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Original Article

Efficacy of Lifestyle Interventions on Body Weight and Elevated Liver Enzymes among Patients with Non-Alcoholic Fatty-Liver Disease

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ABSTRACT

Non-alcoholic fatty liver disease is called the silent epidemic mortality for young adults. Lifestyle interventions including healthy diet, physical activity, and exercise programs remain the cornerstone treatment approach for this disease. Aim: To examine the effect of lifestyle interventions on body weight and elevated liver enzymes among patients with non-alcoholic fatty liver disease. Methods: Design: A quasi-experimental design. Subjects: A simple random sample of 200 patients with non-alcoholic fatty liver. Sitting: Outpatients' clinics of Teaching Hospital and the National Liver Institute, Menoufia Governorate, Egypt. Instruments: Five tools: Structured Interview questionnaire, Reported patient's dietary practices questionnaire, The Nordic Physical Activity and Exercise questionnaire-Short, The 24-Hours dietary recall, and Bio-physiological measurements' tool. Results: There were significant post-intervention improvements in the total mean scores among the study group regarding healthy dietary practices as it increased from 37.8±4.6 on pre-intervention to 49.6±5.8 post, body weight measures significantly decreased from 80.0±16.7 pre- to 73.4±18.3 post- and body mass index decreased from 30.1±12.2 pre- to 27.6±13.1 post. Besides, liver enzymes' total post-intervention mean scores for the study group significantly reduced to 43.5±21.9 and 36.9±11.7 compared to the control's 68.2±12.4 and 54.4±12.0, respectively for Aspartate aminotransferase and Alanine aminotransferase, likewise, physical exercise practices' total post-intervention mean scores were statistically significant ($p<0.05$). Conclusion: Lifestyle interventions; practicing physical exercise and healthy nutrition, proved to be effective in a gradual reduction of both body weight and liver enzymes. Recommendations: Healthy lifestyle modifications should be considered as an initial step for both the prevention and management of Non-alcoholic fatty liver disease.

Keywords: Body weight; Lifestyle Interventions; Liver Enzymes and Non-Alcoholic-Fatty Liver

Introduction

Chronic liver disease (CLD) is a significant global cause of mortality, morbidity, and the use of medical resources **(Marcellin & Kutala, 2018)**. The estimated worldwide prevalence of CLD, spanning all stages of disease severity, stands at

1.5 billion cases **(Moon et al., 2020)**. The most common causes of disease prevalence in most low-income and low-middle-income nations in Asia and Africa are Non-Alcoholic Fatty-Liver Disease (NAFLD) (59%), followed by Hepatitis B Virus (HBV) (29%), Hepatitis C Virus (HCV) (9%), and Alcoholic Liver Disease (ALD) (2%) (**Devarbhavi et al., 2021**).

Non-Alcoholic Fatty-Liver Disease (NAFLD) usually occurs due to obesity, insulin resistance, type 2 diabetes mellitus (T2DM), hypertension, hyperlipidemia, and metabolic syndrome. The subtype of NAFLD which is histologically categorized as non-alcoholic steatohepatitis (NASH) has a potentially progressive course leading to liver fibrosis, cirrhosis, hepatocellular carcinoma (HCC), and liver transplantation. All of NASH's complications can pose significant health and economic burdens on patients, their families, and society **(Younossi et al., 2022)**.

Largely, the Middle East and North Africa (MENA) region has one of the highest NAFLD prevalence rates, which is estimated to affect 31.8% of all adults **(Younossi et al., 2022)**. Young adults are often overlooked under the presumption they are ‘healthy’; however, the prevalence of NAFLD in this group could be a serious public health concern and pose a substantial cost to the local healthcare systems **(Teng et al., 2023)**.

According to a recent meta-analysis, the prevalence of NAFLD has increased to as high as 25.2% worldwide, and by 2030; this percentage is predicted to reach 33.5 % **(Estes et al., 2023)**. Therefore, determining long-term outcomes, including morbidity and mortality, among NAFLD patients has major ramifications for public health decision-making and clinical practice **(Ling et al., 2023)**.

Moreover, a cohort of college students in Egypt illustrated that around 1 in 3 had steatosis and 1 in 20 had moderate-to-advanced fibrosis, an established risk factor for hepatic and extra-hepatic morbidity and mortality. These findings highlight the need for swift action to stop the silent epidemic of NAFLD affecting young adults in the Middle East and North Africa **(Tomah et al., 2021)**. Deaths attributable to non-communicable diseases represent about 71% of the total mortality burden **(WHO, 2021)**.

For that reason, the presence of metabolic syndrome (MetS) and its components, such as hypertension (HTN), obesity, type 2 diabetes mellitus (DM), and dyslipidemia, are expanding the peril of progressing NAFLD. Additionally, numerous extra-hepatic symptoms, such as cardiovascular disease and sleep apnea, have been connected to NAFLD **(Eslam et al., 2020)**. NAFLD has recently been renamed metabolic (dysfunction)-associated fatty liver disease (MAFLD) to emphasize the substantial link between overweight/obesity, type 2 diabetes, and the MetS **(Baratta et al., 2020 & Umbro et al., 2020).**

Whilst, the lifestyle factors of excessive calorie consumption and decreased exercise and physical activity are directly linked to the development of NAFLD. In the 20th and 21st centuries, global urbanization and modernization have been connected to unhealthful lifestyle changes **(Asrani et al., 2021)**. Accordingly, the mean global body mass index (BMI) and prevalence of obesity, which are the pathophysiological derivatives of NAFLD have increased significantly over the past three decades. These are the pathophysiological consequences of non-alcoholic fatty liver disease (NAFLD) (**Mitra et al., 2020**). The underlying factors influencing poor lifestyle choices and habits are intricate and multifaceted, yet they may be effectively countered to provide notable health advantages, and these unhealthy behaviors have been linked to a considerable number of preventable fatalities (**Powell et al., 2021 & Ahmed et al., 2019**). On the other hand, the international recommendations indicate that the first therapeutic step for treatment of NAFLD is to follow healthful lifestyle choices such as food adjustments along with frequent exercises, and slow weight reduction remain the cornerstone of management for most hepatic diseases as they have a substantial impact on person's health **(Montemayor, 2022)**.

Dietary modifications in the form of increased intake of fruit and vegetable-rich diets, along with decreased intakes of carbohydrates, fructose, total fat, saturated fatty acids, and trans-fatty acids, have been shown to improve inflammatory markers, hyperlipidemia, abdominal and body fat, and insulin resistance **(Kwon et al., 2023)**. What is more, maintaining a balanced diet is the most successful strategy for managing patients with non-alcoholic fatty liver disease (NAFLD) since it improves the Alanine aminotransferase (ALT) and Aspartate aminotransferase (AST) levels **(Zou et al., 2021)**.

Furthermore, continuous training in moderate-to-high intensity exercise improved serum ALT and AST levels, and intra-hepatic fat improved, irrespective of weight change **(Katsagoni et al.**, **2020)**. In addition, interventions combining exercise and diet showed decreases in ALT and improvement in NAFLD activity score **(Byambasukh et al., 2021; and Bull et al., 2020)**.

Significance of the study

Non-alcoholic fatty liver disease is a major leading cause of liver disease worldwide (**Cheemerla & Balakrishnan, 2021**). The estimated global incidence of NAFLD is 47 cases per 1,000 populations and is higher among males than females. The estimated global prevalence of NAFLD among adults is approximately 32% and is higher among males (40%) compared to females (26%) (**Teng et al., 2023**). In Egypt, the prevalence of NAFLD is rising owing to the rising prevalence of obesity (**Eletreby et al., 2021**). At the same time, the **Statistical records of the National Liver Institute and the teaching Hospitals' outpatient clinics, (2020)** in Menoufia Governorate, Egypt, pointed up that about 4.1% of the reported patients' admissions were diagnosed with NAFLD in the year prior to the start of this study.

Implementing healthy lifestyle modifications, such as dietary adjustments, consistent exercise training, and gradual weight loss side by side with the follow-up for body weight and liver enzymes levels are the best approaches that should be clinically recommended and holistically implemented together as an initial step for the prevention, treatment, and management of NAFLD **(Ahmed et al., 2019)**. For that, the current study recommended that NAFLD management in patients with metabolic syndrome should be focused on lifestyle modifications.

Operational definition:-

Lifestyle interventions: are directed nursing interventions for the management of NAFLD associated with elevated liver enzymes for achieving a steady loss of weight through increased physical activity and exercise practice along with dietary modifications (**Kamada et al., 2021**).

AIM OF THE STUDY

The aim of this study was to examine the effect of lifestyle interventions on body weight and elevated liver enzymes among patients with non-alcoholic fatty liver disease.

RESEARCH HYPOTHESIS

H1: Patients who receive lifestyle interventions (study group) will have significant improvement in the practices of dietary and physical activity exercise in comparison with patients who don't receive lifestyle interventions (control group).

H2: Patients who receive lifestyle interventions (study group) will have a significant reduction in body weight and total BMI in comparison with patients who don't receive lifestyle interventions (control group).

H3: Patients who receive lifestyle interventions (study group) will have a significant reduction in liver enzymes Alanine aminotransferase (ALT) and Aspartate aminotransferase (AST) in comparison with patients who don't receive lifestyle interventions to (control group).

METHODS

Design: A quasi-experimental design (study and control) was used.

Settings:- The study was conducted at outpatient clinics of the National Liver Institute and Teaching Hospital at Shebien El-Kom City, Menoufia governorate; Egypt. These hospitals were selected because of the considerable number of patients with liver problems who visit them for medical examinations and follow-ups, besides, these hospitals provide appropriate venues for providing health education.

Subjects: A simple random sample of 200 patients with NAFLD was selected from previously chosen settings and divided equally and randomly to 100 patients for the study and control groups. Those patients were chosen according to the following criteria:

Inclusion criteria:-

1. Medical diagnosis of NAFLD confirmed with diagnostic ultrasonography.
2. Alanine aminotransferase (ALT) level > 56 units/liter of serum and Aspartate

aminotransferase (AST) level >40 units/liter of serum (**Bermant, Frandsen, & Synders, 2022**)

3. Both sexes aged 21 years and over.
4. Willing or able to give informed consent to participate in the study

Exclusion criteria:-

1. Medical conditions that interfere with patients' body metabolism e.g. Cushing’s syndrome or chronic pancreatitis, active thyroid disease, and liver cancer
2. Currently pregnant or breastfed mothers
3. Already participating in a weight control program or on medication to promote weight loss to avoid interference with current study results

Sample size and power of the study:-

The researchers used the **Epi** statistical program from the Open Source Statistics for Public Health, in order to calculate the required sample size for assessing the efficacy of behavior change-based lifestyle nursing interventions on the metabolic profile of patients characterized by elevated liver enzymes. The assumptions were a two-sided confidence level of 95% = (1- α)**;** A power (1- β) or (% chance of detecting) of 80%**;** Ratio of sample size, unexposed (control)/ exposed (cases) = 1; % of unexposed with outcome (change of metabolic profile) =25%. Then, researchers entered one of four parameters which was a percentage of exposure with outcome (change of metabolic profile) = 40%, and the other three parameters would be calculated by the **Epi** website program and results were presented using methods of Kelsey, Fleiss, and Fleiss with a continuity correction nearly 200 patients with liver diseases as the current study's sample size. **(Kelsey, Fleiss & Fleiss, 1996)**

Instruments: Five tools were used to collect the needed data for this study:-

I. **A structured interview questionnaire: was** created by the researchers to analyze patients' socio-demographic variables and includes the following information: age, marital status, level of education, income, place of residence, and employment.

II. **Reported patient's dietary practice questionnaire (pre-posttest):** The researchers developed it according to the **Food and Nutrition Board, Institute of Medicine, (2002)** to assess the patient's dietary practice through 29 assessing questions such as; "constantly tracking your weight", "ability to detect any increase in your weight", "drinking soft drinks" and "drinking milk", "the method used to cook food most of the time" Two points Likert scale (1- 2) was used for each question's response, where 1 = unhealthy practice, and (2) = healthy practice. The total score ranged between "29-58". The unhealthy practice level of participants' opinion ranges between "29-43", and the healthy practice level of participants' opinion ranges between "44-58"

The tool's reliability was done using test-retest reliability and proved to be reliable; demonstrated a high Cronbach's alpha (0.81) which suggested an excellent internal consistency of the instrument.

III. A 24 Hours dietary recall questionnaire (Pre-post-test):

Patient's dietary habits were measured by using the 24-hour dietary recall sheet, which consists of recordings of all foods that are eaten or drunk by the patient for a 24-hour period for three consecutive days. Nutritional specialists at nutritional database identified the caloric number eaten and this tool was adopted from **(National Nutrient Database for Standard Reference, 2000)** for determination and evaluation of dietary nutrient intake: Nutritional values of consumed food were calculated using computer Diet Analysis for Ready to Eat Egyptian foods, used by faculty of Home Economics Menoufia University, Egypt. The adequacy of diets was estimated by using DRI (2007). Statistical Analysis has been achieved using a computer (SPSS 1995-PC= for BIM) program. It was reported that it has a coefficient alpha reliability of 0.92.

IV. The Nordic Physical Activity and Exercise Questionnaire-Short (pre-post-test): It is a four questions survey tool based on telephone interviews was adapted from **(Zhang et al., 2020**) to assess physical activity and exercise during the past week, two questions consider the duration of exercise in minutes and hours, the third question asks about frequency or number of exercising days. The last question assesses the intensity of exercise either moderate results in dyspnea and increased heart rate e.g. walking continuously, for at least10 minutes, for recreation, exercise or to get to or from places, or vigorous like gardening or heavy work around the yard, practicing a vigorous physical activity that can result in sweating, heart racing and speaking became difficult.

Scoring: The total score of this tool was calculated according to patients' answers according to their reported number of minutes and hours spent in moderate or vigorous daily physical activity and exercise, and the higher mean scores indicate better improvement in practicing exercise.

The tool's reliability was done using test-retest reliability and proved to be reliable; demonstrated a high Cronbach's alpha (0.84) which suggested an excellent internal consistency of the instrument.

V. Bio-physiological measurements (Pre-post-test): it has two parts (measuring the body mass index and biochemical values):

Va) Measuring the body mass index (BMI): it was measured for all patients in the initial visit and follow-up visit. BMI Categorized as Underweight <18.5, normal weight = 18.5–24.9, overweight = 25–29.9, obesity = BMI of ≥30 **(Chatuvrvedi et al., 2023)**. The tool's reliability was done using test-retest reliability and proved to be reliable; demonstrated a high Cronbach's alpha (0.85) which suggested an excellent internal consistency of the instrument.

Vb) Bio-chemical values: The patient's blood test results including (Liver enzymes test (ALT), (AST); were collected from the patient's medical records.

Validity of the tools: A jury of seven experts; two professors in medical-surgical nursing, one professor in medicine, one nutritionist, two professors in community health nursing, and one expert in statistics tested the validity of the current study tools.

Pilot study: This was carried out to assess the questionnaire's usability and applicability, as well as to identify any potential concerns that might arise during data collection. In addition, to guess how long it would take to complete the questionnaire. Twenty patients participated in the pilot study. Patients who participated in the pilot study were not involved in the total sample. However, they were given a copy of the educational intervention booklet afterward.

Ethical consideration

The study was approved by the Ethical Committee for Scientific Research Review, Faculty of Nursing, Menoufia University, Egypt conducted on September 16, 2020, with registered number (N:724). Informed consent was obtained from participants after the study's purpose and procedures were explained by the researchers. Confidentiality of all information was guaranteed. Participants were assured that their participation in the study was voluntary and that they could withdraw from the study at any time. They were informed that participation in the study has no cost. The researchers gave participants copies of the educational intervention booklet for achieving the beneficence and ethical principles of research.

Procedure:

- Firstly, an extensive review of past and current literature covering the various aspects of the problem was done using books, articles periodicals, magazines, and studies related to fatty liver and lifestyle nursing intervention.
- Data were collected during the first of March 2021 to the end of February 2022.
- A baseline assessment was done through the structured interview questionnaires. It took about 30-35 minutes to be completed.
- Patients' investigation results (Liver enzymes tests (AST), (ALT)) were collected from patients' medical records.
- Each patient was personally interviewed in the waiting room of the outpatient clinic.
- The interview lasted from 9–12:30 AM, three times per week; follow-up days for the study group were Saturdays, Mondays & Wednesdays while the control group was on Sundays, Tuesdays &Thursdays to prevent bias.
- The period of baseline assessment lasted for three months.
- Following the assessment, the patients were randomly divided into two equal groups: the intervention group and the control group.

The Study Group:

- The researchers started the lifestyle interventions program that lasted seven months through health education about unhealthy behaviors change through the application of lifestyle interventions, which included face-to-face and telephonic sessions. The face-to-face session took about 60 minutes and the telephonic session took about 10-15 minutes at every time of intervention.
- All enrolled patients in the study group received lifestyle interventions regarding their diet and physical activity from the researchers guided by two professional physicians (one dietician and one exercise physiologist).
- The researchers used a variety of teaching materials and techniques in the implementation of the lifestyle interventions including; lectures, group discussions, as well as demonstrations, and improved patient learning, a PowerPoint presentation was combined with videos as well as posters, and an educational booklet that was given for each patient.
- The educational booklet was developed by the researchers and reviewed by a jury of experts in the fields of medical-surgical nursing, medicine, nutrition, and community health nursing. Booklets were written and printed out in Arabic language according to the sample size with additional copies.

The control group: -

The control group received routine follow-up care at outpatient clinics only.

<u>Nine sessions of lifestyle interventions:</u>

Lifestyle intervention sessions included five face-to-face and four telephonic sessions, which contained:

Session1 (Face to face):

- This session aimed at rapport formation with patients and family members and helping patients gain knowledge about liver disease and its management. It included health education about the role of lifestyle interventions in the management of NAFLD and explaining the meaning of the deranged metabolic parameter.
- The researchers set small and achievable goals for each patient. The researchers encouraged the patients to buy a weighing scale and to follow a tailored eating plan that merged the ideas of a well-balanced diet with a one-day meal plan that takes into account regional, cultural, and economic preferences as well as related symptoms and co-morbidities related to non-alcoholic fatty liver disease.
- Additionally, the researchers introduced the concept of “Sitting less and walking regularly for a healthy liver” stressed the benefits of regular walking in NAFLD management, and taught the patient the method of writing a food diary.
- At the end of this session, the researchers and the patients exchanged phone numbers.

Session 2 (Telephonic):

- This session aimed at strengthening the rapport and emphasizing the prescribed diet.

- The time was within 15 days from the first session.
- In this session, the researchers reinforced the healthy diet and weight loss prescriptions by explaining the importance of a low caloric controlled diet, emphasized the concept of small-frequent meals, and remembered patients by the right method for writing a food diary.

Session 3 (Telephonic):

- This session aimed at monitoring the patient's progress in terms of dietary, and physical activity changes and weight loss as well as, motivating the patient to adhere to the prescribed lifestyle interventions.
- The time was at the completion of one month when the researchers inquired whether the recommended changes had been made in the daily diet and physical activity.
- In addition, the researchers inquired about the patient's weight.
- Moreover, the researchers explained the patient's progress to motivate him/her for adherence.

Session 4 (Face to face):

- This session aimed at empowering the patient with the basic knowledge of meal planning for healthy eating and stressing the role of exercise in weight loss and improvement of NAFLD.
- The time was at the completion of two months.
- In addition, in order to encourage patients to follow their prescribed regimen, the researchers inquired about their weight and checked their food and dairy to understand the routine of the patient and to ascertain that they had made the suggested adjustments to their daily dietary and exercise schedule.
- Moreover, the researchers educated each patient about how to plan his/ her meals from the recommended food group intake and motivated the patient to maintain a food diary.
- As well, the researchers explained the role of exercise in weight management and set exercise targets with the patient.

Session 5 (Face to face):

This session aimed to reset a new diet and exercise goal for the patient as per his/ her progress in the preceding three months.

- It also, explains the journey of weight loss and associated barriers.
- The time was at the completion of three months.
- It included; monitoring NAFLD patients' progress with respect to healthy dietary, physical activity, and exercise modifications as well as weight reduction, the researchers checked the food diary to understand the patient's routine and then gave a new customized diet plan based on the current need of the patient (weight loss or maintenance).
- In order to get insight into patients' daily routines, the researchers reviewed each patient's food diary, and then a new, personalized diet plan was created tailored to

his/her current needs (weight loss or maintenance).

- When any patient shows no progress, the researchers explained the potential causes and discussed ways to overcome healthy diet barriers.
- Furthermore, the researchers offered a recipe booklet for low-calorie snacks, as well as updated the patient's targets of weight reduction and activity and exercise, if needed.

Session 6 (Telephonic):

- This session aimed at motivating the patient to continue with the prescribed lifestyle instructions and making the patient feel positive.
- The time was 15 days after the completion of three months.
- It was a reminder call to check the patient's progress to keep him/her adhered to and motivated by stressing the role of exercise in weight loss and fatty liver disease improvement.

Session 7 (Telephonic):

- The time was at the completion of four months.
- This session aimed at motivating the patient to continue with the prescribed lifestyle instructions. In addition, making patients feel positive, keeping an optimistic outlook on making a long-term lifestyle adjustment, making the patient feel that he/she is being constantly monitored and the researchers reiterated the role of weight loss in the improvement of liver enzymes' test results.

- **Session 8 (Face to face):**

- This session aimed at empowering the patient to make informed and healthy food choices.
- The time was at the completion of five months.
- The researchers gave an education session on how to read and interpret nutrition labels and empower patients to make informed and healthy food choices and explained how to eat healthy while eating outdoors.
- Moreover, they helped each patient to control social influences correctly react to cravings, and get back on track without disturbing his/ her diet plan.
- Likewise, the researchers encouraged patients to consume low-fat and simple sugar snacks and drinks as well, boosting motivation through recognizing one's own accomplishments to date to keep and maintain behavior change and habit modification.

Session 9 (Face to face):

- This session aimed to analyze the progress made by the patient during six months of self-management in terms of metabolic parameters.
- In addition, it enhances motivation to maintain behavior changes by recognizing personal successes so far.
- The time was at the completion of six months

- The researchers made the final patient's progress assessment and how he/she established a future-oriented, healthful diet and fitness regimen, then explained how to stay motivated for a long life.
- **A post-test session:** was performed using tools; II, III, IV & V for both study and control groups to evaluate and compare the results of the applied interventions; two months after the last intervention session.

Statistical analysis:

Statistical Package of Social Science (SPSS), ed., 23 to enter and analyze the data and Excel application to make the figures applied. Quantitative data was presented as (X ± SD) and evaluated by using the independent sample t-test and paired t-test to compare two means before and after the intervention. P value < 0.05 was chosen as the level of significance for all significant tests. The evaluation of effect size (ES), the rule of jump for interpretation of Cohens' D as follows (≤)Less than and equal to 0.2 = Small ES, 0.5 = Medium ES, and (≥) 0.8 or more = Large ES". It was used to measure the effect of lifestyle intervention on the study group.

RESULTS

Table 1: Indicates that, there were no significant differences between the study and control groups regarding all the socio-demographic data (p>0.05) this was evidenced by; the mean age of the study and control groups was 51.1 ± 10.9 and 52.7±10.0 respectively. The majority of the sample, 72%, and 64% were females, 85% and 86% were married, 87% and 78% lived in rural regions, 63%, and 65% had primary and technical education, 97% and 94% living with family, 80% and 71% had not enough monthly income and about half of them 52% and 48% were housewives in study and control group, respectively.

Table 2: Represents that, the total mean score of healthy dietary practice among the study group statistically improved from 37.8±4.6 pre-intervention to 49.6±5.8 post-intervention, with 91% of patients had high healthy dietary practice post-intervention compared to 16% pre-intervention in the study group compared to 10% in control group on post-intervention. Moreover, there was a statistical significance observed in dietary practices post-intervention in comparison between study and control groups (P3<0.05).

Table 3: Illustrates that there was a statistically significant difference observed regarding hard and heavy work in pre-intervention comparison between the study and control group as (P2=0.02). Besides, a high post-intervention significance was observed regarding the total mean scores of exercise and physical activity practices (P3<0.000) in the post-intervention comparison between the study and control group.

Table 4: Shows that, a high post-intervention statistical significance was seen for all macronutrient items' total mean scores as (P3**<**0.05) in comparison between the study and control group, while no pre-statistical significant difference was observed (P2>0.05) excluding total mean score of protein A intake.

Concerning the magnitude of the effect of the lifestyle intervention on dietary practices, it was studied among the study group through Cohen's d effect size (ES) which revealed a large effect size in three-quarters of macronutrients (9/12=75 %), about 2/12 (16.7%) showed medium effect size and only 1/12 (8.3%) showed small effect size.

Table 5: Reveals that there was no significance observed in pre-intervention regarding all micronutrient items while, an obvious post-intervention statistically significant improvements in all micronutrient items (P2<0.0001) except in main intake of Ca, zinc, and RDA of magnesium in comparison between study and control group.

So, it can be concluded from this table that the effect of lifestyle interventions on dietary practices which studied among study groups through Cohen's d effect size which illustrated a large effect size in more than one-third of micronutrients (4/13=30.8 %), 4/13(30.8%) showed medium effect size and 5/30 (38.4%) showed small effect size.

Table 6: Clarifies that, the statistically significant improvement observed among the study group regarding total body weight mean score post-intervention as it decreased from 80.0 ± 16.7 pre- to 73.4 ±18.3 post- additionally, the same significant improvement was observed for the total mean score of BMI as it reduced from 30.1±12.2 to 27.6± 13.1. Moreover, this table reveals there were statistical significance reductions regarding total mean scores of post-intervention anthropometric measurements for body weight and BMI in comparison between study and control groups (P3<0.0001).

Table 7: Demonstrates that there was a statistically significant improvement (p <0.05) of total mean scores of liver enzymes tests including ALT & AST on post-intervention than pre-intervention among study and control groups. These evidenced by the that, on pre-intervention the total mean score of the ALT test was 64.2±15.2 among the study group and the control group is66.1± 24.1. While post-intervention the total mean score of the ALT test among the study group decreased to 43.5±21.9 compared with 68.2±12.4 among the control group. Also, the total mean score of the AST test was 54.9±14.3 among the study group and the control group was 55.8±15.8 on pre-intervention. While, on post-intervention, the total mean score of the AST test among the study group decreased to 36.9±11.7 comparable with 54.4±12.0 among the control group. Likewise, there were statistically significant reductions in total mean scores of liver enzymes (ALT&AST) among study and control groups in post-intervention (P3<0.0001).

Table 1: Distribution of Socio-demographic data among Study and Control Groups of patients with non-alcoholic fatty-liver disease (N = 200)

Socio demographic data	Study group (n=100) Mean ± SE or N0.=%	Control group (n=100) Mean ±SE or N0.=%	P value
Age (years)	51.1 ± 10.9	52.7±10.0	P=0.27
Gender • Male • Female	 28 72	 36 64	0.23
Marital status • Married • Widowed • Single/divorced	 85 10 5	 86 10 4	0.95
Residence • Rural • Urban	 87 13	 78 22	0.09
Education • Illiterate./R&W • Primary, preparatory & Technical Education • University	 23 63 14	 24 65 11	0.71
Live with • On own • With a family	 3 97	 6 94	0.59
Occupation • Housewife • Workers • Employees • Others	 52 10 25 13	 48 10 27 15	0.49
Family members • 1-3 • 4-6 • 7-10	 24 69 7	 32 59 9	0.53
Family monthly income • Not enough • Enough	 71 29	 80 20	0.06
Total	100	100	

Table 2: Effect of Lifestyle Interventions on Dietary Practices among Study and Control Groups of patients with non-alcoholic fatty-liver disease

The reported patients' Dietary practices	Study group		Control group		P1	P2	P3
	Pre intervention (n=100) Mean ± SE or N=%	Post intervention (n=100) Mean ± SE or N=%	Pre intervention (n=100) Mean ± SE or N=%	Post intervention (n=100) Mean ± SE or N=%	0.0001	0.12NS	0.0001
Unhealthy dietary practice (28-43)	84	9	90	90			
Healthy dietary practice (44-58)	16	91	10	10			
Total	100	100	100	100			
Mean± SD for total score of the reported patients' Dietary practices	37.8±4.6	49.6±5.8	37.3±4.8	37.3±4.8			

P1= Comparison between pre and post intervention dietary practice among study group.

P2= Comparison between study and control groups on pre intervention dietary practices.

P3= Comparison between study and control groups on post intervention dietary practice.

S= Statistically significant at P < 0.05

Table 3: Effect of Lifestyle Interventions on Physical Activity and exercise Practices Pre and Post Intervention, among Study and Control Groups of patients with non-alcoholic fatty-liver disease

The Nordic Physical Activity and Exercise questionnaire Items	Study group		P1 value	Control group		P2	P3
	Pre intervention n=(100) Mean ± SE or N=%	Post intervention n=(100) Mean ± SE/ or N=%		Pre intervention n=(100) Mean ± SE /N=%	Post intervention n=(100) Mean ± SE / N=%		
Walked for at least 10 minutes continuously No Yes	36 64	7 93	0.000	49 51	48 52	0.06	0.000
Frequency Mean ± SE	3.6 ±1.3	5.5 ± 0.6	0.01	3.3±1.1	3.2 ±0.1	0.09	0.004
Duration (Minutes) Mean ± SE	67.3±20.4	104.4±24.8	0.000	57.7±16.1	58.5±16.5	0.08	0.000
Duration in hours Mean ± SE	1.1±0.5	1.7±0.8	0.03	0.9±1.3	0.9±0.08	0.13	0.000
Worked a hard or heavy work that result in (dyspnea, sweating, heart racing that speaking become difficult) No Yes	61 39	52 48	0.03	76 24	81 19	0.02	0.000
Frequency Mean ± SE	2.5±1.2	2.9±1.4	0.03	2.0±1.3	1.1±1.2	0.07	0.04
Duration (Minutes) Mean ± SE	38.8±13.2	47.8±22.7	0.001	36.1± 18.1	37.6± 12.8	0.09	0.01
Duration in hours Mean ± SE	0.7±0. 5	1.3 ±0. 4	0.002	0.6±0.07	0.5±0.02	0.06	0.001
Practicing a hard physical activity which result in dyspnea & increased heart rate No Yes	86 14	80 20	0.04	85 15	92 8	0.84	0.001
Frequency Mean ± SE	2.6±1.4	3.8 ±0.2	0.01	2.1±0.8	1.1±0.3	0.26	0.001
Duration (Minutes) Mean ± SE	47.5±14.3	53.5±12.6	0.04	41.7±19.3	30.5±14.2	0.33	0.001
Duration in hours Mean ± SE	0.8±0.07	1.2±0.05	0.03	0.7±0.06	0.3±0.1	0.32	0.04
Practicing moderate physical activity No Yes	69 31	12 88	0.000	77 23	66 34	0.20	0.000
Frequency Mean ± SE	3.3±0.6	4.4±0.1	0.01	2.9±0.8	2.6±0.1	0.15	0.000
Duration (Minutes) Mean ± SE	48.6±20.5	94.9±24.2	0.000	43.3±17.1	61.4±18.5	0.07	0.000
Duration in hours Mean ± SE	0.8±0.1	1.6±0.07	0.000	0.7±0.1	1.0±0.1	0.10	0.000

P1= Comparison between pre and post intervention exercise and physical activity practice among study group.
P2= Comparison between study and control groups on pre intervention regarding exercise and physical activity practices.
P3=Comparison between study and control groups on post intervention regarding exercise and physical activity practices.
S= Statistically significant at $P < 0.05$

Table 4: Distribution of Total Mean Scores of the 24-hours dietary recall's Macronutrients Pre and Post-Intervention among Study and Control Groups of patients with non-alcoholic fatty-liver disease

Macronutrients/24 hours recall	Pre intervention			Cohen's d*	Effect size of change	Post intervention		
	study group (n=100) Mean ± SD	control group (n=100) Mean ±SD	P1			study group (n=100) Mean ± SD	Control group (n=100 Mean ± SD	P2
Main intake of water (gm)	1093.6±39.6	1115.2±25.3	0.18	0.635	Medium ES	1458.9±50.7	1166.2±35.5	<0.0001
Main intake of calories (kcal)	2453.4±88.1	2705.4±80	0.56	-1.312	Large ES	1493.1±36.4	2762.1±96.5	<0.0001
RDA of calories (kcal)%	103.8±4.1	115.3±3.6	0.82	-1.046	Large ES	68.1±2.9	116.4±4.7	<0.0001
Main intake of protein-A (gm)	41.6±2.1	40.3±1.6	0.22	-0.313	Small ES	37.5±1.4	42.6±1.8	0.13 NS
Main intake of protein-P (gm)	51.2±1.9	52.1±1.8	0.53	-1.062	Large ES	32.2±1.1	53.6±2.1	<0.0001
Main intake of total protein (gm)	93.1±3.2	92.5±2.3	0.26	-0.950	Large ES	69.8±1.9	95.9±2.8	<0.0001
RDA of total protein (mg)	159.3±6.2	160.7±4.5	0.42	-0.542	Medium ES	131.4±6.8	165.4±5.1	<0.002
Main intake of fat- A (mg)	44.5±2.8	49.2±2.2	0.31	0.846	Large ES	30.7±1.5	51.7±2.7	<0.0001
Main intake of fat- P (gm)	53.9±4.1	54.7±2.9	0.56	-1.074	Large ES	21.8±1.4	56.9±3.6	<0.0001
Main intake of total fat (gm) 2	98.1±5.0	103.7±3.8	0.31	-1.255	Large ES	51.9±1.9	108.7±4.5	<0.0001
Main intake of carbohydrate (gm)	322.2±11.7	356.7±12.5	0.48	-1.296	Large ES	182.2±4.8	367.7±14.6	<0.0001
Main intake of Fiber (gm)	22.9±1.1	21.9±1.1	0.14	-0.497	Large ES	18.8±0.5	24.1±1.3	<0.001

Cohen's d: It measure the effect size of change in macronutrients. *ES = Effect size S= Statistically significant at P < 0.05

P1= Comparison between study and control groups regarding macronutrients on pre intervention.

P2= Comparison between study and control groups regarding macronutrients on post intervention.

Table 5: Distribution of Total Mean Scores of the 24-hours dietary recall's Micronutrients among Study and Control Groups on Pre and Post-Intervention of patients with non-alcoholic fatty-liver disease

Micronutrients	Pre intervention				Effect size of change	Post intervention		
	Study group (n=100) Mean ± SE	Control group (n=100) Mean ±SE	P1	Cohen's d		Study group (n=100) Mean ± SE	Control group (n=100 Mean ± SE	P2
Main intake of calcium (mg)	834.2±130.2	727.5±26.4	0.80	0.662	Medium ES	955.5±34.4	735.4±28.1	0.37
RDA of calcium%	88.3±4.1	90.9±3.3	0.87	0.736	Medium ES	124.1±4.5	91.6±3.5	<0.0001
Main intake of sodium (mg)	5403.6±475.4	812.1±28.5	0.01	-1.191	Large ES	2702.8±92.3	905.8±29.5	<0.0001
RDA of sodium%	993.1±36.4	4065±42.1	0.04	-1.131	Large ES	576.2±30.4	4878±74.1	<0.0001
Main intake of zinc (mg)	11.2±0.36	12.9±040	0.49	-1.022	Large ES	59.6±50.7	13.4±0.47	0.34
RDA of zinc%	80.9±3.02	100.4±6.3	0.86	0.706	Medium ES	68.8±3.1	99.2±4.7	<0.006
Main intake of magnesium (mg)	446.2±16.5	529.5±21.1	0.71	-0.914	Medium ES	354.7±9.4	537.3±23.2	<0.0001
RDA of magnesium%	138.3±5.7	173.9±8.5	0.58	-0.338	Small ES	133.9±12.3	168.9±7.5	0.74
Main intake of vitamin A (G)	1088.1±167.1	803.4±39.3	0.11	0.459	Small ES	1448.1±67.7	990.9±119.5	<0.04
RDA of vitamin A%	119.6±17.6	109.5±12.7	0.08	0.499	Small ES	164.6±8.1	109.5±12.7	<0.02
Main intake of vitamin-C (mg))	179.2±16.9	183.5±15.1	0.12	0.439	Small ES	243.1±11.2	183.5±15.1	<0.001
RDA of vitamin- C%	299.1±28.2	305.5±25.3	0.11	0.489	Small ES	422.6±21.0	305.5±25.3	<0.0001
Main intake of cholesterol (mg)	319.8±32.6	331.6±17.5	0.30	-0.904	Large ES	192.5±8.5	331.6±17.5	<0.0001

Cohen's d: It measure the effect size of change in macronutrients. *ES = Effect size

P1= Comparison between study and control groups regarding macronutrients on pre intervention.

P2= Comparison between study and control groups regarding macronutrients on post intervention.

S= Statistically significant at P < 0.05

Table 6: Comparison between the pre and post-interventions' total mean scores of anthropometric measurements among study and control groups of patients with non-alcoholic fatty-liver disease

Study variables	Study group		P1 value	Control group		P2	P3
	Pre intervention (n=100) Mean ± SE or N=%	Post intervention (n=100) Mean ± SE or N=%		Pre intervention (n=100) Mean ± SE or N=%	Post intervention (n=100) Mean ± SE or N=%		
Anthropometric measurements							
Height (Cm)	163.3 ± 6.8	163.4 ±6.8	0.97	163.1 ±6.3	163.2±6.3	0.96	0.96
Weight (Kg)	80.0 ± 16.7	73.4±18.3	<0.0001	84.1 ±15.2	84.5±19.5	0.01	<0.0001
BMI:	30.1±12.2	27.6± 13.1	<0.0001	30.6±11.4	31.9±14.6	0.12	<0.0001
Normal	8.0	17.0		4.0	8.0	0.13	
Overweight	47.0	64.0		31.0	22.0		
Obesity	45.0	19.0		65.0	70.0		

P1= Comparison between pre and post intervention anthropometric measures among study group.
P2= Comparison between study and control groups on pre intervention anthropometric measures.
P3= Comparison between study and control groups on post intervention anthropometric measures.
S= Statistically significant at P < 0.05

Table 7: Comparison between the pre and post-interventions' total mean scores of liver enzymes test among the study and control groups pre-post intervention of patients with non-alcoholic fatty-liver disease

Study variables	Study group		P1 value	Control group		P2	P3
	Pre intervention (n=100) Mean ± SE or N=%	Post intervention (n=100) Mean ± SE or N=%		Pre intervention (n=100) Mean ± SE or N=%	Post intervention (n=100) Mean ± SE or N=%		
Liver enzymes test							
ALT	64.2±15.2	43.5±21.9	<0.0001	66.1± 24.1	68.2±12.4	0.12	<0.0001
AST	54.9±14.3	36.9±11.7	<0.0001	55.8±15.8	54.4±12.0	0.13	<0.0001

P1= Comparison between pre and post intervention liver enzymes test among study group.
P2= Comparison between study and control groups on pre intervention liver enzymes test.
P3= Comparison between study and control groups on post intervention liver enzymes test.
S= Statistically significant at P < 0.05

Discussion

Approximately 33% is the prevalence percentage of non-alcoholic fatty liver disease (NAFLD), which is on the rise in tandem with the obesity and metabolic syndrome epidemics as well as other chronic illnesses including diabetes, hyperlipidemia, and hypertension **(Lim et al., 2023)**. Lifestyle modification is a crucial strategy for the treatment of NAFLD, which can lead to a reduction in liver fat with concomitant weight loss **(Méndez-Sánchez, & Díaz-Orozco, 2021)**.

Answering hypothesis 1: Patients who receive lifestyle interventions (study group) will have significant improvement in the practice of dietary and physical activity exercise in comparison with patients who don't receive lifestyle interventions (control group).

As regards healthy dietary practices among the study group, the current study found a significant improvement in the total score of the healthy dietary practices in which the total score of the study group was 37.8±4.6 on pre-intervention improved to 49.6±5.8 on post-intervention. This result indicated the effectiveness of the diet program followed by patients, which translated into the food preparation changes; in the type of added fat, with less butter, margarine, and corn/sunflower oils added, while more olive oil was consumed. This finding was in the same line with **Mosa et al., (2023)**; who concluded that "a significant improvement in healthy dietary practice after three and six months of program application".

Likewise, it was agreed with **Moneim et al., (2020)**; who found "a significant reduction of dairy product made with full cream and chicken skin/meat fat intake with follow up". From the researchers' point of view, this consistency was due to the patient’s desire to follow a healthy diet and lose weight, which enables them to perform activities of daily living.

As well concerning the effect of lifestyle interventions on dietary practices among the study and control group, the present study illustrated that the most of patients in the study group had highly healthy dietary practices post-intervention compared to pre-intervention and ten percent in the control group post-intervention. These findings agreed well with a study conducted by **Haidari & Behrouz et al., (2020)**; the researchers reported "statistically significant positive changes following dietary intervention had occurred for both study arms". These improvements could be related to the result of the reduction in total calorie intake and physical activity.

Concerning to total mean score of total fat intake among the study and control group, the present study stated that, there was a high significance improvement in total intake of total fat and carbohydrate post-intervention. This finding was supported by **George et al., (2022)** reported that "in the Med Diet group at the macronutrient level, there was a significant reduction in carbohydrate intake, and in the LFD group, at the macronutrient level, there was a significant reduction in total fat".

As well, the current study revealed that there was a high significant improvement in post-intervention than pre-intervention among the study group than the control group. These findings agreed well with a study was conducted **by Mohamad Nor et al., (2021)**; the authors stated that "a significant decrease in the daily total fat intake in the probiotics group after the intervention compared with the placebo group". This similarity in results could be due to that, the patients in a study group adhered to better practices of good dietary intake and physical activity intervention instructions.

Furthermore, the present study demonstrated that there were highly significant improvements in mean intake of calories, total protein, total fat, and carbohydrate at post-intervention among study and control groups. These results came agreed with **Sohouli et al., (2020)**; who stated that "significant differences were demonstrated in intakes of macronutrients (protein, fats, and carbohydrates) between the case and control groups (P < 0·05)". Additionally, this result was consistent with **Entezari et al. (2021)** who noted, "The total energy consumption, low-fat dairy, and meats intake were reduced after application of intervention program".

The present study represented a highly significant improvement found in the mean intake of total calories and in determining the dietary components that had the biggest positive effects on liver-related outcomes in post-intervention than pre-intervention among the study and control groups. This result was equal to the result of a study carried out by **Mosa et al., (2023)** who revealed "a significant reduction in total calorie intake post six months of program application". In addition, this finding was congruent with **Haigh et al., (2022)**; who reported that "post-intervention; the participants were broadly acceptable to follow caloric intake modification as prescribed with significant improvement". These results correspondences could be related to balanced caloric intake having an important role in reducing weight and in liver fat mobilization.

As regards all micronutrient items, the present study showed a statically significant improvement in all micronutrient items on post-intervention (P2<0.0001) except in the main intake of Ca, zinc, and RDA of magnesium which showed non-significant difference among study and control groups. This result was equivalent to a study carried out by **Entezari et al. (2021)** which revealed, "The increased consumption of fruits, vegetables, legumes, seafood, and nuts was substantially correlated with the Mediterranean diet (MED)". In the same way, this is evidenced by a study conducted by **Sohouli et al., (2020)**; who reported that " significant differences were demonstrated in intakes of more micronutrients (vitamin C) between the case and control groups (P < 0·05)".

Regarding the practicing of physical activity exercise among study groups in pre and post-intervention, the current study showed a statistically significant difference. This finding was similar to **Amer K., (2020)**; who reported, "Before intervention the minimum of patients were practicing exercise, primarily walking, that increased significantly on post intervention".

In addition, the concurrent study revealed that there were highly significant improvements among study and control groups on post-intervention regarding the total mean scores of exercise and physical activity practice, which included; walking continuously, for at least 10 minutes, for recreation, exercise or for get to or from places, doing vigorous gardening or heavy work around the yard, practicing vigorous physical activity and practicing moderate physical activities. These findings were on the same line with **Katsagoni et al., (2020)**; who found that the "Mediterranean lifestyle group increased vigorous exercise compared with the control group". Additionally, this result was consistent with **Chaturvedi et al., (2023)** who noted, "The physical activity score was recorded a higher percentage among cases of intervention when compared to control groups ($p < 0.05$)".

Likewise, these findings were consistent with **Mobasheri et al., (2022)**; who reported, "None of the control group members succeeded in reaching their weight loss objectives; stated, "The control group's participants were unable to reach their weight loss goals at all however, the intervention group was achieved and a significant difference between the groups was found". This resemblance could be explained by the fact that the decreased patients' anthropometric indices are the outcome of increased physical activity and adopting a high-nutrient diet followed by the intervention group patients after training sessions.

Answering hypothesis 2: Patients who receive lifestyle interventions (study group) will have a significant reduction in body weight and total BMI in comparison with patients who don't receive lifestyle interventions (control group).

Regarding the anthropometric measures, the present study revealed that post-intervention, there were statistically significant differences in body weight and BMI measurements between the study and control groups. This result came in agreement with **Katsagoni et al., (2020)**; who stated that "Mediterranean diet group (MDG) and Mediterranean lifestyle group (MLG) showed greater weight loss and BMI reductions compared with the control group". Also, this finding was congruent with **Mobasheri et al., (2022)**; who reported that "The BMI findings for the intervention group showed a noteworthy decline when compared to the control group". This similitude was due to their commitment to the intervention to prevent disease progression and complications.

Finally, a study conducted by **Guagnano et al (2022)** revealed that "after 3 months of lifestyle changes, a significant weight loss was observed, with a marked improvement in all adiposity indices and improvement was observed for steatosis degree. In addition, the liver size showed improvement with positive correlations to body weight, BMI, neck and waist circumferences, waist to height ratio". From the researchers' points of view, these consistencies may be due to that, encouraging patients to initiate and adhere to lifestyle modifications, aiming at weight loss through engagement in physical activities, and adopting healthy dietary habits are keystones of NAFLD management.

On the other hand, these results contradicted **George et al., (2022)**; who found that "the dietary intervention group, weight, and BMI were not significantly different from pre- to post-intervention". This contradiction could be related to their population with NAFLD having a low adherence to the program instructions besides the short duration of their intervention.

Answering hypothesis 3: Patients who receive lifestyle interventions (study group) will have a significant reduction in liver enzymes Alanine aminotransferase (ALT) and Aspartate aminotransferase (AST) in comparison with patients who don't receive lifestyle interventions to (control group).

Concerning the total mean score of the liver enzymes test; the present study revealed that, there was a significant reduction in the liver enzymes test in the study group compared to the control group post-intervention. These findings came on the same line with **Lim et al., (2023)**; who reported that "there were significantly greater reductions of ALT and AST in the intervention group compared to the control group after 6 months of intervention". In addition, this finding was congruent with **Mobasheri et al., (2022)**; who reported, "After the intervention, the educational group's liver enzymatic mean results (ALT and AST) showed a significant ".

Moreover, these results were similar to a study carried out by **Amer K. (2020)** who illustrated that "in the two exercise training groups, Alanine aminotransferase and Aspartate aminotransferase serum levels were significantly decreased compared to the control group" Likewise, these results were on the same line with **Dossoki et al. (2020)**; who reported "a statistically significant decrease in ALT and AST test level among study group compared to the control group".

This consistency could be attributed to the fact that providing hypo-energetic feeding regimes (alone or in combination with physical activity) in NAFLD patients has shown significant improvements in both liver enzymes and liver fat content.

Finally, all hypotheses of the study were supported by the study findings and this highlighted that the lifestyle interventions used in this study were effective approaches in managing patients with NAFLD.

Conclusion:

Healthy lifestyle interventions including maintenance of physical activity and exercise and healthy diet modification are evidence-based interventions for the management of NAFLD. Besides, lifestyle changes are effective in the management of NAFLD. Diet and exercise combined are superior to these interventions alone in reducing body weight and BMI and improving liver enzymes (ALT & AST).

Recommendations:

- Healthy lifestyle interventions such as dietary modifications, regular physical activity, and gradual weight loss should be implemented together as an initial step for the prevention, treatment, and management of NAFLD.
- Better results may be achieved if these lifestyle interventions are used by the Egyptian population to prevent NAFLD.
- Future research must continue to develop combined interventions to assist persons with NAFLD in improving their diet quality, losing weight, and reversing their health trajectory.
- Booklets on healthy lifestyle modifications should be available for all patients complaining of NAFLD for better prognosis.

Conflict of interest

The authors have no conflict of interest with respect to this manuscript.

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