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Evaluation of the nutritional education program for the prevention of non-alcoholic fatty liver disease in people with obesity in Morocco

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RESUMEN

La obesidad y la enfermedad del hígado graso no alcohólico (EHGNA) crecen exponencialmente y amenazan el desarrollo mundial. En Marruecos la situación también es problemática y constituye un reto creciente para los servicios sanitarios. En la actualidad, no existen tratamientos aprobados para la enfermedad del hígado graso no alcohólico relacionada con la obesidad. Sin embargo, la pérdida de peso y una ingesta alimentaria adecuada pueden mejorar la enfermedad hepática (histología). Para ello es necesario concienciar a la población sobre el alcance de este problema de salud, lo que puede garantizarse mediante la sensibilización y la educación en materia de nutrición y estilo de vida saludable. Una educación nutricional bien realizada es un elemento clave para la prevención de la EHGNA. El objetivo de este trabajo es evaluar el impacto de un programa de educación sobre parámetros clínicos y metabólicos en personas obesas con o sin EHGNA en Marruecos. Método: se realizó un estudio de intervención en una consulta médica de gastroenterología de la ciudad de Marrakech (Marruecos). Se llevó a cabo un programa de educación nutricional de seis meses mediante la adopción de la dieta mediterránea y la práctica regular de actividad física en 210 participantes obesos. Los profesionales sanitarios realizaron un seguimiento de todos los participantes durante dicho periodo y se evaluaron parámetros clínicos y metabólicos al inicio y al final del programa educativo. Resultados: de los 210 participantes diagnosticados como obesos, 131 tenían EHGNA y 79 no presentaban esta patología. Tras los seis meses de educación nutricional los participantes mostraron mejoras significativas en los parámetros antropométricos, en la alanina aminotransferasa, el aspartato aminotransferasa, la gamma-glutamiltransferasa, los triglicéridos, el colesterol de lipoproteínas de alta densidad y el colesterol total. Conclusión: la educación nutricional es una vía eficaz para el tratamiento de la EHGNA relacionada con la obesidad.

Palabras claves:

EHGNA
Obesidad
Alimentación
Programa de educación nutricional

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ABSTRACT

Obesity and non-alcoholic fatty liver disease (NAFLD) are growing exponentially and threaten global development. In Morocco, the situation is also problematic and constitutes a growing challenge in health services. Currently, there are no approved treatments for obesity-related nonalcoholic fatty liver disease. However, weight loss and adequate food intake can improve liver disease (histology). This requires awareness among the population about the extent of this health problem which can be ensured through sensitization and education in terms of nutrition and healthy lifestyle. Well-conducted nutritional education is a key element for the prevention of NAFLD. The objective of this work is to evaluate the impact of an education program on clinical and metabolic parameters in obese people with or without NAFLD in Morocco. Method: An interventional study was conducted in a gastroenterology medical practice in the city of Marrakech (Morocco). On 210 obese participants, a six-month nutritional education program was carried out through the adoption of the Mediterranean diet and regular physical activity. A follow-up of all participants for six months was carried out by health professionals. Clinical and metabolic parameters were assessed at the beginning and at the end of the education program. Results: Among the 210 participants diagnosed as obese, 131 had NAFLD and 79 were without this pathology. After six months of nutrition education, participants showed significant improvements in anthropometric parameters, alanine aminotransferase. aspartate aminotransferase, gamma-glutamyltransferase, triglycerides, high-density lipoprotein cholesterol, and total cholesterol. Conclusion: Nutrition education is effective way for the treatment of obesity-related NAFLD.

Keywords:

NAFLD
Obesity
Food
Nutritional education program

Introduction

The World Health Organization (WHO) defines obesity as an abnormal or excessive accumulation of fat that can impair health (WHO, 2022). Its global prevalence in 2016 is 13% (Janssen, Bardoutsos & Vidra, 2020). Obesity has also been associated with an increased risk of non-alcoholic fatty liver disease (NAFLD) (Li et al., 2016). This disease occurs in 60 to 95% of obese patients in all countries of the world (Angulo, 2002). In Morocco, the prevalence of obesity was estimated at 33.6% by a prospective study carried out in 2000 by the Moroccan Ministry of Health. The prevalence of obesity-related NAFLD is estimated at 83.5%, between 2000 and 2017 (Liba & Belahsen, 2022). NAFLD is the chronic liver disease that generally refers to excessive accumulation of triglycerides without excessive alcohol consumption (less than 20 or 30 g/day for women and men, respectively) (Vernon, Baranova & Younossi, 2023) or other liver diseases such as viral, autoimmune, metabolic or drug-induced diseases (Fabbrini, Sullivan & Klein, 2010). In the context of the global transition including the epidemiological, demographic and nutritional transitions experienced by countries including Morocco, diet is one of the risk factors incriminated in the predisposition to obesity-related NAFLD (Ghoshal, Goel & Quigley, 2020; Janssen, Bardoutsos & Vidra, 2020; Vernon, Baranova & Younossi, 2023). Indeed, a diet rich in red and processed meats, sugar and refined grains, saturated fats, dairy products and sugary drinks is at the origin of an excessive calorie intake which can promote an accumulation of triglycerides and fats in the liver (Ludwig et al., 2018). Several studies have also reported the obesogenic effect of daily consumption of large amounts of added sugars (Choi & Diehl, 2008; Madero et al., 2011; Goran et al., 2013). This effect is associated with the breakdown of the feeling of satiety generated by the ingestion of fructose (Campos & Tappy, 2016). According to the WHO (2015), sugars should represent less than 10% in the daily diet. Similarly, high energy intake as well as consumption of refined grain products, pastries and sweets are associated with NAFLD, independent of changes in body weight (Jia et al., 2015). In addition, high consumption of animal protein and total fat, soft drinks and snacks have also been associated with NAFLD (Bray, 2010).

Biologically, obesity-related NAFLD is associated with elevated serum liver enzymes, including alanine aminotransferase (ALT), aspartate aminotransferase (AST), and gamma-glutamyl transferase (GGT) (Miyake et al., 2003; Wieckowska, McCullough & Feldstein, 2007). Previous studies have reported that GGT is an independent predictor of NAFLD (Angulo, 2002; Hossain et al., 2016). Moreover, GGT could be a simple and useful biomarker for the accumulation of visceral and hepatic fat (Hossain et al., 2016) and that visceral adiposity is associated with NAFLD (Kim et al., 2016). Thus, the hepatic enzymes ALT, ASAT, and GGT are commonly used markers for hepatic steatosis and the increase in their levels reflects liver damage. In addition, other factors have been associated with obesity and could be used to predict NAFLD. These are waist circumference (WC), body mass index (BMI) (Zheng et al., 2012; Kim et al., 2016), triglycerides (TG) (Li et al., 2020; Xie et al., 2021), total cholesterol (TC)/high density lipoprotein (HDL) cholesterol (Chen et al., 2019), HDL cholesterol, and low density lipoprotein (LDL) cholesterol (Ren et al., 2019). Therefore, weight loss, liver enzyme adjustment, and obesity-related indices including BMI, WC, TG, GGT, HDL, LDL, and CT are predictive of NAFLD improvement (Zheng et al., 2012). However, there is no official consensus on how to treat NAFLD currently (Wieckowska, McCullough & Feldstein, 2007). Nevertheless, as a healthy diet, the Mediterranean diet (MD), which is also the type of diet in Morocco, is referenced as being beneficial for the prevention and improvement of NAFLD (Trichopoulou et al., 2014). It has indeed been reported effective in the treatment of obesity and its comorbidities (Casas, Sacanella & Estruch, 2014), in reducing LDL-cholesterol, and total cholesterol (Trichopoulou et al., 2003; Serra-Majem et al., 2019), and to have a role in the prevention of oxidative stress (Jomova & Valko, 2013), considered an environmental risk factor for obesity-related NAFLD (Angulo, 2002; Janssen, Bardoutsos & Vidra, 2020).

Adopting MD would therefore reduce NAFLD while promoting weight reduction and adjustment of liver enzymes. The protective effect of MD against health problems and non-communicable diseases was

indeed attributed to the virtues of its food composition associated to its significant content in antioxidants, anti-inflammatories, hepato-protectors, hypolipidemics and chemopreventives (Martirosyan, 2013; Trichopoulou et al., 2014). Among these components, polyphenols, anthocyanins, carotenoids, flavonoids, glucosinolates, isoflavonoids, limonoids, omega-3 and 6 fatty acids, phytoestrogens, phytosterols, probiotics, resveratrol and terpenoids have been cited (Ortega, 2006; Trichopoulou et al., 2014; Meybeck et al., 2017).

The traditional MD is characterized by a high consumption of vegetables, fruits, legumes, nuts, unrefined whole grains, a high consumption of olive oil as the main source of dietary fat, a moderate consumption of fish and seafood, low to moderate consumption of dairy products, and low consumption of red and processed meats (Jomova & Valko, 2013). The beneficial effects of MD, both on health and on the environment, made of it a model of sustainable diet (Trichopoulou et al., 2003; Casas et al., 2014; Serra-Majem et al., 2019). Moreover, physical activity (PA) is also prescribed to patients by the Haute Autorité de Santé (HAS) (Stamatakis et al., 2019). The HAS methodological guide published on October 17, 2018 and relating to the prescription of physical activity, provides useful information to guide patients towards appropriate PA (Stamatakis et al., 2019). Energy expenditure by the body depends on the intensity, duration, level and type of physical activity or sedentary lifestyle (Hogan, 2014; Vaara et al., 2019; Leung & Wong, 2022). PA includes walking, stairs, cycling, housekeeping, DIY, gardening, and work or school activities, physical exercises and sports activities (Hogan, 2014; Stamatakis et al., 2019). A sedentary lifestyle is characterized by a low energy expenditure and includes all activities performed at rest in a seated or lying position (watching television, reading, writing, working on a computer, moving around in a motor vehicle) or static standing (Stamatakis et al., 2019). Since physical activity is accessible to everyone, it can be practiced at different levels of intensity. The World Health Organization recommends to practice a minimum of 2h30' endurance physical activity of at least moderate intensity at a frequency of 3 to 5 times a week (Stamatakis et al., 2019; Vaara et al., 2019). Physical activity is assessed by the duration, the type of each activity, and also the time spent daily watching television, reading, writing, working on a computer or driving a motor vehicle (Stamatakis et al., 2019).

In this perspective, the general objective of this work was to evaluate the impact of an education program on clinical and metabolic parameters in obese people with or without NAFLD in Morocco. More specifically, this program aims to provide participants in the study with theoretical and practical knowledge enabling them to make lifestyle changes beneficial to their state of health.

Methodology

This interventional study was conducted in a gastroenterology medical practice in the city of Marrakech (Morocco), on a sample of 210 adult patients with a BMI≥ 25, with or without NAFLD. The minimum age was 19 years and the maximum 98 years. The operational objectives focused on nutrition education planning, implementation, and evaluation (Table 1). Table 2 shows the main characteristics of the studied sample.

Objectives and conduct of the education program stages

The first goal was to reduce body weight by 5 to 10% in six months. The proposed activities emphasize the importance of adopting a healthy lifestyle in the management of NAFLD with or without obesity. It is about the adoption of healthy behaviors such as, adherence to the Mediterranean diet and the removal of industrialized foods, good chewing, respect for sleep schedules and the reduction of smoking as well as the practice of physical activity.

The second objective emphasizes the adoption of the Mediterranean diet and regular physical activity. The activities explain the importance of a balanced diet and the clarification of doubts.

The third objective is to check the progress of the patient in terms of diet modification and weight reduction, as well as the patient's motivation to pursue the healthy lifestyle. Also, the activities focused on checking progress and keeping motivation high and explaining possible reasons, in cases of no progress being made for the patient.

The fourth objective was to motivate the patient to maintain a positive state of mind regarding a

permanent change in lifestyle. The activities consist of the incentive to lose weight for the improvement of NAFLD.

The fifth objective was to analyze the progress made by the patient during the six months of self-management, and to motivate him/her to maintain the change in behavior by recognizing personal successes.

Study protocol

The health examination was carried out by a specialist in gastroenterology. The diagnosis of NAFLD was made by ultrasound. At the first visit to the gastroenterology medical office, weight and height were measured with light indoor clothing, without shoes. Waist circumference was measured as the horizontal circumference passing through the position of the navel. Liver enzymes ALT, ASAT, GGT, and obesity indices including TG, TC, LDL and HDL were measured in dedicated analysis laboratories. Patients an-swered to questionnaires on dietary habits and physical activity (PA).

This last was as-sessed by the self-questionnaire on physical activity or AQAP questionnaire (in French "Auto-questionnaire sur l'activité physique"), which is a valid an easy-to-use tool for individual assessment of PA (Vol et al., 2011). All patients included in the study re-ceived individual nutritional instruction in accordance with the national nutrition pro-gram (MS, 2016). The aim is to detect negative behaviors to be corrected through per-sonalized prescription based on patients' needs and expectations and to set self-monitoring and behavior changes in patients, consolidating positive, and improving neg-ative behaviors. They also agreed to present their analysis reports before and after the nutrition education. A plan is developed in which the objectives, activities, tools, loca-tion and duration of each nutrition education session are set out. The details of each step are illustrated in Table 1.

Study variables

Anthropometric data included age (years), height (m), weight (kg), body mass index (BMI) (kg/m2) and waist circumference (WC) (cm). Overweight was defined as a BMI between 25 and 30 kg/m2, and obesity when the BMI was≥30 kg/m2. Waist circumference defined as high if WC≥88 cm in women or WC≥102 cm in men (Leung & Wong, 2022). These parameters along with biochemical analyses such as ALT, ASAT, GGT, TG, CT, LDL and HDL were used to monitor the health status of the participants. Table 2 shows the main characteristics of the studied sample.

Statistical analysis

All statistical analyzes were performed using SPSS (Statistical Package for Social Sciences) Windows, version 25.0. Quantitative variables were presented as means ± standard deviations (SD), while quantitative variables were presented as frequencies and percentages. The parametric test on paired sample made it possible to conclude that there were statistically significant differences between the means of the parameters before and after nutritional education (Table 3). Differences were considered statistically significant for p-values less than 0.05. Non-parametric tests were also used for statistical analysis. The Mann-Whitney tests was applied to compare means between the group studies. The level of rejection of the null hypothesis was set al 0.05 or 5% (Table 4).

Results

The present study involved a final sample of 210 patients who were divided into two groups, NAFLD (n=131) and non-NAFLD (n=79), of which 8% were overweight with a BMI between 25 and 30, and 92% were obese with a BMI ≥30. The latter are divided into 62% of patients with NAFLD and 38% without NAFLD. The minimum age was 19 years and the maximum 98 years. The percentage of NAFLD in obese women was higher than in obese men. Among patients with NAFLD, 23% were male and 77% were female. In the patients without NAFLD, 15% were male and 85% female.

Table 3 compares the anthropometric and biochemical variables of the sample before and after nutritional education. The mean values of weight, BMI, WC, ALT, ASAT, TG, GGT, LDL cholesterol, total cholesterol, and HDL cholesterol were higher in the obese group with NAFLD (n=131) than in the obese group without NAFLD (n=79). After the nutritional education program, the anthropometric and

biochemical variables improved in the obese groups with NAFLD or without NAFLD

Table 1. Nutrition education planning for people with or without NAFLD.

Goals	Activities	Tools	Duration	
Session 1	Establishment of the patient's consent.	Pre-established questionnaire on obesity and its comorbidities, in particular NAFLD, and the need to change the problem.		
Emphasize the goal of weight reduction in six months to aid recovery from NAFLD.	Identification of the patient's needs, expectations and health problems as a basis for his motivation. Administration of a questionnaire on eating habits.	Questionnaire on dietary habits. Tape-Meter.	1hour	The 1st medical visit to the gastro-enterologist doctor.
Emphasize the goal of weight reduction in six months to aid recovery from NAFLD.	Introduction to NAFLD and obesity and its comorbidities. Explanation of the importance of the Mediterranean diet. Advice on the adoption of healthy behavior. Taking anthropometric measurements. Exchange of telephone numbers.	Personal scale.		
Session 2 Focus on the Mediterranean diet and physical activity.	Patient motivation for adherence to MD. Clarification of doubts. Explanation to patients of parameters Weight, ALT, AST, HDL Cholesterol, LDL Cholesterol, Total cholesterol, GGT.	Questions answers. Analysis report Recipe booklet inspired by the Mediterranean diet pyramid.	1/2hour	The 2nd visit to the Doctor as a gastro-enterologist.
Session 3 Motivate the patient to pursue a healthy lifestyle (Mediterranean diet, physical activity).	Motivation maintaining. Explanation of possible reasons for the patient. in cases no progress is made. Providing of a new diet plan based on the patient's current needs (weight loss or maintenance). Setting new goals of weight loss and exercise to patients	Questions answers. Recipe booklet inspired by the Mediterranean diet pyramid.	1/2hour	The 3rd visit.
Session 4 Motivate the patient to maintain a positive mindset regarding a permanent lifestyle change.	Maintenance of motivation. Explanation of possible reasons for the patient. in cases where no progress is made. Reaffirmation of weight loss in improving NAFLD.	Questions answers.	1/2hour	The 4th visit.
Session 5 Analyze the progress made by the patient during the six months of self-management. Motivate the patient to sustain the behavior change by acknowledging personal successes to date.	Final evaluation of the patient's progress. Anthropometric measurements: Weight, BMI, Waist circumference. Analysis of blood balance after nutritional education.	Questions answers. Results of the patient's biological examinations. Tape-Meter. Personal scale.	1hour	The 5th visit.

Table. 2. Characteristics of the studied population.

Variables		With NAFLD n=131(62%)	Without NAFLD n=79 (38%)
Age		44±11.86	40±12.59
Gender	Men	23%	15%
	Women	77%	85%
Weight (kg)		29.23±107.38	103.87±24.59
BMI (kg/m^2)		40.40±10.29	40.71±8.22
WC (cm)		115.92±20.03	116.66±18.90

NAFLD : Non Alcoholic Fatty Liver Disease; BMI: Body Mass Index; WC: Waist Circumference.

Table 3. Effects of nutritional education on anthropometric and biochemical parameters in people with obesity-related NAFLD.

	With NAFLD (n=131)			Without NAFLD (n=79)		
Variables	**Before**	**After**	**t**	**Before**	**After**	**t**
Weight (kg)	107.38±29.23	101.70±28.96	6.1	103.87±24.59	98.45±21.92	4.62
BMI (kg/m^2)	40.40±10.29	37.83±10.31	23.14	40.71±8.22	38.00±7.96	20.36
WC (cm)	115.92 ±20.03	106.94±22.16	7.149	116.66±18.90	108.14±21.53	6.57
Total Cholesterol g/L	1.83±0.29	1.7±0.31	11.35	1.83±0.27	1.65±0.26	10.22
LDL Cholesterol g/L	1.54±0.15	1.30±0.17	15.95	1.52±0.15	1.3±0.20	11.6
HDL Cholesterol g/L	0.42 ±0.71	0.49±0.09	-11.84	0.42 ±0.80	0.48±0.09	-9.31
TG g/L	1.71±0.51	1.30±0.50	20.06	1.60±0.43	1.20± 0.46	18.49
ALT UI/L	32.22±19.29	18.44±11.67	28.23	42.90±6.31	22.99±4.98	21.3
ASAT UI/L	37.52± 13.62	31.52±13.62	E	33.83±10.33	27.88±10.33	E
GGT UI/L	51.33±16.66	42.55±16.16	17.75	34.95±13.80	27.82±11.49	13.99

The Table values are means ± standard deviation of ALT. AST. BMI. TC. GGT. HDL. HDL and LDL. A paired sample t-test was used to assess differences before and after nutrition education, $p<0.05$. E: standard error of the difference is zero.

Table 4. Differences of the variables in patients without NAFLD versus those with NAFLD.

Variables	Without NAFLD (n=79)	With NAFLD (n=131)
Weight (kg)	5.42±2.67	5.67±0.27
BMI (kg/m^2)	2.7±1.2	2.57±1.26
WC (cm)	8.59±11.52	8.98 ±14.41
Total Cholesterol g/L	0.17±0.15	0.14±0.14
LDL Cholesterol g/L	0.22±0.17	0.24±0.17
HDL Cholesterolg/L	-0.06±0.06	-0.07 ±0.06
TG g/L	0.40±0.19	0.42±0.21
ALT UI/L	5.42±10.12	5.6±2.34
ASAT UI/L	5.87±0.05	5.97±0.94
GGT UI/L	7.12±4.4	8.78±5.64

The differences of the parameters in patients with NAFLD versus those without NAFLD was respectively: 5.67± 0. 27 vs. 5.42±2.67 (p= 0.34) for weight; 2.57± 1.26 vs. 2.7± 1.2 (p=0.24) for BMI; 8.98±14.41 vs. 8.59±11.52 (p=0.39) for WC; 0.14±0.14 vs. 0.17±0.15 (p=0.04)) for Total Cholesterol; 0.24 ±0.17 vs. 0.22±0.17 (p= 0.44)) for LDL Cholesterol; 0.42±0.21 vs. 0.40±0.19 (p=0.63) for TG; 5.6± 2.34 vs. 5.42±10.12 (p=0.93) for ALT; 5.97±0.94 vs. 5.87±0.05 (p=1) for AST; 8.78±5.64 vs 7.12±4.49 (p=0.02)) for GGT and -0.07 ±0.06 vs -0.06±0.06 (p=0.17)) for HDL cholesterol. The non-parametric Mann-Whitney U test shows that the difference of these parameters means between the two groups NAFLD and without NAFLD is statistically significant for total cholesterol (p=0.04) and GGT (p=0.02) (Table 4).

For physical activity (PA), sedentary behavior is a major determinant of health status that also affects weight status. The majority of the present study participants (70%) spend more than 5 hours of their daily life watching television or in front of a computer screen. 1% spend an hour reading or writing and 20% move in a mobile vehicle. The most mobilizable physical activities over the long term are 30% active travel, 10% walking, 0% cycling or sports activities, and 90% find it difficult to climb stairs. After the 6-month nutritional education program, 90% of the participants practiced walking and active movements, and decreased the time in front of the television and the computer screen. The daily time spent in front of a screen decreased in average of 2 hours for participants. Also, the participants' weight decreased by 5.67±9.95 kg in NAFLD and 5.42±10.36 kg in non-NAFLD.

Discussion

This study showed that nutritional education was effective in improving the weight and metabolic status of obese patients with or without NAFLD. After the six-month nutritional education period, a significant decrease in the values of the anthropometric and biochemical variables measured was indeed demonstrated in the present studied obese patients with or without NAFLD. The significant reduction was in weight, BMI, waist circumference, ALT, AST, TG, GGT, LDL cholesterol and total cholesterol; an increase in HDL cholesterol was also observed. However, there was no significant difference in the paired mean of these parameters between the NAFLD group and the non-NAFLD group, except total cholesterol (p=0.04) and GGT (p=0.02). These results were in agreement with several studies that have demonstrated a positive impact of nutritional education in the treatment of obesity, insulin resistance and NAFLD (Elias et al., 2010; Esposito et al., 2011; Jia et al., 2015). In the present study, the education program led to a weight reduction of 5.67 kg ±9.95 in obese with NAFLD and 5.42 kg ±10.36 in non-NAFLD obese participants. Weight reduction in obese people is an important part of the management of patients with chronic liver disease, particularly NAFLD. This result confirms those reported in other studies showing an association of weight loss with a decrease in NAFLD, an improvement of hepatic enzyme profile and serum insulin levels as well as the quality of life (Burgert et al., 2006; Larson-Meyer et al., 2008). It is also reported that no specific diet is shown to be superior in improving NAFLD in the absence of weight loss (Burgert et al., 2006). This is also consistent with those studies reporting the treatment of patients with NAFLD with a combination of diet and exercise with a 5% body weight loss, with these patients showing reduced aminotransferase levels.

Thus, the components of nutrition education followed in the present study included a combination of diet and physical activity. Regarding diet, since Morocco is a Mediterranean country, nutritional recommendations for obese patients with or without NAFLD were based on adherence to the Mediterranean diet by respecting the different food sources dictated by the guidelines of the food pyramid (Trichopoulou et al., 2014; Serra-Majem et al., 2019). This is, an intake of complex carbohydrates, less than or equal to 50% of the total energy intake with a share of simple carbohydrates less than 10%. The food sources of complex carbohydrates are cereals. However, the amount of fructose consumed, rather than the total amount of sugars, is also reported by several studies to have a greater impact on the risk of NAFLD (Ouyang et al., 2008). Indeed, excessive and chronic consumption of fructose is likely to promote liver function, alter the oxidation of fatty acids, induce endoplasmic stress, and contribute to liver inflammation through the production of uric acid and gut-derived endotoxins (Ouyang et al.,

2008). Additionally, high dietary fructose intake has also been linked to impaired gut microbiota, with a shift towards depletion of beneficial microbial species (Lambertz et al., 2017). When fructose is consumed with a high-fat diet, mitochondrial function in the liver is further impaired (Souza et al., 2022). The results of another study further showed that a fructose intake below normal may be protective against the development of NAFLD in obese adolescents, as opposed to a high fructose intake compared to normal, leading to a risk increased NAFLD (Ilich et al., 2020). Each gram of fructose consumed daily by obese patients aged 14 years was associated with a 9% increased risk of NAFLD at 17 years (DiStefano & Shaibi, 2021). The consumption of fructose should therefore not be excessive.

A protein intake of less than or equal to 0.8g/kg body weight per day is recommended and should include good quality protein. Concerning the recommended lipid intake, it should not exceed 30% of the total energy intake (TEI), with a composition containing monounsaturated fatty acids (MUFA) and polyunsaturated fatty acids (PUFA) mainly present in foods of plant origin including oil olives -the central element of the Mediterranean diet-, and oily fish. Among the other dietary recommendations, an intake of unprocessed foods rich in fiber (that induces satiety) recommended intakes are 25g minimum and 30g optimum, including 15g of soluble fibers. Fiber, the main source of which is plants, is known for its role in blood sugar regulation and reducing cholesterol absorption (Larson-Meyer et al., 2008).

Nevertheless, a balanced diet is not achieved in a single meal but rather from one meal to another and over several days by a combination of foods with nutritional values. The interest in using certain food equivalences is to consume a variety of foods, while providing the body with essential, diversified and complementary elements. Our results were in agreement with those of an American study that evaluated the effect of a 6-month nutritional intervention on non-alcoholic fatty liver disease, using an intervention protocol comparable to that of the present study (Elias et al., 2010). This latter study showed that the nutritional intervention applied to 31 NAFLD patients as exclusive treatment was effective in the treatment of non-alcoholic fatty liver disease with a loss of at least 5% of the initial weight.

The strengths and limitations of the study

This study adopted a personalized approach through a balanced diet aimed at gradual weight loss while being a participatory approach to inculcate self-monitoring. It was based on a six-month healthy lifestyle nutritional intervention program developed for obese patients with or without NAFLD, and led by a healthcare professional, trained in subject nutrition and education, and finally assessed by a gastroenterologist. The content is established on the basis of a literature review and on the national nutrition program, Morocco. Although this intervention seems simple and cost-effective in the short term, ensuring its long-term success rate requires more in-depth long-term research. Bias is that patients tend to overestimate or underestimate food intake.

Conclusion

Obesity-related NAFLD is a more common cause of chronic liver disease worldwide and is a growing public health problem. Lifestyle intervention is currently a mainstay of therapy. A 6-month nutritional education program, tailored to each patient according to their personal needs and expectations and the socio-cultural context, has led to a significant decrease in average weight values, BMI, WC, ALT, ASAT, TG, GGT, LDL cholesterol, total cholesterol, and a significant increase in HDL cholesterol. This program was based on the principle of reducing fat mass and not lean mass, implying respect for the main principles of a balanced diet which consists of eating at regular times. Eat all food groups to avoid monotony, reduce salt, sugar and trans-fat intake, eat enough vegetables/legumes, increase fiber intake, encourage fish consumption, limit consumption of processed products, avoid snacking, drink plenty of water and engage in regular physical activity. After the 6-month nutrition education program, 90% of participants engaged in walking and active movement, and reduced television and computer screen time. Daily screen time decreased by an average of 2 hours for participants. Additionally, participants' weight decreased by 5.67 ±

9.95 kg for NAFLD and 5.42 ± 10.36 kg for non-NAFLD.

Therefore, this study demonstrated that a correct diet combined with weight loss was effective in improving the clinical course of patients with obesity-related NAFLD. A limitation of our study was the difficulty patients have in adhering to a lifestyle intervention. Larger, longer-term studies are needed to confirm the sustainability of the benefits of a nutrition education program.

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Ethical considerations

The researcher asked for participants' approval if they agreed to take part and follow the nutrition education program in order to improve their health, the participants signed the informed consent. The researcher also guaranteed the respect of the participants' rights to anonymity and confidentiality. Exclusions criteria were identified as genetic disease, endocrine problem. and chronic alcohol consumption or other causes of steatosis and people who did not agree to participate in this study.

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