

Development and evaluation of a mobile game to enhance the nutrition knowledge of elderly

Desenvolvimento e avaliação de um jogo móvel para aumentar o conhecimento de idosos sobre nutrição

Loiva Beatriz Dallepiane^{1✉}, Bárbara De Carli Silveira², Enio Giotto³, Cariza Teixeira Bohrer³



The objective of this study was to develop and test a nutrition education methodology for the elderly using a mobile game. The study followed three phases: in the first one, the mobile application was designed, and, in the second phase the nutrition education methodology was developed. Finally, a sample of eleven elderly residents in the city of Palmeira das Missões, Brazil used and tested the game installed on a tablet for three days. At this phase, the speech, expression, and application-handling difficulties of each elderly have been captured. Each elderly was interviewed to identify difficulties and the ease to use of the game and satisfaction and understanding of the nutrition education methodology. Some difficulties were recognized, but on average, 87.9% of the elderly indicated that the game is easy to use, 100% stated that icons and images are easy to recognize, 93.9% found the game fun, 100% indicated that it was able to generate clear knowledge about healthy eating. The game met the specificities of the target public and increased conceptual notions about nutrition and nutritional status in this population

Software. Aging. Nutrition assessment.

O objetivo deste estudo foi desenvolver e testar uma metodologia de educação alimentar e nutricional para idosos utilizando um jogo para celular. O estudo foi desenvolvido em três fases: na primeira, o aplicativo foi delineado e na segunda fase a metodologia de educação nutricional foi desenvolvida. Finalmente, uma amostra de onze idosos residentes na cidade de Palmeira das Missões, Brasil usou e testou o jogo instalado em um tablet por três dias. As dificuldades de fala, expressão e manipulação de aplicativos de cada idoso foram capturadas. Cada idoso foi entrevistado para identificar dificuldades, facilidades de uso do jogo e satisfação e entendimento sobre a metodologia da educação nutricional. Algumas dificuldades foram reconhecidas, mas, em média, 87,9% dos idosos indicaram que o jogo é fácil de usar, 100% afirmaram que ícones e imagens são fáceis de reconhecer, 93,9% acharam o jogo divertido e 100% indicaram que ele era capaz de gerar conhecimento claro sobre alimentação saudável. O jogo atendeu às especificidades do público-alvo e aumentou as noções conceituais sobre nutrição e estado nutricional nessa população.

Software. Idosos. Avaliação nutricional.

Introduction

The global elderly population is growing due to the decline of fertility and improvement of life expectancy, which characterizes a demographic shift. Then, the proportion of the population aged 60 years or over will increase and is expected to double and reach approximately 2.1 billion around 2050. Furthermore, population data shows that between 2017 and 2050, the number of persons aged 80 years or over will increase more than threefold (UN, 2017).

Even if expectancy growth discloses health progress, the elderly has been an important topic in the public agenda, for dealing with aging issues like chronic disease growth, changes in body composition, and decline of cognitive function, and immune function (NAP, 2015). Healthcare systems are working more to guarantee the necessary conditions to promote healthy aging, to prevent and treat chronic conditions and non-communicable diseases (NCDs) (IBGE, 2015; UN, 2017).

To face these challenges health policymakers and healthcare providers should consider nutrition education as a valuable strategy, to promote health and quality of life (AHN; PARK; KIM, 2018). As noted, nutrition education focused on the elderly is an important action to improve health attitudes and knowledge (CASAGRANDE et al., 2018; CHIU; KUO; LIN, 2017).

In this context, nutrition education should be based on the reflection of the social and cultural environments to guide educational practices and to promote education aiming at a "good diet" or at "promoting adequate and healthy food practices" (NASCIMENTO; CARVALHO; PRADO, 2017).

Information and communication technology (ICT) has been used as a means of nutrition and health education. Mobile tools and applications are used to improve self-care and treatment adherence (HIRSCHEY et al, 2018), provide higher quality care (SALOME e ROSA, 2020) and it is also useful to influence dietary behavior changes, consciousness, and self-education about nutrition that conduct to healthy life promotion (WANG et al., 2016). A study carried out in China, testing a technology-embedded approach in nutrition education showed that the method was suitable and improved the knowledge of common food, nutrition information, and noncommunicable diseases (CHIU; KUO; LIN, 2017). In addition, multimedia devices allowed personalized nutritional council and improved the competencies related to food choice, although there is still room for developing this type of approach (TURNIN et al., 2016).

As stated by some authors, in the case of the elderly population, ICT can be an instrument to link generations, in order to promote search and exchange of information and to improve family and social relationships (GUIMARAES, 2017). Furthermore, future research can be implemented to evaluate self-efficacy and teaching methods (JUDGES et al., 2017), as well as the usability and usefulness of mobile apps and similar tools that support self-care and treatment adherence (HIRSCHEY et al, 2018). It is also worthy to clarify the use of electronic devices by the elderly to provide actions for competent use needed to better integrate them into a technological society (COSTA; BIFANO, 2017; DA SILVA SANTANA; LEESON, 2015). At the same time, these actions will ease the contact between healthcare professionals and caregivers, to improve the healthcare provided to the elderly (DA SILVA SANTANA; LEESON, 2015).

Amorim et al. (2018) conducted a study to describe the applications related to the health and care of the elderly and found 25 applications, but none of them was directly related to eating habits and nutrition. To help fill a literature and practice gap, this study aims to develop a nutrition education methodology using a mobile game to stimulate changes in elderly eating habits, promote health behavior and prevent non-communicable diseases. In addition, it tests if elderly specificities were met, through an interactive, playful, and accessible environment.

Materials and methods

This study used a combination of qualitative and quantitative methods, and it was developed in three phases. The first phase was based on the design of the mobile game and the second phase was crucial for the development of the nutrition education methodology. Then, the third phase could take place, when an elderly sample used and tested the game. These phases are described as follows.

First phase: design of the mobile game

The mobile game was developed from August to September 2017, by a Science Extension Project team of a Brazilian University that is entitled here as "ICT development team". The game was named "Filling Your Plate". To choose the game operating system, the ICT development team considered the most popular. As stated by Wang et al (2016) when studying a user group of health-related apps, they almost exclusively reported Android and iPhone OS operating systems. It is the same operating system used in other studies (BILJON; RENAUD, 2016; HIRSCHEY et al, 2018; JIANG; ZHOU, 2018). In addition, the KitKat version was used because it is one of the most popular versions and the Eclipse platform was chosen because of its ease of use, its practical, simple, and wide interface, streamlining the process of programming and construction of the game layout. Java was also used because it is specific for the development of games on mobile devices (ALBINSSON; ZHAI, 2003).

Touch screens seem to enrich the topics in interface usability because it shortens the distance between users and the interface and grants a more realistic sensation. At the same time, it provides a larger font size, and high contrast screen and frees elderly hands, which is necessary to diminish physical, motor, and eyesight impairments. Considering these features is important to achieve the best match between technology and the elderly needs. Furthermore, easy-to-understand language and simple screens or steps, are used to minimize the difficulty of users' interaction with the game, like memory impairments (DANIAL-SAAD et al., 2019; BILJON; RENAUD, 2016; HSIAO et al., 2017; JUDGES et al., 2017).

Second phase: development of the nutrition education methodology

The second phase was carried out by the nutrition team, who worked on the nutrition education subjects. Then, they established the rules of the mobile game, which aimed to inform elderly users about adequate and inadequate Body Mass Index (BMI), dietary habits related to calories, cholesterol, sodium and fiber, and water consumption.

The nutritional status assessment was set by BMI, calculated by the application, and measured by the current

weight and height reported by the elderly. The rules and alerts were based on Pan American Organization Health (OPAS, 2001), to assess elderly status. When BMI is normal the following warning is triggered: "Congratulations, keep in good shape ". Otherwise, if the BMI is not normal then the message is as follows: "Your weight is at odds with your recommended weight for your age, take care!".

To evaluate nutrient intake and adequacy, three flowcharts were developed (with minimum, average, and maximum limits), so that they were established as the rules, to be confronted with the personal data entered at the beginning of the game.

Further, as a nutrition education methodology, the mobile game was able to process a food diary (24-hour dietary recall) and calculate informed daily calories, cholesterol, fibers, sodium, and water consumption data. At the same time, depending on the results (if adequate or not) the game was configured to trigger sound and text alerts, that were established to achieve nutrition education goals, based on elderly needs.

Thus, the rules considered calorie and nutrient intake data that, when unhealthy, are involved in the risk for the development of chronic diseases in aging, compromising their quality of life. To define the nutritional rules, the nutrition team followed elderly nutrient requirements and dietary guidelines, as follows.

To set calorie demands, Dietary Reference Intake (DRI) was used, considering that for the elderly it differs between the age group and sex. For men aged 51 to 70 years, it is recommended 2,400 Kcal, and for women 1,875 kcal. For men over 70 years, it is recommended 2,100 kcal, and for women 1,700 kcal (IOM, 2005). For Cholesterol, Fiber, and Sodium (Na) dietary intakes, the reference was based on the IV Brazilian Guideline for Dyslipidemia and Prevention of Atherosclerosis (SPOSITO et al., 2007). The water consumption per day was evaluated according to the Ministry of Health (BRASIL, 2010). The intake of other beverages has not been considered since the Ministry of Health's recommendation is only about water consumption.

These guidelines were used to evaluate the 24-hour dietary recall entered by the elderly while using the mobile game. It converts food consumption into nutrition intake, summarizes results in a daily report, and compares results with the nutrition rules. Data was considered "ADEQUATE" when BMI, calories, nutrients, and water consumption were in accordance with the rules. On the other hand, the results were considered "INADEQUATE" for BMI, calories, nutrients, and water consumption that disagreed with the rules established by the mobile game, as showed in Table 1.

Table 1 | Mobile Game Rules for Body Mass Index (BMI), Calories, Cholesterol, Fiber, Sodium, and Water consumption.

Evaluation	Adequate	Inadequate
BMI	> 23 Kg/m ² or < 28 Kg/m ² 25 a 29.99	< 23 kg/m ² or ≥ 28 kg/m ²
Calories	Kcal/kg/day ≥ 30 Kcal/kg/day	≤ 24.99 Kcal/kg/day or ≥ 30 Kcal/kg/day
Cholesterol	< 200 mg/day	> 200 mg/day
Fiber	≥ 25/day	< 25 g/day
Sodium (Na)	< 2000 mg/day	>2000 mg/day
Water consumption	≥ 2 liters/day	< 2 liters/day

Third Phase: Game Test and Evaluation. Source: own authorship.

To test and evaluate the mobile game, elderly of 60 years or more were recruited through Snowball sampling. This technique consists of the recruitment of non-probability samples based on referrals from an initial subject that nominate another member of the sample, and so on. The pursuing of further cases ends when research objectives are reached and there is no new data emerging. That is, when new subjects start repeating data, without adding new relevant information to the survey.

The test and evaluation phase started after ethics approval was obtained from the University's Research Ethics Board, under Protocol 1812652 and Ethics Certificate (CAAE in Portuguese) 61477916.0.0000.5346.

Elderly who signed the Informed Written Consent and who had previous contact with computers and information and communication technologies were recruited. This technology contact was verified through a questionnaire identifying the socio-demographic data. We did not recruit illiterate elderly or those with some cognitive impairment evaluated through Lewandowski's test (LEWANDOWSKI, 2014).

The first elderly subject recruited for the study was a member of an elderly community group of Palmeira das Missões because of her convenient accessibility and because she was a subject in previous research held by the university.

The mobile game testing was held at the elderly's place. The researchers went to the elderly's house three times (once a week), with the game installed on a tablet, to explore the game test. After a brief explanation of the research objectives, the researcher gave the tablet to the subject to play. The researcher helped the elderly only when asked to. During all three session tests, elderly feelings were observed, and audio and video were recorded. After each one of these game session tests, the subject was interviewed to find his or her outlook on the game and moreover to evaluate his or her feelings about the game, after several attempts. Audio recording transcription of the interviews was analyzed to recognize what they liked, disliked, their doubts, problems faced, and what they would change about the game.

User satisfaction was the first game feature evaluated. For this, the elderly answered nine multiple choices closed-ended questions and one open-ended question regarding game usage. At this point, the interview aimed to assess if the elderly has fun playing the game if it was easy to play if the software presented any bug and if words, terms, images, and icons were large and easy to recognize.

To evaluate the game as a nutrition education methodology, the elderly answered two multiple choices closed-ended questions and two open-ended questions, to

inform if the game helped them to improve their knowledge about food, healthy eating, and their nutritional status.

The results described in the following section are based on the three test times and the following interviews done just after each one. Descriptive statistics are reported as percentages and the most important user's statements, questions, and feelings are reported.

Results

The game's technical specifications were designed by the ICT team, helped by the nutrition team. It was important to meet the particularities of the elderly stage of the life cycle, considering the physiological changes that occur with aging, such as hearing, visual and cognitive impairments. The game operating system chosen was Android® and it was then installed on a 9.7-inch screen and touch screen equipment (tablet), aiming at having a larger screen, compared to a mobile phone. The mobile game interface was developed with high definition of contrast colors, icons, and texts ranging from medium to large font sizes. Finally, easy-to-understand language and simple screens were relevant to meet elderly needs.

In order to develop the Nutrition education methodology, the mobile game was composed of several screens, as follows: First screen and nutritional assessment: First of all the user should register him/herself (name) to have access to the other screens of the game. At the same time, the user must agree to the privacy policy by clicking on "START". Then the user must fill in the blanks with age (years), weight (kg), and height (m) data and the game calculates the body mass index (BMI). The result is automatically classified according to the elderly

cut-off points proposed by the Pan American Health Organization (OPAS, 2001) and warnings are triggered, as set earlier.

"Filling Your Plate" game: This screen is used to portray and analyze the user's diet and water intake, as shown in Figure 1. Before starting the game, the user can read the "How to play" guidelines in the tutorial printed. The screen displays six meals a day and the user should choose the meal he/she wants to start informing. The user should select the "+ New" option to view the current date then it is directed to the new screen to select the food group the user wants to add to the diary. After opening the food group, a list of food options will show up. The user should select the food and then the amount consumed, based on one of the measures informed by the application. After clicking on "CONFIRM", the user can continue to pick up other foods for the same meal or he/she can choose to "EXIT" to return to other meals. The application automatically analyzes the data, and the user can get a brief report, of the general results, by clicking the "CALCULATE DIARY-REPORT" option. Furthermore, the game analyzes the daily meal, an option in which the user can obtain results of the analysis of how food consumption is throughout the day. The analysis is based on the nutritional rules and then alerts are triggered to notify the adequacy or not of the informed intake. In addition, in "OTHER OPTIONS", the user can check general tips on healthy eating, to seek guidelines to improve eating habits. Some of these screens are shown in the figure as follows.

Water consumption: the user should fill in the blank by writing the amount of daily water intake (in liters). Another screen offers nutrition and dieting information, based on the 10 Healthy Eating Tips for Seniors (BRASIL, 2010).

Figure 1 | Screens of the Filling Your Plate Game



Source: own authorship.

The study comprised 11 elderly individuals, 91% female, and 9% male. Most of them were ranging in age from 70 to 74 years (36.4%) and all of them were graduate. On average, participants reported a month income of 4.6 minimum salaries. According to marital status, 63.7% reported being married and 100% lived with the partner.

When asked about the experience with information and communication technologies, most of them (54.5%) answered positively but pointed out that he/she needed any support, depending on the task. During data collection, 81.8% of them

needed any assistance with the game features and functions. Table 2 presents the results of the multiple choice closed-ended questions regarding the elderly's satisfaction with the game and its interface.

Table 2 | Elderly Satisfaction with the game and its Interface

Question	First Interview n (%)	Second Interview n (%)	Third Interview n (%)
Did you find the game funny?	Yes 10 (90.9%) No 0 (0%) Indif. 1 (9.1%)	Yes 11 (100%) No 0 (0%) Indif. 0 (0%)	Yes 10 (90.9%) No 0 (0%) Indif. 1 (9.1%)
Did you consider the game easy to play?	Yes 9 (81.8%) No: 2 (18.8%) Indif. 0 (0%)	Yes 10 (90.9%) No 0 (0%) Indif. 1 (9.1%)	Yes 10 (90.9%) No 0 (0%) Indif. 1 (9.1%)
Did you consider the colors and buttons of the game pleasant?	Yes 11 (100%) No 0 (0%) Indif. 0 (0%)	Yes 11 (100%) No 0 (0%) Indif. 0 (0%)	Yes 11 (100%) No 0 (0%) Indif. 0 (0%)
Did you easily understand the words, icons, and images of the game?	Yes 11 (100%) No 0 (0%) Indif. 0 (0%)	Yes 11 (100%) No 0 (0%) Indif. 0 (0%)	Yes 11 (100%) No 0 (0%) Indif. 0 (0%)
Were the images and icons easily to recognize?	Yes 11 (100%) No 0 (0%) Indif. 0 (0%)	Yes 11 (100%) No 0 (0%) Indif. 0 (0%)	Yes 11 (100%) No 0 (0%) Indif. 0 (0%)
How did you advance through the game?	It stopped 0 (0%) It didn't stop 11 (100%)	It stopped 0 (0%) It didn't stop 11 (100%)	It stopped 0 (0%) It didn't stop 11 (100%)
Icons size	Big 9 (81.8%) Medium 2 (18.2%) Small 0 (0%)	Big 9 (81.8%) Medium 2 (18.2%) Small 0 (0%)	Big 9 (81.8%) Medium 2 (18.2%) Small 0 (0%)
Language	Easy 10 (90.9%) Difficult 1 (9.1%) Indif. 0 (0%)	Easy 11 (100%) Difficult 0 (0%) Indif. 0 (0%)	Easy 11 (100%) Difficult 0 (0%) Indif. 0 (0%)
Font size	Small 0 (0%) Medium 2 (18.2%) Large 9 (81.8%)	Small 0 (0%) Medium 2 (18.2%) Large 9 (81.8%)	Small 0 (0%) Medium 2 (18.2%) Large 9 (81.8%)

Source: own authorship.

Some statements about user's satisfaction were clear about their opinion: "I loved the game, it's funny, it's nice to know if what we eat every day is good or bad " (Female, 72 years old).

Regarding the easy and troubles faced during the game test, 81.8% (n = 9) of the elderly reported the game was easy to play (with the researcher's help). The citation below illustrates some feelings: "At the beginning of the game I confess that I didn't like it very much, because I believed it was too much information, however, in the end, I realized that this game is easy to use, if I have help, of course! I also have to say that it is much more than a simple game, with it I've learned about my food and then I can change my habits improving my life, contributing to living longer" (Female, 60 years old).

On the other hand, 18.2% stated the game was difficult to play. These subjects, however, were those who did not ask for help for most of the game's screens. The further interviews showed that less trouble was reported, it means, fewer subjects found the game difficult to play. This progress seems to be linked to the repetition of the game, as follows: "Today the game was much easier than last week, it seems that I added meals faster, I'm happy and today I find it easy!!" (Female, 67 years old).

When they were asked about the most pleasant feature of the game, the statements below are remarkable: "I've liked the most the screen because the drawn pictures are nice and large, and the colors are beautiful" (Female, 72 years old). And "I liked to fill in the food diary and the large font size, I don't even need to wear glasses" (Female, 74 years old).

All the users, during the three interviews, answered "yes" when asked about knowledge creation concerning healthy eating and their nutritional status. As follows: "I've increased my knowledge about food, especially after I've read the 10 Healthy Eating Tips for Seniors. From this, I could understand the importance of reducing table salt, since my sodium intake was high" (Female, 60 years old).

When asked what they have learned about food with the game, the following answers stand out: "I've learned what fibers are, what vegetables and derived vegetables are, and what I should eat more often during the day. I've also learned that I should drink more water and not just *chimarrão* (a kind of hot tea, from south Brazil) that I thought was water" (Female, 69 years old). And "I've learned that I have a high salt intake because I eat a lot of ham mortadella and cheese, that is why I have high blood pressure and I take medicine" (Male, 60 years old).

Discussion

According to the interviews, we noticed the elderly thought the game easy to play. As stated by some authors, this type of equipment minimizes the difficulties related to keypads and small buttons (BILJON; RENAUD, 2016; HÄIKIÖ et al., 2007). Furthermore, touch screen devices permit a closer and a more realistic relationship between the user and interface (HSIAO et al., 2017).

Strong color screens and contrasts, and few images were used on the mobile game interface, and it satisfied the subjects during the tests. It is one of the features of mobile interface design guidelines for the elderly, to surpass impaired eyesight (BILJON; RENAUD, 2016). Moreover, to benefit from effective communication, no more than five colors and simple iconography should be used in the layout (STEPHAN et al., 2017).

Small font sizes are one of the main interaction problems of the elderly with websites, and it can decrease the interface usability for the elderly with impaired eyesight (BILJON; RENAUD, 2016; HÄIKIÖ et al., 2007). Therefore, the font size chosen in this study was from medium to large, guaranteeing greater game user accessibility, which was noted by the users.

During the test sessions, we could notice that some subjects forgot what they have read on the previous screen and went back and forth between screens. Some troubles in using ICT are related to memory problems, and special approaches and features are needed when developing ICT for the elderly (DA SILVA SANTANA; LEESON, 2015; HÄIKIÖ et al., 2007; HSIAO et al., 2017; JUDGES et al., 2017; NSTC, 2019). However, it is important to notice that through test sessions, the perception of ease in the use of the game improved. It was especially pleasant playing the game after the second session test, providing an enjoyable moment for both the player and the researcher. This fact can be explained because the elderly got used to the game. By acquiring more knowledge of the game screens, it was easier to fill in the food diary. This progress is like the results found when an experiment was held with seniors to test a touch-based user interface to choose meals. As the sessions continued, some problems clearly decreased (HÄIKIÖ et al., 2007). Improvements were also revealed when the skills gained by seniors after learning how to use a digital communication tool make them able to further technology adoption. Furthermore, the results showed that the elderly turned eager to explore additional applications (JUDGES et al., 2017).

Even if usage duration seems to influence easy-to-use ICT, when testing diet and physical activity apps, duration of use did not influence users' perceived effectiveness for all the food products tested in a study held in Norway with adults (WANG et al., 2016). It was not an objective of our study, but it raises some interesting questions for further research.

According to the nutrition education methodology, some remarks about the elements approached are interesting. First, the group of elements chosen (Cholesterol, Fiber, Sodium, Calories, and water intake) seems to be relevant, as these are some specific nutrients that are associated with the development of chronic diseases in population aging (NAP, 2015). As high cholesterol is associated with cardiovascular risk factors, nutrition education strategies are essential to lead with elderly chronic diseases (MARTINS et al., 2017). Moreover, high-density lipoprotein cholesterol (HDL) levels are associated with memory function (KINNO et al., 2019). So, studies focusing on cognitive decline, biomarkers, and nutrition education are especially important to be developed with the elderly.

At the same time, the association between constipation and aging is well established. Even if diet and lifestyle modifications are not always effective to manage constipation, a multifactorial approach can improve the elderly's quality of life (DE GIORGIO et al., 2015). Moreover, it is noted that fiber intake also helps a slight decrease in hypertension (MALACHIAS et al., 2016). So, nutrition education activities putting together water and fiber intake, such as the game proposed and tested in this study, can be helpful to decrease the negative impacts of bowel symptoms on the elderly's quality of life.

The nutrition team considered salt intake because sodium is the micronutrient that most influences the development of hypertension (MALACHIAS et al., 2016). As hypertension is the most prevalent noncommunicable disease among the aging population, and preventive measures to remove table salt significantly reduce its incidence (SOUZA et al., 2016), nutrition education focusing on this topic is central.

According to calorie intake, as frailty, functioning loss and disability are all associated with it (DE GIORGIO et al., 2015; HE; GOODKIND; KOWAL, 2015), its analysis is important to prevent malnutrition and muscle mass losses (SOUZA et al., 2016). On the other side, obesity is prevalent in some Latin America countries and diet, and sedentary behaviors are associated with obesity, diabetes, and cardiovascular disease (NAP, 2015). Furthermore, obesity has also increased in other countries, and it is an important risk factor in mortality (HE; GOODKIND; KOWAL, 2015). So, considering this factor can improve elderly health care, considering obese and malnourished groups.

Finally, we chose to evaluate water intake, since the elderly have a diminished sensation of thirst. This factor is important to be assessed because good hydration is associated with positive results in cognitive tests, and otherwise, dehydration can decrease cognitive abilities (BIAŁECKA; PIETRUSZKA, 2019). In addition, dehydration is associated with poor food intake, frailty, and immobility. At the same time, reduced water and fiber intake affect gastrointestinal motility and as a result, it can conduct to constipation condition (DE GIORGIO et al., 2015).

These aspects, established as important elements to be evaluated by the nutrition team, even though not assessed by the researchers through the daily report, were fundamental as nutrition education subjects. According to this objective, we found that all users reported having learned more about nutrition, using the game. During the interviews, the elderly pointed to changes in various aspects of eating behavior and diet intake, such as a higher frequency of meals, and increased water consumption. Similar results were found when educational software programs were used as interactive devices by children and showed the potential to improve their food choices competencies (TURNIN et al., 2016).

Then, these results show that nutrition education methodology impacted in a good way in dietary habits and nutritional knowledge. Similar results were found by authors who investigated the effects of an individualized nutritional education and support program on dietary habits, nutritional knowledge, and nutritional status of older adults living alone (AHN; PARK; KIM, 2018). Finally, as the elderly's dietary patterns and socioeconomic factors are associated (SOUZA et al., 2016), this mobile game can be an easy and cheap strategy for nutrition education since it was developed to be downloaded for free.

According to the study limitations, it is noted that it was difficult to better evaluate the elderly troubles using the game only considering the questions made by them when testing it. Instead of that, the barrier could be elderly's memory. We noticed that in some moments, the elderly forgot what they have read on the previous screen and therefore had to return to another functionality. In addition, we expected to improve the game after tests, but most of the elderly (54.55%) were not able to suggest improvements or to point out the application interface problems.

Conclusion

The nutrition education methodology focused on nutrients that may be related to the development of chronic diseases in aging seemed to be useful in the improvement of their nutrition knowledge. the objective of the nutrition education methodology was realized by users when they recognized some faulty eating habits. Regarding food and nutrition information, it was possible to notice that this mobile game increased knowledge about nutrition and nutritional status. Even though aspects related to food and nutrition are difficult to change and depend on the elderly's individual history, family, or social group, this study demonstrated that funny and interactive activities can create favorable conditions for these changes.

Therefore, these results must be carefully interpreted. Further research evaluating the mobile game and its data will be useful in understanding whether the game is useful as an educational and effective tool in supporting nutrition education. So, these findings must have their external validity improved in other studies, using a larger sample and/or more geographically representative samples.

References

- AHN, J. A.; PARK, J. W.; KIM, C. J. Effects of an individualized nutritional education and support programme on dietary habits, nutritional knowledge and nutritional status of older adults living alone. *J Clin Nurs.* v.27, n. 9-10, p. 2142-2151, Mai. 2018.
- ALBINSSON, P. A.; ZHAI, S. High precision touch screen interaction. In: CHI'03, Ft. Lauderdale. *Anais... SIGCHI Conference on Human Factors in Computing Systems.* Nova York: ACM Digital Library; 2003. p. 105-112.
- AMORIM, D.N.P. et al. Aplicativos móveis para a saúde e o cuidado de idosos. *Reciis – Rev Eletron Comun Inf Inov Saúde*, v. 12, n. 1, p. 5-71, 2018.
- BIAŁECKA, A.; PIETRUSZKA, B. The association between hydration status and cognitive function among free-living elderly volunteers. *Aging Clin Exp Res.* v. 31, n. 5, 694-703, Mai. 2019.
- BILJON, J. V.; RENAUD, K. Validating Mobile Phone Design Guidelines: Focusing on the Elderly in a Developing Country. In: SAICSIT'16, 2016, Johannesburg. *Anais... Annual Conference of the South African Institute of Computer Scientists and Information Technologists.* Nova York: ACM Digital Library; 2016. Article No. 44.
- BRASIL. Ministério da Saúde. Secretaria de Atenção à Saúde. Departamento de Atenção Básica. *Alimentação saudável para a pessoa idosa: um manual para profissionais de saúde – Dicas em Saúde.* Brasília: BVS do Ministério da Saúde, Dez. 2010.
- CASAGRANDE, K. et al. Avaliação da Efetividade da Educação Alimentar e Nutricional em Idosos. *Rev Bras Obes Nutr e Emagrecimento*, v. 12, n. 73, p.591-597, set-out. 2018.
- CHIU, C. J.; KUO, S. E.; LIN, D. C. Technology-embedded health education on nutrition for middle-aged and older adults living in the community. *Glob Health Promot.* v. 26, n. 3, p. 80-87, set. 2017.
- COSTA, E.O.; BIFANO, A.C.S. Idosos e tecnologias: uma pesquisa bibliográfica. *Estud. Interdiscipl. Envelhec.*, Porto Alegre, v. 22, n. 2, p. 113-131, 2017.
- DA SILVA SANTANA, C.; LEESON, G. Elderly Users' Perspective on the Use of Technology in Daily Life: A Comparative Study of a sample in the UK and Brazil. *Inteligencia Artificial*, v. 18, n. 55, p. 35-49, Jun. 2015.
- DANIAL-SAAD, A. et al. "Touchscreen Assessment Tool" (TATOO), an Assessment Tool Based on the Expanded Conceptual Model of Frailty. In: GANCHEV, I. et al eds. *Enhanced Living Environments.* 1 ed. Genebra: Springer Open, 2019.
- DE GIORGIO, R. et al. Chronic constipation in the elderly: a primer for the gastroenterologist. *BMC Gastroenterol.* v. 15, n. 130, out. 2015.
- GUIMARÃES, H.N. *A importância das tecnologias de informação e comunicação na vida social dos idosos.* Patos, Paraíba. Trabalho de Conclusão de Curso (TCC). Universidade Estadual da Paraíba. 2017.
- HÄIKIÖ, J. et al. Touch-Based User Interface for Elderly Users. In: Mobile HCI'07, 2007, Singapura. *Anais... 9th international conference on Human computer interaction with mobile devices and services.* Nova York: ACM, 2007. p. 289-296.
- HE, W.; GOODKIND, D.; KOWAL, P. *An Aging World:* 2015. Vol P95/16-1. Washington; 2016. Disponível em: <https://www.census.gov>. Acesso em: 16.03.2019.
- HIRSCHEY, J. et al. Evaluating the usability and usefulness of a mobile app for atrial fibrillation using qualitative methods: Exploratory pilot study. *JMIR Hum Factors.* v. 15, n. 5, p. 1-16, mar. 2018.
- HSIAO, S. et al. User interface based on natural interaction design for seniors. *Comput Human Behav.* 75, 147-159, out. 2017.
- IBGE. Mudança Demográfica No Brasil No Início do Século XXI: *Subsídios Para as Projeções da População.* v. 3. Rio de Janeiro: Instituto Brasileiro de Geografia e Estatística, 2015. Disponível em: <https://biblioteca.ibge.gov.br/visualizacao/livros/liv93322.pdf> . Acesso em: 16.03.2019.
- IOM. Institute of Medicine (U.S.). *Dietary Reference Intakes for Energy, Carbohydrate, Fiber, Fat, Fatty Acids, Cholesterol, Protein, and Amino Acids.* Washington: National Academies Press, 2005.
- JIANG, L.; ZHOU, W. Design and implementation of college course teaching platform based on Android system. In:

- ICRIS, 2018, Changsha. *Anais... 2018 Int Conf Robot Intell Syst (ICRIS)*. Piscataway: IEEE; 2018. p. 413-416.
- JUDGES, R. A. et al. "InTouch" with seniors: Exploring adoption of a simplified interface for social communication and related socioemotional outcomes. *Comput Human Behav.*, v. 75, p. 912-921, out. 2017.
- KINNO, R. et al. High serum high-density lipoprotein-cholesterol is associated with memory function and gyrification of insular and frontal opercular cortex in an elderly memory-clinic population. *NeuroImage Clin.*, v. 22, 101746, mar. 2019.
- LEWANDOWSKI, A. *Saúde bucal de idosos longevos*. 2014. Dissertação (Mestrado) – Programa de Pós-Graduação em Gerontologia Biomédica, Pontifícia Universidade Católica do Rio Grande do Sul, Porto Alegre, 2014.
- MALACHIAS, M. V. B. et al. *7a Diretriz Brasileira de Hipertensão Arterial*. v. 107, n. 3, supl. 3, set. Rio de Janeiro: Sociedade Brasileira de Cardiologia, 2016.
- MARTINS, M. V. et al. Association between triglycerides and HDL-cholesterol ratio and cardiovascular risk factors among elderly persons receiving care under the family health strategy of Viçosa, Minas Gerais. *Rev Bras Geriatr e Gerontol.* v. 20, n. 2, 236-243, abr. 2017.
- NAP. The National Academies Press. *Strengthening the Scientific Foundation for Policymaking to Meet the Challenges of Aging in Latin America and the Caribbean: Summary of a Workshop*. Washington: The National Academies Press; 2015. Disponível em: <http://www.prb.org/Publications/Reports/2014/latin-america-life-expectancy.aspx>. Acesso em: 16.03.2019.
- NASCIMENTO, M. N. C. do; CARVALHO, M. C. D. V. S.; PRADO, S. D. Análise sobre Orientações Políticas de Educação Alimentar e Nutricional. *DEMETRA Aliment Nutr Saúde*, v. 12, n. 3, p. 637-664, 2017.
- NSTC. National Science and Technology Council. *Emerging Technologies to Support an Aging Population*. Washington; 2019. Disponível em: <http://www.whitehouse.gov/ostp>. Acesso em: 16.03.2019.
- OPAS. Organización Panamericana de la Salud. Oficina Sanitaria Panamericana, La Oficina Regional Del Organización Mundial de la Salud CAIS 36/2001.5. XXXVI Reunión del Comité Asesor de Investigaciones em Salud. *Encuesta Multicéntrica*, 2001.
- SALOME, G. M.; ROSA, G. C. M. Aplicativo móvel de apoio à aspiração do tubo endotraqueal e de vias aéreas superiores. *Revista Saúde (Sta. Maria)*. v. 46, n. 2, 2020.
- SOUZA, J. D. et al. Padrão alimentar de idosos: caracterização e associação com aspectos socioeconômicos. *Rev Bras Geriatr e Gerontol.*, v. 19, n. 6, 970-977, nov-dez. 2016.
- SPOSITO, A. C. et al. IV Diretriz Brasileira sobre Dislipidemias e Prevenção da Aterosclerose: Departamento de Aterosclerose da Sociedade Brasileira de Cardiologia. *Arq. Bras. Cardiol.*, v. 88, supl. 1, p. 2-19, abr. 2007.
- STEPHAN, L. S. et al. Processes and Recommendations for Creating mHealth Apps for Low-Income Populations. *JMIR mHealth uHealth*, v. 5, n. 4, abr. 2017.
- TURNIN, M. C. et al. Effect of Nutritional Intervention on Food Choices of French Students in Middle School Cafeterias, Using an Interactive Educational Software Program (Nutri-Advice). *J Nutr Educ Behav*, v. 48, n. 2, p. 131-137.e1, fev. 2016.
- UNITED NATIONS. *World Population Ageing [Highlights]*. 2017. Disponível em: https://www.un.org/en/development/desa/population/publications/pdf/ageing/WPA2017_Highlights.pdf. Acesso em: 16.03.2019.
- WANG, Q. et al. Diet and Physical Activity Apps: Perceived Effectiveness by App Users. *JMIR mHealth uHealth*, v. 4, n. 2, e33, abr-jun. 2016.

Apêndice

Reimpressões e permissões

Informações sobre reimpressões e permissões estão disponíveis no site da RBCEH.

Informações da revisão por pares

A RBCEH agradece ao(s) revisor(es) anônimo(s) por sua contribuição na revisão por pares deste trabalho. Relatórios de revisores por pares estão disponíveis no site da RBCEH.

Resumo do relatório

Mais informações sobre o desenho da pesquisa estão disponíveis no site da RBCEH, vinculado a este artigo.

Conflitos de interesses

Os autores declaram não haver conflitos de interesses.

Correspondência

A correspondência e os pedidos de materiais devem ser endereçados a L.B.D. I loiva.dallepiane@hotmail.com.

Vínculo institucional

¹Universidade Regional do Noroeste do Estado do Rio Grande do Sul, Ijuí/RS, Brasil.

²Prefeitura Municipal de Novo Tiradentes, Novo Tiradentes/RS, Brasil.

³Universidade Federal de Santa Maria, Santa Maria/RS, Brasil