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Lifestyle determinants as predictor of severity of metabolic associated fatty liver disease (MAFLD)

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Abstract

Background Metabolic-associated fatty liver disease (MAFLD) is a public health issue that can result in liver cirrhosis and its complications.

Aim of work Assess the dietary pattern, physical activity, and sleep quality of MAFLD patients.

Methods Cross-sectional study of 77 MAFLD patients being present in the outpatient clinic of Endemic Medicine Department at Cairo University Hospital. An interview questionnaire including sociodemographic, medical history, validated food frequency questionnaire (FFQ), Pittsburg Sleep Quality Index (PSQI), and international physical activity questionnaire (IPAQ) were utilized to collect data.

Results Among patients, 36%, 34%, and 30% had liver steatosis grades I (mild), II (moderate), and III (severe) respectively. Waist circumference, body mass index (BMI), daily caloric and carbohydrate intake, impaired sleep quality, and low physical activity were significantly linked with steatosis grades. The independent significant predictors for MAFLD severity were waist circumference ($P=0.011$, OR 1.119), poor sleep quality ($P=0.038$, OR 3.871), habitual sleep efficiency (OR 3.402, 95%CI 1.403–8.252), daytime dysfunction (OR 2.487, 95%CI 1.374–4.501), and physical activity ($P=0.027$, OR 4.6).

Conclusion Waist circumference, poor sleep quality, habitual sleep efficiency, daytime dysfunction, and low physical activity were the real marked predictors for MAFLD severity.

Keywords MAFLD, Lifestyle, Pittsburg sleep quality index, Physical activity, Food frequency questionnaire

Introduction

Non-alcoholic fatty liver disease (NAFLD) is a multifactorial disorder combining genetics, environmental, and metabolic variables. Recent proposals by a group of worldwide experts to redefine the condition metabolic (dysfunction)-associated fatty liver disease (MAFLD) [1]. These are three conditions—overweight or obesity, the presence of type 2 diabetes mellitus (T2DM), or signs of metabolic dysregulation—are the basis for the criteria for MAFLD. The distinction between diagnosing MAFLD and NAFLD is that MAFLD emphasises the role of metabolic dysfunction more so than NAFLD does, and does not need the elimination of heavy alcohol abuse or other forms of chronic liver disease [2].

Growing evidence suggests that MAFLD is a multisystem disorder that impacts a number of extra-hepatic organs and raises the incidence of cardiovascular diseases and chronic kidney disease. This information has been revealed over the past ten years, demonstrating that the

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global health burden of MAFLD is not limited to potentially progressive hepatic disorder [3].

High calorie consumption and decreased physical exercise are key lifestyle variables that contribute to the occurrence of MAFLD [4]. Furthermore, contrasted to exercise and diet, sleep disorders have received less attention, and there aren't many published findings that link poor sleep to MAFLD [5, 6].

Exercise and nutrition have been demonstrated to be helpful lifestyle therapies for MAFLD prevention and treatment when sufficient weight reduction is accomplished [7]. As a result, this study aims to evaluate the correlation between the lifestyle factors of nutrition, exercise, and sleep quality in individuals with MAFLD and the severity of the condition.

Patients and methods

This cross-sectional analytic study was performed at the outpatient clinic of Endemic Medicine department, Kasr-Al-Ainy Hospital, Cairo University, including 77 patients according to the following inclusion criteria: participants of both sexes aged above 18 years and proved to fulfil the criteria of fatty liver infiltration via abdominal ultrasound. Cases with hepatocellular carcinoma (HCC) and decompensated liver cirrhosis, cases known to have a viral cause hepatitis C virus (HCV), hepatitis B virus (HBV), metabolic disorders (e.g., Wilson's disease, haemochromatosis), or autoimmune causes for liver disease (e.g., autoimmune hepatitis, primary sclerosing cholangitis, and primary biliary cholangitis) were excluded from the study.

Sampling

Sampling type was non-probability convenient sampling including all patients that fit the criteria of fatty liver as detected by ultrasonography according to inclusion and exclusion criteria. A sample size of 77 was calculated using Open Epi version 3, open-source calculator, with anticipated prevalence of sleep disorders in NAFLD patients of 54% and 95% confidence interval [5].

Data collection and study tools

Structured interview questionnaires

A structured Arabic interview questionnaire recorded by the researcher. It was designed to cover four sections: sociodemographic and medical included questions about the following: personal and sociodemographic history, e.g., age, sex, smoking, residence and occupation; medical history (e.g., diabetes mellitus (DM), hypertension, hypertriglyceridemia, and hypercholesterolemia) and family history of fatty liver disease, DM, hypertension, etc.

A standardised questionnaire is applied to evaluate the features of sleep (sleep duration, total time in bed, sleep efficacy, sleep quality and sleep disturbances), called the Pittsburgh Sleep Quality Index (PSQI). There are 19 self-administered questions in it, and the results yield 7 component scores with subscales from 0 to 3. For the purpose of evaluating the quality of sleep, these component values are added together to get a final score that ranges from 0 to 21. "Poor sleepers" are those with a worldwide score greater than 5, while "excellent sleepers" are those with a score of 5 or less. A short sleep duration was determined to be a self-recorded sleep time of less than 6 h each night [5, 8].

Semi-quantitative food frequency questionnaire (FFQ) A validated 32-item semi-quantitative FFQ was utilized to assess each person's typical dietary consumption utilizing the typical serving size for Egyptians. Each food item's planned serving frequency throughout the previous year had to be reported by participants on a daily, weekly, or monthly manner. Each food item's frequency category selection was then translated into a daily consumption. The portion sizes of the foods consumed were converted to grams using standard household measurements. Principal component analysis was used to find the primary eating trends [9–11].

International Physical Activity Questionnaire–Short Form (IPAQ) Detailed history of physical activity (PA) was taken using the International Physical Activity Questionnaire (IPAQ) [12, 13]. Three distinct activity categories, involving vigorous-intensity activities, moderate-intensity activities, and walking, were covered in this questionnaire. Following that, IPAQ assessment computed the metabolic equivalent task (MET) as follows: vigorous MET (minutes/week) = 8.0 × vigorous-intensity activity minutes × vigorous-intensity days, moderate MET (minutes/week) = 4.0 × moderate-intensity activity minutes × moderate days and walking MET (minutes/week) = 3.3 × walking minutes × walking days. Walking, moderate, and vigorous MET (minutes/week) scores add up to the total PA MET (minutes/week). Following the computation of the final MET score, the individuals will be categorised into the following categories:

- Category 1 (low): < 600 MET (minutes/week).
- Category 2 (moderate): ≥ 600 to < 3000 MET (minutes/week).
- Category 3 (high): ≥ 3000 MET (minutes/week).

Ultrasonography Patients whose fatty liver was confirmed by abdominal ultrasound were categorized into three categories rely on the degree of steatosis depending on ultrasound characteristics (the examination was performed in accordance with the manufacturer's recommendations using 3.5 MHz convex linear transducer to assess hepatic steatosis): gradations of liver echogenicity include mild (grade 1); slight increase in liver echogenicity, moderate (grade 2); visualisation of intrahepatic vessels, mild diaphragm impairment, and severe (grade 3), which includes a significant rise in liver echogenicity, poor penetration of the posterior segment of the right lobe of the liver, and poor or no visualization of the diaphragm and hepatic vessels [14].

Anthropometric measurements

1- Weight: using a digital scale, the individuals' body weight in light clothing and without shoes was determined and documented to the closest 0.5 kg [15].
2- Height: the patient's height was determined to the closest 0.1 cm while standing straight up against a wall and without shoes on [15].
3- While standing, the waist circumference was determined midway between the iliac crest and the final rib border.
4- BMI: body weight in kilogrammes was divided by height in square metres (Kg/m^2) to get the individuals' BMI. Standard weight status categories were linked to adult BMI ranges [16].

Data management and statistical methods

The Statistical Package of Social Science software, version 23 (SPSS), was utilized to enter pre-coded data into the computer for statistical analysis. Data were summarized utilizing the mean, standard deviation, range and median with interquartile range (IQR) for quantitative variables. Frequency and percentage were utilized for qualitative variables. Shapiro–Wilk test was used to determine if quantitative variables had a normal distribution. For qualitative data, the chi-square test was utilized to compare the variables. When one or more anticipated cell counts are fewer than five, the Fisher exact test was utilized. The independent *t* test was utilized to determine quantitative variables between two groups when data were normally distributed. When data were not normally distributed, the Mann–Whitney test was utilized. When grades of hepatic steatosis (mild/moderate and severe) were the dependent variable, multiple logistic regression was utilised to identify important predictors. Statistics were regarded significant at a *P* value of ≤ 0.05. Utilizing food composition tables for Egyptian foods from the National Nutrition Institute, nutritional intake assessment for the various macronutrients was done [17].

Ethical consideration

The study protocol and the study tools were revised and approved by Public Health and Community medicine Department, Endemic Medicine Department as well as the Research Ethical Committee (REC), Faculty of Medicine, Cairo University. An informed consent was collected from every participant after enough orientation of the study goals. Participation was voluntary, only those who accepted were involved and the participant had the right to discontinue participation at any time.

As per the Helsinki Declaration, strict privacy and confidentiality were upheld via the data collecting, entry, and analysis processes [18].

Results

This cross-sectional study was performed on 77 cases with MAFLD in a period from February 2021 to January 2022. Among the studied population, grading for liver steatosis due to MAFLD using trans-abdominal ultrasound was done revealing that 36%, 34%, and 30% had liver steatosis grades I (mild), II (moderate) and III (severe) respectively. We further classified the cases into 2 groups (group with mild (I) and the other group with moderate-severe steatosis (II–III)), we found that 63.6% of the studied patients were among the moderate-severe steatosis group.

There was no statistically obvious difference between sociodemographic features of the studied population with grades of liver steatosis as revealed in (Table 1). Lifestyle-related factors of MAFLD for the included patients are illustrated in (Table 2). Hypertension and hyperlipidaemia were markedly greater in individuals with moderate-severe steatosis as the prevalence of hypertension and hyperlipidaemia in those cases was 57.1% and 63.3% respectively ($p=0.002$ and $p=0.042$ respectively). BMI and the waist circumference were markedly greater in cases with moderate-severe steatosis ($p=<0.001$ both BMI and waist circumference). Family history of DM was markedly greater in cases with moderate-severe steatosis ($p=0.023$). Individuals with moderate-severe fatty liver had markedly greater daily caloric and carbohydrates intake than those with mild fatty liver ($p=0.01$ and $p=0.028$ respectively). However, no statistically significant differences were detected among participants regarding the daily proteins and fats intake. In the studied population, the spread of poor sleep quality was markedly higher in patients with moderate-severe fatty liver than those with mild fatty liver ($p=0.029$) with statistically significant lower grade physical activity among

Table 1 Sociodemographic features of MAFLD cases with different grades of liver steatosis (*N* = 77)

Variables	Total (%)	Mild steatosis (*N* = 28) (%)	Moderate-severe steatosis (*N* = 49) (%)	*P* value
Age				0.469
mean ± SD	49.74 ± 10.9	49 ± 11	50 ± 11	
Sex *N* (%)				0.245
Male	24(31.2)	11(39.3)	13(26.5)	
Female	53(68.8)	17(60.7)	36(73.5)	
Residence *N* (%)				*0.193
Rural	12(15.6)	2(7.1)	10(20.4)	
Urban	65(84.4)	26(92.9)	39(79.6)	
Occupation *N* (%)				*0.068
No work/housewife	44(57.1)	11(39.3)	33(67.3)	
Industrial or agricultural worker	9(11.7)	6(21.4)	3(6.1)	
Skilled worker (mechanic…)	7(9.1)	3(10.7)	4(8.2)	
Semiprofessional (typist, clerk…)	16(20.8)	8(28.6)	8(16.3)	
Professional (doctor, lawyer, teacher)	1(1.3)	0(0)	1(2)	

Test of significance chi-square in all qualitative comparisons except with *Fisher's exact test; $P \leq 0.05$ statistically significance

patients with moderate-severe MAFLD ($p = 0.006$). Concerning the lifestyle predictors of steatosis, it was found that high waist circumference increased the probability to develop severe MAFLD by 11% (OR (95% CI) = 1.19 (1.026–1.22)), poor sleep quality increased the risk of severe NAFLD 3 times (OR (95% CI) = 3.871 (1.075–13.933)) and low physical activity increased the risk 4 times (OR (95% CI) = 4.6 (1.195–17.746)) as illustrated in (Table 3). Table 4 and Fig. 1 showed that very bad sleep latency and fairly bad sleep disturbance and daytime dysfunction were significantly higher in moderate-severe steatosis grade 46.9%, 44.9%, and 40.8 versus 17.9% and 14.3%, 21.4 in mild steatosis. In addition, there was a great positive correlation between the levels of habitual sleep effectiveness, disturbed sleep, and daytime impairment and MAFLD steatosis grades where worse sleep quality scores were associated with moderate-severe fatty liver (r 0.300**, 0.338**, and 0.363** respectively). Table 5 showed that habitual sleep effectiveness and daytime impairment were found to be great predictors for MAFLD severity. Very bad habitual sleep efficiency carries three times risk for moderate-severe steatosis (OR (95% CI) = 3.402 (1.403–8.252)) while very bad daytime dysfunction has two times risk (OR (95% CI) = 2.487 (1.374–4.501)). The significance of waist circumference, BMI, physical activity and sleep duration hours is shown in (Fig. 2).

Discussion

Metabolic dysfunction-associated fatty liver disease (MAFLD) is a growing public health issue globally that needs attention to put plans for its control and prevention in nations where the spread is raising [19]. Thus, this study aimed to assess lifestyle determinants (diet, sleep quality and physical activity) among patients with different grades of MAFLD.

As regards the metabolic syndrome, in the current study, both hypertension and hyperlipidemia were markedly linked with greater grades of liver steatosis (57.1%, 63.3% of cases with moderate-severe liver steatosis, $P = 0.002$, $P = 0.042$). In accordance with a cross-sectional study done in Germany where greater grades of hepatic steatosis were significantly linked to greater levels of blood pressure [20]. In accordance with a systematic review, by Oikonomou et al., for all researches that investigated the possible association between hypertension and MAFLD, hypertension was found to be a predictor of new-onset MAFLD diagnosed by ultrasound. This is due to the fact that hypertension causes insulin resistance and renin-angiotensin system-sympathetic nervous system activation [21, 22]. Concerning hyperlipedemia, the same was concluded by the study of Mahaling et al. which observed that elevating levels of MAFLD were significantly linked to raising levels of serum total cholesterol VLDL and LDL and reducing HDL [23]. A cross-sectional Egyptian study done by Rafat et al. has concluded the same results [24]. This could be attributed to the adverse effect of hyperlipidemia on lipoprotein and lipid production in the liver, leading to raised low-density lipoprotein (LDL) and triglycerides (TG) levels and diminished high density lipoprotein (HDL-C) levels that eventually lead to abnormal fatty acid accumulation [25].

Regarding diabetes mellitus, despite that there was no statistically significant difference between the grades of

Table 2 Lifestyle-related factors for MAFLD cases with different grades of liver steatosis (*N* = 77)

Comorbidities	Mild steatosis (*N* = 28)	Moderate-severe steatosis (*N* = 49)	*P* value
Diabetes mellitus (*n* = 20)	5(17.9)	15(30.6)	0.219
Hypertension (*n* = 34)	6(21.4)	28(57.1)	**0.002**
Hyperlipidemia (*n* = 42)	11(39.3)	31(63.3)	**0.042**
Ever smoking (*n* = 13)	6(46.2)	7(53.8)	0.53
BMI (kg/m^2) (mean ± SD)	30.28 ± 5.46	36.18 ± 6.72	****< 0.001**
Waist circumference (cm) (median(IQR))	96 (91:101)	109 (100:124)	**#< 0.001**
Family history	*N*(%)	*N*(%)	
Diabetes mellitus (*n* = 51)	14(50)	37(75.5)	**0.023**
Hyperlipidemia (*n* = 28)	8(28.6)	20(40.8)	0.283
Cardiovascular disease (*n* = 26)	8(28.6)	18(36.7)	0.466
Obesity (*n* = 22)	6(21.4)	16(32.7)	0.294
Fatty liver (28)	10(35.7)	18(36.7)	0.929
Dietary pattern	N(%)	N(%)	
Energy (Kcal)			***0.01**
Needs improvements 50–75% (*n* = 6)	5(17.9)	1(2)	
Acceptable 75–120% (*n* = 49)	19(67.9)	30(61.2)	
Overconsumption > 120% (*n* = 22)	4(14.3)	18(36.7)	
Proteins			*0.619
Acceptable 75–120% (*n* = 4)	2(7.1)	2(4.1)	
Overconsumption > 120% (*n* = 73)	26(92.9)	47(95.9)	
Total fats			*0.151
Unsafe < 50%	0(0)	1(2)	
Needs improvements 50–75% (*n* = 13)	8(28.6)	5(10.2)	
Acceptable 75–120% (*n* = 34)	12(42.9)	22(44.9)	
Overconsumption > 120% (*n* = 29)	8(28.6)	21(42.9)	
Carbohydrates			**0.028**
Needs improvements 50–75% (*n* = 16)	10(35.7)	6(12.2)	
Acceptable 75–120% (*n* = 41)	14(50)	27(55.1)	
Overconsumption > 120% (*n* = 20)	4(14.3)	16(32.7)	
Sleep pattern			
Sleep quality index *N* (%)			**0.029**
Good sleep quality (*n* = 24)	13(46.4)	11(22.4)	
Poor sleep quality (*n* = 53)	15(53.6)	38(77.6)	
Physical activity grade *N* (%)			
Low (*n* = 35)	7(25)	28(57.1)	**0.006**
Moderate (*n* = 42)	21(75)	21(42.9)	

Test of significance chi-square in all qualitative comparisons except with (*) fisher exact test. (**) Independent t test. (#) Mann Whitney U test. $P \leq 0.05$ statistically significant. *BMI* body mass index

liver steatosis and DM, 30.6% of the recruited patients in this study with moderate-severe steatosis were diabetic which is nearly double the prevalence (17.9%) of DM in patients with mild steatosis however there was significantly higher family history of DM in cases with moderate-severe steatosis ($p = 0.023$). In alignment with our findings, a cross-sectional prospective study by Loomba et al. concluded that family history of diabetes, particularly in non-diabetics was linked to NASH and fibrosis in MAFLD [26].

The current research reported great association between obesity and waist circumference with moderate-severe grades of liver steatosis ($P < 0.001$) with a finding that high waist circumference (which reflects central obesity) was a significant predictor for MAFLD severity. The same conclusion was reported by Hasan

Table 3 Lifestyle predictors of grades of MAFLD

	B	***P* value**	**OR**	**95% C.I. for OR**	
				Lower	**Upper**
BMI kg/m^2	0.038	0.634	1.038	0.889	1.213
Waist circumference in cm	0.112	**0.011**	1.119	1.026	1.22
Sleep quality assessment (good/poor)	1.353	**0.038**	3.871	1.075	13.933
Physical activity (moderate/low)	1.527	**0.027**	4.605	1.195	17.746
Energy (Kcal) Acceptable/overconsumption	0.045	0.955	1.046	0.217	5.055
Constant	− 13.705-	0.002	0		

Independent variables: waist circumference in cm, *BMI* body mass index in kg/m^2, sleep quality assessment (poor/good), physical (low/moderate), and energy (Kcal) Acceptable/overconsumption

Dependent: MAFLD grades (mild/moderate and severe)

Table 4 Sleep quality subscores comparison between grades of MAFLD

	Mild steatosis (*N* = 28)	**Moderate-severe steatosis (*N* = 49)**	***P* value**	***r(Spearman correlation)***	**#*P* value**
Subjective sleep quality	N(%)	N(%)	0.798	0.052	0.656
Very good	14(50)	23(46.9)			
Fairly good	10(35.7)	16(32.7)			
Fairly bad	4(14.3)	10(20.4)			
Sleep latency	*N*(%)	*N*(%)	**0.025**	0.203	0.077
Very good	12(42.9)	18(36.7)			
Fairly good	5(17.9)	2(4.1)			
Fairly bad	6(21.4)	6(12.2)			
Very bad	5(17.9)	23(46.9)			
Sleep duration score	*N*(%)	*N*(%)	0.607	− .060-	0.602
Very good	9(32.1)	16(32.7)			
Fairly good	6(21.4)	16(32.7)			
Fairly bad	11(39.3)	13(26.5)			
Very bad	2(7.1)	4(8.2)			
Habitual sleep efficiency	*N*(%)	*N*(%)	0.072	.300	**0.008**
Very good	18(64.3)	17(34.7)			
Fairly good	8(28.6)	21(42.9)			
Fairly bad	2(7.1)	9(18.4)			
Very bad	0(0)	2(4.1)			
Sleep disturbance	***N*(%)**	***N*(%)**	**0.006**	.338	**0.003**
Very good	3(10.7)	1(2)			
Fairly good	21(75)	26(53.1)			
Fairly bad	4(14.3)	22(44.9)			
Sleep medication use	***N*(%)**	***N*(%)**	1	0.087	0.453
No	28(100)	48(98)			
Yes	0(0)	1(2)			
Daytime dysfunction	***N*(%)**	***N*(%)**	**0.013**	.363	**0.001**
Very good	13(46.4)	7(14.3)			
Fairly good	7(25)	12(24.5)			
Fairly bad	6(21.4)	20(40.8)			
Very bad	2(7.1)	10(20.4)			

* Test of significance chi-square $P \leq 0.05$ statistically significant

** Spearman correlation test

p value of Spearman correlation test

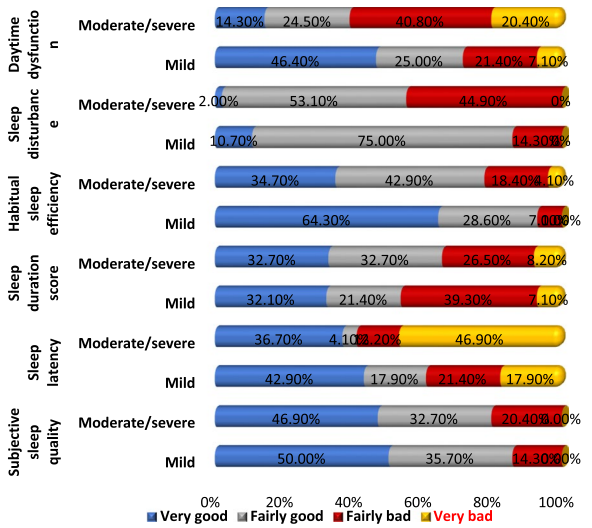

Fig. 1 Comparison of Pittsburg sleep quality index (PSQI) scores and grades of MAFLD

Table 5 Sleep quality subscores predictors of grades of MAFLD

	B	*P* value	OR	95% C.I. for OR	
				Lower	Upper
Subjective sleep quality	−.876-	0.063	0.416	0.166	1.047
Habitual sleep efficiency	1.224	**0.007**	3.402	1.403	8.252
Daytime dysfunction	0.911	**0.003**	2.487	1.374	4.501
Constant	−.805-	0.093	0.447		

Variable(s) entered on step 1: subjective sleep quality, sleep duration score, sleep latency, habitual sleep efficiency, sleep medication usage, sleep disturbance, and daytime dysfunction. *R* square 0.223

NB the variables entered in the model as scores 0 = very good, 1 = fairly good, 2 = fairly bad, 3 = very bad

et al. where BMI and waist circumference were markedly linked to the different grades of steatosis [27]. This also agreed with Shao et al.which concluded that waist circumference was a significant predictor for MAFLD severity in obese and overweight MAFLD cases [28]. A meta-analysis of 8 retrospective and13 prospective studies illustrated that compared to normal weight individuals, obesity independently resulted in a 3.5-fold high risk of developing MAFLD. It also concluded an apparent dose-dependent association between BMI and N = MAFLD risk (per 1-unit increment in BMI: RR = 1.20, 95%CI 1.14 to 1.26, $P < 0.001$) [29]. This may be due to the fact that there is a close association between obesity and the development of MAFLD and its severity due to insulin resistance and alteration in fatty acid metabolism [30].

On the other hand, many studies concluded that MAFLD can occur in non-obese individuals, and it needs careful evaluation and follow-up [31–33]. Lean MAFLD can be attributed to genetic factors.

The relationship between diet and the development of MAFLD is complicated and goes beyond total calorie consumption as diet composition is more important factor [34]. The mechanism by which diet causes MAFLD is through its effect on liver lipogenesis and insulin resistance [4, 35]. Also, excessive ingestion of carbohydrates is a major stimulus for hepatic denovo lipogenesis with more incidence of MAFLD than consumption of dietry fat intake [36]. In this study, individuals with moderate-severe liver steatosis had markedly greater daily caloric and carbohydrates intake than those with mild fatty liver ($P = 0.01$ and $P = 0.028$ respectively). Among participants, 72.4% and 64.4% of those with moderate-severe steatosis over consumed fats and proteins respectively versus 27.6% and 35.6% of those with mild steatosis. However, no statistically significant differences were identified between participants regarding the daily proteins and fats intake ($P = 0.619$ and $P = 0.151$ respectively). These outcomes match with those of Gonzalez et al. where the relation between steatosis grade and the daily caloric and carbohydrate intake was significant confirming that less calories and less carbohydrate in the diet are linked to less fat in the liver of the cases with MAFLD [37]. On the other hand, Lang and colleagues in Germany had concluded that higher intake of dietary protein was linked to both disease severity and activity in cases with MAFLD [38]. Matching the recommendation of AISF which favors the approach to the Mediterranean diet that includes decreased intake of industrial and refined sugars and this reduces hepatic fat content and decrease cardiovascular risk for MAFLD [39].

Physical inactivity is a unique predisposing factor for MAFLD and its severity regardless of body weight because it is linked to metabolic syndrome and insulin resistance [40]. In the current research, cases with moderate-severe steatosis revealed markedly lower MET than those with mild grade. Physical activity was identified to be a great predictor for MAFLD severity where individuals with low physical activity were four times more liable to develop severe MAFLD. According to the research of Vilar-Gomez et al. MAFLD risk was lower in physically active (≥600 metabolic equivalent of task (MET) min/week) versus inactive individuals (<600 MET min/week) (OR 0.71, $p = 0.043$) [41]. This association illustrates the protective impact of physical activity.

Owing to the risk factors for development of MAFLD, AASLD recommended a mixture of a hypocaloric diet (daily decrease by 500–1,000 kcal), daily protein intake of 1.2–1.5 g/kg of body weight/day together with moderate-intensity exercise to provide sustained weight loss

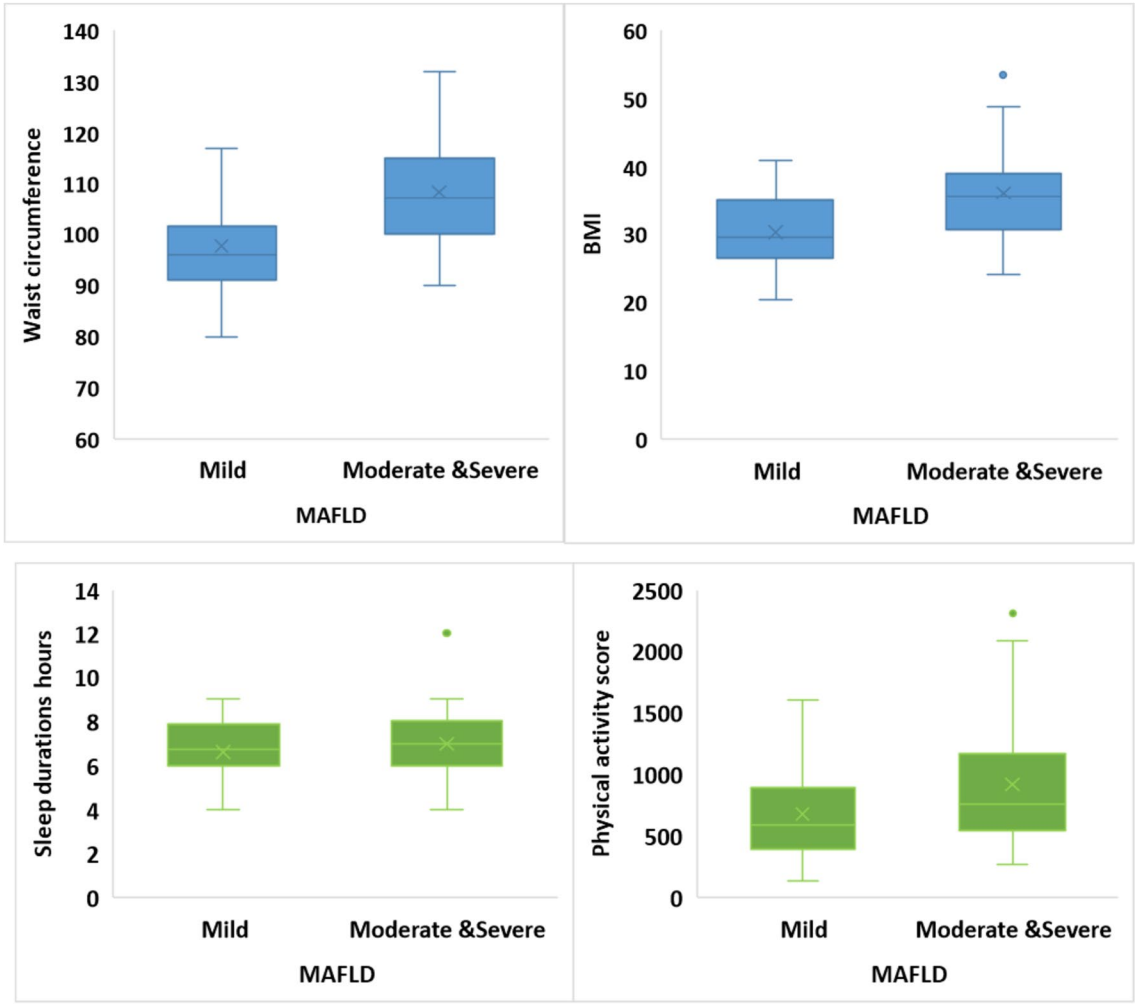

Fig. 2 Lifestyle determinant (BMI, waist circumference, physical activity score, and sleep duration) and grades of MAFLD

(7–10% loss target) over time thus reducing hepatic steatosis and regression of fibrosis [42].

The current research revealed that the spread of poor sleep quality was significantly greater in patients with moderate-severe grade of steatosis (71.7%, $P=0.029$) with significantly worse scores for sleep latency, sleep disturbance and daytime dysfunction (46.9% very bad, 44.9% and 40.8% fairly bad, respectively) when compared to mild steatosis grade. A significant positive correlation was identified between MAFLD steatosis grades and worse scores of sleep disturbance, habitual sleep efficacy, and daytime dysfunction (r 0.300**, 0.338**, and 0.363** respectively). In Taiwan, Chou et al. study showed comparable results where the spread of poor sleep quality in individuals with moderate-severe liver steatosis was 53.6% [43]. A case control study by Jiahui et al. revealed that liver steatosis degree was positively linked to PSQI score ($r=0.444$, $P<0.001$) [44]. Using the Epworth sleepiness scale, Bernsmeier et al. have concluded that daytime sleepiness was markedly greater in MAFLD cases especially NASH subgroup in comparison to controls (26.5% vs. 13.6%; $p=0.0228$) [45].

The logistic regression analysis in the current research revealed that poor sleep quality ($P=0.038$, OR 3.871), habitual sleep efficiency (OR 3.402, 95%CI 1.403–8.252) and daytime dysfunction (OR 2.487, 95%CI 1.374–4.501) were great predictors for severe MAFLD. These results match those of Jiahui et al. where the multivariate logistic regression analysis revealed that a high degree of somnolence (OR = 5.420, $P<0.001$), poor sleep quality (OR = 8.493, $P<0.001$), and circadian rhythm disturbance (OR = 3.805, $P<0.001$) were predisposing factors for MAFLD [44]. According to Takahashi et al., worse daytime dysfunction scores were linked to higher OR for NAFLD in both females (OR 2.08, 95%CI 1.10–3.92) and males (OR 2.82, 95%CI 1.39–5.75). The ratings for habitual sleep efficacy in women and sleep latency in both sexes were similarly linked to NAFLD [6].

Inadequate sleep and short sleep duration were linked to a variety of negative health results, involving type 2 diabetes mellitus, obesity, and the risk and progression of MAFLD [5]. However, there was no statistically significant correlation between grades of steatosis regarding sleep duration. This could be attributed to the fact that despite the sleep duration was adequate, the sleep quality was poor. Chou et al. study has concluded the same results in men but not in women [43]. The stimulation of the hypothalamic–pituitary–adrenal (HPA) axis that cause the release of stress hormones including catecholamines and cortisol, is the primary mechanism through which sleep quality leads to MAFLD and raises the risk of metabolic syndrome [6].

Limitations

The study has limitation concerning the ability to use fibroscan to measure the degree of hepatic steatosis, which may be considered a point for further research.

Conclusion

The study concluded that the actual significant predictors for MAFLD were waist circumference, poor sleep quality, habitual sleep efficiency, daytime dysfunction, and low physical activity. Thus, controlling lifestyle factors is essential in prevention of MAFLD. Further study is recommended on the usage of non invasive methods of diagnosis of liver steatosis (controlled attenuation parameter) and liver function tests in correlation with ultasound staging of hepatic steatosis severity with follow-up of the lifestyle determinants.

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Authors' contributions
Abeer Attia (AA): analysis, interpretation and conception of data. Nargis Albert Labib (LNA): conception, design, and final revision. Noha Essameldin Elsayed Abdelzaher (ANEE): collection of data and drafting of paper. Sherief Musa (MS): clinical work and revision. Mira Atef (AM): clinical work, drafting of paper, and submission. All authors read and approved the final manuscript.

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Availability of data and materials
The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Declarations

Ethics approval and consent to participate
This research was approved by Public Health and Community medicine Department, Endemic Medicine Department as well as the Research Ethical Committee (REC), Faculty of Medicine, Cairo University.

Competing interests
The authors declare that they have no conflicts of interest.

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