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Original research

Effect of a gamified digital platform in increasing learning about the prevention of metabolic syndrome, obesity, and type 2 diabetes mellitus

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ABSTRACT

Introduction: Gamified digital platforms allow non-health related individuals to learn about the prevention, management and treatment of obesity, metabolic syndrome, and type 2 diabetes mellitus (T2DM). **Objective:** The purpose of this study was to evaluate whether a new gamified digital platform increases learning about the prevention of metabolic syndrome, obesity, and T2DM. **Methods:** An exploratory, randomized, cause-effect study was carried out in 150 children between 10 and 12 years of age. Three exploratory, cause-effect experiments were designed to evaluate each one of the following pathologies: T2DM, obesity and metabolic syndrome. For each experiment, two study groups of 25 individuals each were formed. The experimental group was asked to use the digital platform that contained the information on the pathology under study in an animated storytelling and playful way. The control group received written information about each pathology. The assessment was carried out by applying a validated questionnaire including basic questions about the three diseases. This test was performed before and after the intervention. **Results:** We found a significant improvement ($p<0.05$) in the post-intervention knowledge acquired within the experimental group about metabolic syndrome, obesity, and T2DM when using the digital platform and compared to the control group. Children in the control group significantly improved their scores after the intervention compared to their baseline ones. **Conclusion:** Gamified digital platforms have the potential to be a novel primary prevention method for metabolic diseases. The present study allows us to conclude that any validated learning instrument increases knowledge about metabolic diseases. However, gamified digital platforms significantly increase learning compared to other types of methods (written information).

Key words: gamified digital platforms; obesity; metabolic syndrome; type 2 diabetes mellitus.

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RESUMEN

Introducción: Las plataformas digitales gamificadas facilitan el aprendizaje para las personas no relacionadas con la salud sobre temas como son la prevención de la obesidad, el síndrome metabólico y la diabetes *mellitus* tipo 2 (DM2). **Objetivo:** El propósito de este estudio fue el de evaluar si una nueva plataforma digital gamificada incrementa el aprendizaje sobre la prevención del síndrome metabólico, la obesidad y la DM2. **Métodos:** Se realizó un estudio exploratorio, aleatorio de causa-efecto en 150 niños de entre 10 y 12 años de edad. Se diseñaron tres experimentos exploratorios de causa-efecto para evaluar por separado la DM2, obesidad y síndrome metabólico. Para cada experimento se formaron dos grupos de 25 individuos cada uno. Se pidió al grupo experimental que utilizara la plataforma digital con la información sobre la patología en estudio de forma animada y lúdica. El grupo control recibió información escrita sobre cada patología. La valoración se realizó aplicando un *test* antes y después de la intervención. **Resultados:** Encontramos una mejora significativa ($p<0.05$) en el conocimiento adquirido después de la intervención sobre las tres patologías al usar la plataforma digital y en comparación con el grupo control. Los niños en el grupo control mejoraron significativamente ($p<0.05$) sus puntajes después de la intervención en comparación con sus valores iniciales. **Conclusión:** Las plataformas digitales gamificadas representan un método novedoso de prevención primaria de enfermedades metabólicas. El presente estudio permite concluir que cualquier instrumento de aprendizaje validado aumenta el conocimiento sobre las enfermedades metabólicas. Sin embargo, las plataformas digitales gamificadas aumentan significativamente el aprendizaje en comparación con otros métodos (información escrita).

Palabras clave: plataformas digitales gamificadas; obesidad; síndrome metabólico; diabetes *mellitus* tipo 2.

INTRODUCTION

Obesity and particularly abdominal obesity are associated with an increased risk of cardiovascular disease (CVD) and all-cause mortality.[1-3] Obesity is often accompanied by other metabolic comorbidities, such as insulin resistance and atherogenic dyslipidemia. Moreover, patients with obesity also have an increased risk of developing type 2 diabetes mellitus (T2DM) and metabolic syndrome, both of which increase the risk of developing cardiovascular disease.[4-6]

In Mexico, the prevalence of T2DM increased from 9.2% in 2012 to 12.1% in 2018-2019.[7] Interestingly, these estimates are higher than those reported by the World Health Organization (WHO) for the global adult population, which is 8.5%.[8]

It is important to mention that 75.2% of the adult population in Mexico has obesity and overweight (36.1% obese and 39.1% overweight), percentage that in 2012 was 71.3%.[9] Moreover, an alarming increase in overweight, obesity, and T2DM has been noticed among children and adolescents in the past decades.[10-13]

Since CVD remains the most common cause of mortality worldwide,[14] it is of great importance to develop novel prevention methods for the main metabolic conditions associated with CVD: obesity, metabolic syndrome, and T2DM. Currently, attempts are being made to attract the attention of the population that has or is at risk of metabolic diseases through the use of digital platforms that allow the interaction of each individual with a certain disease. Gamification techniques have scarcely been introduced as possible means to motivate patients to prevent diseases and/or sustain adherence to medical treatment. For instance, Klaassen and coworkers developed a platform that integrated diverse tools to support young patients (12-18 years old) in diabetes self-management through educational game playing, monitoring, and motivational feedback. Gamification uses elements of game design (i.e., points, leader boards, levels, competitions, rewards, achievements, mini games, goals, experience points, rules, narrative, graphics, imagination, role identification, or setting stepwise challenges) in pursuit of a goal.[15] Digital education through gamification will begin to transform the meaning of health for everyone, particularly from childhood and adolescence, with the consequent benefit that everyone can learn continuously and more effectively about the most prevalent diseases among us.

The present study aimed to evaluate a new digital tool that can provide an innovative and efficient option. This digital tool fulfills the objective of allowing learning about the prevention, management and treatment of obesity, metabolic syndrome, and T2DM through a gamified platform where the origin, development and management of

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these diseases are taught through animated storytelling and ludic games. This platform also includes interactions with health professionals, who can transmit their knowledge through informative podcasts and make themselves known through the directory of medical specialists. Participants are offered specific activities that require changes in life habits or the acquisition of knowledge or skills, thus being able to create self-learning communities and receive guidance through professionals who are experts in the areas of interest.

MATERIALS AND METHODS

This study was carried out in three phases until the implementation.

Phases

Phase I: Conceptualization of the game on the digital platform

In this phase, the digital platform was structured using an interactive and playful map that graphically presents the information on the pathologies, measures for their prevention and recommendations to follow if this condition is already present. A series of gamified challenges were designed in which the user makes use of the knowledge acquired and previously learned from experiences prior to the application of the platform. Challenges are a very useful tool which through their use and repetition, the interest of a wide range of users is achieved. As a consequence, four important types of gamification players can be identified: 1) Achievers: their objective is to solve challenges successfully and get a reward; 2) Explorers: they aim to discover and learn new or unknown things about the system; 3) Socializers: are attracted by the social aspects over the strategy of the game; 4) Killers (term used for the sense of competition): they aim to compete with other players.

During the use of the application, at any time the user can navigate through the different areas from where the individual will obtain information on the pathologies, either through a story (linked to the pathology with animated characters and audio components), a leaflet, an article, or infographics. In the challenges, the participants can test their knowledge through competition with another user connected to the application or the highest number of positive responses against the clock. In this phase, the objectives granted by gamification were achieved, namely offering a range of personalities an attractive option in playful games:

- Players vs. world: some users (socializers and killers) seek to relate, in whatever way, with other users, while others (explorers and achievers) prefer dynamics that allow them to relate to the world of the system.

- Interaction vs. action: some users (killers and achievers) want to act directly on some element, either against another user or the system itself, while others (socializers and explorers) prefer dynamics of mutual interaction.

These relationships are an example of gamification axes and types of players depending on their attitude towards the game (Figure 1).

Figure 1. Bartle taxonomy with the gamification axes and the types of players depending on their attitude towards the game.

Phase II: Design and programming of the digital platform

The digital platform is made up of two fundamental parts for its operation (Figure 2):

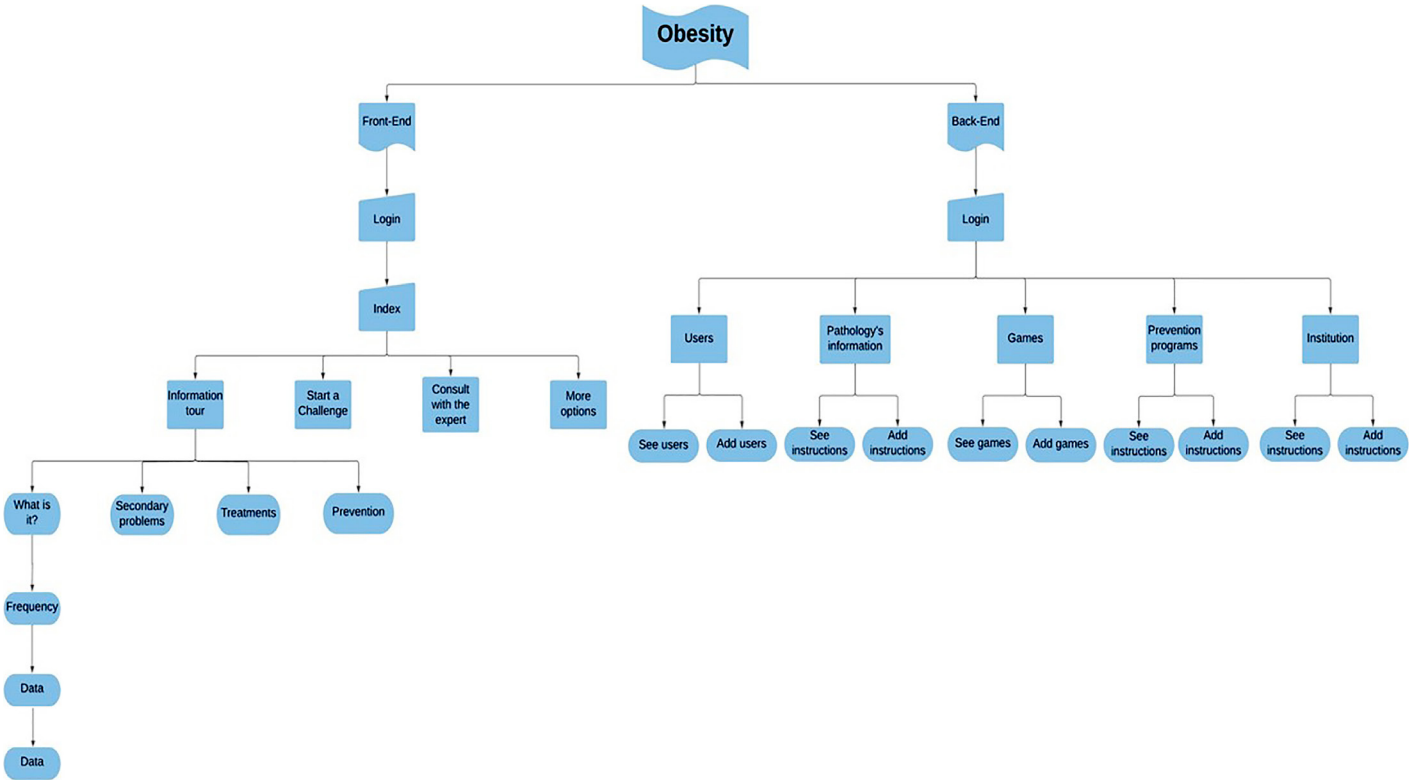

FIGURE 2. Gamified digital platform design. Example of the digital platform on obesity.

A. Front End: Is the section in which users enter to the platform and make use of it.
B. Back End: Allows the user to create, edit, modify, and update all the information that is necessary in the platform.

Hardware requirements:

- Number of processors: Two.
- Processor Type: High Performance Intel (3.5 GHz).
- Memory: 3.5 GB.
- Hard disk: 1 GB of space after the installation of the S.O.
- Operating system: Ubuntu 12.04, open SUSE 13.1, or Windows Server 2008 R2.
- Administration manual: During the content management tool training, an administration manual was designed.

Phase III: Evaluation of the digital platform

Upon completion of the applications in the platform, each of them was evaluated by means of the implementation of an instrument (multiple choice quiz) with which the learning was assessed before and after the use of the digital platform. A quiz was developed for each experiment. The grading of the questionnaire was based on a 0-10 point scale.

Study design

An exploratory, randomized, cause-effect study was carried out in 150 children between 10 and 12 years of age from public schools in the State of Mexico, Mexico. This

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age range was determined according to pilot studies that evaluated the user experience. The learning obtained with the use of the digital platform under study was evaluated. The assessment was carried out by applying a test before and after the intervention. Three exploratory, cause-effect experiments were designed, where each one evaluated a digital application for each of the following pathologies: T2DM, obesity and metabolic syndrome. The Committee of the Faculty of Health Sciences of the Anahuac University (ID 201550, 201652 and 201735) approved these three experiments.

Groups evaluated

For each experiment, two study groups of 25 individuals each were formed. For group assignments, the names of fifty individuals were placed in a tombola. Afterwards, each name was randomly selected from the tombola and sequentially allocated to one of two groups (experimental and control groups), until reaching 25 individuals per group. The experimental group was asked to use the digital platform that contained the information on the pathology under study in an animated storytelling and playful way. The control group received written information about the pathology to be evaluated. The document was written in an elementary reading level allowing the children to ask about any doubts on the meaning of words. In both cases (digital platform or written information), the information of pathologies provided to individuals was related to epidemiology, predisposing factors, main causes of the disease, signs and symptoms of the disease, interventions for preventing the disease (lifestyle factors, nutrition intake, exercise, etc.) and management of the disease.

Before carrying out each experiment, a pre-intervention evaluation was carried out by means of a questionnaire (multiple choice) –applied by the researcher- to know the basic knowledge about the pathology to be evaluated in both groups. After this, each group was given the opportunity to read the written information for 2 hours (control group) or browse the digital platform for 2 hours (experimental group). At the end of the intervention, another questionnaire (multiple choice) was applied (post-intervention) to evaluate the same contents as in the initial test. This helped determine the knowledge acquired after the intervention in each group. The intervention took place in a group setting.

All questionnaires were evaluated by experts on the corresponding disease and experts on questionnaire development and met the appropriate degree of reliability and validity. The results of the questionnaires were evaluated by the researcher with the help of an expert on the subject.

Evaluation of the reliability of questionnaires

The items in the multiple-choice questionnaires were aimed at exploring knowledge about what the disease is, risk factors, affected organs, secondary pathologies, balanced diet, energy contribution of fruits and vegetables, junk food, recommended food and general habits to reduce the risk of pathology, pathology detection, and management (questionnaires are provided as supplementary material). The questionnaires were scored based on a 0-10 point scale. The reliability of the questionnaires was assessed by internal consistency measures with Cronbach's alpha. All the questionnaires used, reached a Cronbach's alpha equal to or greater than 0.95. The assessment contained basic questions about the diseases included in the digital platform, and was adapted to the population group studied.

Sample size

Given the nature of this research as an exploratory study, the sample size was determined by the feasibility of recruitment. A sample of 25 children per group was established considering that the number of children per grade in school -with the criteria required for the study- fluctuated between 25 and 30 children. This sample size allows the detection of an effect size of 0.1 or larger. Therefore, the established sample (25 children) per group was recruited according to the inclusion criteria (Table 1).

Table 1. Inclusion, exclusion, and elimination criteria.

Inclusion criteria	• Children who can read. • Children between 10 and 12 years of age from public schools in the State of Mexico, Mexico.
Exclusion criteria	• Children who cannot read. • Children with a mental or visual disability. • Children who do not have a basic knowledge of computers. • Children who do not wish to participate.
Elimination criteria	• Children who do not complete the learning assessment. • Children whose parents/tutor do not sign the informed consent.

Statistical analysis

The data distribution was obtained through the Shapiro-Wilk test. To compare the intragroup results (before and after the intervention in the same group) the paired Student t-test or the Wilcoxon test was used. In the case of intergroup comparisons (between the groups studied), the Student t-test was used for independent groups. Statistical significance was established at $p \leq 0.05$.

Ethical considerations

This investigation was carried out under the guidelines of the Declaration of Helsinki, the regulations of the General Health Law on Health Research Matters, and the Official Mexican Standard NOM-012-SSA3-2012. A letter of informed consent was obtained from family members and a letter of assent was obtained from each child included in the study. Patient records were always kept anonymous, and confidentiality was guaranteed for each child by providing a consecutive number on confidential files. All procedures were approved by the Research Committee at the Faculty of Health Sciences, Universidad Anáhuac México Campus Norte.

RESULTS

In the assessment of knowledge prior to the intervention, it was observed that in both groups of each experiment, 100% of the individuals obtained a passing grade, with improvements in their scores in the post-intervention result in both modalities, with a mean of ≥ 1 point increase in their final grade. When analyzing pre-intervention scores, a significant difference was not observed between the groups of each experiment (Table 2 and Figures 3-5). However, the post-intervention results did demonstrate a statistically significant difference between the groups evaluated ($p < 0.05$).

Table 2. Average of the pre- and post-intervention results on a scale from 0 (lowest grade) to 10 (highest grade).

Averages	Digital platform group (app)		Written information group (reading)	
	Pre-intervention	Post-intervention	Pre-intervention	Post-intervention
Average in metabolic syndrome section	Mean: 6.67 SD: 0.22 n: 25	Mean: 8.18 SD: 0.24 n: 25	Mean: 6.80 SD: 0.16 n: 25	Mean: 7.22 SD: 0.15 n: 25
Average in obesity section	Mean: 7.43 SD: 0.19 n: 25	Mean: 8.87 SD: 0.11 n: 25	Mean: 7.52 SD: 0.24 n: 25	Mean: 7.71 SD: 0.31 n: 25
Average in type 2 diabetes mellitus section	Mean: 6.95 SD: 0.30 n: 25	Mean: 8.02 SD: 0.20 n: 25	Mean: 6.69 SD: 0.29 n: 25	Mean: 7.11 SD: 0.23 n: 25
Global avergae	Mean: 7.41 SD: 0.71 n: 17	Mean: 9.35 SD: 0.60 n: 17	Mean: 7.52 SD: 1.00 n: 17	Mean: 8.88 SD: 0.60 n: 17

SD: standard deviation; n: sample size.

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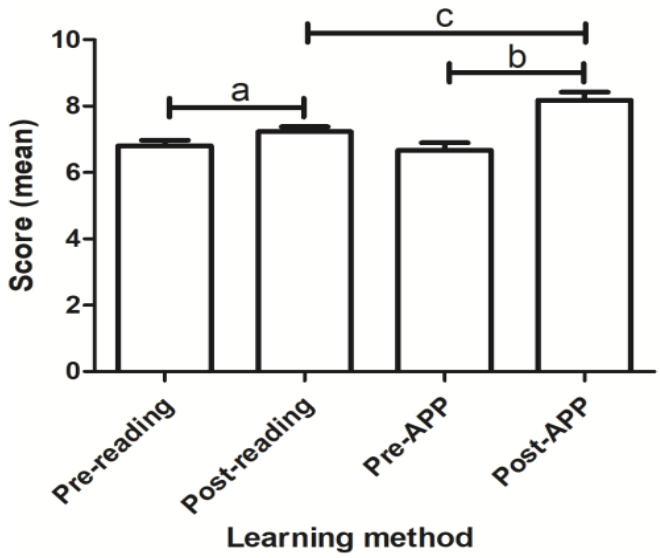

Figure 3. Inter- and intra-group comparative results of metabolic syndrome.

The use of a digital platform improved learning on the disease. Bars represent the mean ± SD of 25 individuals. a: p = 0.004, paired t test; b: p < 0.0001, paired t test; c: p = 0.001, unpaired t test.

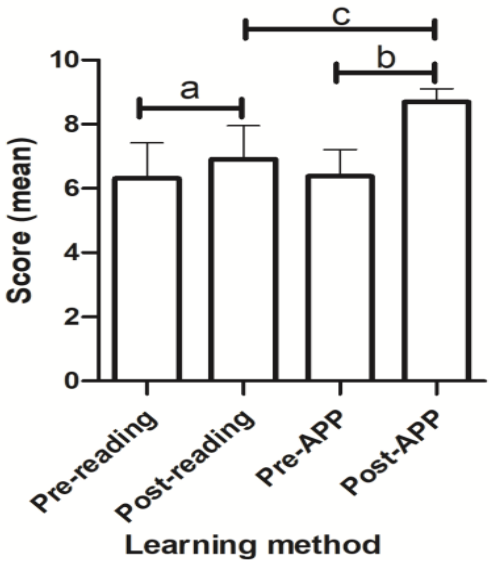

Figure 4. Inter- and intra-group comparative results of obesity.

Children using the digital platform showed a better learning on the disease. Bars represent the mean ± SD of 25 individuals. a: p = 0.006, paired t-test; b: p < 0.0001, paired t-test; c: p < 0.0001, unpaired t-test.

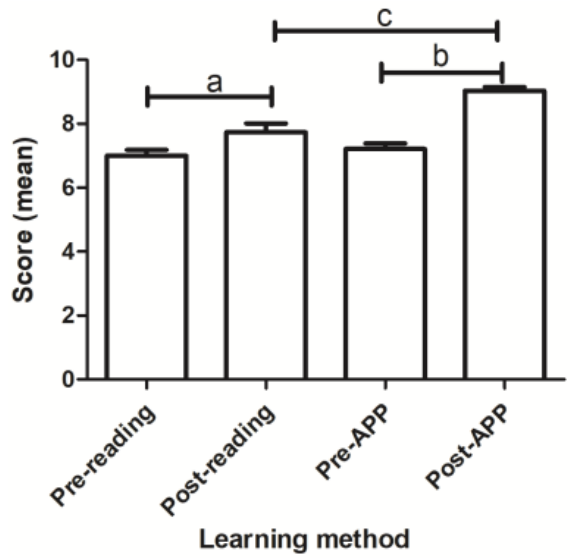

Figure 5. Inter- and intra-group comparative results of T2DM.

Learning using a digital platform is better than reading a written information. Bars represent the mean ± SD of 25 individuals. a: p = 0.002, paired t-test; b: p < 0.0001, paired t-test; c: p < 0.0001, unpaired t-test.

Figures 3, 4, and 5 show a significant improvement in the post-intervention knowledge acquired about metabolic syndrome (p = 0.001, Student t-test; Figure 3), obesity (p < 0.0001, Student t-test; Figure 4), and T2DM (p < 0.0001, Student t-test; Figure 5), respectively, when using the digital platform and compared to the control group. It is important to mention that children in the control group significantly improved their scores after the intervention compared to their baseline ones (metabolic syndrome: p = 0.004, paired t-test; obesity: p = 0.006, paired t-test; T2DM: p = 0.002, paired t-test).

DISCUSSION

In the present study, it was found that the use of a digital platform favors learning compared to using only written information. Even though the group that acquired the most knowledge was the one that used the digital platform, it is important to mention that both groups showed improvements in their post-intervention scores, which reflects that, regardless of the study instrument used, the result will be favorable for obtaining new knowledge. However, the development of digital platforms that integrate educational game playing, monitoring, and motivational feedback

seems to be a better option to learn. This kind of instrument could be useful to improve learning on adherence to therapy, disease management or even prevention. Nevertheless, this should not be the only element conforming the preventive strategy, since childhood lifestyle maintenance is mostly structured and guided by parents, in addition to information, children should be accompanied by parents to make the change and maintain a healthy lifestyle. From a behavioral management and/or change perspective, the role of parents in the children's lifestyle options and choices is pivotal to include in this type of endeavor.

When patients with impaired fasting glucose and impaired glucose tolerance do not take appropriate preventive actions, 25% to 40% of them develop T2DM in the next 5 years.[16] This evidence has prompted more research on diabetes prevention methods.[17,18] Furthermore, an alarming increase in overweight and obesity has been noticed among children and adolescents in the past decades.[10] In fact, about one-third of children and adolescents in the United States are classified as either overweight or obese and,[19] currently, the average age onset of T2DM in the youth is 13 years of age.[11,12] These pathologies lead to the development of metabolic syndrome, which raises the risk of coronary heart disease, stroke, and other health problems. Metabolic syndrome is largely preventable. Knowing the risk factors and promoting healthy lifestyle changes can help decrease the possibility of developing metabolic syndrome. Therefore, it is of great importance to develop new primary prevention methods that can be extrapolated to the young population.

The Diabetes Prevention Program, a milestone study in diabetes care developed in 3234 nondiabetic, middle-aged, obese persons with elevated fasting and post-load plasma glucose concentrations, demonstrated the success of diabetes prevention through weight loss (5-7% loss of body weight) with dietary changes (less fat and calories) and increased physical activity (150 minutes per week). Therefore, prevention programs could be based on lifestyle changes.[20] Alongside these programs, it is important to mention a novel method of primary prevention of metabolic diseases for the population of young adults and children: digital platforms (e.g., smart phone, apps, eLearning environment). Since young adults and children have different communication and interaction skills than middle-aged adults and the elderly, it is necessary to develop a diabetes/obesity prevention program for this age group based on such technology.[16,21] A recent pilot study examined the feasibility and preliminary efficacy of an age-specific diabetes prevention program based on digital platforms (mobile applications, online activities) in young adults (18-29 years) with prediabetes. The intervention resulted in reduced hemoglobin A1C and a trend for decreased BMI in obese sedentary young adults with prediabetes after 12 weeks of intervention. This study demonstrates that digital platform-based interventions are of great potential to prevent T2DM in young adults with prediabetes.[16] Another recent pilot study conducted in overweight college students and staff ranging from 18 to 35 years of age, measured the effect of a 12-week mobile health (mHealth) intervention on body weight, BMI, and specific lifestyle behaviors. Participants in the intervention group decreased their BMI, increased their physical activity, and reported an increased vegetable and decreased sugar-sweetened beverage intake.[21] The use of digital platforms for preventing metabolic syndrome has not been reported. Therefore, in our knowledge, this is the first study analyzing the use of this technology to increase learning and further prevent this pathology.

In our study, it was shown that the gamified digital platform significantly increases learning about T2DM, obesity and metabolic syndrome in children between 10 and 12 years of age. These results make the digital platform used in this study a novel tool for the primary prevention of metabolic diseases. On the other hand, it is of great importance to mention that future studies should reassess whether the acquired knowledge remains for a longer period of time. Additionally, it is necessary to evaluate a greater number of subjects and follow them over time to assess whether the application of digital platforms as a primary prevention method reduces the incidence of metabolic diseases in the population studied.

CONCLUSIONS

The results observed in the present study allow us to conclude that any validated learning instrument increases knowledge about obesity, metabolic syndrome and T2DM. However, the use of gamified digital platforms produces a significant increase in learning compared to other types of methods (written information). We have gained insights that, despite gamified digital platforms having only been implemented in the healthcare system for a few years, they have the potential to be a novel primary prevention method for metabolic diseases that could improve the lifestyle of individuals at any age, including children. Moreover, the implementation of digital platforms as a primary prevention method could reduce the overall burden of obesity, metabolic syndrome, and T2DM.

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CONFLICT OF INTEREST

The authors declare that the study was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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