This checklist assesses the validity of the articles in terms of the guiding research question, the presence of bias in the selection of study subjects, parity between study groups, methods for dealing with dropouts, the use of blinding to mitigate bias, a description of the intervention, the validity and elasticity of the outcome measurements, an appropriate statistical analysis, whether the conclusions drawn are supported by the results, and the absence of bias in the sources of funding (conflict of interest).

Extracting and summarizing data

The articles that met the criteria were read in full to produce a matrix table (Table 2). The table summarized information regarding author, year of reference, study design, location, sample, objective, intervention, measurement of results, and main findings.

RESULTS

A total of 63 articles were identified for the study. Using the PRISMA guidelines, some of these were excluded because they were duplicates (n=15), others were excluded after reading the abstracts (n=36) and, finally, there was exclusion after reading the full text (n=2). Therefore, a total of 10 articles were selected which met all the inclusion criteria defined by the authors (Figure 1).

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Most of the studies carried out their research with children and adolescents up to 13[23-31], and only one study carried out interventions with adult subjects over 18[32]. In general, among the studies included in this review, there was a wide distribution of locations, including countries in Europe: Germany[23,26], the Netherlands[24,31]; Oceania: Australia[27]; and America: Mexico[29,30], the United States[28,31] and Canada[23] (Figure 1).

The studies were evaluated according to the parameters of the Evidence Analysis Manual[22] (Table 1) and summarized (Table 2). The most frequent study model was the randomized controlled trial[24-26,31,32], some were carried out without a control group[28-30,] and among the studies with control groups, one did not use randomization[23] and another randomized the intervention sites[27]. Most of the studies clarify how the interventions were carried out and mention the presence of assistants or teachers who were on site and applied the intervention tool[23-26,28,29,31,32]. Only two studies did not make it clear who was responsible for applying the intervention[27,30].

Methodology for assessing articles

Of the articles evaluated, eight used questionnaires before and after the intervention to measure the level of knowledge acquired through the use of serious games[23-30], of which one only used a questionnaire beforehand without a questionnaire afterwards[29], but used food frequency questionnaires and a parental perception questionnaire.

One study obtained its data on eating behavior only by collecting it within the game[31] and another evaluated different outcomes, looking at adherence to nutritional consultations for those participants who used the game[32].

Among the studies that used questionnaires as assessment tools, only Espinosa-Curiel et al.[29,30] used the same questionnaire, since this study is part of a comprehensive

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project on the effectiveness of using serious games with children. Each of the other studies used different questionnaires, three of which had been previously validated as assessment tools (Nutrition Attitudes and Knowledge (NAK) Questionnaire[24], Nutrition Knowledge Questionnaire for Australian Children (CNK-AU)[27] and Behavioral Risk Factor Surveillance System (BRFSS) 2015 Youth Risk Behavior Survey[28] and the others used pilot questionnaires without validation[23,25,26].

Outcomes

The main outcomes of interest found in the articles were the content learned by the subjects[23-31], changes in eating behavior[26,28,29,31], effects on biochemical markers[31,] and the subjects' adherence to nutritional guidelines[32].

DISCUSSION

Summary of evidence

Most of the studies reported positive outcomes from the use of serious games as an educational tool, but the methodological quality of some of the articles was not satisfactory, which interfered with the evaluation of this review. Only the studies by Froome et al.[24], Vlieger et al.[27], and Ruggiero et al.[28] used validated instruments. Along with most of the studies evaluated, these also show differences between the types of games and evaluation methodologies used, allowing for bias in terms of the effect of games on education, corroborating the findings of Gorbanev et al.[33] who in their study pointed out the need for methodological standardization in the use of serious games, to better understand their pedagogical effectiveness.

In most studies, the interventions were declared to be too short to achieve a significant change in eating behavior, which corroborates the idea put forward by Putnam

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et al.[34] that a longer exposure time to educational interventions is directly related to greater learning among children.

Most of the articles evaluated considered that the samples used in their studies were not representative in terms of size[23,24,27-31] to obtain more robust and meaningful data.

Thus, these studies are based on the beginning of a discussion about the use of serious games as educational tools in comparison to traditional teaching models (understood as methodologies centered on the teacher as the holder of knowledge, focused on the transfer of content and information in a positivist manner, and expecting similar results from different groups)[35,36] and about other games that have the same purposes.

Knowledge acquired

Eight studies[23-30] evaluated the concepts learned through the use of games as a nutritional education tool, but only five used control groups[23-27]. All the authors reported that the subjects exposed to the intervention showed a significant increase in knowledge related to food and nutrition. These findings corroborate a recent meta-analysis, according to which serious games have proven to be effective in terms of learning and improving cognitive skills related to problem-solving, decision-making, and the application of rules[20].

It is worth noting that specific knowledge about food groups[23], the food pyramid[26], nutrient functions[27], macronutrients[24,25], the risk of cardiovascular disease[24,] and healthy and unhealthy foods[29] were used as evaluation criteria. Two studies did not evaluate the learning categories but conducted a general survey on the knowledge gained from the intervention[28,30].

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The studies that compared the use of serious games with traditional teaching methodologies[23,26] presented divergent results as to which would be the best intervention strategy. The differences found can be attributed to the methodological differences between the studies, since the study by Holzmann et al.[23] used lectures given by a teacher, in a traditional teaching model, on the themes of the game with the control group, while the study by Mack et al.[26] only provided an information leaflet to the subjects in the control group. From what was found, it can be understood that traditional methodologies present a better response to learning when compared to exposure to educational materials without prior contextualization or reinforcement of what was presented.

Adding to this discussion, a recent meta-analysis evaluated the impact of serious games on the teaching of biological sciences when compared to traditional teaching methodologies. With the standardization of samples for learning outcomes, it was found that those subjected to gamified methodologies showed a higher level of learning, greater retention of acquired knowledge, and gain in procedural knowledge. The findings of this meta-analysis also indicate that further studies in the area and with the use of larger samples may find that serious games have a greater impact on learning other subjects[37].

The study by Espinosa-Curiel et al.[30] found that serious games have the potential to generate fun and that this is directly associated with learning[38,39]. Thus, fun can be a differentiating factor of gamified methodologies when compared to traditional ones, taking into account that in the gaming environment there is greater freedom for mistakes with minimal consequences, engaging the player in the process of trial and error, allowing the student to develop their learning concepts[40,41].

In this context, a recent study showed that children with greater digital skills have greater cognitive abilities related to language and vision, indicating that exposure to technologies and games in youth can be a way of promoting better cognitive development

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for children[42]. The use of serious games has emerged as a viable strategy for offering a controlled and non-invasive learning environment, which helps children develop new skills[43] and learn new information according to the themes covered by the games.

Research carried out with children aged 9 to 12 in Germany[26] and Australia[27], which evaluated their learning with the use of serious games, showed similar results in which the subjects significantly increased their level of knowledge on the subjects of food categorization, energy density, nutritional labels, and balanced meals after the interventions. These findings corroborate the use of serious games as teaching tools, according to the age group of the target audience, their interests, and which types of games they have a greater predilection for[44].

Changes in eating habits

Only one study found favorable results in terms of changes in the subjects' eating habits[29], in which they consumed fewer foods considered to be unhealthy. Despite this, the intervention was not enough to promote a significant increase in the consumption of healthy foods, showing that exposure to the game may not be enough to change the preference for healthy foods, and constant exposure to these foods is necessary[45].

Despite the difficulty faced in understanding the questions about portions presented in the post-intervention questionnaire used by Ruggiero et al.[28], this was still the only study, among those that evaluated changes in eating behavior[26,31], to show significant changes in the intention to consume healthy foods after the nutritional education intervention using a serious game.

It is important to note that the studies cited did not control or evaluate the family eating patterns of these subjects, generating a bias regarding changes in eating behavior,

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since eating habits in childhood are directly related to the availability of food in the home and the parents' eating practices[46].

It is therefore important to emphasize that healthy eating is not merely a matter of personal choice and that the process of changing eating habits is gradual and non-linear. It involves different obstacles such as information, supply, cost, advertising, time, and cooking skills. The determination of eating behavior is not limited to cognitive components, but also involves affective and situational components, so to achieve a significant change in eating habits, interventions limited to teaching methodologies may be insufficient[4,47].

Changes in biochemical markers

Only one study[31] carried out this survey and used fasting insulin levels of the subjects assessed before and after the intervention, but did not find favorable results in terms of insulin changes, pointing out as a problem the fact that there were a large number of dropouts and a non-representative sample, in addition to using a serious game produced in 2003, which would possibly no longer be attractive and interesting to the subjects in 2016.

The findings of this study, despite the limitations presented, corroborate the findings of a systematic review[48], which pointed to a low body of evidence about changes in blood markers with the use of mobile health apps, none of which presented significant data.

Adherence to nutritional management

Motivation is considered to be one of the most important factors when it comes to adherence to treatment, which complements informational and behavioral factors,

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forming part of the information-motivation-behavioral skills model (IMB) conceptualized by Fisher and Fisher[49]. In this context, serious games stand out as tools capable of fostering adherence and engagement with treatments due to the motivational factor present in games[50].

In line with this theme, only one article[32] in this review evaluated the use of games as a complementary tool to nutritionist consultations and their effects on treatment adherence and weight loss. It found that the intervention group showed greater adherence to treatment, no dropouts, and a higher percentage of weight loss. These findings corroborate a meta-analysis that indicated that the use of serious games has positive effects on knowledge and behaviors about healthy lifestyles and their determinants[51]. It is worth noting that, among the articles evaluated in this review, this was the only intervention with adult subjects, indicating the potential application of serious games with different age groups[52].

Conclusion

Gamified approaches to nutritional education show promise in the context of the teaching-learning process, as these games demonstrate the potential to promote changes in eating behaviors and are not restricted to a single age group. However, the heterogeneity of the methodologies used exposes interventions based on serious games to failures in terms of acceptance and playability, indicating a reproducibility bias in the evaluation of serious games as an educational tool.

This highlights the importance of using standardized games with similar basic mechanisms to enable a consistent comparison of outcomes. In addition, future research could be aimed at systematically evaluating different forms of the same game, analyzing

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the elements that have the greatest impact on learning, and also using larger samples that significantly represent the target populations.

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Figure 1: Flow diagram of the process of identifying and screening included studies according to PRISMA guidelines.

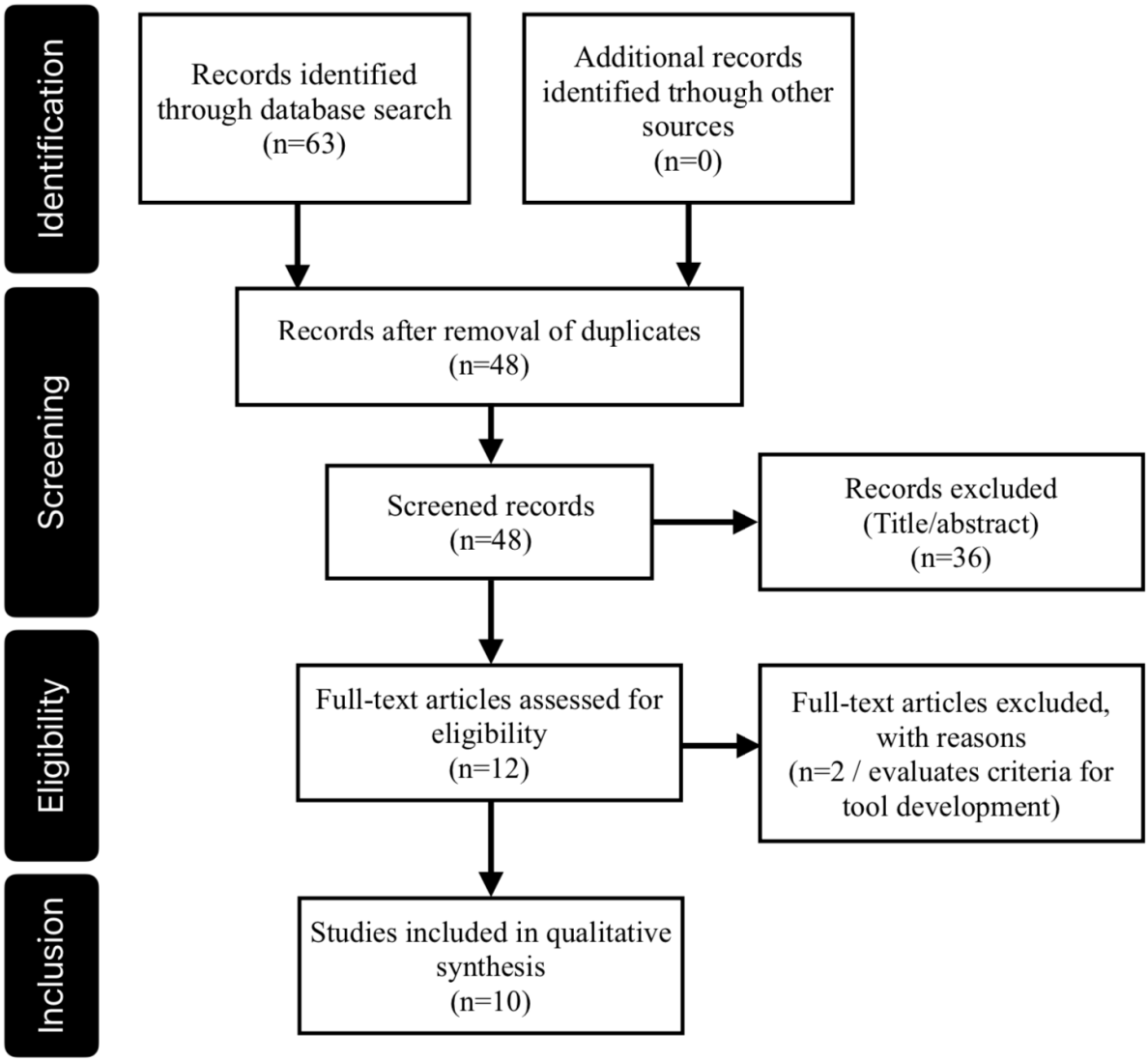

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Table 1: Summary of quality criteria

	Holzmann et al. 2019[23]	Froome et al. 2020[24]	Hermans et al. 2018[25]	Mack et al. 2020[26]	Vlieger et al. 2021[27]	Ruggiero et al. 2020[28]	Espinosa-Curiel et al. 2020[29]	Espinosa-Curiel et al. 2020[30]	Baranowski et al. 2019[31]	Aalbers & Peeters, 2020[32]
Overall quality rating	Ø	+	+	+	-	-	-	-	+	+
Questions of relevance										
1. Would the implementation of the studied intervention or procedure (if successful) result in better outcomes for the patients/clients/population group?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
2. Did the authors study an outcome (dependent variable) or topic that patients/clients/population group would care about?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
3. Is the focus of the intervention or procedure (independent variable) or subject of study a matter of common concern to the practice of dietetics?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
4. Is the intervention or procedure feasible?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Validity issues										
1. Was the research question presented?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
2. Was the selection of study subjects/patients free from bias?	Yes	Yes	Yes	Yes	No	No	No	No	Yes	Yes
3. Were the study groups comparable?	Yes	Yes	Yes	Yes	No	Yes	No	No	Yes	Yes
4. Has the method for handling withdrawals been described?	Yes	Yes	Yes	Yes	Yes	Uncertain	Uncertain	No	Yes	Yes
5. Was blinding used to avoid introducing bias?	No	Yes	Yes	Yes	No	No	No	No	Yes	Yes
6. Has the intervention/therapeutic regimen/exposure factor or procedure and any comparison(s) been described in detail? Have the intervention factors been described?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
7. Were the results clearly defined and the measurements valid and reliable?	Uncertain	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
8. Was the statistical analysis appropriate for the study design and the type of outcome indicators?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
9. Are conclusions supported by results with biases and limitations considered?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
10. Is bias due to study funding or sponsorship unlikely?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Legend: (Ø): indicating neutral quality; (+): indicating positive quality; (-): indicating negative quality. If the majority (six or more) of the answers to the validity questions above are "No", the analysis should be designated with a minus symbol (-) in the Overall Quality Rating. If the answer to any of the first four validity questions (1 to 4) is "No", but other criteria indicate strengths, the review should be designated with a neutral symbol (Ø) in the Overall Quality Rating. If the majority of the answers to the validity questions above are "Yes" (this should include 1, 2, 3, and 4), the review should be designated with a plus symbol (+) in the Overall Quality Rating.

According to the Evidence Manual formulated by the Academy of Nutrition and Dietetics[22]

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Table 2: Study information: Design, Population, Description, Measures and Findings.

Authors/year	Design	Location and sample	Objective	Intervention	Measuring results	Key findings
Control group studies						
Holzmann et al. 2019[23]	Non-randomized controlled study	Sample: Children and adolescents, average age 13, n=76 / Location: Two secondary schools in the city of Bavaria, Germany /Duration: Both groups, 15 min per day, for 3 consecutive days.	To evaluate the short-term effectiveness of the "Fit, Food, Fun" (FFF) serious game on nutritional knowledge among high school students and to compare this approach with a traditional teaching format (classic lecture).	I: You played the serious game FFF, about a journey through Europe, where each country presents 3 different mini-games, on themes based on the document "10 guidelines of the German Nutrition Society for a healthy diet", n=36. C: The content, similar similar to that presented in the games, was using a blackboard, in lecture format, n=40. Lecture format, n=40. Only group C was accompanied by a teacher during the intervention. Group I was accompanied by two assistants.	Pre- and post-intervention questionnaires, assessing knowledge of nutrition, and a food frequency questionnaire, assessing eating behavior.	I and C showed improvements in their knowledge after the intervention, with group C showing a more significant improvement than group I.
Froome et al. 2020[24]	Randomized Controlled Trial	Sample: Children, average age 8, participating in the technology camp, n=73. /Location: University of Ontario Institute of Technology, Canada. /Duration: Both groups, 15 min per day, for 5 consecutive consecutive days.	To evaluate whether the serious game "Foodbot Factory" increases general knowledge about nutrition in children compared to a control application. And secondary evaluation of the change in nutrition knowledge.	I: The serious game "Foodbot Factory" is divided into 5 modules (beverages, whole foods, fruit and vegetables, animal protein foods, and vegetable protein foods), and each of these was played every day for 15 minutes. n=39. C: The serious game My Salad Shop Bar focuses on preparing healthy food, each level takes an average of 5 minutes, but participants had 15 minutes to ensure consistency, n=34. An assistant was present during the interventions.	Nutrition Attitudes and Knowledge (NAK) questionnaires before and after the intervention, assessing knowledge of nutrition.	Group I showed a significant increase in nutritional knowledge compared to Group C.
Hermans et al. 2018[25]	Randomized Controlled Trial	Sample: Children, age 10 to 13, n = 108. /Location: Three elementary schools in the southern part of the Netherlands. / Duration: Both groups, 30 min per day, for 2 consecutive days days	To test the effects of the Alien Health Game on children's nutritional knowledge, and to obtain more information on its relative effectiveness compared to conventional approaches.	I: Played the serious game Alien Health Game, where they had to choose healthy food options to keep the alien healthy. The activity was carried out for 30 minutes on 2 consecutive days, n=58. C: Played the Super Shopper game, where they have to choose goods after knowing their nutritional content. This activity was carried out for 30 minutes on 2 consecutive days, n=50. Two study assistants were present during the interventions.	Questionnaire on knowledge of nutrition, applied pre-, immediately after, and 2 weeks after the intervention, for both groups	The intervention group showed greater knowledge of the nutrition topics covered, even two weeks after the intervention.
Mack et al. 2020[26]	Randomized Controlled Trial	Sample: Children, aged 9 to 12, n = 82 / Location: School in Germany / Duration: 2 weeks, with re-evaluation after 4 weeks	To test the "Kids Obesity Prevention" game (this program is subdivided into 6 modules, consisting of mini-games) in a randomized trial with a control group, to assess the gain in knowledge about healthy lifestyle issues and the maintenance of this knowledge.	I: The group played the game 2 times over 2 weeks, different modules of the game each day. Each session lasted 45 minutes, n=40. C: The group received information about healthy eating through a leaflet, prepared by the Ministry of Agriculture, but the group received the information not concurrently, after group I, for ethical reasons, n=42. An assistant was present during the Intervention.	Self-reported self-reported nutrition knowledge questionnaire, applied before, 2 weeks after, and 4 weeks after the intervention.	The intervention group showed an increase in knowledge on the subject of the food pyramid and food energy density.
Vlieger et al. 2021[27]	Cluster Randomized Controlled Trial	Sample: Children aged between 9 and 12, n=169. / Location: Two schools in Newcastle, NSW - Australia. / Duration: Both groups, 1 day a week, for 2 weeks, with 20-30 minutes of intervention.	To investigate the feasibility and acceptability of the VitaVillage game as a tool for nutritional education in elementary school.	I: The group played the serious game VitaVillsge 2 times over 2 weeks, for 20-30 minutes each session. The game consists of maintaining a healthy city by farming your farm, n=75. C: The group played mathematical games, with the same duration and frequency as group I played VitaVillage, n=94. The person responsible for applying the intervention was not mentioned	Questionnaire (CNK-AU), Conducted pre and post intervention, for both groups.	The intervention group showed an increase in general knowledge of nutrition.
Studies without a control group						
Ruggiero et al. 2020[28]	Non-controlled study	Sample: Children between the ages of 8 and 13, n=48 / Location: Chicago, Illinois - USA / Duration: January 15 to August 15, 2019	To describe the development, training, and initial assessment of the feasibility, acceptability, and preliminary results of the MyPlate Picks (MPP) educational game.	Phase 1: Evaluation of the acceptability of the individual and group game, with the application of pre- and post-intervention questionnaires. Phase 2: Focusing on assessing group acceptability, the intervention was carried out with 3 groups, using the same pre- and post-intervention questionnaires.	Pre- and post-intervention questionnaire (the part of the behavioral intention questionnaire about positioning was not well understood by the subjects).	Most of the children showed an improvement in their knowledge after the intervention.

Espinosa-Curiel et al. 2020[29]	Non-controlled study	Sample: Children aged between 8 and 10 years old, n=60. / Location: Tepic City, Nayarit - Mexico. / Duration: 45 days, with 12 game sessions lasting 15 minutes each. Minutes each.	Designing and testing the FoodRateMaster serious game with children aged between 8 and 10.	The participants were divided into groups by age (8, 9, and 10 years). All groups completed the pre-and post-intervention knowledge questionnaire, as well as the food frequency frequency questionnaire. After the intervention, the parents of the participants completed the questionnaire. The interventions were monitored by the authors of the study.	Prior knowledge questionnaire, self-reported food frequency questionnaire, and parental perception questionnaire.	The participants showed an improvement in their knowledge of "healthy" and "unhealthy" foods, as well as a higher frequency of "healthy" foods and a reduction in "unhealthy" foods.
Espinosa-Curiel et al. 2020[30]	Non-controlled study	Sample: Children up to 10 years old, n=60 (29 girls, 31 boys) / Location: City of Tepic Nayarit - Mexico / Duration: 12 sessions of 15 minutes, for 45 days.	To examine the relationship between learning, user satisfaction, and fun in children between 8 and 10 years old when they play a serious game.	The participants took part in the intervention in a single group, completing the pre-and post-intervention questionnaires. The person responsible for applying the intervention was not mentioned.	Pre- and post-intervention knowledge questionnaire.	A strong correlation was found between learning and having fun.
Study with control groups - Clinical outcomes						
Baranowski et al. 2019[31]	Randomized Controlled Trial	Sample: 145 overweight or obese children aged between 10 and 12 with BMI percentiles between 85 and 99. / Location: Houston, Texas - USA / Duration: 3 months of intervention	Experiencing a decrease in fasting blood insulin concentration by at least 2 lU/dL; increasing fruit and vegetable (FV) consumption by at least 1.0 portion/day; and increasing moderate to vigorous physical activity by at least 10 min/day from the start of the intervention to 3 months afterward.	I: The group had access to the combination of the two games Escape from Diab and Nanoswarm: Invasion from Inner Space, played in their homes, with up to 3 months to complete the game. Samples and questionnaires were taken before and after the intervention (3 months and 5 months). C: The group was put on hold for 5 months, and at the end of all the collection from group I, access to the games was made available to this group. The interventions were carried out online, but there was access by trained staff to participants' adherence (online).	Self-reported data collection on pre-programmed tablets; gameplay data collected over the internet; blood and anthropometric assessments by trained personnel; and body-worn accelerometers.	No significant results were found endorsing the use of games as a health behavior change tool for children. -- evidence to support changes in PV consumption but was not found in the study.
Aalbers & Peeters 2020[32]	Randomized Controlled Trial	Sample: Adults over the age of 18, with a BMI over 25kg/m², n=47 / Location: Amhem, Netherlands / Duration: 27 days, players had free access to the game daily.	Investigate whether the game is fun to play, whether nutritionists find it suitable to support their work, and whether it increases dietary adherence.	I: Group attended accompanied by the use of the Digest-Inn game as an adherence tool, n=25. 15 subjects played and 10 chose not to play. C: The group is made up of individuals with characteristics similar to those of group I. This group only attended nutritional consultations, without using the game, n=22. The person responsible for (The interventions took place online, and the subjects were accompanied by nutritionists, the authors had access to game data for each participant).	Subjects were evaluated according to their adherence to appointments (assessed based on attendance at appointments), progress in the game, physical activity (data acquired in the game using the Google Fit step count app), weight loss, and satisfaction with the use of the appointments + game.	The control and intervention groups did not show significant differences in weight loss, but group I showed better adherence to nutritional appointments, as the players were encouraged by the game to return to their appointments.

I: intervention group; C: control group

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