TEENPOWER: AN INTERDISCIPLINARY GAME-BASED MHEALTH SYSTEM TO EMPOWER ADOLESCENTS TOWARDS OBESITY PREVENTION

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Abstract: Adolescent obesity grasped epidemic proportions, being critical to find effective prevention strategies. This paper describes the design and development of an interdisciplinary and innovative mHealth program directed to promote healthy behaviors and prevent adolescent obesity. The mHealth application includes educational resources, self-monitoring, social support, interactive training modules and motivational tools. The positive evaluation of the program will stimulate the inclusion of technologies in the promotion of salutogenic behaviors and obesity prevention. This e-therapeutic system can be used by health and exercise professionals in improving community interventions tailored to teenagers.

Keywords: Interdisciplinary, mHealth, ICT, adolescents, obesity, health behaviors.

I. INTRODUCTION

The prevalence of overweight and obesity among children and adolescents have risen dramatically from just 4% in 1975 to just over 18% in 2016. In fact, over 340 million children and adolescents were overweight or obese in 2016 (WHO, 2018).
Obesity can disrupt a child's immediate health, educational attainment and quality of life. Children with obesity are very likely to remain obese as adults and are at risk of developing serious noncommunicable diseases. Despite the rising prevalence of overweight and obesity, awareness of the magnitude and consequences of childhood obesity is still lacking in many settings (WHO, 2017).

Recently, the World Health Assembly adopted the "Global Action Plan for the prevention and control of noncommunicable diseases 2013-2020", including halting of the global obesity rates in school-aged children, adolescents and adults (WHO, 2017b).
Therefore, combating obesity is urgent and must be linked to comprehensive health promotion strategies, with particular interest to vulnerable groups such as children and adolescents (Styne et al., 2017).

Overweight and obesity cannot be solved through individual action alone. Comprehensive responses are needed to create healthy environments that can support individuals in making healthy choices grounded on knowledge and skills related to health behaviors (WHO, 2017a). Presently, single interventions are unlikely to be successful for all individuals, striking the need for an interdisciplinary and multimodal approach (Courtenay et al., 2018; van Middelkoop et al., 2017) to increase physical activity, decrease inactivity, improve healthy eating behaviors and reduce energy intake (Styne et al., 2017).

The technological revolution in health has the potential to improve and provide better, safer and sustainable care for all (Sardi, Idri, &Fernández-Alemán, 2017). The mass education through advanced technologies is changing the way the public gets information on health and relates to health professionals. Adolescents already use internet as their primary source of information, so healthcare professionals should ensure the access and reliability of the information (Arps, 2014).

Intervention programs that use technology as the smartphone or the Internet are associated with a more rational use of health services by helping patients and caregivers in the decision-making process (Sardi et al., 2017). These technological solutions can make health institutions more flexible, skilled and efficient, oriented to meet the specific needs of citizens and professionals.
The TeenPower is a practice-based research called from local health stakeholders, in the absence of an integrated and dynamic strategy for the promotion of salutogenic behaviors in adolescence. This need was faced as an opportunity to network and explore synergies between different territorial partners.
This paper describes the design and development of an interdisciplinary and innovative mHealth program directed to promote healthy behaviors and prevent adolescent obesity, using interactive and collaborative technologies and taking advantage of a virtual therapeutic community with a game-based approach (Fig. 1).
Based on our previous experience (Sousa et al., 2015) and on recent literature, it was theorized that using mHealth interventions allows: a) more extensive and frequent contact with the healthcare team, b) use of alternative communication channels, c) use of interacting/dynamic technologies, d) more rational use of health services, e) support the decision-making process.

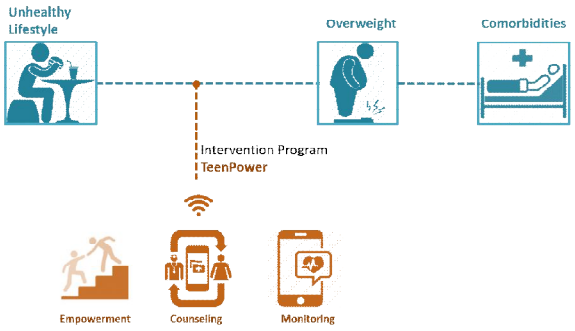


Fig. 1 - TeenPower design concept

II. TEENPOWER INTERDISCIPLINARY AND COLLABORATIVE APPROACH

The project framework lays in a healthcare system that empower people to make healthier choices and manage more effectively their health; a healthcare system where technology can help tackle inequalities and improve access for the vulnerable (Calvillo, Román, &Roa, 2015). The existence of reliable and relevant information, available when and where it is needed, enables professionals and consumers to make informed and timely decisions.

To address complex intervention programs demands interdisciplinary and multimodal approaches to implement cognitive-behavioral change strategies (Styne et al., 2017; van Middelkoop et al., 2017). It is increasingly recognized that collaboration and teamwork across health professionals are necessary to empower patients, and improve the quality and safety of healthcare (Courtenay et al., 2018).

The need for an integrated and dynamic strategy for the promotion of salutogenic behaviors in adolescence was faced as an opportunity to network and explore synergies between territorial partners, namely from nursing, nutrition, sport, psychology, informatics, statistic, design and teaching. An interdisciplinary intervention program was structured, using a collaborative process of assessment, planning, care coordination and evaluation, to meet an individual's comprehensive health needs through communication and available resources to promote quality cost-effective outcomes (case management) (CMSA, 2010).

The intervention includes behavioral, nutritional and physical activity counselling through a mHealth app. The program takes into account the most recent guidelines on health promotion and obesity prevention among adolescents (WHO, 2017a), using the Health Information Technology Acceptance Model (HITAM) as a conceptual framework and the contributions of our previous research (Sousa et al., 2015).

An agile product development process was adopted, an iterative and incremental approach for planning and implementing, in an intense and permanent dialogue with healthcare professionals, and adolescents throughout the platform and the mobile app development process. In a first phase the nursing, nutrition, sports and psychology team applied their knowledge towards the research of key behavioral change messages to empower youth. In a second phase the multimedia design team was integrated to develop communicational products regarding adolescents' empowerment, whether in formats like video, illustration, animation or photography. In a third and parallel phase, the informatics team pursued a software development process including the following main phases: requirements definition and specification, software design and prototyping, implementation, testing and deployment.

According to the WHO (2017a), one of the key elements for a successful obesity prevention program is the "capacity-building", highlighting the need for all stakeholders to work together to strengthen institutional capacity and provide appropriate training to health care workers, child-care and school staff for the successful implementation of the recommendations.

III. A MHEALTH INTEGRATED SYSTEM FOR OBESITY PREVENTION

Intervention programs that use technology as the smartphone or the internet are associated with a more rational use of health services by helping patients and caregivers in the decision-making process (Coughlin et al., 2015; Schoeppe et al., 2017). The TeenPower team will be testing this framework with service users, care organizations and technology suppliers. The e-therapeutic system includes:

a) *The TeenPowerbackoffice*, a web-based application created for teachers and health professionals, to support the decision-making process regarding the customization of the mHealth intervention. The backoffice application contains the following modules: users management module, content management system and showcase contents (videos, images and documents), social interaction module (private chat and discussion forums), data analysis module with interactive charts and filters (dashboard with all the users' monitoring data such as physical condition, eating habits, hydration, physical activity and sleep monitoring);

b) *The TeenPower mobile application* for adolescents, including educational resources (videos, infographics, menus, and daily tips), self-monitoring (eating habits, hydration, BMI and waist circumference adjusted for age and gender, sleep habits, steps counter, and physical activity records such as sit-ups and push-ups), social support (chats, discussion forums and personalized messages), interactive training modules and motivational tools (progression of health behaviors and biometric data, positive reinforcement) (Fig. 2). The structure of the

TeenPower app will seek to create a virtual environment attractive to adolescents, with a game-based learning process, where the engagement of the user will be rewarded with points/coins and progress in the wall of fame.

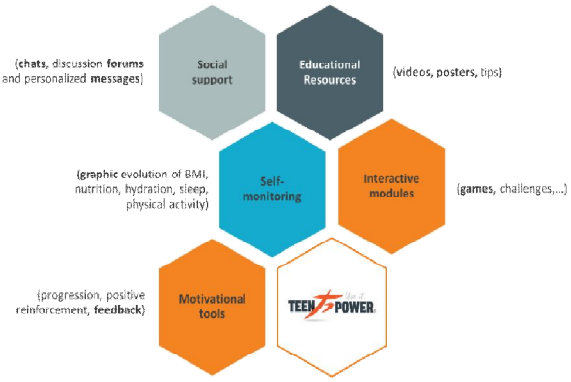


Fig. 2 – TeenPower system features

In the development of the TeenPower system, a gamified approach was adopted, linking real world activity (regarding the monitoring of health behaviors) with gaming applications. A number of highly interactive elements can be embedded in eHealth adolescent programs to foster engagement, education, and intervention. In particular, adding game elements to learning and instruction can be appealing and facilitate their engagement. Game-based learning makes use of the entertaining power of games for educational purposes, supporting social interactive learning (Huen et al., 2016).

A number of key game attributes have been identified, such as setting the game in a fantasy environment, designing scenarios that induce curiosity, assigning tasks which pose a reasonable level of challenge for players to complete, and allowing players to control their actions, which may potentially influence the game progress. Taken together, eHealth intervention programs may take the form of game-based learning by incorporating certain game attributes to appeal to youngsters and motivate their learning (Huen et al., 2016).

IV. TEENPOWER AFFECTIVE DESIGN AND USER EXPERIENCE

A user-centered design was followed, involving final users during each stage of the development process. This approach aims to make interactive systems more usable by focusing on the use of the system and applying human factors/ergonomics and usability knowledge and techniques (Bazzano, Martin, Hicks, Faughnan, & Murphy, 2017).

With the purpose of nurture the user engagement, it is important to create an emotional link between the user and the mHealth app. In fact, a modification of the emotional state means switching among different ways of thinking. In particular, positive affects increase intrinsic motivation and has some effects on cognition (Carrino et al., 2014).

The affective design will encourage the prolonged use of the system and improve the learning of the proposed concepts. Currently, affective learning is based on the idea that emotions are intertwined with cognitive capabilities and several re-searches demonstrate its influence in conditioning the rational behavior and the decision making of the learner (Carrino et al., 2014).

The main goals for the desired user experience with the use of the TeenPower mHealth appare: “Be Happy”, “Be Connected”, “Be Active” and “Be Aware”.

“Be Happy” - It is expected that adolescents learn more about each thematic module (eating, exercise, sleep, stress management, and interpersonal relationships) while playing and having fun. The use of educational games can be beneficial when working with adolescents, providing a greater capacity of involvement, by increased stimuli and challenges. Using games to health promotion makes learning new knowledge more interesting, while improving message transmission and behavior change (Huen et al., 2016).

“Be Connected” - Connect online with other adolescents, ask questions to health professionals and share ideas and suggestions with others, are also keycomponents that influence the user experience(Arps, 2014). The importance of the access to reliable information, having contact with specialized health professionals and other adolescents, are important components of this project as well as the share of experiences, tips or even doubts.

“Be Active” - Doing physical exercise not only improves physical condition, but also helps improving the individual to daily tasks, preventing the development of some diseases, improving cognitive ability, mental health and well-being (WHO, 2017a). Therefore, we will deliver frequent active challenges to the adolescent, so that they have fun while moving.

“Be Aware” - To empower adolescents to be aware and understand better how they eat, sleep and move, is crucial. Monitoring and evaluation can also serve to sustain awareness of the problem of childhood obesity and are necessary to track progress in the development, implementation and effectiveness of interventions (WHO, 2017a).

4.1 User Journey

The user journey method is very useful to explain the proposed gamification technique, because it combines two powerful instruments: storytelling and visualization (Kaplan, 2013).

The concept created around this serious game reflects the intention to affect the user behavior by experience non-recreational purposes, focusing on areas such as

exercise, nutrition, sleep, relationships and stress management.

The engagement occurs from the moment that each adolescent has the opportunity to customize his character/avatar in the mobile app and uploading or updating their biometric and clinical data. The character/avatar starts in the "house", where he will be able to found some tips about healthy eating, choose to try some healthy snacks recipes or monitoring his nutritional habits, hydration or sleep habits. All of this, involves small interactive challenges and rewards/points, according to healthcare professionals' decisions that are tracking the adolescents' behavior through the backoffice.

The game also offers tips and informational videos that adolescents may use, specifically selected by healthcare professionals. The main goal is to encourage the user to move toward the desired health behavior, achieving knowledge about how this behavior change can impact their health and wellbeing.

The user has several other options to achieve points and improve his rank in the game, exploring different locations in the TeenPower map, such as the gym, the park, the media library, and the live events (games based on location / GPS). During the experience, the user can accept challenges, chat with other users or with health professionals, either by private messages or by public forums.

V. PRELIMINARY RESULTS AND PROCESS INDICATORS

This is an ongoing research project which design includes conducting several complementary studies to achieve the desired outcomes.

Initially, it was necessary to conduct a pilot study to characterize and assess the devices and type of mobile apps more frequently used by adolescents, as well as to better understand the features that mHealth apps should have to be more appealing for adolescents. This study also aimed to better comprehend the usage facilitators and barriers adolescents may have to use a mHealth app. Findings of this study will soon be published but reinforces the fact that smartphones are part of adolescents' everyday life, and that adolescents are interested in mHealth apps. Particularly, we found out that the majority of adolescents have interest in food suggestions and physical activity suggestions (Luz et al, *in press*),adopting creative and interactive therapeutic strategies such as gamification. These findings supported the development of the TeenPower e-therapeutic system.

In a second phase, we will conduct a school-based survey to assess adolescents' health status and cognitive-behavioral indicators, in order to fully understand the adolescents' needs.

In a third phase, we will perform a mixed methods research to assess the usability of the TeenPower system and a multicenter trial to assess user experience, adherence to the TeenPower intervention program and impact of the program.

Figure 3 summarizes the preliminary process indicators of the project. The project consortium includes four different Portuguese partners: the polytechnics of Leiria (namely: School of Education and Social Sciences; School of Technology and Management; School of Health Sciences; School of Arts and Design), Santarém (namely: School of Sports and School of Health Sciences) and Castelo Branco (namely: School of Education and School of Health), as well as the Leiria City Council, in a total of nine poles of research.

The project will be implemented in a wide trans-territorial area (district of Leiria, Santarém and Castelo Branco, in Portugal) exploring synergies between territorial partners as the local primary healthcare stakeholders and schools, key partners in the development phase and in the implementation of the intervention program.



Fig. 3 -TeenPower Process Indicators

We intend to establish a scientific initiation program for undergraduate students, based on the close interaction between students and researchers, namely the nursing, nutrition, health informatics, sports, multimedia design, sound & Image and illustration students from Leiria, Santarém and Castelo Branco Polytechnics. The direct collaboration of these students will be adjusted according to the project tasks and integrated in the curricular units of Health Education, Statistics, Research/Project, and clinical practices. They will have close supervision of senior researchers (project research team) and the three research scholarships (two computer engineers and one psychologist).

However, the main outcome is the delivery of the TeenPower intervention program, including an interactive application (web and mobile), in a wide trans-territorial setting.

VI. EXPECTED OUTCOMES AND VALIDATION OF THE TEENPOWER SYSTEM

The TeenPower project is directed to the cognitive-behavioral empowerment of adolescents through increased and interactive contact between adolescents and the interdisciplinary healthcare team. This interdisciplinary intervention uses a collaborative

process of assessment, planning, care coordination and evaluation to meet individuals' comprehensive health needs. The expectations lay on the population health gains, empowerment in decision making and adoption of healthier lifestyles.

The expected outcomes of this project are:

a) Delivery of an innovative health service to adolescents and school community, bringing health professionals closer to schools;
b) Improvement of the adolescents' access to primary healthcare;
c) Adoption of healthier behaviors and better decisions regarding their health, by the adolescents;
d) Satisfaction and positive user experience among the different users (adolescents, teachers, and health professionals);

Gamification has been identified as a key element of the TeenPower approach and constitutes the main factor for the engagement strategy. The overall system will be evaluated in a pilot study enrolling about 450 adolescents. The validation of the platform will assess the following factors:

- Technology acceptance and system usability
- Reliability in assessing the adolescents' lifestyle and behaviorchange
- Effectiveness of the system in encouraging lifestyle change
- System compliance to stakeholders needs.

Among the potential benefits, we can point out the following:

- reduction of the overweight prevalence and associated comorbidities, through health promotion strategies and empowerment of individuals to make healthy choices and adapt to the environmental demands
- improvement of the adherence to the recommendations of the health professionals focusing on the monitoring of health behaviors
- Reduction in costs of printing and distribution of brochuresat printed resources for health promotion, as the platform can function as an e-learning strategy with online educational contents

The results of this project will promote reflection on new approaches directed towards health promotion. We expect to gather empirical evidence of the intervention program effectiveness. We expect that this intervention programwill be further replicated at other institutions ad contexts, using the knowledge and the strategies developed among the various health stakeholders.

CONCLUSIONS

Promote healthy behaviors in adolescents is crucial considering the high and increasing prevalence's in adolescence overweight and obesity (Currie et al., 2012; OECD/EU, 2016). The prevention of this chronic health condition has been considered as a priority (Daniels, 2006; Filipe, Godinho, &Graça, 2016). Moreover, considering the multifactorial etiology of obesity (Loche&Ozanne, 2016; Sancho et al., 2014), prevention programs should be multidisciplinary and include different professionals from different health fields. It is also acknowledged that adolescents have difficulties engaging in more theoretical programs.Therefore, the use of preventive strategies that are both playful, interesting and motivational is essential for adolescents to join prevention programs and, thus, become healthier people.

The TeenPower project aims to fill some of these gaps by creating a program/application to promote healthy behaviors with particular characteristics that should make it more appealing, fun, interesting and consequently more effective. Moreover, the TeenPower app joined with the Backoffice aims to enable a greater exchange of correct and scientifically approved information between adolescents, teachers and health professionals, enabling and motivating adolescents to adopt healthier behaviors validated by competent professionals in the area.

The intervention program will foster the inclusion of ICTs (information and communication technology) in the promotion of salutogenicbehaviors and obesity prevention, creating technological interfaces that allow the customization of intervention parameters and streamline the monitoring and follow-up processes. Along with the therapeutic aim, the project purposes to produce more knowledge regardingadolescent's behaviors and skills, providing important information that will helpto direct future interventions and intervention programs.

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