U.PORTO

MASTER DEGREE COURSE
HEALTH EDUCATION

Impact of the use of an educational web-application on nutritional knowledge and food consumption in children and adolescents with overweight or obesity

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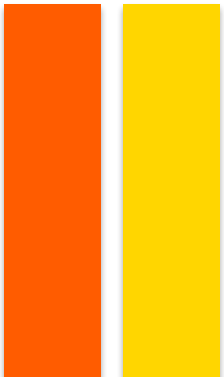

ADMINISTRATIVE HEADQUARTERS

FACULTY OF **MEDICINE**

FACULTY OF **PSYCHOLOGY AND EDUCATIONAL SCIENCES**

Acknowledgement

First, I would like to express my gratitude to my supervisor, Dr. Francesca Scazzina, for the opportunity to join her team and integrate her projects, for trusting my abilities, allowing me to work autonomously, and for the guidance provided throughout this year.

To Dr. Joana Araújo, my co-supervisor, I want to express my deepest appreciation for all her help, even before the beginning of this year, for the support she gave me to embark on an adventure in another country, and for all her availability, support, and great advice. I would like to extend my gratitude to Dr. Alice Rosi for her mentorship and for involving me in her projects and allowing me to take on so many responsibilities.

I also want to thank Helena Trigueiro, who I was lucky enough to meet during my degree and who, since then, has given me unparalleled support, never letting me give up on my dreams and always advising me on the best path to follow. Thank you for the difference you have made in defining my path.

To my colleagues in the Human Nutrition Unit, thank you for welcoming me to the team, for your company, advice and friendship. In particular, I want to thank Perla, for working side by side with me every day, and for sharing so many experiences and accomplishments with me throughout this year.

To the Erasmus Student Network, ESN-ASSI Parma, I want to thank for the warm welcome to Parma, for providing so many good moments, allowing the creation of such good friendships and memories, which will certainly last a lifetime.

To my family, thank you for encouraging me in all of my pursuits and inspiring me to follow my dreams. I am especially grateful to my parents, for the good example they gave me throughout my life, allowing me to dream big and always work for my goals. Thank you for all your hard work and sacrifice, encouragement and love, which have led me to where I am now. I also want to thank my sister, for being my safe haven and for making me feel at home whenever we talk or see each other, anywhere in the world.

To my friends, I am grateful for all the support they have given me, for listening to me, offering valuable advice, and trying to keep up with my life. Your presence, even from a distance, has made a significant difference in my journey.

Lastly, I would like to deeply thank all the people with whom I interacted throughout this year, for the opportunity they gave me to do what I love most, and for motivating me to always do better.

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Abstract

Background: The number of children living with overweight and obesity has increased in recent decades, and Italy is one of the countries with the highest rates of this disease. Several factors contribute to this problem, including eating habits, lifestyle, the influence of parents and peers, and the environment surrounding children and adolescents. Numerous technology-based interventions have been developed to combat pediatric obesity, for example through the use of web-applications for knowledge transmission, dietary behavior change, and weight reduction, with the aim of improving the health status of this age group. In this context, the Med4Youth study was initiated, with the purpose of comparing the effectiveness of an intervention based on the Mediterranean Diet (MD) with a traditional low-fat diet (LFD) in reducing the BMI of children and adolescents with overweight and obesity in three Mediterranean countries (Italy, Portugal and Spain).

Aim: The overall aim of this work is to evaluate the effect of an intervention using a web-application by Italian children and adolescents with overweight or obesity on their knowledge, eating habits, and weight change.

Methods: Over a period of 4 months, children and adolescents were included in an intervention with an educational component that used a web-application, to provide a dietary plan to participants, as well as educational content, tips and quizzes, and was also used to collect dietary and lifestyle data before the participants' meeting with the research team every two months. From May 2021 until November 2022, 80 volunteers were recruited in Italy and were randomly divided into two groups: one with a prescribed dietary plan based on the Mediterranean diet and the other a traditional low-fat diet. For this study, app usage data (number of accesses, of tips and topics consulted, and of questionnaires answered correctly), results of a nutritional knowledge, food frequency, and KIDMED questionnaires were collected for the first and last visits of the intervention period. Anthropometric data was also collected during these visits. The usability and engagement of the app was studied in relation to the variables described above, using Spearman's correlation. Comparison of continuous variables between groups was done using parametric and non-parametric tests. The McNemar test was used for the comparison of paired samples in categorical variables.

Results: The 54 participants who completed the study used the web-application rarely, having only consulted a median of 11.0 of the daily available tips (P25 – P75: 7.0 – 16.0), representing about 9.24% of these, correctly answered a median of 4.0

questionnaires (0-0 – 13.5), about 1.57% of the totals available, and viewed a median of 0.0 of the weekly available educational content (0.0 – 1.0). Nutritional knowledge remained stable, not showing any improvement, but there was an improvement in the participants' eating habits, with an increase in the consumption of fruits, vegetables and pulses, and a decrease in the frequency of consumption of sweets, coke and other soft drinks, and salty snacks. Regarding the KIDMED score, participants obtained a statistically significant mean increase of 1.8 points (SD 2.6) between the two visits (p<0.001). Both the MD and LFD groups showed a significant increase in adherence to the Mediterranean diet, although there was no statistically significant difference in delta score between the two groups (p=0.935). There was also an improvement in anthropometric parameters in both groups, with a decrease in BMI and BMI z-score, from 31.0 Kg/m^2 (27.6 – 33.2) to 30.1 Kg/m^2 (27.6 – 33.1) and from 2.0 (0.3) to 1.9 (0.4), respectively, in the total sample. No statistically significant correlation was found between web-application usage and the variables studied above.

Conclusion: The results showed that this intervention was effective in improving the participants' eating habits and anthropometric parameters and demonstrated that a dietary intervention based on the MD did not produce any additional benefits over anthropometric parameters, dietary habits and nutritional knowledge compared to the LFD. The frequency of app use by the participants of this study was very low, not allowing the proper investigation of a relationship between its use and the modification of the variables under study. In order to develop an application that is more effective in its purpose of transmitting nutritional knowledge and changing the eating behavior, it should be easily accessible, it should remind and motivate its use through notifications and have a social component. It should also take into account the theories of eating behavior change and be accompanied by personalized nutritional counseling.

Keywords: Health Education; Educational Web-Application; Nutritional Knowledge; Food Consumption; Pediatric Overweight

List of abbreviations and acronyms

BMI. *Body mass index*
Ccm. *National Center for Prevention and Control of Diseases*
CDC. *Center for Disease Control and Prevention*
COSI. *European Childhood Obesity Surveillance Initiative*
DBCI. *digital behavior change intervention*
FFQ. *Food Frequency Questionnaire*
HBSC. *Health Behaviour in School-aged Children*
HELENA. *Healthy Lifestyle in Europe by Nutrition in Adolescents*
KIDMED. *Mediterranean Diet Quality Index for children and teenagers*
LFD. *Low-Fat Diet*
MD. *Mediterranean Diet*
Med4Youth. *Mediterranean Enriched Diet for tackling Youth Obesity*
OECD. *Organization for Economic Cooperation and Development*
UNESCO. *United Nations Educational, Scientific and Cultural Organization*
WHO. *World Health Organization*

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1. Background

1.1. Overview of overweight and obesity

It is estimated that about one-third of the world's adult population lives with overweight or obesity, a percentage that has been increasing over the years (1, 2). Regarding the pediatric age, the World Health Organization (WHO) estimates that in 2016 the prevalence of overweight and obesity was 18%, having increased dramatically in the last decades (2). There has also been an increase in morbid obesity in recent years (3).

Regarding European data, the most recent report from the WHO European Childhood Obesity Surveillance Initiative (COSI) reported that 29% of children aged 7-9 years in the European region are overweight (including obesity) (4). Considering the Mediterranean area, many countries are also facing high rates of overweight and obesity (3, 4). According to the Organization for Economic Cooperation and Development (OECD), the average rates of overweight and obesity are 32.4% in Portugal, 34.1% in Spain, and 36.8% in Italy (3, 5).

In Italy, the National Center for Prevention and Control of Diseases (Ccm) initiated a surveillance system called "Okkio alla Salute" in 2007, which aims to provide insights into the behaviors and lifestyles of children aged 6-10 years that can potentially lead to chronic-degenerative diseases (6). According to its latest report in 2019, 20.4% of children had overweight and 9.4% had obesity (6, 7), making this one of the countries with the highest rates of this disease (4).

It is important to understand the consequences of obesity, as it is estimated to be the fifth most common cause of death globally, leading to several health concerns (8). Obesity is associated with metabolic syndrome and a number of chronic diseases, including type 2 diabetes, cardiovascular diseases and some types of cancer (9, 10). For children and adolescents, having overweight can also present negative consequences at school, since young people with a healthy weight are 13% more likely to have a good performance at school (3, 11).

1.2. Causes of obesity and the need for its prevention

Obesity is a chronic multifactorial disease. The fundamental cause is energy imbalance, that is, the imbalance between energy consumed and expended, which is stored as body fat (2, 8). However, many factors contribute to this imbalance, including biological, psychological, socioeconomic, sociodemographic, environmental, individual, social, health, and lifestyle/behavioral factors (8, 12).

The mediators and moderators of childhood obesity can be better explained with an ecological model and it is important to understand them in order to effectively prevent obesity at this age (13, 14). Regarding the child's factors involved in the development of obesity, these are their eating habits and their physical and sedentary activity. Family factors include parent modelling, parental weight status, home nutritional environment, parental nutritional knowledge, parenting style, encouragement of activity, and parent monitoring. At the community level, factors such as access to recreation facilities, access to convenience foods and restaurants, ethnicity, socioeconomic status, meals and physical education programs at school, and neighborhood safety are implicated (13). Taking this into account, the risk factors for the development of childhood obesity can be summarized into genetic factors, behavioral factors, and environmental/social factors (13). Genetic factors include the family food environment and the weight status of the parents (since a misbalance of these can promote overweight and obesity in children) (15), as well as some monogenic and hormonal disorders (13). Behavioral risk factors include increased consumption of fast foods and processed snacks, decreased physical activity, poor sleep duration or quality, and increased stress (13). Finally, concerning environmental factors, living in a lower-income neighborhood, where one does not feel safe, or that is distant from parks or food stores, are also risk factors for the development of childhood obesity (13, 16, 17).

Considering specifically the dietary habits and lifestyles, these have a great influence on the well-being of individuals and societies (18). Healthy lifestyle behaviors are protective against malnutrition and various non-communicable diseases, while poor eating habits and lack of physical activity are risk factors for various health problems (8, 18). As mentioned before, children's eating habits are influenced by several factors that reciprocally interact (19), among them the parents' feeding practices (9), the environment in which they live (a predictor of poor eating habits, in the case of an obesogenic environment) and the socioeconomic status of their family (19). Also noteworthy is the access to health education programs and the provision of a wide variety and a continuous exposure of foods as early in life as possible (19).

An inadequate intake of fruits and vegetables and an excessive consumption of foods rich in sugar, salt, and saturated fats are major contributors to the development of childhood obesity and its associated problems (20, 21). This inappropriate and unbalanced food consumption happens globally, and is largely due to the easy and affordable access that children have to unhealthy, energy-dense, and low-nutrient foods (22-25), resulting in a low adherence to national dietary recommendations (20).

In Italy, 8.7% of children skip breakfast, 48.3% and 9.4% consume sweet or salty snacks, respectively, more than three times a week and 25.4% consume sweetened or fizzy drinks every day. Moreover, almost 25% of children fail to consume vegetables or fruits at least once a day, and 39% consume legumes less than once a week (7).

The pediatric age is not only a critical period because of the susceptibility of these individuals to external factors, but also a major window of opportunity to establish healthy lifestyle habits (26, 27). Food preferences and habits created during childhood are predictors of dietary and lifestyle patterns practiced in adulthood (9, 26, 28, 29). Since children with obesity are likely to be adults living with obesity, they are at increased risk of developing health complications associated with this disease (2, 9, 10, 29). Given the global burden of non-communicable diseases, especially the negative impact of obesity, namely on quality of life, it is crucial to prioritize its prevention and treatment with population-level interventions, especially for children and adolescents, as unhealthy habits established at a young age can have long-lasting consequences (2, 20, 30, 31).

One strategy that has been proven as effective to treat childhood obesity is the promotion and adoption of the Mediterranean diet (32-34).

1.3. The Mediterranean Diet as a strategy to fight obesity

Mediterranean Diet (MD) has gained attention in recent years as a promising dietary approach for health promotion and reducing the risk of disease (35) and may be effective in weight loss in overweight and obese children and adolescents (34). The Mediterranean diet is not only a healthy diet, but also a lifestyle full of culture and the transmission of knowledge from generation to generation. It has, in fact, been recognized by UNESCO as an "Intangible Cultural Heritage of Humanity" (36). This eating pattern emphasizes a high consumption of plant-based foods, whole grains, fruits and vegetables and a moderate intake of dairy products, fish, and poultry. It also includes a low intake of red meat, processed foods, and sweets, with a moderate consumption of wine with meals (35, 36).

Studies in children and adolescents have investigated the association of their adherence to the Mediterranean Diet with various parameters such as BMI, waist circumference, fat mass, and the likelihood of having overweight and obesity. These studies showed that greater adherence to this dietary pattern improves the previously mentioned parameters (32, 33). A clinical trial study in children and adolescents who had overweight and obesity and at least one predictor of metabolic syndrome compared the effectiveness of a Mediterranean diet rich in polyunsaturated fatty acids, fibre, flavonoids, and antioxidants with a traditional diet in improving health parameters. This study found that the group following the Mediterranean diet had a reduction in BMI, fat mass, lean mass, glucose, total cholesterol, triglycerides and LDL-C and an increase in HDL-C (34). Other studies and systematic reviews have also demonstrated a positive effect of the Mediterranean Diet with different components of the metabolic syndrome, with abdominal obesity and with glucose levels (37, 38), also reducing body weight and adiposity, especially when combined with energy restriction (5, 39, 40). Thus, it is necessary to inform and motivate the population to follow this lifestyle in order to improve their nutritional status and prevent or treat non-communicable diseases.

1.4. Nutritional knowledge and eating habits

If before it was thought that simply transmitting knowledge to the population would be enough to change their behavior, today it is known that in order for an intervention to be effective in forming or modifying eating habits, it has to take behavioral science into account (41). Behavioral change techniques are a strategy composed of coordinated sets of activities that help change behavior, for example in order to promote better health (42, 43). Some of these strategies, and those most commonly used in promoting healthy eating are providing information of the consequences of a behavior, environmental restructuring, time management, goal setting, action planning, and self-monitoring. An intervention must alter one or more mediating variables, which can be personal, physical, environmental, behavioral, or familial (41).

A systematic review explored whether nutrition knowledge translated into healthy eating practice and aimed to understand the factors affecting eating behavior in order to implement interventions capable of changing them (22). Although higher consumption of fruits and vegetables was reported in children with a greater nutritional knowledge, they concluded that this was not enough to translate into changes in eating behavior (22). The authors have also reported that parents with a higher knowledge of nutrition, and a higher education and socioeconomic status, positively influenced their children in the

direction of healthy eating (19, 22, 44). In fact, children's eating behavior is influenced not only by their knowledge, but by many other factors such as their gender, age, nutritional status, and the influence of their peers and parents (22). Interventions that aim to change the eating behavior of school children should not only focus on transmitting knowledge, but should be holistic interventions that promote healthy behavior through the development of healthy eating skills and the improvement of the food environment around them (22).

1.5. Interventions to combat obesity

Interventions to combat childhood obesity must consider the integration of multiple components, such as nutrition, exercise, and psychological therapy, among others (45-47). According to a review on obesity in children and adolescents, a multicomponent behavioral intervention should include a combination of the above-mentioned components, as well as address sedentary behaviors, sleep hygiene, and also some behaviors related to the family relationship (45). As far as nutritional interventions are concerned, these should include an educational component, combined with moderate energy restriction and based on the principles of healthy eating through a structured food plan (45, 48, 49). Both of these strategies and the use of the other components should use a form of behavioral therapy, such as goal setting, stimulus control (modification of the environment surrounding children and adolescents, whether at home or the food supply in and around schools), and self-monitoring (45, 50, 51). Regarding how these interventions should be delivered, the literature suggests, for example, group programs, individual sessions, or even electronic health strategies (45, 52-55).

Some randomized controlled trials in children and adolescents used game-based interventions (gamification) with the aim of testing their effectiveness in modifying nutritional knowledge and eating behaviour, some in particular regarding the consumption of snacks, fruits and vegetables (56). Game-based interventions are a growing strategy to carry out or complement education initiatives for the promotion of healthy habits (56, 57). Through the mechanisms inherent to games (missions, prizes, rewards, level evolution, etc.) and the use of new technologies such as the internet (web-based applications) or mobile applications (58-60), interventions using this strategy offer greater freedom for learning, respecting the rhythm of the participants and increasing their motivation to join the intervention, as they adapt to the new learning needs of young people and the evolution of teaching methods (56, 61). These interventions showed an improvement in nutritional knowledge and eating habits, with an increase in the

consumption of fruits, vegetables and whole foods and a decrease in the consumption of sugars, and also showed an improvement in self-efficacy in healthy eating practices, such as meal preparation (56). In particular, a study conducted in Italy used the support of a humanoid robot to develop an educational activity with children, but concluded that it was no more effective in improving their knowledge than the traditional development of the activity, with only a nutrition educator (56, 62).

1.6. Effect of digital platforms on food knowledge and behavior

Given the widespread use of mobile devices and new technologies by the population and the particular ease with which young people use it, the question has been raised whether these means could be useful in increasing the population's food literacy and changing their behaviors (26). The interest in using web-applications is growing, and it is known that it is necessary to consider the theories of behavior change in order to plan an intervention using these technologies (26, 63).

A web-based intervention is described as "a primarily self-guided intervention program that is executed using a prescriptive online program operated through a website and used by consumers seeking health and mental-health related assistance. The intervention program itself attempts to create positive change and or improve/enhance knowledge, awareness, and understanding via the provision of sound health-related material and use of interactive Web-based components" (64).

A systematic review evaluated several web-based interventions aimed at promoting healthy behavior change in adolescents aged 10-24 years, with a mean age of 16.7 years. It showed a positive effect of these interventions on behavioral change, including increased motivation to engage in physical activity, decreased alcohol consumption, improved attitudes and knowledge regarding sexual behaviors, decreased intention to smoke, and increased consumption of fruit and vegetables (26, 65). The strategies used in the studies included in this systematic review ranged from sending emails with multimedia messages (66), handheld devices for recording data and providing feedback (67), to using websites that presented content and challenges, combined with recording progress in the program (26, 68). It concluded that these interventions can significantly contribute to a shift towards healthy behavior in young people, with reasonable levels of acceptability and feasibility (26).

Another review studied this type of intervention (41), classifying it as a digital behavior change intervention (DBCI), "a product or service that uses computer technology to

promote behavior change" (69). This review, which included studies involving various age groups of the population, concluded that these interventions may be able to modify health-related knowledge, attitudes, and behaviors (41). For example, in a study with college students involving a web-based intervention with twenty-one lessons and regular emails showed increased fruit and vegetable intake in the intervention group (41, 70). Another study with students (18-24 years old) consisting of 10 online lessons with weekly goal setting, feedback and interactive questions, found an increase in fruit and vegetable consumption in the intervention group (41, 71). A study in children explored the effect of a web-based intervention on reducing salt intake, which consisted in the delivery of weekly interactive online educational sessions for five weeks. It found an increase in knowledge regarding foods with higher salt content and a change in eating behavior regarding salt consumption (41, 72). The review concluded that the effectiveness of these DBCIs depends on the commitment and continuous interaction of the target population with them (41).

As mentioned before, multiple intervention strategies are needed in order to achieve long-term health behavior change (30). A smart feature of health-promoting applications is to use techniques such as goal setting, self-monitoring, performance feedback, etc. to facilitate behavior change in the target population (30, 41).

It is also important to register access to the app and the frequency of its use in order to be able to draw conclusions about its effectiveness in changing these behaviors, allowing better and better interventions to be developed for this purpose (30).

Although Italy, Portugal, and Spain are countries where the average eating pattern is based on a Mediterranean pattern, they are among the countries with the highest rates of childhood overweight and obesity. This shows that it is necessary to test new interventions to combat this disease and its associated complications. Although it is known that a diet based on the Mediterranean Diet may be effective in preventing and combating obesity, there is a lack of studies comparing the effectiveness of this diet with a traditional low-fat diet, in children and adolescents. In this sense, the European Project MED4Youth (Mediterranean Enriched Diet for tackling Youth Obesity) was initiated, in order to compare the effectiveness of these two diets in combating childhood obesity (5). This project uses a web-application through which participants have access to their dietary plan and also to daily educational content, tips and quizzes, in order to improve their nutritional knowledge and to provide an improvement in their eating habits and compliance with the diet (5).

2. Objectives

The overall aim of this thesis is to evaluate the effect of an intervention using a web-application by children and adolescents on their knowledge, eating habits, and weight change.

Specifically, this work aims to describe the engagement and usability of an educational web-application by Italian children and adolescents with overweight or obesity from a nutritional and educational intervention project for weight loss and health improvement. It also seeks to relate the use of the educational web-application with the differences in knowledge, food intake, weight loss and improvement of health parameters of the Italian population under study, during the four months' duration of the project.

3. Material and methods

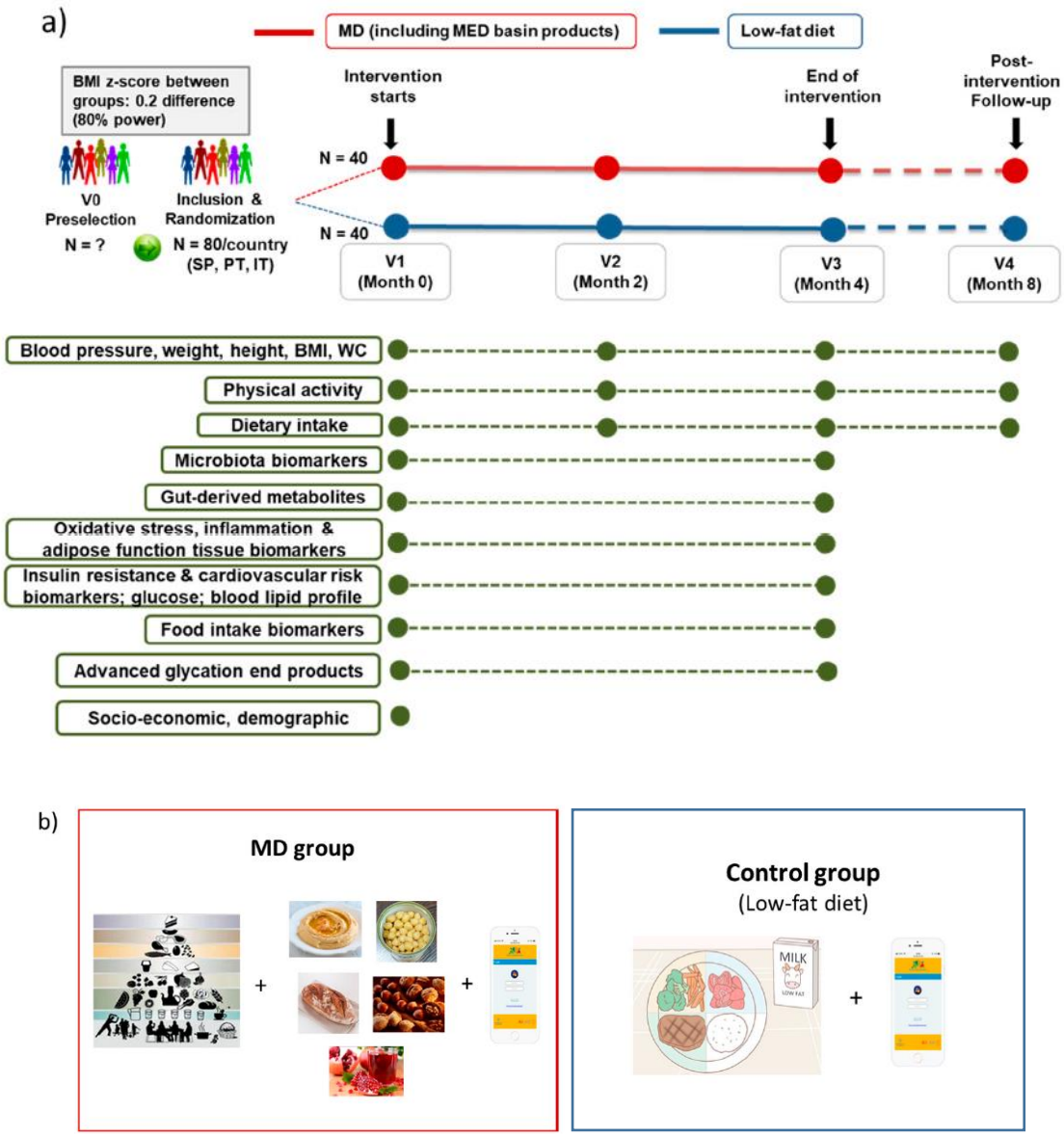
3.1. Setting and sampling

3.1.1 Med4Youth study

The MED4Youth study is a multicenter single-blinded, randomized, parallel-group controlled clinical trial carried out with children and adolescents with overweight or obesity from Italy, Portugal, and Spain (5).

The overall aim of the study is to compare the effectiveness of a Mediterranean Diet (MD)-based intervention with a traditional low-fat diet (LFD) intervention in tackling obesity and associated cardiovascular risk factors in 240 children and adolescents living with overweight or obesity from these Mediterranean countries. Each country aimed to recruit 80 volunteers, to be randomly assigned either to the MD group (following a personalized hypocaloric MD) or to the LFD group (following a personalized hypocaloric LFD). Both diets administered followed the principles of healthy eating, by including foods from all food groups in the recommended proportions and divided into main and intermediate meals throughout the day. Volunteers in the MD group were periodically given typical foods of the Mediterranean diet, such as sourdough bread, chickpeas, pomegranate juice and nuts.

The intervention lasted for four months for each volunteer, during which three visits occurred at two-month intervals (V1, V2 and V3), and a follow-up visit (V4) occurred after four months from the last one (V3) to assess whether they continued to follow the suggested diet and had changed their habits. During the study period, a variety of data was collected from the participants at each of the visits, either by completing validated questionnaires and food diaries, by measuring anthropometric, bioimpedance and cardiac parameters, or by collecting their urine, feces, and blood. The study design is summarized in Figure 1.



Note: images from the original study protocol paper (5).

Figure 1. Overview of the project: a) Design of the study; b) Overview of the intervention groups.

Since only in Italy it was possible to reach the target number of volunteers, and because it was the only country so far where the intervention period was completed by all the volunteers under study, this thesis will only analyze the data collected in Italy. From the 80 volunteers recruited in Italy between May 2021 to November 2022, 74 completed V1, 59 continued to V2, and 54 completed the intervention period with V3. The project's flowchart is shown in Figure 2, including the distribution of volunteers across the two groups and the drop-outs during the intervention.

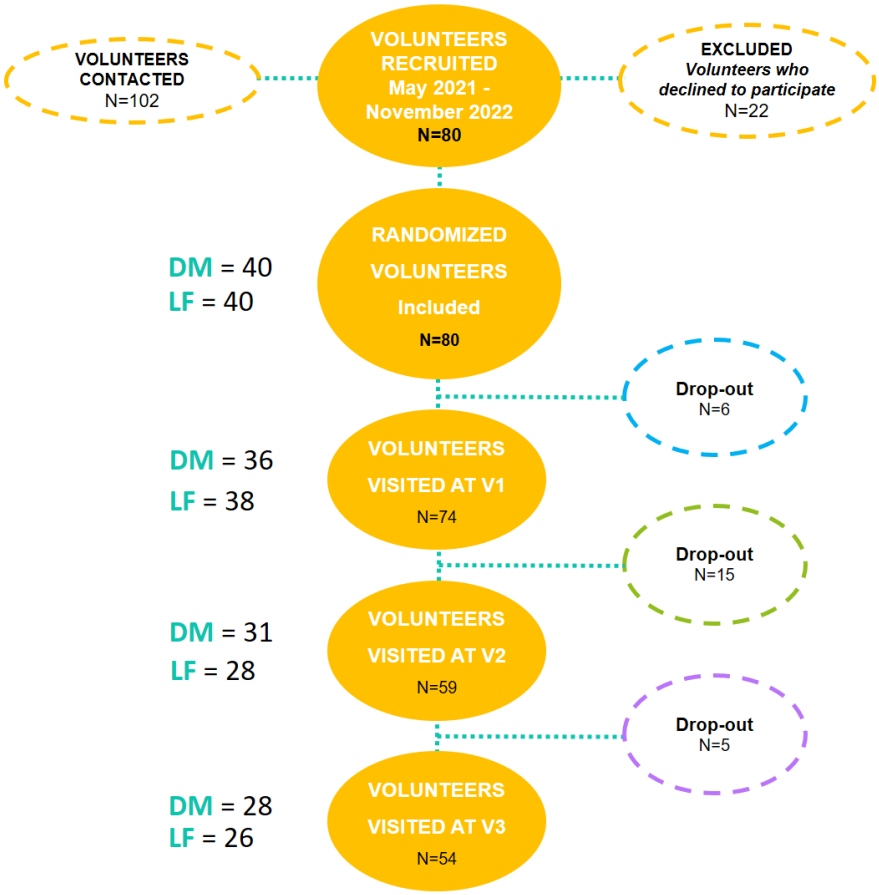


Figure 2. Flowchart of the Med4Youth project volunteer recruitment in Italy.

3.1.2. Educational web-application

The study volunteers were provided with an innovative education web-application specifically developed in Italy to be used during the intervention period, combined with the dietary intervention. The web-application was designed to be accessible to both participants and their parents to increase their engagement through a "learning-through-playing" approach (73). Therefore, the web-application includes each participant's diet, assigned by the nutritionist, educational content, daily tips, quizzes and daily recipes. It was also used to collect data through the 3-day food dairy and seven questionnaires to gather socio-demographic data, adherence to the Mediterranean Diet, physical activity level, food habits/intakes, knowledge on food and nutrition and quality of life. Figure 3 shows the main page of the web-application, specifically the section of the diet plan, the food diary, and the educational content, tips and quizzes.

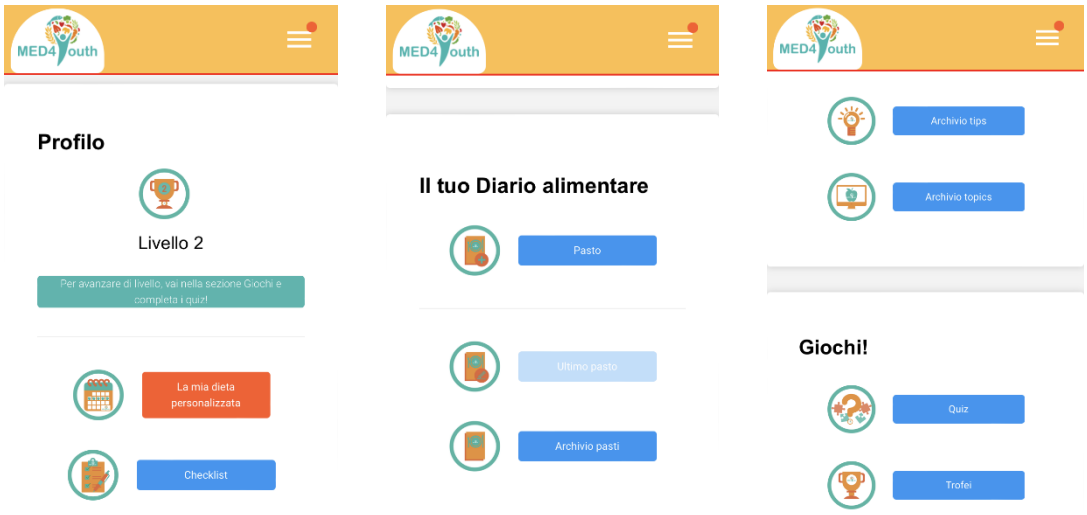
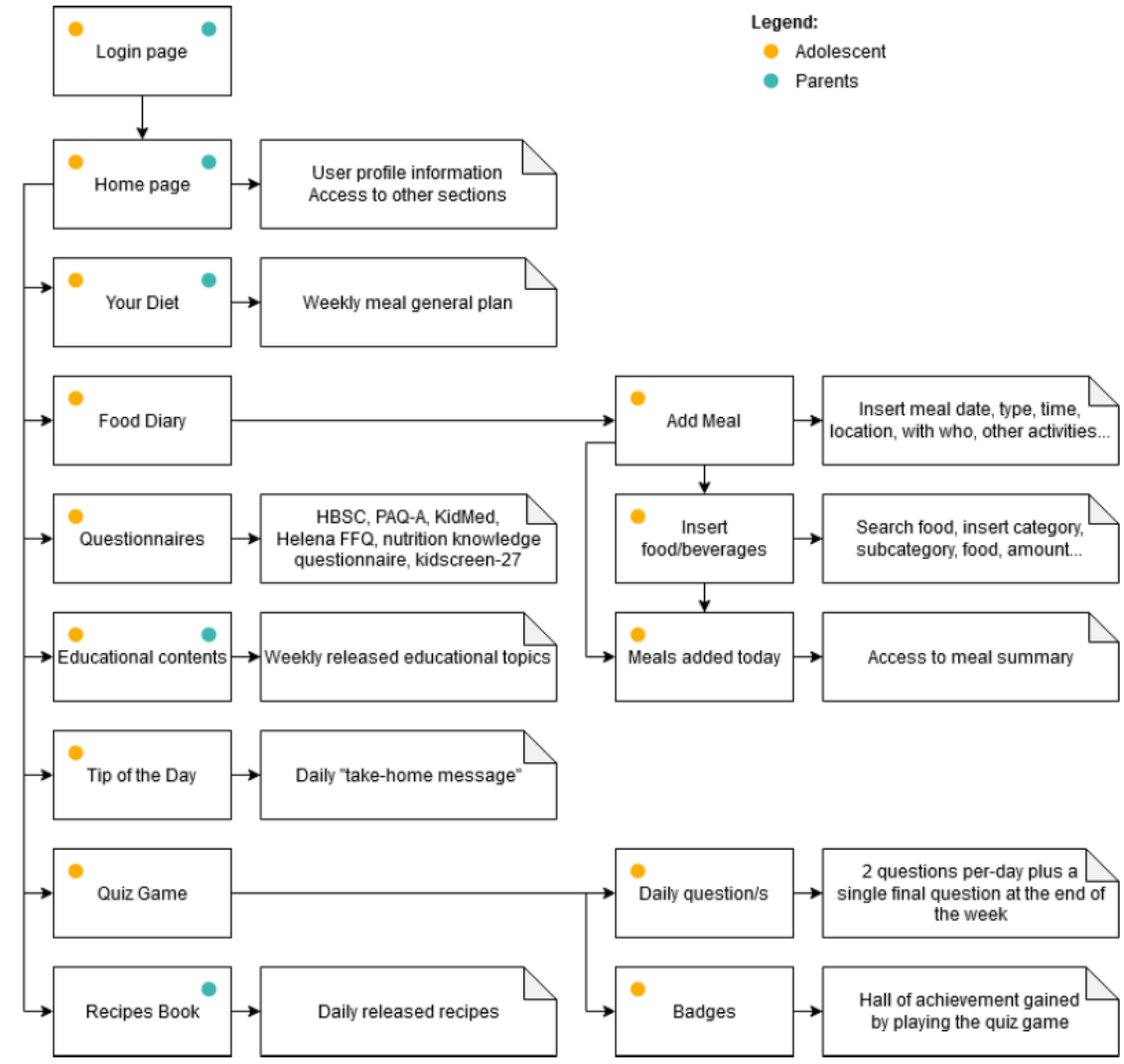


Figure 3. Main page of the web-application.

The application was developed as a cross-browser web-application with responsive design, so it was available for both desktop and mobile devices. It was accessible at a specified secure URL and required a username and a password to enter in the main page. The flowchart diagram presented in Figure 4 shows an overview of the web-application pages and functionalities. Application data was stored in a back-end database that comprises user details, encrypted user access credentials, relevant usage logs, food details, meals and activities inserted by the users.

The contents available in the web-application varied depending on the group (intervention or control group), as well as on the type of user (participants or their parents). Children and adolescents had access to their personalized diet, food diary and questionnaires (to be filled before each visit), group-specific educational contents, "tips of the day" and multiple-choice quiz games based on the topic of the week. On the other hand, parents had access to their children's diet, group-specific educational contents and recipes.



Note: image from the original study protocol of the web-application.

Figure 4. Overview of the web-application pages and functionalities.

Educational contents: In the educational contents section, both the participants and their parents had access to group-specific topics. One educational topic was released each week during the 16 weeks' duration of the project plus one "welcome topic" in the beginning of the study. The weekly topics available in the web-application throughout the study period were: "Welcome Topic: The meaning of Diet and healthy eating"; "Mediterranean Diet (MD group)/ Low Fat Diet (control group)"; "Lifestyle"; "Healthy and sustainable diet"; "Nutrients"; "Food groups"; "Food seasonality"; "Drinks and hydration"; "Meals"; "The healthy eating plate"; "The breakfast"; "Food consumption frequencies"; "Food portions"; "Learning from mistakes!"; "Recognizing hunger"; "Eating out"; "Grocery shopping and cooking". The contents of the previous weeks were available for reading during the entire intervention period.

Tip of the day: In the section “tip of the day”, the participant had access to a daily group-specific short and easy tip related to the topic of the week, for a total of 119 tips. It was also possible to have access to all previous tips during the intervention period.

Quiz game: In this section, a group-specific multiple-choice quiz game was available, based on the topic of the week. The game was composed by 15 questions per week: 2 questions per day plus one final general question. The user had to answer the right option to move to the next question/level (only two attempts were available for each question per day), and every week a new level was released.

To increase participants’ engagement a scheme with badges/achievements was available which were won after consulting the topics, entering the food diary and completing the questionnaires in the app and viewing a certain number of tips.

An example of an educational content, “tip of the day” and quiz game are presented in Annex A.

3.1.3. Inclusion and exclusion criteria

Participants of both sexes were included, aged between 11 and 17 years old, having great overweight or obesity (age- and sex-specific BMI in the ≥90th percentile), and having the written informed consent signed by both parent and child/adolescent.

Subjects who had one of the following criteria were excluded from the study: living with diabetes and other metabolic, endocrine and chronic disorders; intake of antibiotics, drug, probiotics or nutritional supplements in the last month; taking a prescribed medicine to control hypertension, inflammation or dyslipidemia, having followed a prescribed diet for any reason, including weight loss, in the last 3 months; following a religion-restricted diet; living with celiac disease; and having allergies or food intolerances to nuts, pomegranate, bread or chickpeas (since these foods will be offered to the MD group).

Participants were recruited from the Pediatric Clinic of the Maternal and Child Department of the Parma University Hospital. After the clinicians’ pre-selection of potential participants meeting the inclusion criteria, families were contacted by phone to present more information regarding the study and were asked to participate. After an initial verbal consent of the parents, participants were invited to an appointment at the hospital and were recruited. Participants have given their consent to participate, and their parents/legal guardians signed the informed consent. A total of 102 potential participants

who met the inclusion criteria for the study were contacted and 22 of those refused to participate.

3.1.4. Ethics

The project adheres to the Helsinki Declaration and Good Clinical Practice guides of the International Conference of Harmonization. All study partners had the approval of the relevant Clinical Research Ethical Committee before the start of the intervention study: Area Vasta Emilia Nord (AVEN) Ethical Committee (Italy), Ethics Committee of Centro Hospitalar e Universitário de Coimbra and Portuguese National Data Protection Commission (Portugal) and Institut d'Investigació Sanitària Pere i Virgili (Spain).

3.2. Data collection

3.2.1. Engagement and usability of the web-application

As previously stated, the web-application stored information from the volunteers regarding the number of accesses to the app, the correct completion of the games, and the number of tips and topics read. These data on engagement and usability of the web-application/digital platform were obtained by download from the app's back-end database. At the end of the intervention period the volunteers were asked about the usefulness of the app, the frequency of its use, and possible suggestions for improvement to increase engagement with it and thus potentially increase its effectiveness.

3.2.2. Nutritional knowledge

To collect information regarding the children's knowledge on food and nutrition, the Nutritional Knowledge Questionnaire of the Healthy Lifestyle in Europe by Nutrition in Adolescents (HELENA) study was used. This questionnaire was design to be completed by children and adolescents and is composed of 23 multiple-choice questions, each with 4 possible answers (one of which is "don't know"), with only one correct answer (74). The score for this questionnaire is calculated by summing up all the correct answers (74).

The questions in the questionnaire can be divided and analyzed into five subscales: A, Energy Intake and Energy Metabolism; B, Nutrient Contents; C, Sweeteners and Oral Health; D, Food Knowledge; and E, Special terms and Definitions. Subscale A includes questions 1, 12, 13, and 16; in subscale B are questions 2, 8, and 22; subscale C comprises questions 11, 14, 21, and 23; subscale D includes questions 3, 4, 6, 7, 17, 18, 19, and 20; subscale E includes the remaining questions 5, 9, 10, and 15 (75). The questions and their correct answers and subscales are shown in Table 1.

Table 1. Nutritional Knowledge Questionnaire, questions, correct answers and subscales.

Questions	Correct answer	Subscales
1. What is the other commonly used term for energy?	Joule	A
2. Bread, cake, pasta, potatoes and rice contain mainly…	Carbohydrates	B
3. Which row lists three types of edible fish?	Codfish, turbot, carp	D
4. Raw minced meat should be stored in the refrigerator for a maximum of…?	Half a day	D
5. How much salt should one consume per day in addition to that contained in the foods eaten?	None at all	E
6. How many cubes (teaspoons) of sugar are there in a can (0.33 L) of coke or lemonade?	Approximately twelve cubes (seven teaspoons)	D
7. Which row lists three dishes that have all been prepared using very little fat?	Boiled egg, boiled potatoes, steamed fish	D
8. A breakfast merely consisting of bread, jam and butter does not contain enough…	Protein	B
9. What effect does the fiber contained in our food have on the human body?	It stimulates the process of digestion	E
10. Dietitians use the American term ‘Junk Food’ to describe certain foods. What do they mean by this?	Foods that contain a lot of energy but are of very little nutritional value	E
11. What is another name for the coating that develops on teeth when one eats a lot of sweets?	Plaque	C
12. Marcel has been playing with a ball all afternoon. During this time Kevin has been sitting at home watching television. Which of the following statements is most applicable?	Marcel burns more energy than Kevin	A
13. A small bag of roasted peanuts (125 g) contains as much energy…	As a whole lunch meal	A
14. Which of the following statements about sugar is correct?	Sugar only provides energy	C
15. Which one of the following types of mineral water would be the healthiest?	Mineral water with a high Mg content	E
16. How long must one swim in order to burn the amount of energy contained in a single chocolate?	Approximately 10 min	A
17. Which row lists three foods that contain a lot of vitamin C?	Peppers, cabbage, citrus fruit	D
18. How many cubes (teaspoons) of sugar are there in a bottle of ketchup (250 mL)?	Approximately twenty-three cubes(fourteen teaspoons)	D
19. The ingredients list found on food items may contain a number of different terms for sugar. Which row lists three terms for special types of sugar?	Dextrose, fructose, maltose	D

20. What can consuming large amounts of salt result in or aggravate?	High blood pressure	D
21. Which substance is good for your teeth?	Fluoride	C
22. Which of the following fast-food menus contains the most nutrients?	Hamburger with salad and orange juice	B
23. Which row lists three terms for energy-free sweeteners?	Aspartame, saccharin, cyclamate	C

3.2.3. Eating habits

To collect data on children's eating habits, the Food Frequency Questionnaire (FFQ) of the HELENA study was used, as well as some questions used in the Italian Health Behavior in School-aged Children (HBSC) 2018 study. The HELENA FFQ was created for the European HELENA study, with the aim of estimating the frequency of consumption of different food groups, certain dietary behaviors and lifestyle of adolescents (76, 77). As for the HBSC questionnaire, from the original, this paper only analyzed the questions regarding eating habits and frequency of consumption of the various food groups (78-80). The questionnaire includes questions that aim to assess the habitual consumption of food groups (fruits, vegetables, sweets, carbonated/sweetened beverages, salty snacks, cereals and legumes) within a specified time period (seven days) (76, 77). It also investigates the meal completeness throughout a whole day, asking the participants how often they snack between main meals and how often the latter are shared with the remaining part of the family (78-80). Table 2 presents a description of the questions used for this paper.

Since the Med4Youth project also aims to increase young people's adherence to the Mediterranean Diet, the KIDMED questionnaire (Mediterranean Diet Quality Index for children and teenagers) was used to study the volunteers' eating habits and their shift towards this diet and lifestyle. The KIDMED test was developed and validated in 2004 and has been used to collect data on MD adherence in children and adolescents as an index of healthy diets (81). Extensively described in the scientific literature, it consists of 16 questions, which can be answered affirmatively or negatively (82). These questions are based on the consumption of specific foods or food groups representative of MD such as fresh and dried fruits, vegetables, pasta and cereals, fish products, legumes, milk and dairy products, olive oil and also foods whose consumption should occur occasionally such as sweets and fast food (82). The questionnaire can be self-administered or administered through an interview (82). A score of (-1) is given to questions with a negative connotation with the MD and (+1) is given to questions that concern habits characteristic of this dietary pattern (82). The index ranges from 0 to 12,

and the sum of the values obtained is classified into three levels: optimal Mediterranean Diet (score >8), improvement needed to adjust intake to Mediterranean patterns (score between 4 and 7), very low diet quality (score <3) (82).

Table 2. Description of the Food Frequency Questionnaire (FFQ).

Questions	Description	Response options
Meals Consumption Questions		
Breakfast (week days)	Frequency of consumption of breakfast during week days	Never; 1 day per week; 2 days per week; 3 days per week; 4 days per week; 5 days per week.
Breakfast (weekends)	Frequency of consumption of breakfast during weekends	Never; Only on one day of the weekend; On both days of the weekend.
Morning and afternoon snacks	Usual frequency of consumption of morning and afternoon snacks	Never; Only the morning snack; Only the afternoon snack; Both the morning and afternoon snacks.
Meals together with family	Frequency of meal consumption with the family	Everyday; Most days; About once a week; Never.
Food Frequency Questions		
Fruits	Frequency of consumption of each food item from each of the food groups	Never; Less than once a week; Once a week; 2-4 times per week; 5-6 times per week; Once a day; More than once a day.
Vegetables		
Sweets		
Coke or other soft drinks		
Salty snacks (French fries,…)		
Cereals (corn flakes, muesli...)		
Cereals (bread, pasta, rice...)		
Pulses (peas, beans, chickpeas...)		

3.2.4. Anthropometric measurements

The participants' height was measured using the mobile stadiometer Seca® 217, with a range of 20-205 cm, using a millimeter scale. The TANITA Professional Bioimpedance Analyzer MC-580 with the Column Kit 580-CK75 was used to measure body weight and fat percentage, since, for children and adolescents between 5 and 17 years old, it is only validated to analyze these parameters. To measure the waist and hip circumferences the Flexible meter Seca® *201* was used.

At the time of the anthropometric measurements, the participants remained only in their underwear, without socks, and removed all metallic accessories (earrings, necklaces, watch, etc.) (83). For the height measurement, the participants stood at the base of the stadiometer, positioned with their backs to the device, with their feet together and heels touching the device, their arms, hands and shoulders relaxed, with their arms laterally to the body and palms facing their thighs, their head was positioned in the Frankfurt plane, with their gaze fixed to the horizon (83). For the measurement of weight and fat mass, the participants followed the instructions of the device by first placing their feet parallel on top of the metal devices and then, after a signal from the instrument, they placed their hands on the metal devices for this purpose, remaining still for 40 seconds while the instrument took the measurement. Finally, for the measurement of circumferences, the patients stood with their arms alongside their bodies and feet together (83). Waist circumference was measured in a horizontal plane, in the lumbar region, at the smallest circumference at waist level (between the last rib and the iliac crest) (83). For the measurement of the hip circumference, the participant remained in the same position and the measurement was made in a horizontal plane, at the largest circumference at the level of the gluteus maximus, without compressing the skin (83).

The BMI of the volunteers was calculated and classified as great overweight (BMI ≥ 90 to < 95th percentile) and obesity (≥ 95th percentile) according to the Center for Disease Control and Prevention (CDC) cut-off points and also converted into BMI z-score according to the same guidelines (84).

3.3. Statistical analysis

The distribution of variables was accessed through the Kolmogorov-Smirnov test for the initial characterization of the total sample of volunteers (n=74). Subsequently, the distribution was accessed through the Shapiro-Wilk test only for those volunteers who completed the intervention period between visit V1 and V3 (n=54). Mean and standard deviation (SD), or median and 25th and 75th percentiles (P25-P75) were used to describe normal and non-normally distributed data, respectively.

Comparison of continuous variables between groups was done using parametric (Student's t test for independent and paired samples) and non-parametric tests (Mann Whitney and Wilcoxon), accordingly. Categorical variables were characterized using absolute (n) and relative frequencies (%), and the McNemar test was used for the comparison of paired samples. Due to the low frequency in some categories of the

variables of the various food groups of the food frequency questionnaire, these were recoded. Thus, for the variables "fruits", "vegetables", "cereals (muesli, corn flakes)" and "cereals (bread, pasta, rice)", the categories "never", "<1x/week" and "1x/week" were converted to "low consumption", the categories "2-4x/week" and "5-6x/week" were converted to "regular weekly consumption" and the categories "1x/day" and ">1x/day" were converted to "daily consumption". For the variables "sweets", "salty snacks" and "pulses", the categories "never" and "<1x/week" were converted to "low consumption", the categories "1x/week" and "2-4x/week" were converted to "regular weekly consumption" and the categories "5-6x/week", "1x/day" and ">1x/day" were converted to "daily consumption". For the variable "coke and other soft drinks", the categories "never" and "<1x/week" were converted to "low consumption", the category "1x/week" remained as "1x/week" and the categories "2-4x/week", "5-6x/week", "1x/day" and ">1x/day" were converted to "frequent consumption".

For the main objective, descriptive statistics were used to characterize the frequency of use of the app, specifically the number of times it was accessed, the tips and topics consulted, and the quizzes completed correctly. These results were then related to nutritional knowledge, eating habits and anthropometric parameters using Spearman’s correlation. The use of the app by the participants' parents/legal guardians was also studied, and this engagement was related to the participants' engagement using Spearman's correlation.

Differences within and between the MD and LFD groups were studied concerning nutritional knowledge, adherence to the Mediterranean Diet, and anthropometric parameters using parametric and non-parametric tests, specifically student t-test for paired samples or Wilcoxon for the comparison within each group, and student t-test for independent samples or Mann Whitney for the comparison between groups. However, since all volunteers had access to similar contents in the web-application, the relationship of its use with the parameters under study was performed with the total group of project volunteers (without dividing them into MD and LFD groups).

Statistical analysis was performed in IBM SPSS® version 27.0 for Windows®. Statistical significance was considered for an α of 0.05.

4. Results

This dissertation analyzed the data collected in Italy in the corresponding period between visits 1 (V1) and 3 (V3). In Italy, the study was conducted by the Human Nutrition Unit of the University of Parma, in collaboration with the Pediatric Clinic of the Maternal and Child Department and recruited 80 volunteers. The volunteers were randomized in one of the groups, DM or LFD. Of the total number of volunteers included in the study, 74 started the intervention (V1), 59 finished the first two months of treatment (V2) and 54 the other two months (V3).

At the beginning of the intervention, the volunteers (n=74) had a median age of 14.0 years (P25 – P75: 13.0 – 14.0), a median weight of 78.8 Kg (72.4 – 91.5), a median BMI of 30.9 Kg/m^2 (27.8 – 33.0) and a mean BMI z-score of 2.0 (SD=0.3). Of the initial population, 52.7% (n=39) were male, 48.6% (n=36) belonged to the DM group and 51.4% (n=38) to the LFD group.

The results presented below concern only those volunteers who completed the entire duration of the intervention period (four months), i.e., 54 participants, 28 in the MD group and 26 in the LFD group.

At the beginning of the intervention (Table 3), there were no statistically significant differences between the MD and LFD groups for sex (p=0.408), age (p=0.329) and BMI (p=0.436). In the MD group, 53.6% of the participants were female, the mean age was 13.5 years (1.2), and the median BMI was 30.6 Kg/m^2 (27.6 – 32.6). In the LFD group, 57.7% were male, the median age was 13.9 years (1.4), and the median BMI was 31.2 Kg/m^2 (27.5 – 34.8).

Table 3. Characteristics of the participants at the beginning of the intervention.

	MD (n=28)	**LFD (n=26)**	*p*
Sex – n (%)			0.408
Female	15 (53.6)	11 (42.3)	
Male	13 (46.4)	15 (57.7)	
Age – years			0.329
Mean (SD)	13.5 (1.2)	13.9 (1.4)	
Min – Max	11 - 16	11 – 16	
BMI – Kg/m^2			0.436
Median (P25 – P75)	30.6 (27.6 – 32.6)	31.2 (27.5 – 34.8)	
Min – Max	25.1 – 36.0	26.2 – 46.9	

BMI: body max index; LFD: low-fat diet; Max: maximum; MD: Mediterranean diet; Min: minimum

4.1. Engagement and usability of the web-application

Table 4 shows the engagement and usability results of the web-application for the total sample and, specifically, the results of the MD and LFD groups separately, as well as the data of the participants' parents/legal guardians. Participants accessed the web-application a median of 24.5 times (15.0 – 51.0). Of the 119 daily tips available in the web-application, participants consulted a median of 11.0 tips (7.0 – 16.0) and a median of 0.0 topics (0.0 – 1.0) out of a total of 17 weekly topics. Of the 255 quizzes available, the participants answered a median of 4.0 correctly (0.0 – 13.5). The MD group viewed about 9.24% of the available tips and 0% of the topics, while the LFD group consulted about 9.66% of the tips and 2.94% of the topics. Regarding the available quizzes, the participants in the MD group answered about 1.18% of the questions correctly and those in the LFD group answered 1.57% correctly.

Table 4. Engagement and usability results of the web-application by participants and their parents/legal guardians, in total sample and by MD and LFD groups.

	Total (n=54)	**MD (n=28)**	**LFD (n=26)**	*p*
User access – participants				0.736
Median (P25 – P75)	24.5 (15.0 – 51.0)	26.0 (15.0 – 47.5)	24.0 (13.3 – 52.3)	
Min – Max	0 – 309	3 – 309	0 – 262	
Tips consulted – participants				0.372
Median (P25 – P75)	11.0 (7.0 – 16.0)	11.0 (0.0 – 16.0)	11.5 (7.8 – 16.5)	
Min – Max	3 – 119	3 – 54	4 – 119	
Topics consulted – participants				0.212
Median (P25 – P75)	0.0 (0.0 – 1.0)	0.0 (0.0 – 1.0)	0.5 (0.0 – 1.0)	
Min – Max	0 – 17	0 – 3	0 – 17	
Quizzes answered correctly – participants				0.790
Median (P25 – P75)	4.0 (0.0 – 13.5)	3.0 (0.0 – 18.8)	4.0 (0.0 – 10.8)	
Min – Max	0 – 85	0 – 73	0 – 85	
User access – parents				0.317
Median (P25 – P75)	4.0 (1.0 – 13.0)	4.0 (1.0 – 52.3)	4.5 (0.0 – 9.3)	
Min – Max	0 – 136	0 – 136	0 – 52	
Tips consulted – parents				0.740
Median (P25 – P75)	1.0 (0.0 – 7.3)	1.0 (0.0 – 7.5)	1.0 (0.0 – 7.5)	
Min – Max	0 – 80	0 – 80	0 – 48	
Topics consulted – parents				0.237
Median (P25 – P75)	0.0 (0.0 – 1.0)	0.0 (0.0 – 1.0)	0.0 (0.0 – 0.3)	
Min – Max	0 – 7	0 – 7	0 – 5	

LFD: low-fat diet; Max: maximum; MD: Mediterranean diet; Min: minimum

Note: the p value refers to the comparison of the variables' medians between the MD and LFD groups.

No statistically significant differences were found between the MD and LFD groups regarding the web application's usability and engagement parameters in either the participants or their parents.

Table 5 shows the Spearman correlations between usability and engagement parameters of the participants and their parents with the web-application. There was a positive, statistically significant and weak linear correlation between the number of accesses to the web-application by the participants and: the number of accesses by their parents/legal guardians (ρ=+0.45; *p*<0.001), and the number of tips they (the parents/legal guardians) consulted (ρ=+0.49; *p*<0.001). Regarding the number of accesses by parents/legal guardians, there was also a positive, statistically significant and moderate linear correlation with the tips they consulted (ρ=+0.74; p<0.001) and a weak correlation with the topics they consulted (ρ=+0.44; *p*=0.001). A positive, statistically significant and weak linear correlation was observed between the number of tips and the number of topics consulted by the participants (ρ=+0.33; p=0.016). Between the number of tips and the number of topics consulted by parents/legal guardians, a positive, statistically significant and moderate linear correlation was observed (ρ=+0.56; p<0.001).

Table 5. Spearman correlation between usability and engagement parameters of the participants and their parents with the web-application.

		Participants				**Parents**		
		User access	Tips consulted	Topics consulted	Quizzes answered correctly	User access	Tips consulted	Topics consulted
Participants								
User access	ρ	1.00	0.07	-0.20	-0.01	**0.45**	**0.49**	0.18
	p value		0.611	0.147	0.946	**<0.001**	**<0.001**	0.199
Tips consulted	ρ		1.00	**0.33**	0.06	0.06	0.05	0.02
	p value			**0.016**	0.688	0.648	0.742	0.910
Topics consulted	ρ			1.00	0.15	0.01	-0.03	-0.10
	p value				0.280	0.941	0.850	0.470
Quizzes answered correctly	ρ				1.00	0.06	0.12	0.06
	p value					0.644	0.391	0.661
Parents								
User access	ρ					1.00	**0.74**	**0.44**
	p value						**<0.001**	**<0.001**
Tips consulted	ρ						1.00	**0.56**
	p value							**<0.001**
Topics consulted	ρ							1.00
	p value							

ρ: Spearman correlation coefficient

Note: Statistically significant results are indicated in bold color.

At the end of the intervention period, that is, at visit V3, when asked about the use of the app and their satisfaction with it, only 8 out of the 54 volunteers said that they were completely satisfied with the app and that they used it from time to time. Another 8 volunteers gave some constructive feedback about the app or gave some advice to improve it. The remaining reported not using the app (some only accessed it to complete the food diary and the questionnaires), either because they forgot or because they were not interested or not motivated to use it. Thus, they had no opinion about how it worked and no suggestions for improvement.

Among the opinions/suggestions given regarding this tool, volunteers reported that it was uncomfortable to always have to open an internet browser to access the app and they suggested that the intervention should be done through a social network. Participants have also suggested that it should be possible to download the app and that it should also have a social component. Some reported that the diet plan presented was very small in size and therefore not easily seen. Regarding the content, some participants have said they liked the tips, topics, and games available, but they proposed that more than one recipe per day should be presented, and that they should also be easier to make. The volunteers also recommended that the app send them some notifications to remind them to use it, to see its educational content and daily games, and this suggestion could solve the "forgetting to use the app" problem that some volunteers pointed out as a reason for not using it.

4.2. Nutritional knowledge

Figure 5 shows the mean Nutritional Knowledge questionnaire score between visits V1 and V3 in the total sample (n=54), and in the MD (n= 28) and LFD (n=26) groups.

The results of the Nutritional Knowledge questionnaire remained similar (p=0.851) in the scores of the total sample, from an average of 54.0% to 54.3%. The MD group presented lower scores than the LFD group, but no differences were observed from V1 to V3 neither in the MD group (average of 49.5% to 49.1%, p=0.890), or in the LFD group (from 58.9% to 60.2%, p=0.621). No statistically significant differences were also found regarding the delta score between the groups, p=0.678.

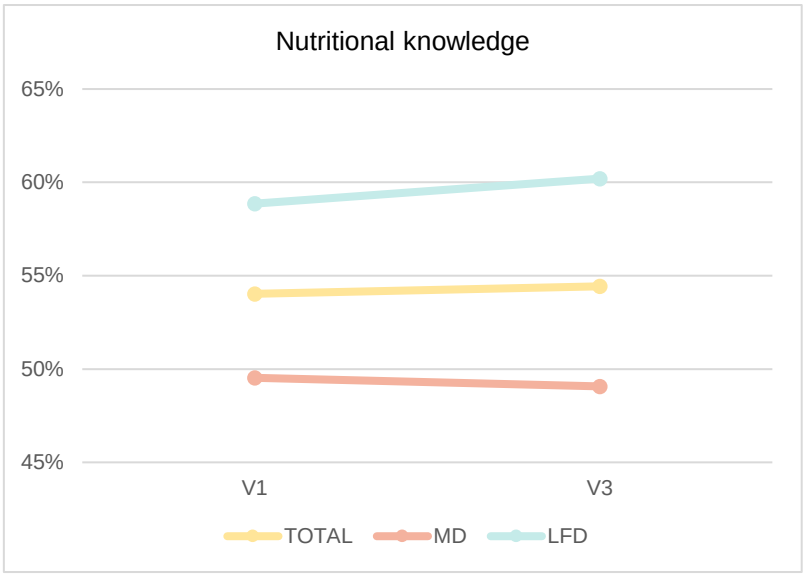


Figure 5. Nutritional knowledge questionnaire score, in the total sample and in the MD and the LFD groups.

The differences in the scores of the subscales from this questionnaire were then studied in the total sample (n=54) and are presented in Figure 6. The difference in scores on the various subscales of the Nutritional Knowledge questionnaire, A (Energy Intake and Energy Metabolism), B (Nutrient Contents), C (Sweeteners and Oral Health), D (Food Knowledge), and E (Special terms and Definitions) between V1 and V3 were not statistically significant: respectively p=0.615; p=0.418; p=0.252; p=0.823; p=0.339; although a decrease was observed in subscale B, from 100.0% to 66.7%, and an increase in subscales C and D, from 25.0% to 50.0% and from 55.1% to 62.5%, respectively.

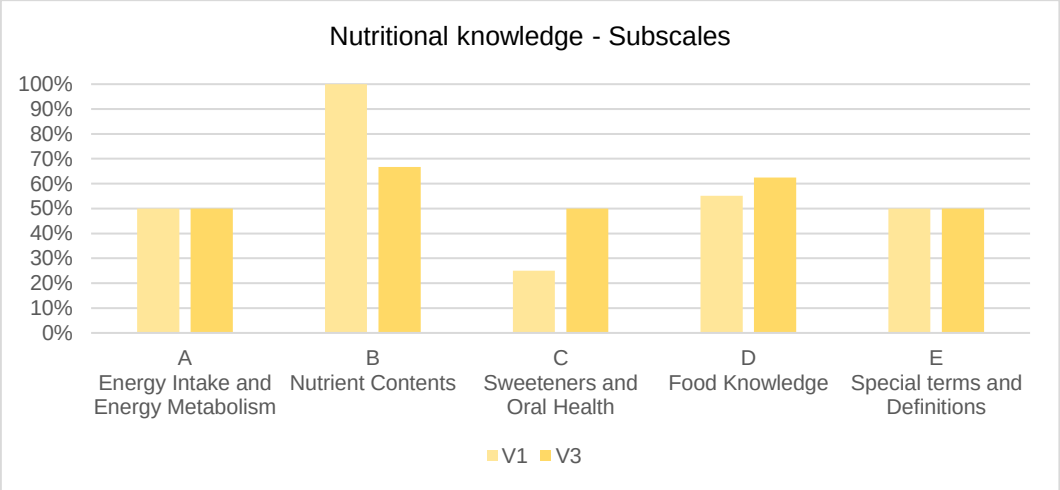
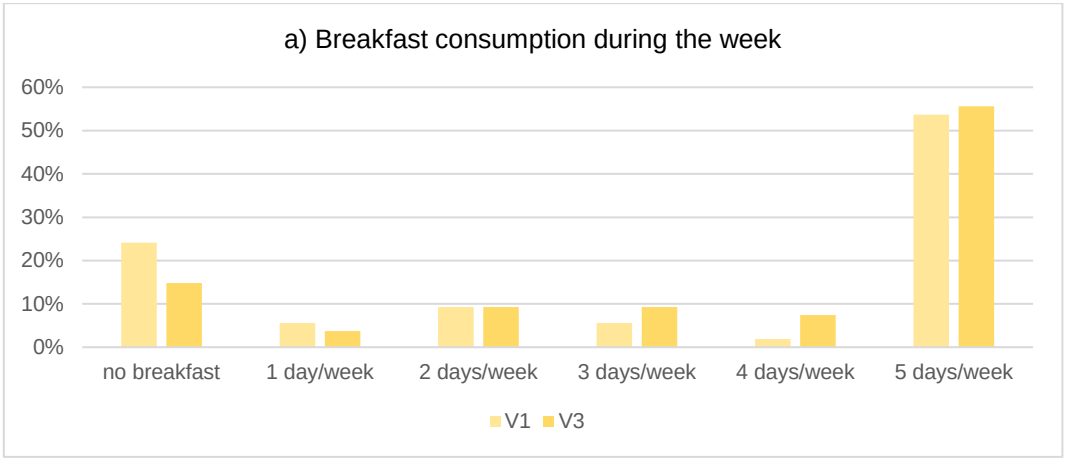


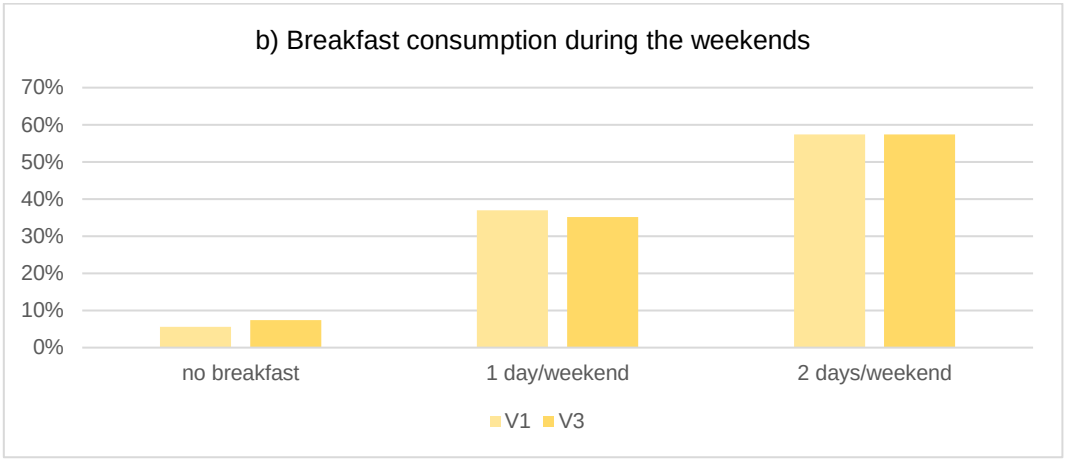
Figure 6. Nutritional knowledge questionnaire score divided by the subscales.

4.3. Eating habits

4.3.1. Meals consumption

Figure 7 shows the distribution of the volunteers' responses regarding the frequency of consumption of breakfast and snacks in visits V1 and V3, in the total sample (n=54).





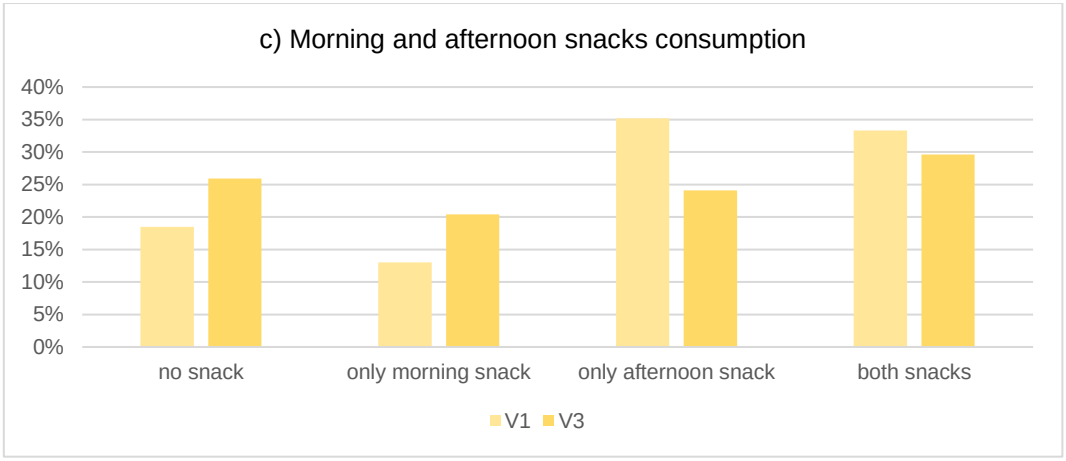


Figure 7. Frequency of consumption of a) breakfast during the week, b) breakfast during the weekend and c) morning and afternoon snacks.

In V1, 24.1% of the participants reported never eating breakfast during the week, while 1.9% and 53.7% reported eating breakfast 4 and 5 times a week, respectively. In V3, the proportion of those who reported never eating breakfast during the week decreased to 14.8% and the proportion of those who reported eating breakfast 4 or 5 times a week increased to 7.4% and 55.6%, respectively, showing an increase in breakfast consumption during the week, although differences were not statistically significant (p=0.299). The results show a slight reduction in breakfast consumption during the weekend (p=0.392) as the proportion of those who reported eating breakfast only on one day decreased from 37% to 35.2% and those who reported never eating breakfast increased from 5.6% to 7.4%; the proportion of those who ate breakfast on both days of the weekend remained similar.

The proportion of participants who reported consuming both snacks (morning and afternoon) decreased from 33.3% to 28.6%, in favor of not consuming any snacks (from 18.5% to 25.9%) or only one of the snacks. Regarding each of the snacks, the results show that there was an increase in the consumption of the morning snack (from 13.0% to 20.0%) and a decrease in the consumption of the afternoon snack (from 35.2% to 24.10%). However, the differences in the distribution of frequency of morning and afternoon snack consumption between V1 and V3 were not statistically significant (p=0.898).

Figure 8 presents the frequency of meal consumption with the family in visits V1 and V3, in the total sample (n=54).

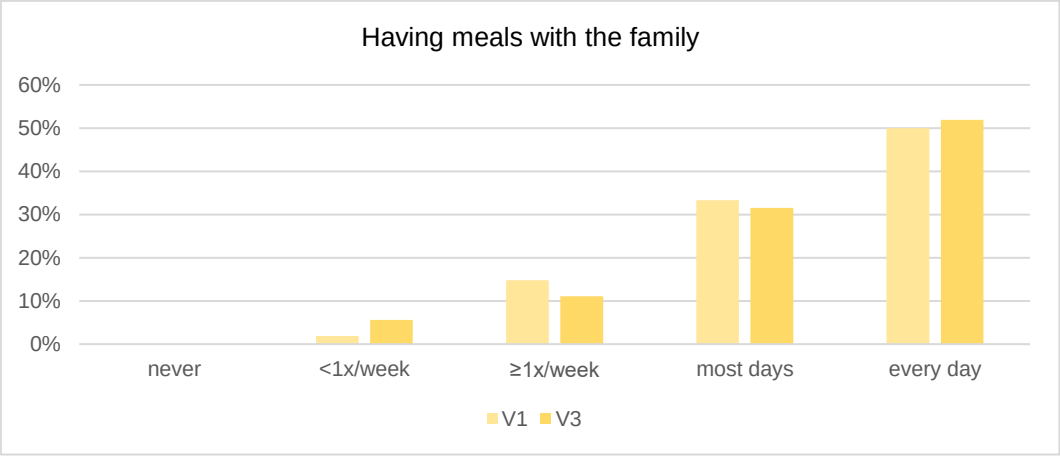


Figure 8. Frequency of meal consumption with the family.

In V1, about half of the participants reported eating meals with their family every day, and this proportion remained similar in V3. There was a decrease in the proportions of the categories "most days" and "≥1x/week" from 33.3% to 31.5% and 14.8% to 11.1%, respectively, although the differences found were not statistically significant (p=0.663).

4.3.2. Food-groups frequency consumption

Figure 9 presents the weekly frequency of consumption of fruits and vegetables in visits V1 and V3, in the total sample (n=54). The results obtained showed that there was a daily increase in the consumption of fruits and vegetables. For example, there was a decrease in the proportion of participants who reported never consuming fruits, from 7.4% to 1.9%, and an increase in those who reported consuming fruits once a day (from 7.4% to 31.5%) or more than once a day (from 11.1% to 13.0%). Regarding vegetable consumption, there was a large increase in the proportion of those who said they consumed them more than once a day, from 13.0% to 33.3%. After recoding the variables due to low frequency in some categories, it was found that the differences found between fruit and vegetable consumption between V1 and V3 were statistically significant, respectively p=0.003 and p=0.013.

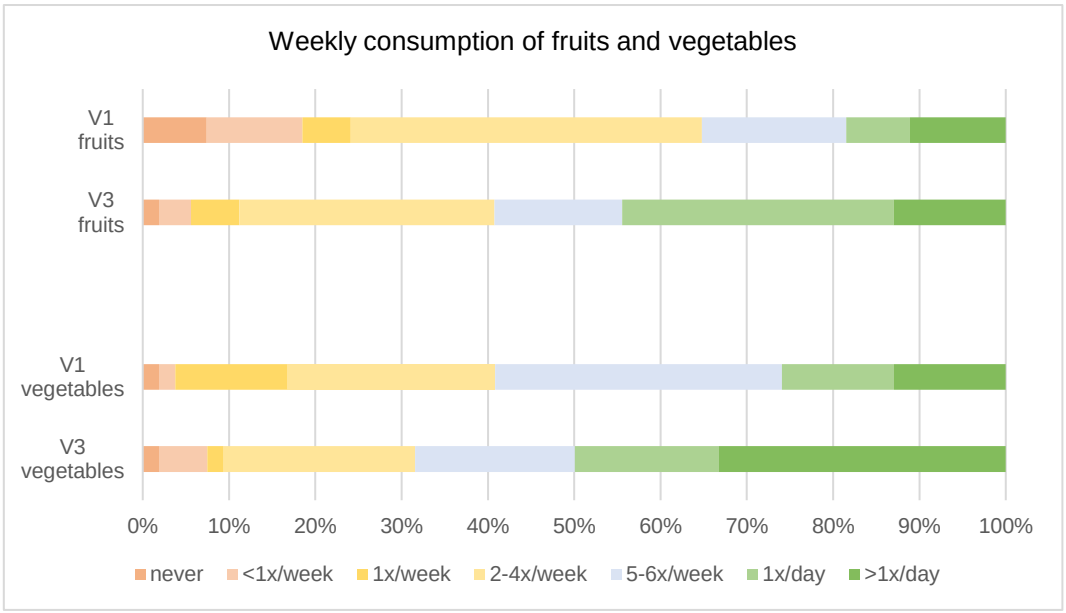


Figure 9. Weekly frequency of consumption of fruits and vegetables, b) sweets, soft drinks, and salty snacks, c) cereals and pulses.

Figure 10 presents the weekly frequency of consumption of sweets, coke and other soft drinks, and salty snacks in visits V1 and V3, in the total sample (n=54). There was a decrease in the consumption of sweets, coke and other soft drinks, and salty snacks. The proportion of those who never drank coke or other soft drinks almost doubled, from 22.2% to 42.60%, and there was a large decrease in those who reported drinking these drinks once a week (from 31.5% to 13.0%) or between two and four times a week (from 20.4% to 5.6%). The proportion of participants who reported never consuming sweets increased between the two visits from 5.6% to 20.40% while those who reported consuming sweets once a day or more than once a day in V1 decreased from 5.6% and 3.7%, respectively, to 0% in V3. Also the consumption of salty snacks decreased between the two visits, with the categories of consumption of this food group that showed an increase being "never" (from 7.4% of the participants to 18.5%), "less than once a week" and "once a week", while the other categories showed a decrease, for example from 38.9% to 29.6% in the case of the "2-4 times a week" category and from 11.1% to 1.9% in the case of the "5-6 times a week" category. After recoding the variables due to low frequency in some categories, the differences found between the consumption of sweets, soft drinks and salty snacks between V1 and V3 were statistically significant, respectively p=0.017, p=0.002 and p=0.043.

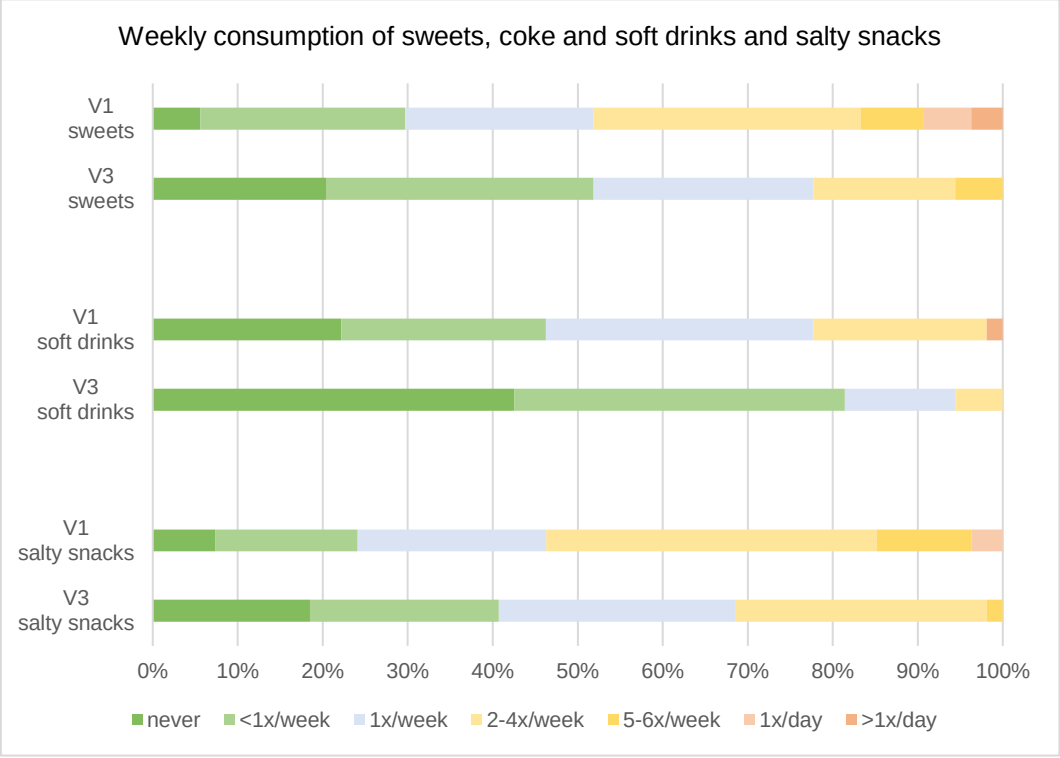
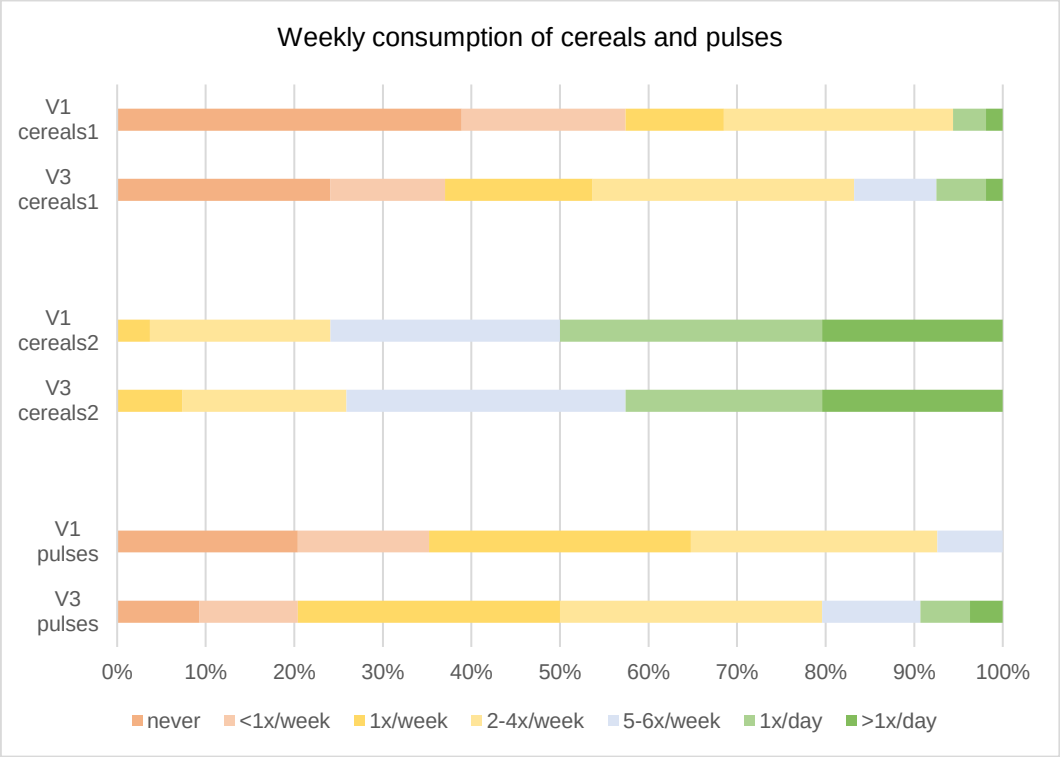


Figure 10. Weekly frequency of consumption of sweets, coke and soft drinks, and salty snacks.

Figure 11 presents the weekly frequency of consumption of cereals and pulses in visits V1 and V3, in the total sample (n=54). The regular consumption of cereals remained similar. The variables were recoded due to low frequency in some categories and no statistically significant differences were found in the consumption of cereals “corn flakes, muesli” and cereals “bread, pasta, rice” between V1 and V3, respectively p=0.140 and p=0.536. The proportion of non-consumers of pulses decreased from 20.4% to 9.3% between the V1 and V3 visits, and the category that registered the greatest increase was the consumption of this food group five to six times a week, from 7.4% to 11.1%. The variable was recoded and a statistically significant difference was found in the consumption of this food group between V1 and V3, p=0.020.



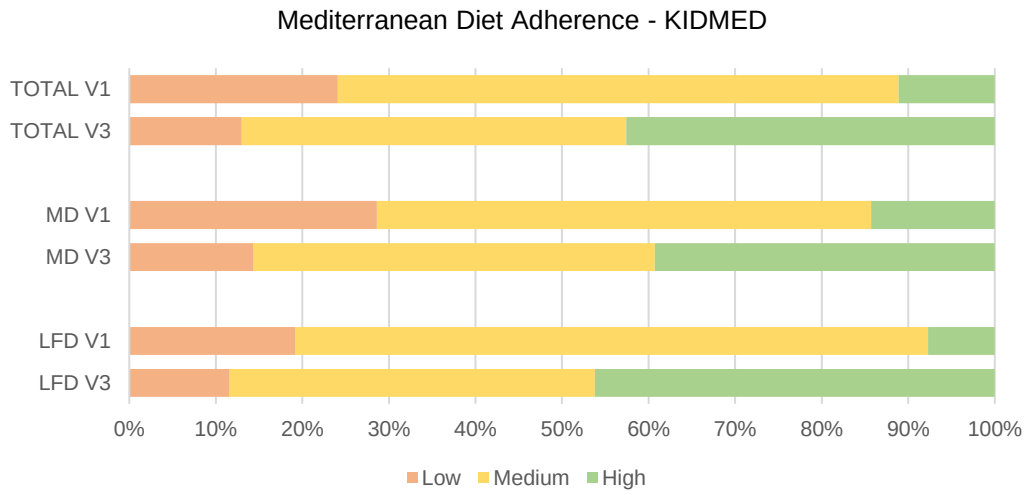
Cereals 1: corn flakes, muesli; Cereals 2: bread, pasta, rice

Figure 11. Weekly frequency of consumption of cereals and pulses.

4.3.3. Mediterranean Diet adherence

Regarding the KIDMED questionnaire, the total sample registered a statistically significant increase of 1.8 points (2.6), $p<0.001$, from a mean score of 4.8 (2.3) to 6.6 (2.5). Regarding KIDMED scores in the study groups, the MD group changed from a mean score of 4.8 points (2.3) to 6.5 points (2.7), $p=0.002$, while the LFD group changed from a mean score of 4.8 points (2.2) to 6.6 points (2.4), $p<0.001$. No statistically significant differences were found between the delta score of the groups, $p=0.935$.

Figure 12 shows the distribution of the Mediterranean Diet adherence categories (low, medium, or high) in the total sample (n=54) and by intervention group (MD: n=28; LFD: n=26). Overall and in both groups, an increase in adherence to this dietary pattern was observed. The percentage of participants who achieved high adherence to the Mediterranean Diet increased from 11.1% to 42.6%. In the MD group it changed from 14.3% to 39.3%, and in the LFD group it went from 7.7% to 46.2%.



LFD: low-fat diet; MD: Mediterranean diet

Figure 12. Adherence to the Mediterranean Diet between visits V1 and V3.

4.4. Anthropometric measurements

Table 6 presents the results of the anthropometric parameters of the volunteers at visits V1 and V3 and the absolute and relative change, in the total sample (n=54), and in the MD (n=28) and the LFD (n=26) groups.

Table 6. Anthropometric parameters of the volunteers at visits V1 and V3 in the total sample, and in the MD and the LFD groups.

TOTAL	V1 (n=54)	V3 (n=54)	*p* (V1-V3)	Absolute change (n=54)	Relative change (n=54)
Weight (kg)	81.8 (13.3)	81.1 (14.2)	0.169	-0.3 (-2.1 – 2.4)	-0.8%
BMI (kg/m^2)	31.0 (27.6 – 33.2)	30.1 (27.6 – 33.1)	**<0.001**	-0.6 (-1.5 – 0.2)	-3.0%
BMI z-score	2.0 (0.3)	1.9 (0.4)	**<0.001**	-0.1 (-1.1 – 0.0)	-6.4%
Fat mass (%)	36.1 (6.6)	35.2 (6.5)	0.055	-0.8 (0.2)	-2.3%
Waist circumference (cm)	98.9 (10.3)	97.9 (11.2)	0.089	-1.0 (4.3)	-1.0%
Hip circumference (cm)	108.2 (8.0)	106.8 (8.3)	**<0.001**	-1.0 (-3.5 – 0.1)	-1.3%
Waist hip ratio	0.9 (0.1)	0.9 (0.1)	0.693	0.0 (0.0)	0.0%
MD	**V1 (n=28)**	**V3 (n=28)**	***p* (V1-V3)**	**Absolute change (n=28)**	**Relative change (n=28)**
Weight (kg)	78.3 (71.2 – 87.3)	78.4 (69.1 – 84.8)	0.111	-1.2 (3.7)	0.06%
BMI (kg/m^2)	30.6 (27.6 – 32.6)	29.7 (26.7 – 31.6)	**0.004**	-1.9 (1.4)	-2.9%
BMI z-score	2.1 (1.7 – 2.2)	1.9 (1.7 – 2.2)	**<0.001**	-0.1 (-0.2 – 0.0)	-6.7%
Fat mass (%)	36.1 (6.6)	35.0 (7.0)	0.051	-1.2 (3.0)	-3.2%
Waist circumference (cm)	96.5 (8.5)	95.5 (9.9)	0.266	-1.0 (4.6)	-1.0%
Hip circumference (cm)	107.7 (8.2)	105.7 (8.1)	**<0.001**	-2.0 (2.6)	-1.9%
Waist hip ratio	0.9 (0.1)	0.9 (0.1)	0.346	0.0 (0.0)	1.1%
LFD	**V1 (n=26)**	**V3 (n=26)**	***p* (V1-V3)**	**Absolute change (n=26)**	**Relative change (n=26)**
Weight (kg)	79.0 (72.6 – 99.8)	80.9 (74.0 – 93.9)	0.611	-0.1 (3.5)	2.4%
BMI (kg/m^2)	31.2 (27.5 – 34.8)	30.4 (27.2 – 34.2)	**0.022**	-0.7 (1.4)	-2.5%
BMI z-score	2.2 (1.8 – 2.4)	2.1 (1.6 – 2.3)	**0.002**	-0.1 (0.2)	-5.6%
Fat mass (%)	36.0 (6.8)	35.5 (5.9)	0.447	-0.9 (-2.2 – 1.8)	-1.4%
Waist circumference (cm)	101.5 (11.6)	100.5 (12.1)	0.202	-1.1 (4.1)	-1.0%
Hip circumference (cm)	108.7 (7.8)	107.9 (8.5)	0.091	-0.8 (2.3)	-0.7%
Waist hip ratio	0.9 (0.1)	1.0 (0.1)	0.479	-0.0 (-0.02 – 0.01)	6.5%

BMI: body max index; LFD: low-fat diet; MD: Mediterranean diet

Note: Data are expressed as mean (SD) or median (P25 – P75) in columns 1, 2 and 4. The *p* value presented refers to the comparison of the means or medians of the parameters between V1 and V3, using the t-student test for paired samples or the Wilcoxon test, according to the normality of the variables. Statistically significant results are indicated in bold color.

In the total sample, there was a statistically significant decrease of 3.0% in BMI, 6.4% in BMI z-score, and 1.3% in hip circumference. In the MD group, there was a decrease in the same parameters, with the median BMI and BMI z-score changing from 30.6 Kg/m^2 (27.6 – 32.6) to 29.7 Kg/m^2 (26.7 – 31.6) and from 2.1 (1.7 – 2.2) to 1.9 (1.7 – 2.2), respectively, and the mean hip circumference from 107.7 cm (8.2) to 105.7 cm (8.1) between visits V1 and V3. Although the change in the mean percentage of fat mass was not statistically significant, it decreased from 36.1% (6.6) to 35.0% (7.0). As for the participants in the LFD group, they achieved a decrease in the median BMI and BMI z-score, from 31.2 Kg/m^2 (27.5 – 34.8) to 30.4 Kg/m^2 (27.2 – 34.2) and from 2.2 (1.8 – 2.4) to 2.1 (1.6 – 2.3), respectively.

Although statistically significant differences were found between V1 and V3 in BMI, BMI z-score (in the total sample and in the MD and LFD groups separately) and hip circumference (in the total sample and in the MD group), when comparing the delta change between the MD and LFD groups, no statistically significant differences were found for the anthropometric parameters under study.

4.5. Relationship between the use of the web-application with changes in nutritional knowledge, food intake and anthropometric parameters

Table 7 shows the correlation between the number of accesses to the web-application, the number of tips and topics consulted, and the number of correct answers in the quizzes with the differences in the nutritional knowledge score, the KIDMED score, and the anthropometric parameters under study.

No statistically significant correlations were found between web-application usage and the variables studied above. Nonetheless, it may be interesting to mention some of the correlations that have shown greater magnitude. For example, the number of accesses to the web-application by participants was negatively related, with a very weak correlation, with BMI z-score and waist hip ratio, respectively ρ=-0.215 and ρ=-0.228. A positive and very weak correlation, ρ=0.122, was observed between the number of tips consulted by the participants and their nutritional knowledge, weight and BMI. The number of topics consulted had a very weak positive correlation with waist circumference and hip circumference, respectively ρ=0.214 and ρ=0.241.

Table 7. Spearman correlation between the use of the web- application and the parameters under study.

	ρ	***p***
Number of accesses to the web-application		
Nutritional knowledge	0.030	0.828
KIDMED score	-0.132	0.342
Weight (kg)	-0.166	0.403
BMI (kg/m^2)	-0.160	0.247
BMI z-score	-0.215	0.118
Fat mass (%)	0.023	0.869
Waist circumference (cm)	-0.184	0.183
Hip circumference (cm)	-0.111	0.424
Waist hip ratio	-0.228	0.097
Number of tips consulted		
Nutritional knowledge	0.122	0.379
KIDMED score	-0.053	0.704
Weight (kg)	0.122	0.378
BMI (kg/m^2)	0.122	0.378
BMI z-score	0.054	0.696
Fat mass (%)	-0.076	0.584
Waist circumference (cm)	0.105	0.452
Hip circumference (cm)	0.087	0.531
Waist hip ratio	-0.023	0.867
Number of topics consulted		
Nutritional knowledge	0.039	0.780
KIDMED score	-0.074	0.594
Weight (kg)	0.156	0.261
BMI (kg/m^2)	0.037	0.790
BMI z-score	0.059	0.670
Fat mass (%)	-0.143	0.302
Waist circumference (cm)	0.214	0.120
Hip circumference (cm)	0.241	0.079
Waist hip ratio	0.104	0.455
Number of correct answers in the quizzes		
Nutritional knowledge	0.021	0.880
KIDMED score	0.047	0.736
Weight (kg)	0.075	0.591
BMI (kg/m^2)	0.060	0.665
BMI z-score	0.046	0.741
Fat mass (%)	0.091	0.511
Waist circumference (cm)	0.026	0.850
Hip circumference (cm)	0.094	0.497
Waist hip ratio	-0.003	0.983

BMI: body max index; MD: Mediterranean diet; *ρ*: Spearman correlation coefficient

5. Discussion

The study of new interventions to tackle childhood obesity is very important for the development of effective strategies to combat this disease in the pediatric age, preventing its progression and worsening in adulthood. This work studied the impact of a web-application on the modification of nutritional knowledge, eating habits and anthropometric parameters in children and adolescents with overweight and obesity. The results showed that over a four-month intervention, participants improved their adherence to the Mediterranean diet by increasing their consumption of fruits, vegetables and pulses, and decreasing their consumption of sweets, coke and other soft drinks, and salty snacks. The participants' nutritional knowledge remained similar but there were improvements in some anthropometric parameters, such as decreased BMI and BMI z-score. However, the use of the web-application throughout this intervention was very infrequent and the improvements found in the previously mentioned parameters were not correlated with its use.

The results of the use of the web-application showed that the participants of the study logged into the web-application about 1.5 times per week during the intervention period. It must be remembered that in the week before each visit, participants were required to enter a food diary into the web-application over a period of 3 days. Thus, disregarding the days when participants accessed the web-application only to complete the food diary and the questionnaires, the average number of times per week that they consulted the app for its educational contents or for the quizzes is even lower. It was also found that participants consulted only a low percentage of the available tips and topics, and no differences were found between the MD and LFD groups. The MD group viewed about 9.24% of the available tips and 0% of the topics, while the LFD group consulted about 9.66% of the tips and 2.94% of the topics. Regarding the available quizzes, the participants in the MD group answered about 1.18% of the questions correctly and those in the LFD group answered 1.57% correctly. Before implementing this web-application in this study, its usability was tested on a group of young people who showed interest in using it. However, it should be noted that the pilot study was conducted with adolescents with normal weight and only for a few days. Thus, differences between this group and the sample that participated in this study cannot be discounted, either because they have potentially different interests and motivations, and because, although they have shown great commitment to using this tool, it is not known whether over time this interest could also decrease, reducing its use.

This work found a relationship between the number of accesses of the participants to the app and the number of accesses and of tips consulted by their parents. It is in fact known that parents influence their children's behaviors, decisions, eating patterns, and lifestyles (19). According to the ecological model, the development of food choices depends on an interaction between several environmental factors and personal characteristics (19, 85). In particular, young people are influenced by their family and peers and by all the other levels that surround them (such as the community, society, the available food supply, digital platforms, etc.) (19, 86). In fact, it has been shown that digital interventions promoting healthy eating habits that target parents can be effective in improving nutrition in both parents and their children (87). Parents act as a role model, advising, defining their food choices, choosing the food available at home and imposing some restrictions. In this sense, it is also important to remember the relevance of family meals, as they are an occasion for children to be exposed to various foods and good eating practices (for example, not watching television while eating, being focused on the food and the signs of hunger and satiety, etc.), being a great moment for control and interaction between parents and children (19, 88). Thus, it is known that it is very important to educate children towards a healthier lifestyle and diet, but it is just as important to educate their parents who can also guide them in this direction, and they should be included when defining policies to combat childhood overweight and obesity and promote health (88).

The nutritional knowledge of the participants did not show any change at the end of the intervention. It is possible that this could be due to the reduced use of the app, as it was the only source of information transmission. It can also be hypothesized that the four months' duration of this intervention was not sufficient for a change in the knowledge of the children and adolescents. Nevertheless, there are studies of shorter duration that have demonstrated the effectiveness of digital interventions (in this case, of serious games - video games designed for educational purposes) in increasing nutritional knowledge of children and adolescents, whether for periods of 5 days (89), 17 days (90), or 2 weeks (91, 92).

Although there were no differences in nutritional knowledge, there were changes in eating habits at the end of the intervention, potentially due to the initial prescription of diet plans and feedback from the nutritionists during the appointments. Regarding the participants' eating habits, in general there was an improvement, showing an increase in the consumption of fruits, vegetables and pulses and a decrease in the consumption of less healthy foods. There was an increase in adherence to the Mediterranean Diet in both groups, although this difference was not statistically significant between the MD and

LFD groups. This result may be explained by the fact that the diet plans of both diets (MD and LFD), even though they differed (different distribution of macronutrients and food supply to the MD group typical of this dietary pattern), they both followed the recommendations for a healthy diet, included breakfast, snacks and main meals every day, where they recommended the regular intake of fruits, vegetables, included sources of healthy fats, among others. Thus, given that the participants revealed that they practiced unhealthy eating habits at the beginning of the intervention, if they followed the prescribed diets they would automatically increase adherence to a healthier eating pattern, such as the Mediterranean Diet.

As for the anthropometric parameters, this intervention proved to be effective in reducing the participants' body mass index, in both MD and LFD groups, with a significant reduction in this and other parameters at the end of the intervention period. In both the total sample and the MD and LFD groups, the median (total sample and MD group) and mean (LFD group) BMI z-score reduction was 0.1. Although it is not yet known how much reduction is needed to reduce obesity-related complications, some evidence seems to point to a BMI z-score reduction of at least 0.25 (45, 93). Comparing the effectiveness of the different diets applied in this study, MD and LFD, it can be noted that one was not more effective than the other in reducing BMI and BMI z-score.

There were no significant associations between the use of the web-application and the parameters discussed above. However, the results obtained seem to show a very low frequency of app use by the participants, making it difficult to investigate a correlation. In fact, according to the literature, DBCIs need to be used for a minimum period of time in order to have a significant effect on the users' behavior, and for this, users need to remain motivated and committed during this time and stimulated to access the application (41). Daily self-monitoring of one's diet seems to positively influence dietary behavioral change (41, 94, 95). From the data collected on web-application access and engagement, it is possible to notice that, in this case, this did not happen. That is, most participants did not use the application long enough for it to have an effect, with many using it only in the weeks before the visits (to complete the food diary and questionnaires) and others did not use it at all. In fact, in the interviews conducted after the end of the intervention, some participants suggested that the application should be more interactive, for example by sending notifications. They also suggested that it should be more convenient to access it, for example through an application that can be downloaded, instead of always having to go to a website and log in.

Despite their great potential for changing eating behavior, it is necessary to remember the possible limitations associated with these interventions (DBCIs), such as access to the internet, the ability to properly use the smartphone or computer, and the digital platforms associated with them (41). In the case of younger participants and some parents/legal guardians, this limitation actually proved to be a problem due to their lack of technological literacy. For example, many said they could not even log into the application's website, a problem that was due to the fact that they did not use the most appropriate browser for the correct functioning of this web-application.

It can be hypothesized that the duration of the intervention period was not sufficient for the discovery of a relationship between the use of the application and the various parameters under study. However, although a longer intervention is thought to be more effective in changing eating behavior than a shorter one, there is still no recommendation for this duration. For example, some studies have found improvements in eating behavior either with interventions lasting a few weeks or several months (96-100). This duration will depend on the goals of the intervention, the tools it uses, its content, and the target population. The field of app-based interventions is constantly evolving, and additional research may provide more specific guidance on the optimal duration of these interventions.

It is also emphasized that the defined sample size was based on the main objective of the Med4Youth study, that is, the comparison of the effectiveness of a DM with a LFD for the reduction of BMI in children and adolescents with overweight and obesity, and it may not be the size needed to study the objectives of this work, that is, to study the usability and engagement of the participants with the web-application and its influence on changing their nutritional knowledge, eating habits, and anthropometric parameters.

Having considered all these limitations of the web-application, it is important to find solutions to make this tool more appealing to young people and their parents/legal guardians and more easily accessible, so that it can fulfill its purpose of transmitting knowledge and motivating/encouraging them to change their eating behavior (both young people and their families).

Since information provision alone is not enough to promote behavioral change, it is necessary to find other factors that accomplish this goal of influencing a transformation toward healthier dietary behaviors in children and adolescents (22, 101). In this study

there was no change in nutritional knowledge but there was a modification of eating behavior, probably by the prescription of a dietary plan, as mentioned before.

Although the effectiveness of mobile health apps has not yet been well demonstrated (102-104), it is quite common to find in the literature the need for these types of interventions to take into account theories of behavioral change (105-109), and that it should be identified which techniques are best to implement (41, 63). Some existing applications use self-monitoring of behavior, goal setting, instructions on how to perform a behavior, and feedback on the behavior (63, 110). Other applications also use personalized counseling, motivational prompts, games, social support, and team challenges (30).

Therefore, it is clear that any type of intervention should be combined with personalized nutrition counseling according to individual goals and include regular feedback on progress (41). It is not enough to include only healthy eating and lifestyle information, but to include content that is interactive with the users and personalized according to their characteristics (87). A promising strategy to increase adherence to such interventions is also the promotion of a social component (41, 111).

More research is still needed to determine the best strategies to implement in a mobile app intervention to promote positive changes in eating behavior (63).

6. Strengths, limitations and future perspectives

In relation to what was found in the literature, it is noteworthy that the application used in this project already had several important and recommended features, such as the inclusion of a personalized diet plan, interactive content (quizzes) and the fact that it was available for parents/legal guardians and not only for children and adolescents participating in the study. Since the project included appointments with nutritionists every two months, it was also possible to evaluate the progress of the participants, giving them feedback and advice to continue their journey in improving their health and diet. Although these regular visits are recommended in interventions to combat obesity, it can be considered that a limitation of this study is not being able to understand wheter the changes in the eating habits and anthropometric parameters of the participants were due to the use of the web-application or the feedback given to them by the nutritionists during the appointments.

Regarding the use of the app, the fact that it was rarely used made it difficult to study its relationship with participants' knowledge and change in their eating habits and weight. In fact, as seen previously, the app failed to include some features, such as setting concrete goals, sending notifications to encourage its use, and including a social component among the participants. Some other limitations were noted, for example, regarding the filling out of the questionnaires. Since these were filled out at home, it was not possible to control whether the participants were actually compiling them by themselves or whether they had help from their parents (something that was noticed during the visits, when participants forgot to fill out the questionnaires on the app and had to fill them out in person, parents tended to try to help – especially with the nutritional knowledge questionnaire). In case they had help from their parents, this may have influenced the results, towards getting a better score, for example on the nutritional knowledge questionnaire, or on the food frequency or KIDMED questionnaires, due to social disability bias.

Some difficulties were also noted in compiling the food frequency questionnaire, with regard to recalling and being able to count the frequency of consumption of the various food groups. This method has some known weaknesses, such as the fact that it is necessary to remember the consumption of foods in the past, and these foods have a high level of aggregation, making this a difficult cognitive task for the respondent (112, 113).

It is important to consider that in this work there was no real control group, that is, in the Med4Youth study there was not a group that was not prescribed a diet plan or that did not have access to the web-application. As explained in the project protocol, the non-existence of an untreated obesity group is due to ethical reasons since it has been shown that children with overweight, if left on a waiting list or given only written information, consistently gain weight (5, 114). We therefore evaluated the effect of the intervention by comparing the pre- and post-intervention data, with a separation of 4 months. During this 4-month period, other factors may have contributed to changes in participants' knowledge or behavior, and it was not possible to control them.

A future perspective of this work will be the development of a more appealing application, easier to access and with better acceptability and greater engagement by children and adolescents, allowing an increase in nutritional knowledge and a change in behavior towards a healthier lifestyle, which can be used as a tool, complementing an intervention for weight loss/prevention of overweight and obesity and improving the health of young people.

7. Conclusion

This study aimed to study the relationship between the use of a web-application and the change in nutritional knowledge and eating habits of children and adolescents with overweight and obesity participating in an intervention project for weight loss and improvement of health parameters. The frequency of app use by the participants of this study was very low, not allowing the proper investigation of a relationship between its use and the modification of the variables under study: nutritional knowledge, eating habits, and anthropometric parameters.

In the case of nutritional knowledge, there was no statistically significant change after the intervention. It is hypothesized that this fact may be related to the low engagement with the app, since it was the only source of knowledge transmission to the participants. Regarding eating habits, these showed an improvement towards a healthier lifestyle and a greater adherence to the Mediterranean Diet. The BMI also suffered a statistically significant decrease, as well as other anthropometric parameters.

Although the project Med4Youth is still ongoing, the preliminary results indicate that a dietary intervention based on the MD did not produce any additional benefits over anthropometric parameters, dietary habits and nutritional knowledge compared to the LFD group, but it is not less effective than the conventional clinical treatment based on a reduction of fat intake. In conclusion, the MD should be an effective, easier to follow and more sustainable dietary intervention to treat youth obesity in the Mediterranean countries.

In conclusion, in order to develop an app that is more effective in its purpose of transmitting nutritional knowledge and changing the eating behavior of children and adolescents with overweight and obesity, it should be an app that is easily accessible (perhaps downloadable), that reminds and motivates its use through notifications and that has a social component, increasing the engagement of young people with it and with each other. It should also take into account the theories of eating behavior change, based on a goal setting methodology, motivational strategies, team games and challenges. Finally, it is important that this intervention be accompanied by personalized nutritional counseling, allowing the prescription of a dietary plan that can be consulted for each user. A version of this application should also be available for parents/legal guardians, given their influence on their children, their knowledge and eating patterns.

8. Conflicts of interest

There are no conflicts of interest to report.

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Annex A – Example of an educational content, tip and quiz

2.2.1.2 Educatoinal contents for the adolescent user

2.2.1.2.1 Welcome topic: The meaning of Diet and healthy eating

2.2.1.2.1.1 Educational content

You are at a stage in your life where nutrition is very important. Your calorie requirement is, in fact, very high, because your body is growing and developing very quickly. But this does not mean that you have to fill up with pizza, chips and desserts! To help your body become strong and healthy, you should follow a healthy and balanced Diet.

Just be careful! The term Diet very often mistakenly refers to slimming or low-calorie diets aimed simply at losing body weight. Diet, however, has a much deeper meaning... the word "Diet" comes from the ancient Greek and means regimen, lifestyle and quality of life. The Diet therefore indicates a correct, healthy and balanced nutrition, aimed to satisfy the physiological needs of the body but also the psychological and relational aspects through the satisfaction of senses, the observance of local traditions and the rhythms of daily life. Therefore, you should think of Diet not as a sacrifice but as a means to live better and to take care of your wellbeing, health, to delay aging and to prevent many pathologies. The first requirement of a Diet is to provide the right amount of energy and nutrients, in well-balanced proportions and distributed in a physiological way throughout the day.

Remember also that there is not an identical Diet for everyone, which is suitable in all situations and for all people, because individual variability is huge, not only in terms of age, sex, physical activity and work, but also in terms of the features of each person that can also have a significant impact on the overall metabolism.

Today begins with us a long journey to discover the simple rules of nutrition that underlie a healthy and correct lifestyle. Follow us every week and you will be able to find lots of new information, ideas and funny games...

2.2.1.2.1.2 Tips

1. To grow up healthy and strong it is essential to follow a varied and balanced Diet.
2. For each person there is an ideal Diet! A balanced Diet varies according to individual needs.
3. Dieting is not a punishment but a good way to take care of yourself!
4. Dieting is a way of life and does not mean "not eating"!
5. A healthy Diet is not just about eating LESS but eating BETTER!
6. Changing food choices fights the monotony of tastes and makes the approach to the meal more stimulating.
7. The first rule of a healthy Diet is that no food, excluding allergies or intolerances, should be excluded!

2.2.1.2.1.3 Quiz

1) What is the meaning of Diet?
   a. Eating very little to lose weight
   b. Eating only specific foods
   c. Eating in a healthy and balanced way
2) Diet, intended as a proper eating regimen...
   a. It is the same for everyone
   b. Varies according to individual needs
   c. Varies only according to the physical activity performed
3) Following a healthy and balanced Diet means...
   a. Just eat less
   b. Eating better
   c. Do not eat
4) To grow up healthy and strong, what absolutely must be done?
   a. Adopt a healthy and balanced diet
   b. Eat lots of meat
   c. Eat a lot, no matter what
5) What should the objective of the Diet be?
   a. Weight loss
   b. Eating healthy and well balanced meals
   c. Eating very little
6) When dieting is very important...
   a. Eat only fruit and vegetables
   b. Eat only protein
   c. Vary the food we eat as much as possible
7) A healthy and balanced Diet should be followed by...
   a. Everybody
   b. Only by adults
   c. Only by growing children
8) The term Diet comes from the ancient Greek and means…
   a. Lifestyle
   b. Sacrifice
   c. Wellness
9) If you achieve your ideal weight...
   a. There is no longer any point in continuing the diet
   b. I should still follow a healthy and balanced diet
   c. I should eat more
10) The concept of Diet...
   a. It concerns only food
   b. It concerns food, life habits and physical activity
   c. It only concerns food without fat and sugar
11) Sweets are excluded from healthy and balanced Diets...
   a. Always, diets are made to lose weight
   b. Never, you can't give up dessert
   c. It depends, within a healthy and balanced diet it is also possible to indulge in a sweet from time to time

12) Diet is important for...

   a. **The whole organism**
   b. The beauty of the skin only
   c. The digestive tract only

13) Which statement is true?

   a. All diets are used to lose weight
   b. **The objective of a diet is to eat in a healthier way**
   c. Only people with serious weight problems should go on a diet

14) When you follow a healthy and balanced Diet you should try to limit mainly the consumption of...

   a. Bread
   b. Seasonings (like oil and vinegar)
   c. **Junk food (as sweet and savoury snacks)**

15) Following a healthy and balanced Diet allows us to have...

   a. The right amount of energy we need
   b. **The right amount of energy and nutrients we need**
   c. A body weight like TV celebrities

Annex B – Questionnaires

B.1. Nutritional Knowledge questionnaire (Italian version)

Questionario Nutrition Knowledge

1. Qual è l'altro termine comunemente usato per indicare le calorie?

- ○ Kilowatt
- ○ Kilovolt
- ○ Joule
- ○ Non lo so

2. Pane, dolci, pasta, patate e riso contengono principalmente...

- ○ Proteine
- ○ Carboidrati
- ○ Minerali
- ○ Non lo so

3. Quale riga elenca tre tipi di pesce commestibile?

- ○ merluzzo - rombo – carpa
- ○ aringa – trottola – spinarello
- ○ pesce rosso – passera di mare – salmone
- ○ Non lo so

4. La carne tritata cruda dovrebbe essere conservata nel frigorifero per un massimo di...?

- ○ Mezza giornata
- ○ Fino a tre giorni
- ○ Fino a cinque giorni
- ○ Non lo so

5. Quanto sale si dovrebbe consumare al giorno in aggiunta a quello contenuto nei cibi che mangiamo?

- ○ Per nulla
- ○ Un cucchiaino pieno
- ○ Un cucchiaio pieno
- ○ Non lo so

6. Quanti cucchiaini di zucchero ci sono in una lattina (0,33 L) di coca cola o di limonata?

- ○ Circa 2 cucchiaini
- ○ Circa 4 cucchiaini
- ○ Circa 7 cucchiaini
- ○ Non lo so

7. Quale riga elenca tre piatti che sono stati preparati usando pochissimo grasso?

- ○ patatine fritte – scaloppine – bastoncini al vapore
- ○ uova bollite – patate bollite – pesce al vapore
- ○ frittata – polpette – spaghetti
- ○ Non lo so

8. Una colazione a base semplicemente di pane, marmellata e burro non contiene abbastanza...

- ○ Carboidrati
- ○ Proteine
- ○ Grassi
- ○ Non lo so

9. Che effetto ha sul corpo umano la fibra contenuta negli alimenti?

- ○ Affatica il sistema circolatorio
- ○ Stimola il processo digestivo
- ○ Ingrassa le persone
- ○ Non lo so

10. I dietisti usano il termine americano "Junk Food" per descrivere alcuni alimenti. Che cosa intendono?

- ○ Alimenti che rispondono alle esigenze di salute degli adolescenti
- ○ Formaggio fresco spalmabile e prodotti a base di latte fermentato
- ○ Alimenti che contengono molta energia ma con basso valore nutrizionale
- ○ Non lo so

11. Qual è un altro nome per la patina che si sviluppa sui denti quando si mangiano troppi dolci?

- ○ Spaccatura
- ○ Periodontosi
- ○ Placca
- ○ Non lo so

12. Marco ha giocato a palla tutto il pomeriggio. Nello stesso momento Luca era a casa seduto a guardare la televisione. Quale delle seguenti affermazioni è la più corretta?

- ○ Marco brucia più calorie di Luca
- ○ Luca brucia più calorie di Marco
- ○ Entrambi i ragazzi bruciano circa la stessa quantità di calorie
- ○ Non lo so

13. Una piccola confezione di noccioline tostate (125 g) contiene tante calorie quanto...

- ○ Due banane
- ○ Un intero pranzo
- ○ Tre mele
- ○ Non lo so

14. Quale delle seguenti affermazioni sullo zucchero sono corrette?

- ○ Lo zucchero contiene vitamine essenziali
- ○ Lo zucchero fornisce solo calorie
- ○ Lo zucchero stimola la crescita dei bambini
- ○ Non lo so

15. Quale dei seguenti tipi di acqua minerale dovrebbe essere la più salutare?

- ○ Acqua minerale ad alto contenuto di nitriti
- ○ Acqua minerale ad alto contenuto di magnesio
- ○ Acqua minerale ad alto contenuto di sodio
- ○ Non lo so

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- ○ Due banane
- ○ Un intero pranzo
- ○ Tre mele
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- ○ Acqua minerale ad alto contenuto di sodio
- ○ Non lo so

16. Per quanto tempo si dovrebbe nuotare per bruciare le calorie contenute in un singolo cioccolatino?

- ○ Circa 2 minuti
- ○ Circa 6 minuti
- ○ Circa 10 minuti
- ○ Non lo so

17. Quale riga elenca tre alimenti che contengono molta vitamina C?

- ○ peperoni – cavoli – agrumi
- ○ sedano – carote – cetrioli
- ○ prezzemolo – pomodori – rabarbaro
- ○ Non lo so

18. Quanti cucchiaini di zucchero ci sono in una bottiglia di ketchup (250 ml)?

- ○ circa 1 cucchiaino
- ○ circa 7 cucchiaini
- ○ circa 14 cucchiaini
- ○ Non lo so

19. La lista di ingredienti che si trova sugli alimenti può contenere diversi termini per indicare gli "zuccheri". Quale riga elenca tre termini per indicare speciali tipi di zucchero?

- ○ destrosio – fruttosio – maltosio
- ○ calcio – sodio – magnesio
- ○ riboflavina – taurina – chinina
- ○ Non lo so

20. Che cosa un eccessivo consumo di sale può provocare o aggravare?

- ○ Danni al fegato
- ○ Pressione alta
- ○ Miopia
- ○ Non lo so

21. Quale sostanza è buona per i denti?

- ○ Nitrato
- ○ Fluoro
- ○ Iodio
- ○ Non lo so

22. Quale dei seguenti menu di fast food contiene più nutrienti?

- ○ Hamburger con insalata e succo di arancia
- ○ Pizza al salame con limonata
- ○ Crocchette di pollo con patatine fritte e coca cola
- ○ Non lo so

23. Quale riga elenca tre termini che indicano dolcificanti senza calorie?

- ○ aspartame – sacarina – ciclammato
- ○ ciclammato – acido ascorbico – sodio
- ○ solfato – dextrina – sodio
- ○ Non lo so

B.2. Food Frequency questionnaire (Italian version)

Questionario Helena FFQ

1. Di solito, quante volte fai colazione?

(si intende qualcosa di più che una tazza di latte o tè o un succo di frutta)
Fai una crocetta per i giorni della settimana e una per il fine settimana
In settimana

- ○ Non faccio mai colazione nei giorni di scuola
- ○ Un giorno alla settimana
- ○ Due giorni alla settimana
- ○ Tre giorni alla settimana
- ○ Quattro giorni alla settimana
- ○ Cinque giorni alla settimana

Il fine settimana

- ○ Non faccio mai colazione il fine settimana
- ○ Di solito faccio colazione uno solo tra i giorni del fine settimana (o sabato o domenica)
- ○ Di solito faccio colazione sia il sabato che la domenica

2. Di solito, quante volte alla settimana mangi o bevi?

Fai una crocetta per ogni riga

	Mai	Meno di una volta a settimana	1 volta a settimana	2-4 giorni a settimana	5-6 giorni a settimana	1 volta al giorno tutti i giorni	Più di una volta al giorno
Frutta	○	○	○	○	○	○	○
Verdura	○	○	○	○	○	○	○
Dolci (merendine o dolci al cioccolato)	○	○	○	○	○	○	○
Cola o altre bibite zuccherate/gassate	○	○	○	○	○	○	○
Snack salati	○	○	○	○	○	○	○
Cereali (come corn flakes, muesli, ecc)	○	○	○	○	○	○	○
Cereali (pane, pasta, riso)	○	○	○	○	○	○	○
Legumi (piselli, fagioli, ceci, ecc)	○	○	○	○	○	○	○

3. Quante volte tu e la tua famiglia consumate i pasti insieme?

- ○ Ogni giorno
- ○ La maggior parte dei giorni
- ○ Circa una volta alla settimana
- ○ Meno di una volta alla settimana
- ○ Mai

4. Di solito, fai uno spuntino (tra i pasti principali)?

- ○ No
- ○ Solo a metà mattina
- ○ Solo a metà pomeriggio
- ○ Sia a metà mattina che nel pomeriggio

5. Quante volte ti lavi i denti?

- ○ Più di una volta al giorno
- ○ Una volta al giorno
- ○ Almeno una volta alla settimana ma non ogni giorno
- ○ Meno di una volta alla settimana
- ○ Mai

6. In questo periodo sei a dieta o stai facendo qualcosa per dimagrire?

- ○ No, il mio peso è quello giusto
- ○ No, ma dovrei perdere qualche chilo
- ○ No, perché dovrei mettere su qualche chilo
- ○ Sì

7. Negli ultimi 12 mesi sei ricorso a una o più delle azioni elencate per tenere sotto controllo il tuo peso?

Fai una crocetta per ogni riga

1.	Attività fisica		
		○SÌ	○NO
2.	Saltare i pasti		
		○SÌ	○NO
3.	Digiuno (per esempio non mangiare per 24 ore o più)		
		○SÌ	○NO
4.	Mangiare meno dolci		
		○SÌ	○NO
5.	Mangiare meno grassi		
		○SÌ	○NO
6.	Bere meno bibite		
		○SÌ	○NO
7.	Mangiare di meno (per esempio quantità minori)		
		○SÌ	○NO
8.	Mangiare più frutta e verdura		
		○SÌ	○NO
9.	Bere più acqua		
		○SÌ	○NO

10.	Restringere la mia dieta a uno o più gruppi di cibi (per esempio mangiare solo frutta e verdura, bere solo, mangiare solo pane e acqua)		
		○SÌ	○NO
11.	Vomitare		
		○SÌ	○NO
12.	Usare pillole (dimagranti o lassativi)		
		○SÌ	○NO
13.	Fumare di più		
		○SÌ	○NO
14.	Dieta sotto la supervisione di un professionista		
		○SÌ	○NO