Original Article

Investigating the Impact of Diet, Physical Activity, and Lifestyle on MASLD Risk in Adults in Qatar

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ABSTRACT

Background

Metabolic dysfunction-associated steatotic liver disease (MASLD) outcomes are significantly influenced by dietary habits, lifestyle behaviors, and physical activity.

Aim

This cross-sectional study evaluated the relationship between dietary habits, dietary diversity, physical activity levels, lifestyle behaviors, and their associations with MASLD indicators in Arab adults in Qatar.

Methods

A descriptive cross-sectional study was conducted with 94 participants. Data on demographics, health status, lifestyle, and dietary habits were collected using the Participant's Personal and Dietary Habits Information Questionnaire. Dietary diversity was assessed using the Food Groups Consumption (FGC) score. Physical activity and sleep were evaluated via the Seven-Day Physical Activity Recall form. Descriptive statistics and linear regression were employed to examine associations between MASLD indicators (BMI, lipid profile, liver enzymes, and glucose levels) and dietary habits.

Results

BMI was associated with snacking (P_{trend}=0.049), while the timing of the first meal correlated with total cholesterol (P_{trend}=0.045), low-density lipoprotein (P_{trend}=0.047), and fasting blood sugar (P_{trend}=0.026). An inverse association was detected between the timing of the last meal and high-density lipoproteins (P_{trend}=0.007). Triglyceride levels were associated with both skipped meals (P_{trend}=0.010) and eating out (P_{trend}=0.002). All participants had adequate dietary diversity (FGC score of 101.9), with no differences between food group intakes except for males consuming more fruit than females (P=0.042). Physical activity analysis revealed that female participants had significantly higher levels of moderate-intensity exercise during both weekdays (P=0.014) and weekends (P=0.026), as well as more total MET minutes of moderate-intensity physical activity compared to males (P=0.011).

Conclusion

Dietary habits, such as snacking, meal skipping, meal timing, and eating out, were associated with MASLD-related anthropometric and biochemical indicators. This study provides valuable insights into dietary and lifestyle factors contributing to MASLD and highlights the need for further research with more robust study designs in Qatar.

Keywords

Metabolic-Associated Steatotic Liver Disease; Nonalcoholic fatty liver disease; Dietary Habits; Dietary Diversity; Physical Activity; Lifestyle

INTRODUCTION

Recently, the American Association for the Study of Liver Disease (AASLD) updated the nomenclature of nonalcoholic fatty liver disease (NAFLD) to Metabolic dysfunction-associated steatotic liver disease (MASLD) [1]. The term "metabolic associated" highlights the connection between liver diseases and metabolic abnormalities such as obesity, insulin resistance, dyslipidemia, and hypertension, going beyond the mere accumulation of hepatic fat. MASLD is increasingly recognized as a multi-system disease that affects almost all organs, not just the liver [2,3]. Not only is it associated with a higher mortality rate, but MASLD itself is a risk factor for developing other comorbidities such as type-2 diabetes mellitus (T2DM) and cardiovascular diseases (CVD) [4]. The natural course of the disease may spontaneously progress or regress over time and align with changes in metabolic state [5].

MASLD is quickly becoming the fastest-growing form of chronic liver disease. It affects almost 30% of the world's population, with the Middle East-North African region having the highest prevalence, affecting almost 46% of its residents [6,7]. The rise of MASLD is closely linked to the ongoing obesity

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epidemic worldwide [8]. It is estimated that MASLD is diagnosed in up to 70-90% of people who also suffer from type 2 diabetes (T2DM) or obesity [4].

MASLD is a condition of excessive hepatic fat accumulation not caused by heavy alcohol use or any other identified cause such as medication or genetic disorders [9]. It is defined as the presence of >5% of hepatic steatosis [9]. With time, MASLD can progress to metabolic-associated steatohepatitis (MASH), which is defined as the presence of >5% of hepatic steatosis combined with inflammation and hepatocyte injury [9]. If left untreated, MASLD can progress to MASH in 3-5% of cases and lead to fibrosis and/ or advanced chronic liver disease (ACLD) as well [10,11]. MASLD progresses to ACLD in 20-25% of patients within 10 years and is irreversible, becoming one of the leading causes of liver transplantation [12]. Therefore, preventative measures should be implemented before this stage is reached, especially since it can take years for fibrosis or ACLD to develop.

MASLD is a cardiometabolic disease primarily influenced by environmental and lifestyle factors. Among these, dietary habits such as meal frequency and meal timing, consumption of caffeinated beverages, water intake, and dining outside the home play a significant role in disease progression [13,14]. Dietary diversity also serves as a key indicator of diet quality [15]. Additionally, lifestyle factors such as working hours, sleep duration, smoking, and physical activity are closely tied to the risk and severity of MASLD.

Despite substantial global evidence linking these factors to MASLD and obesity, there is a critical lack of research examining these relationships within Qatar's unique cultural and environmental context. This gap limits the ability to develop effective, locally tailored prevention and intervention strategies. To address this, the primary goal of this cross-sectional study is to evaluate the dietary habits and diversity, physical activity levels, and lifestyle behaviors of Arab adults living in Qatar and to explore their potential associations with MASLD.

METHODS AND MATERIALS

Study Design and Population

The purpose of this descriptive cross-sectional study was to assess the dietary habits and diversity, lifestyle factors, and physical activity among Arab adults diagnosed with MASLD living in Qatar. Participants were selected from patients visiting the liver disease outpatient clinics at Hamad Medical Corporation (HMC) in Doha, Qatar. A convenience sampling technique was used to recruit participants. A total of 150 male and female participants who visited the outpatient clinics were invited to participate in the study. However, after applying the inclusion and exclusion criteria, the final sample size was reduced to 94 participants (Figure 1). Ethical approval and permission to conduct research involving human subjects were requested from HMC and granted by the Institutional Review Board (IRB). IRB approval was also obtained from Qatar University (IRB number QU-IRB 007/2024-EA) (Supplementary Material 1). This study is part of a larger study conducted by Dr Moutaz Derbala and Dr Souraia Ghazouani titled "Long noncoding RNAs (lncRNA) as non-invasive biomarkers of Non-alcoholic fatty liver disease (NAFLD)", protocol number MRC-01-21-033 (Supplementary Material 2).

The inclusion criteria for the study were Arab patients diagnosed with MASLD aged 18 years or older who attender outpatient clinics at HMC. Participants must be able to communicate verbally, provide formal consent by signing the consent form, and not have any conditions requiring special diets. The exclusion criteria included individuals who consume alcohol (more than 20 g/day for men and 30 g/day for women), those with other known liver diseases (such as hepatitis viruses A to E, autoimmune diseases, or Wilson's disease), those who have undergone bariatric surgery, and those taking medications known to induce fatty liver or promote insulin sensitization, such as estrogens, amiodarone, methotrexate, tamoxifen, and glitazones. In addition, pregnant and lactating women, individuals with type 1 diabetes, other liver or kidney diseases, or cancer were also excluded from the study.

The diagnosis of MASLD was confirmed through ultrasonography or elastography. Participants were eligible for the study if they exhibited any mild fatty liver infiltration on ultrasonography.

DATA COLLECTION

Participant Consent and Confidentiality

Oral and written consent was obtained from all participants involved in the study, with a copy of the consent form provided to each participant (Supplementary Material 3). A witness was also present to sign the document. The consent form

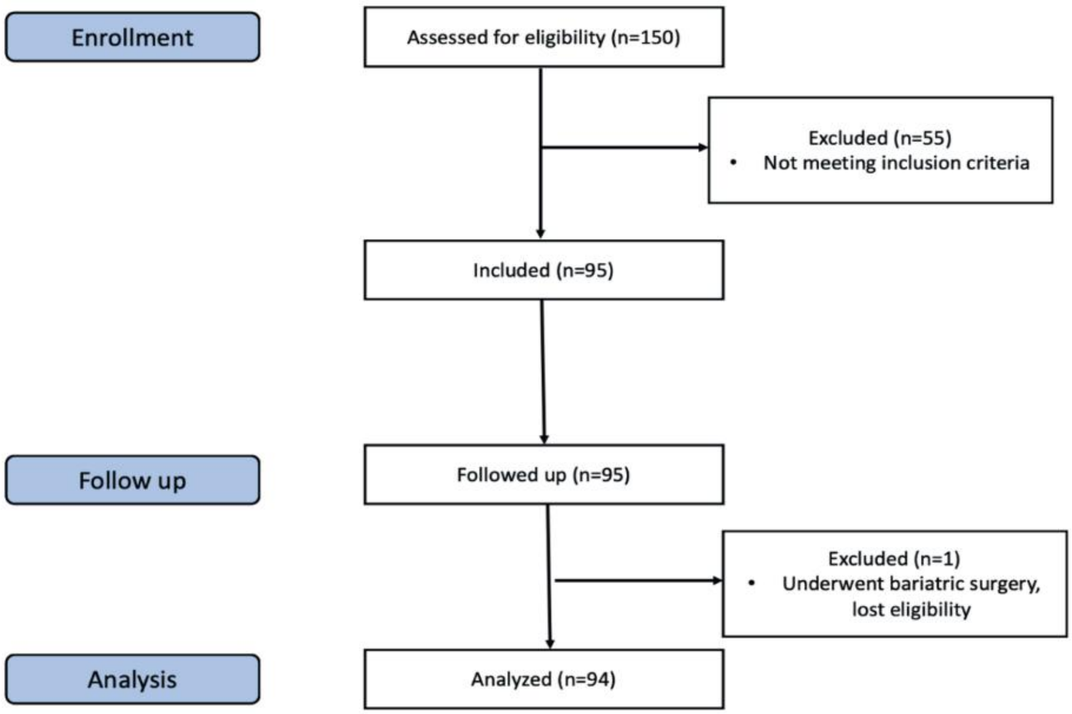

Figure 1. Schematic flow chart of the research plan

clearly outlined the research objectives and aims of the study. Participants were fully informed about the data collection procedures, their expected involvement, the content of the questionnaires, and the estimated time required for the interview. Additionally, they were made aware of their right to withdraw from the study at any time.

To ensure confidentiality, the study data were stored as password-protected digital files, and all participant information was anonymized by assigning each individual a unique identification number. Access to the data was strictly limited to the researchers involved in the study. Participants were also informed that the collected data might be used for secondary analysis.

Participant Personal and Dietary Information Form

All information obtained from the participants was gathered through questionnaires administered by a dietitian. Three questionnaires were used: the Participant's Personal and Dietary Habits Information Form, the Food Groups Consumption (FGC) Score to assess dietary diversity, and the Stanford 7-day Physical Activity Recall (PAR). The Participant's Personal and Dietary Habits Information form included general information such as age, sex, marital status, educational level, nationality (Qatari vs. Non-Qatari), shiftwork, and years living in Qatar (Supplementary Material 4). The Participant's Personal and Dietary Habits Information Form also assessed some lifestyle and dietary habits including smoking, meal timings, meal skipping, number of snacks, eating out, eating alone, frequency of caffeine consumption from coffee or tea, and water intake. Three 24-hour dietary recalls (two weekdays and one weekend) were taken from each participant by another researcher to estimate energy intake and use for adjustment in statistical analysis (Supplementary Material 5). Participants were asked to recall their last meal and go backwards in time to create a quick list of all foods consumed during the last 24 hours, following the multiple-pass 24-hour recall method [16]. Food models were provided as visual aids to help participants accurately quantify food portions and estimate portion sizes.

Dietary Diversity

Dietary diversity was assessed using the FGC score put forth by the Food and Agriculture Organization (FAO) and endorsed by the World Health Organization (WHO) (Supplementary Material 6) [17]. This tool estimates usual household consumption over the last seven days. Each food group is given a standardized weight based on its nutritional importance, which is multiplied and added to calculate a final score [17]. For wealthier countries (defined as those where sugar and oil are consumed daily), a score above 42 shows acceptable food diversity, 28 to 42 shows borderline dietary diversity, and a score lower than 28 shows poor dietary diversity for that household [17,18]. The FGC score was originally developed and validated to assess food security at the household level [18].

Physical Activity

The 7-day PAR questionnaire, developed by Sallis et al., was used to estimate sleep and physical activity levels (Supplementary Material 7). The 7-day PAR questionnaire was previously used with adult populations and was taken to assess sleep and all physical activity, including work and non-work related, over the past seven days [19]. Participants were asked to report the number of hours they spent engaging in light, moderate, high, and very-high intensity exercises [20]. Moderate-intensity activities may range from housework including vacuuming, laundry, and yoga, while very-high intensity may include activities such as football, boxing, and continuous high-speed swimming [20]. All reported activities were converted into metabolic equivalents (METs) to better quantify and express the amount of energy expelled doing various levels of physical activity as it differs from person to person. It allows the standardized expression of physical activity expenditure as a multiple of the resting metabolic rate [21]. MET minutes were calculated by multiplying the MET level of a certain activity by the minutes of exercise per day by the number of days that activity took place in the past week [21]. The total MET minutes for activities were then summed to provide a weekly measure of energy expenditure.

As per the WHO criteria for the recommended physical activity level for adults [22], level of physical activity in MET minutes per week can be classified as low (less than 600 MET minutes), moderate (600 to 3,000 MET minutes) and high (more than 3,000 MET minutes). Minutes of light-intensity exercise were multiplied by the factor 1.5, moderate-intensity exercise was multiplied by the factor 3, and high-intensity exercise was multiplied by the factor 5. Total MET minutes were added up for each participant. The 7-day PAR questionnaire has been tested and used widely in research studies. It has been recognized as a valid and reliable tool to be used in our study [20,23].

Anthropometric Measurements

Anthropometric measurements were collected in person by a trained dietitian. Body weight was measured using an electronic scale with the participant barefoot and wearing light clothes. Standing height was recorded using a stadiometer, with participants standing upright, shoulders relaxed, and arms hanging naturally at their sides. BMI was calculated as weight in kilograms divided by height in meters squared (kg/m^2) [24]. Waist circumference was measured to the nearest centimeter using a tailored measuring tape, positioned midway between the lower rib margin and the iliac crest in a horizontal plane [24,25].

Biochemical Values

Biochemical values were retrieved from participants' online medical records. Biochemical analyses were previously carried out in the HMC laboratory by a specialized lab technician as a routine check-up. Biochemical values and their ranges included hemoglobin (males: 14-18 mg/dL; females 12-16 mg/dL), ferritin (males: 50-553 µg/L; females: 18-340 µg/L), fasting blood sugar (3.3-5.5 mmol/L), glycosylated hemoglobin (HbA1c) (<5.7%), total cholesterol (<5.2 mmol/L), triglycerides (<1.7 mmol/L), high-density lipoprotein (HDL)-cholesterol (males: >1 mmol/L; females: >1.3 mmol/L), low-density lipoprotein (LDL)-cholesterol (< 3.36 mmol/L), alkaline phosphatase (ALK) (males: 40-129 U/L; females 33.5-129 U/L), alanine aminotransferase (males: 0-40 U/L; females 0-30 U/L), vitamin D (>20 ng/mL), vitamin B12 (148-664), thyroid stimulating hormone (TSH) (0.3-4.2 mIU/L), free thyroxine test (FT4) (11-23.3 pmol/L) and uric acid (202-416 µmol/L).

Statistical Analysis

Statistical analysis was performed using Stata 18 SE. All continuous data are presented as mean ± standard deviation and all categorical data are presented as number observed and frequency of observation. Descriptive analysis of all variables was stratified by sex. An independent sample t-test was used to compare continuous variables between males and females. Chi-squared test was employed to assess differences in categorical variables. Linear regression analysis was conducted to identify any associations between predictor variables and outcomes, with a significance level set at *P*< 0.05. Model 1 was unadjusted, and Model 2 was adjusted for age, sex, education level, presence of chronic diseases, special diets, energy intake, and physical activity.

RESULTS

A total of 150 participants were invited to participate in the study, but only 94 met the eligibility criteria and agreed to participate. Table 1 summarizes the demographic characteristics of the participants. Females constituted the majority of the sample (63.8%). Therefore, the data were stratified by sex for analysis. Most participants were of non-Qatari nationality (75.5%), with 20 females and only three males from the Qatari group. Most participants were married (88.3%). Almost 70% of the participants had an education level above high school, with males having a significantly higher education level (*P*=0.03). Employment status showed significant differences, with an overall employment rate of 63.8%; males were more likely to be employed than females (*P*< 0.01). Most participants (80.0%) worked only the morning shift, ranging anywhere from 5:00 AM to 4:00 PM.

Table 1. Socioeconomic Characteristics of Study Participants Presented as Frequency

	Male (n=34)	Female (n=60)	Total (n=94)	*P*-value
		n (%)		
Nationality				
- Qatari	3 (8.8)	20 (33.3)	23 (24.5)	0.008
- Non-Qatari	31 (91.2)	40 (66.7)	71 (75.5)	
Marital status				
- Single	1 (2.9)	3 (5.0)	4 (4.3)	0.548
- Married	32 (94.1)	51 (85.0)	83 (88.3)	
- Divorced	1 (2.9)	4 (6.7)	5 (5.3)	
- Widowed	0 (0.0)	2 (3.3)	2 (2.1)	
Education level				
- High school or less	6 (17.6)	22 (36.7)	28 (29.8)	0.030
- Diploma	6 (17.6)	16 (26.7)	22 (23.4)	
- Bachelor or above	22 (64.7)	22 (36.7)	44 (46.8)	
Employment				
- Yes	32 (94.1)	28 (46.7)	60 (63.8)	<0.001
- No	2 (5.9)	32 (53.3)	34 (36.2)	
Work Timings				
- Morning shift	25 (78.1)	23 (82.1)	48 (80.0)	0.180
- Evening shift	0 (0.0)	2 (7.1)	2 (3.3)	
- Split shift	7 (21.9)	3 (10.7)	10 (16.7)	

All values are listed as number observed (frequency of observation)
Statistical significance was set at P < 0.05.

Table 2 presents health-related characteristics stratified by sex. No significant difference was observed in age between males and females, with an average age of 47.9 years for males and 50.6 years for females. However, males had a significantly higher average weight (96.5 kg) compared to females (85.4 kg, *P*=0.003). The mean BMI for all participants was 33.1 kg/m², with a marginally significant difference between sexes (*P*=0.077). Notably, 67.0% of participants were categorized as having an obese BMI.

The diagnosis of MASLD was confirmed via ultrasound. The date of the initial ultrasound was used to estimate the duration of the diagnosis. Most participants had been diagnosed between one and ten years prior, with the most common timeframe being three to five years. Table 2 also outlines the distribution of comorbidities in the sample. Nearly 78% of participants had at least one chronic disease, with cardiovascular disease (CVD) being the most prevalent, followed by T2DM. Smoking status varied significantly by sex, with almost half of the males identified as either former or current smokers, while the majority of females reported never having smoked (*P*<0.001). Biochemical values for all participants were routinely collected during follow up visits to outpatient clinics and retrieved from their medical records. These values are also summarized in Table 2. Significant differences between males and females were observed in several biochemical parameters, including blood hemoglobin (*P*< 0.001), ferritin (*P*=0.003), triglycerides (*P*=0.002), HDL (*P*< 0.001), FT4 (*P*=0.024) and uric acid (*P*=0.002). The reference ranges for hemoglobin, ferritin, and HDL differ by sex (hemoglobin: males: 14-18 mg/dL; females 12-16 mg/dL; ferritin: males: 50-553 mcg/L; females: 18-340 mcg/ L; HDL: males: >1 mmol/L; females: >1.3 mmol/L). These differences align with the distinct physiological and metabolic profiles of males and females.

Table 2. **Anthropometric, Biochemical and Health-related Characteristics of the Study Patients**

Variables	Male (n=34)	Female (n=60)	Total (n=94)	*P*-value
	Mean ± SD			
Age (years)	47.9 (10.4)	50.6 (9.6)	49.6 (9.9)	0.216
Weight (kg)	96.5 (16.3)	85.4 (17.2)	89.4 (17.6)	0.003
BMI (kg/m²)	31.6 (5.0)	33.9 (6.5)	33.1 (6.1)	0.077
Waist circumference (cm)	111.1 (13.1)	101.7 (21.2)	105.1 (19.2)	0.037
Work (hours per day)	7.8 (1.9)	6.8 (1.8)	7.3 (1.9)	0.036
Hgb (mg/dL)	14.6 (1.6)	12.7 (1.4)	13.3 (1.7)	<0.001
Ferritin (µg/L)	171.7 (212.3)	70.5 (66.9)	104.7 (141.7)	0.003
FBS (mmol/L)	7.0 (2.7)	6.3 (1.7)	6.6 (2.1)	0.169
HbA_{1c} (%)	6.3 (1.3)	6.2 (1.1)	6.2 (1.2)	0.605
Cholesterol (mmol/L)	4.7 (1.1)	4.9 (1.2)	4.8 (1.2)	0.296
TG (mmol/L)	2.2 (1.1)	1.6 (0.7)	1.8 (0.9)	0.002
HDL (mmol/L)	1.1 (0.4)	1.4 (0.3)	1.3 (0.4)	<0.001
LDL (mmol/L)	2.7 (1.1)	2.9 (1.1)	2.8 (1.1)	0.346
ALK (gm/L)	84.7 (61.9)	86.5 (41.0)	85.9 (49.2)	0.862
ALT (U/L)	35.8 (20.2)	29.6 (28.0)	31.9 (25.5)	0.261
AST (U/L)	25.4 (10.1)	22.9 (16.5)	23.8 (14.5)	0.431
Vitamin D (ng/mL)	28.5 (13.0)	28.1 (12.1)	28.2 (12.3)	0.886
Vitamin B12 (pg/mL)	312.1 (100.8)	378.8 (252.2)	356.8 (216.0)	0.183
TSH (mIU/L)	1.9 (1.3)	2.8 (5.7)	2.5 (4.7)	0.408
FT4 (pmol/L)	15.5 (1.6)	14.5 (2.1)	14.8 (2.0)	0.024
Uric acid (µmol/L)	376.6 (105.8)	301.5 (69.6)	326.1 (89.6)	0.002
	n (%)			
BMI Levels				
- Normal	3 (8.8)	3 (5.0%)	6 (6.4)	0.763
- Overweight	9 (26.5)	16 (26.7)	25 (26.6)	
- Obese	22 (64.7)	41 (68.3)	63 (67.0)	
Presence of chronic diseases				
- Yes	25 (73.5)	48 (80.0)	73 (77.7)	0.469
- No	9 (26.5)	12 (20.0)	21 (22.3)	
Prediabetes				
- Yes	32 (94.1)	48 (80.0)	80 (85.1)	0.065
- No	2 (5.9)	12 (20.0)	14 (14.9)	
T2DM				
- No	17 (50.0)	36 (60.0)	53 (56.4)	0.348
- Yes	17 (50.0)	24 (40.0)	41 (43.6)	
CVD				
- No	13 (38.2)	26 (43.3)	39 (41.5)	0.630
- Yes	21 (61.8)	34 (56.7)	55 (58.5)	
HTN				
- No	22 (64.7)	41 (68.3)	63 (67.0)	0.719
- Yes	12 (35.3)	19 (31.7)	31 (33.0)	
Thyroid disease				
- No	32 (94.1)	50 (83.3)	82 (87.2)	0.132
- Yes	2 (5.9)	10 (16.7)	12 (12.8)	
Total chronic diseases				
- None	9 (26.5)	12 (20.0)	21 (22.3)	0.861
- One chronic disease	7 (20.6)	17 (28.3)	24 (25.5)	
- Two chronic diseases	8 (23.5)	12 (20.0)	20 (21.3)	
- Three chronic diseases	9 (26.5)	18 (30.0)	27 (28.7)	
- More than three chronic diseases	1 (2.9)	1 (1.7)	2 (2.1)	
Smoker				
- Yes	11 (32.4)	1 (1.7)	12 (12.8)	<0.001
- No	16 (47.1)	52 (86.7)	68 (72.3)	
- Former smoker	7 (20.6)	7 (11.7)	14 (14.9)	
MASLD diagnosis				
- Less than one year	11 (32.4)	8 (13.3)	19 (20.2)	0.135

Variables	Male (n=34)	Female (n=60)	Total (n=94)	*P*-value
- One to less than years	8 (23.5)	13 (21.7)	21 (22.3)	
- Three to less than five years	9 (26.5)	18 (30.0)	27 (28.7)	
- Five to less than ten years	5 (14.7)	20 (33.3)	25 (26.6)	
- More than ten years	1 (2.9)	1 (1.7)	2 (2.1)	

BMI categorized using WHO criteria
Abbreviations: Hgb: Hemoglobin; FBS: Fasting blood sugar; HbA_{1c}: Hemoglobin A1C; TG: Triglycerides; HDL: High-density lipoprotein; LDL: Low-density lipoprotein; ALK: Alkaline phosphatase; ALT: Alanine transaminase; AST: Aspartate aminotransferase; TSH: Thyroid stimulating hormone; FT4: Free thyroxine test; BMI: Body mass index; Kg: Kilograms; T2DM: Type 2 diabetes mellitus; CVD: Cardiovascular disease; HTN: Hypertension; MASLD: Metabolic associated steatotic liver disease.
Statistical significance was set at P < 0.05.

As shown in Table 3, most participants (81.9%) reported not following any specific diet. Over half (56.4%) consumed only two meals per day, with notable differences in meal exclusion: males most frequently skipped breakfast, while females more frequently skipped dinner (*P*=0.021). Regarding meal timings, most males (20 out of 34) had their first meal before 10 AM, whereas females typically had their first meal between 10:00 AM and 12:00 PM. The majority of participants in both groups reported having their last meal of the day between 8:00 PM and 10:00 PM. Snacking patterns varied, with 44.1% of males consuming one snack per day, compared to 45.0% of females who consumed two snacks per day. Coffee or tea consumption was common, with nearly half of the participants (46.8%) drinking it one to two times daily. Males reported higher consumption levels than females (*P*=0.032). When it came to sugar added to coffee or tea, approximately half of the participants drank it unsweetened, while the other half added between half a teaspoon to three teaspoons per serving. The average amount of sugar added across both groups was three-fourths of a teaspoon. Eating out, defined as meals consumed at restaurants or ordered as takeout or delivery, was reported by most participants as occurring once per week (40.4%). Most participants reported not eating alone for the majority of their meals, both on weekdays (60.6%) and weekends (83.0%). A significant difference in water consumption was observed between the two groups, with males consuming more water than females (*P*=0.002).

Table 3. Reported Dietary Habits of the Study Participants

Variables	Male (n=34)	Female (n=60)	Total (n=94)	*P*-value
	n (%)			
Special Diets				
- Yes	6 (17.6)	11 (18.3)	17 (18.1)	0.934
- No	28 (82.4)	49 (81.7)	77 (81.9)	
Meals consumed per day				
- One meal	3 (8.8)	4 (6.7)	7 (7.4)	0.269
- Two meals	23 (67.6)	30 (50.0)	53 (56.4)	
- Three meals	8 (23.5)	25 (41.7)	33 (35.1)	
- More than three meals	0 (0.0)	1 (1.7)	1 (1.1)	
Excluded meals				
- Breakfast	15 (57.7)	6 (17.6)	21 (35.0)	0.021
- Lunch	2 (7.7)	4 (11.8)	6 (10.0)	
- Dinner	6 (23.1)	16 (47.1)	22 (36.7)	
- Breakfast/ lunch	0 (0.0)	4 (11.8)	4 (6.7)	
- Lunch/ dinner	0 (0.0)	1 (2.9)	1 (1.7)	
- Breakfast/ dinner	3 (11.5)	3 (8.8)	6 (10.0)	
Last meal timing				
- 4 PM to < 6 PM	3 (8.8)	4 (7.7)	7 (8.1)	0.157
- 6 PM to < 8 PM	6 (17.6)	9 (17.3)	15 (17.4)	
- 8 PM to < 10 PM	13 (38.2)	29 (55.8)	42 (48.8)	
- 10 PM to < 12 PM	11 (32.4)	6 (11.5)	17 (19.8)	
- After 12 PM	1 (2.9)	4 (7.7)	5 (5.8)	
Number of snacks per day				
- Never	3 (8.8)	6 (10.0)	9 (9.6)	0.340
- One	15 (44.1)	19 (31.7)	34 (36.2)	
- Two	13 (38.2)	27 (45.0)	40 (42.6)	
- Three	3 (8.8)	3 (5.0)	6 (6.4)	
- More than three	0 (0.0)	5 (8.3)	5 (5.3)	
Number of coffee/teas per day				
- Never	1 (2.9)	8 (13.3)	9 (9.6)	0.032
- One to two times	14 (41.2)	30 (50.0)	44 (46.8)	
- Two to three times	4 (11.8)	12 (20.0)	16 (17.0)	
- Three to four times	5 (14.7)	5 (8.3)	10 (10.6)	

Variables	Male (n=34)	Female (n=60)	Total (n=94)	*P*-value
	n (%)			
- More than four times	10 (29.4)	5 (8.3)	15 (16.0)	
Sugar added to coffee/ tea				
- None	14 (48.3)	29 (50.0)	43 (49.4)	0.144
- Less than one tsp	3 (10.3)	1 (1.7)	4 (4.7)	
- One to two tsp	11 (37.9)	23 (39.6)	34 (39.1)	
- More than two tsp	1 (3.4)	5 (8.6)	6 (6.8)	
Eating out				
- Less than one time per month	5 (14.7%)	14 (23.3%)	19 (20.2%)	0.593
- Once weekly	15 (44.1%)	23 (38.3%)	38 (40.4%)	
- Two to six times per week	9 (26.5%)	18 (30.0%)	27 (28.7%)	
- Everyday	5 (14.7%)	5 (8.3%)	10 (10.6%)	
Water per day				
- Half a liter	0 (0.0)	11 (18.3)	11 (11.7)	0.002
- One liter	5 (14.7)	16 (26.7)	21 (22.3)	
- One and a half liters	8 (23.5)	14 (23.3)	22 (23.4)	
- Two liters	9 (26.5)	15 (25.0)	24 (25.5)	
- Two and a half liters	5 (14.7)	4 (6.7)	9 (9.6)	
- Three liters	4 (11.8)	0 (0.0)	4 (4.3)	
- More than three liters	3 (8.8)	0 (0.0)	3 (3.2)	
Meals alone on weekdays				
- Yes	11 (32.4)	26 (43.3)	37 (39.4)	0.295
- No	23 (67.6)	34 (56.7)	57 (60.6)	
Meals alone on weekends				
- Yes	5 (14.7)	11 (18.3)	16 (17.0)	0.653
- No	29 (85.3)	49 (81.7)	78 (83.0)	

All values are presented as number observed (frequency of observation)
Abbreviations: tsp: teaspoon.
Statistical significance was set at P < 0.05.

Linear regression analysis was performed to assess any associations between dietary habits and BMI, a key predictor of MASLD (Table 4). After adjusting for confounders, a significant association was observed between BMI and the number of snacks consumed per day (P_{trend}=0.049). No other dietary habits showed significant associations with BMI.

Table 4. Association between BMI and certain dietary habits

	Model 1		Model 2	
	(Coef. (95%))	P_{trend} Value	(Coef. (95%))	P_{trend} Value
Meals consumed per day		0.705		0.496
- One meal	-		-	
- Two meals	0.41 (-4.50-5.31)		-0.83 (-6.16-4.49)	
- Three meals	-0.68 (-5.75-4.40)		-1.93 (-7.60-3.74)	
- More than three meals	4.84 (-8.19-17.88)		1.34 (-13.71-16.40)	
Excluded meals		0.936		0.768
- Breakfast	-		-	
- Lunch	3.74 (-1.94-9.41)		2.85 (-5.72-11.43)	
- Dinner	1.55 (-2.19-5.30)		0.67 (-4.49-5.83)	
- Breakfast/ lunch	0.84 (-5.86-7.53)		-0.43 (-8.98-8.11)	
- Lunch/ dinner	-0.51 (-13.07-12.04)		-0.38 (-16.08-15.33)	
- Breakfast/ dinner	0.10 (-5.58-5.78)		-0.68 (-7.71-6.35)	
Last meal timing		0.218		0.062
- 4 PM to < 6 PM	-		-	
- 6 PM to < 8 PM	5.54 (0.08-11.00)		3.98 (-1.97-9.92)	
- 8 PM to < 10 PM	2.95 (-1.93-7.82)		1.31 (-3.88-6.49)	
- 10 PM to < 12 PM	2.56 (-2.80-7.92)		2.55 (-3.17-8.26)	
- After 12 PM	10.15 (3.17-17.14)		11.83 (4.38-19.28)	
Number of snacks per day		**0.020**		**0.049**
- Never	-		-	
- One	2.89 (-1.57-7.35)		3.51 (-1.54-8.55)	

	Model 1		Model 2	
	(Coef. (95%))	P_{trend} Value	(Coef. (95%))	P_{trend} Value
- Two	5.00 (0.61-9.39)		5.07 (-0.01-10.16)	
- Three	4.88 (-1.39-11.15)		6.09 (-0.94-13.12)	
- More than three	5.92 (-0.72-12.56)		5.56 (-1.62-12.74)	
Number of coffee/ tea per day		0.498		0.880
- Never	-		-	
- One to two times	1.14 (-3.22-5.50)		2.30 (-2.83-7.43)	
- Two to three times	2.63 (-2.34-7.59)		4.34 (-1.41-10.08)	
- Three to four times	-3.33 (-8.80-2.15)		-0.97 (-7.27-5.33)	
- More than four times	0.59 (-4.44-5.61)		2.11 (-4.10-8.33)	
Sugar added to coffee/tea.		0.394		0.570
- None	-		-	
- Less than one tsp	-1.03 (-8.08-6.01)		-1.25 (-9.41-6.90)	
- One to two tsp	2.24 (-0.46-4.93)		1.96 (-1.20-5.13)	
- More than two tsp	-1.90 (-7.04-3.24)		-2.75 (-9.12-3.62)	
Eating out		0.235		0.119
- Less than 1/ month	-		-	
- One time per week	1.00 (-2.40-4.40)		1.70 (-2.15-5.56)	
- Two to six times per week	2.77 (-0.85-6.40)		3.95 (-0.12-8.02)	
- Daily	1.33 (-3.40-6.06)		2.12 (-3.52-7.76)	
Water per day		0.203		0.631
- Half a liter	-		-	
- One liter	-0.09 (-4.66-4.48)		0.06 (-5.00-5.13)	
- One and a half liters	-2.11 (-6.64-2.42)		-2.09 (-7.26-3.09)	
- Two liters	-1.52 (-5.99-2.95)		-1.61 (-6.90-3.68)	
- Two and a half liters	-3.54 (-9.06-1.98)		-2.77 (-9.33-3.78)	
- Three liters	-0.69 (-7.86-6.48)		1.87 (-6.71-10.45)	
- More than three liters	-2.96 (-10.96-5.03)		-0.90 (-10.14-8.34)	
Meals alone on weekdays	2.08 (-0.45-4.60)	0.106	3.11 (-0.20-6.43)	0.065
Meals alone on weekends	-0.93 (-4.25-2.40)	0.581	2.43 (-0.40-5.25)	0.091

Model 1 was unadjusted.
Model 2 was adjusted for age, sex, education, presence of chronic diseases, special diets, energy intake, and physical activity.
Bold font indicates statistical significance of $P< 0.05$

Linear regression was also conducted to explore associations between first and last meal timings and MASLD biochemical indicators. For first meal timings, significant associations were observed with FBS (P_{trend}=0.026), cholesterol (P_{trend}=0.045), and LDL (P_{trend}=0.047) after adjusting for confounders (Supplementary Material 8). For last meal timing, a significant association was found with HDL (P_{trend}=0.007) after adjustment for all confounders. Initial significance was noted in FBS (P_{trend}=0.047) and TG (P_{trend}=0.044) with basic confounder adjustments; however, this significance disappeared after further adjustment for physical activity and energy intake (Supplementary Material 9). Further analysis assessed the impact of excluded meals (breakfast or dinner) and eating out on MASLD biochemical indicators. Triglycerides were significantly associated with both excluding meals (P_{trend}=0.010) and eating out (P_{trend}=0.002) after adjusting for confounders (Supplementary Material 10 and 11, respectively).

The dietary diversity assessment findings of the study participants are illustrated in Table 5. The food groups assessed included cereals and starches such as rice and bread, white tubers and roots such as potatoes and carrots, non-starchy vegetables, fruit, eggs, pulses and nuts, dairy products, fats and oils, sweets, spices and herbs, meat including red meats and chicken, and fish and other seafood. Across all participants, the least consumed food groups were fish and seafood (1.4 times per week), white tubers and roots (2.3 times per week), and pulses and nuts (2.7 times per week). Conversely, the most consumed groups included fats and oils (daily consumption), spices and herbs (6.8 times per week), and cereals and starches (6.8 times per week). A significant difference in fruit intake between males and females was reported (*P*=0.042). Males had an FGC score of 102.3 while females had an average score of 101.7, showing no significant difference between both groups. An acceptable FGC score is any number above 42, which all 94 participants surpassed, indicating their food was high in diversity.

Table 5. **Dietary diversity assessment of the study patients using the Food Group Diversity Score**

Variable	Male mean (SD)	Female mean (SD)	Total mean (SD)	*P*-value
- Number of meals consumed by household yesterday	2.2 (0.6)	2.3 (0.6)	2.3 (0.6)	0.541
- Number of meals usually consumed	1.4 (0.6)	1.3 (0.7)	1.3 (0.6)	0.631
- Number of times a type of food was consumed during the last week				
- Cereals/ starches	6.6 (1.3)	6.9 (0.6)	6.8 (0.9)	0.140
- White tubers and roots	2.1 (1.7)	2.5 (2.2)	2.3 (2.0)	0.398
- Vegetables	5.8 (1.8)	5.0 (2.0)	5.3 (2.0)	0.072
- Fruit	5.8 (1.9)	4.8 (2.4)	5.2 (2.3)	0.042
- Eggs	3.5 (2.1)	3.3 (2.3)	3.4 (2.2)	0.721
- Pulses and nuts	2.9 (2.0)	2.6 (2.3)	2.7 (2.2)	0.635
- Dairy products	5.3 (2.2)	5.4 (2.2)	5.3 (2.2)	0.829
- Fat and oils	7.0 (0.2)	7.0 (0.3)	7.0 (0.2)	0.937
- Sweets	4.0 (2.3)	4.7 (2.3)	4.5 (2.3)	0.161
- Spices and herbs	6.6 (1.7)	6.8 (0.7)	6.8 (1.2)	0.300
- Meat	4.6 (1.8)	4.8 (1.8)	4.7 (1.8)	0.524
- Fish and other seafood	1.5 (1.2)	1.4 (1.1)	1.4 (1.1)	0.623
- FGC Score	102.3 (17.3)	101.7 (17.3)	101.9 (17.2)	0.892

Statistical significance was set at $P < 0.05$.
Abbreviations: FGC: Food group consumption

Table 6 summarizes participants' reported sleep duration and physical activity levels. On average, participants reported sleeping 7.2 hours on weekdays and 6.2 hours on weekends, but no significant differences in sleep duration were observed between males and females. The table also highlights the physical activity reported by participants over the last week. A significant difference was observed in moderate-intensity exercise between males and females. Over the last five weekdays, females reported an average of four hours of moderate-intensity activity, compared to two hours reported by males (P=0.014). This trend continued over the weekend, with females engaging in 1.4 hours of moderate-intensity activity compared to 0.7 hours reported by males (P=0.026). Males reported working significantly more days outside the home compared to females (5.0 days vs. 2.3 days, $P< 0.001$). Additionally, males worked longer hours per workday outside the home, averaging 7.6 hours compared to 6.0 hours for females ($P=0.008$). When daily physical activity hours were converted to MET minutes, females had significantly higher total MET minutes of moderate-intensity physical activity compared to males. This difference was due to females engaging in more moderate-intensity physical activity (MET level of 3), while males primarily engaged in light-intensity physical activity (MET level of 1.5). Females accumulated 975 MET minutes of moderate physical activity during the last week compared to 487 MET minutes for males ($P=0.011$).

Table 6. Physical activity and sleep reported by the study patients using the 7-Day Physical Activity Recall (7-PAR) form

Variable	Male (n=34)	Female (n=60)	Total (n=94)	*P*-value
Sleep during the weekday (hours)	6.3 (1.3)	6.1 (1.7)	6.2 (1.6)	0.618
Sleep during the weekend (hours)	7.6 (1.6)	7.0 (1.7)	7.2 (1.7)	0.107
Moderate exercise within the last 5 weekdays (hours)	2.0 (2.0)	4.0 (4.4)	3.3 (3.8)	0.014
Moderate exercise within the last weekend (hours)	0.7 (0.8)	1.4 (1.8)	1.1 (1.5)	0.026
High-intensity exercise within the last 5 weekdays (hours)	0.3 (1.4)	0.1 (0.9)	0.2 (1.1)	0.565
High-intensity exercise within the last weekend (hours)	0.0 (0.2)	0.0 (0.1)	0.0 (0.2)	0.758
Work outside of home (days/week)	5.0 (1.7)	2.3 (2.5)	3.3 (2.6)	<0.001
Work outside of home (hours/day)	7.6 (1.7)	6.0 (2.6)	6.8 (2.3)	0.008
Light activity during work (hours)	1.6 (1.7)	1.6 (1.1)	1.6 (1.4)	0.962
High-intensity activity during work (hours)	0.0 (0.2)	0.0 (0.0)	0.0 (0.1)	0.355
Physical activity in the past week compared to the past 3 months by n (%)				
- More	4 (11.8%)	3 (5.0%)	7 (7.4%)	0.462
- Less	5 (14.7%)	8 (13.3%)	13 (13.8%)	
- Equal	25 (73.5%)	49 (81.7%)	74 (78.7%)	
Total light activity at work (MET minutes)	805.6 (798.1)	615.0 (515.2)	711.9 (675.3)	0.274
Total moderate exercise (MET minutes)	487.1 (446.0)	975.0 (1046.8)	798.5 (906.3)	0.011
Total high-intensity exercise (MET minutes)	97.1 (416.0)	52.5 (293.3)	68.6 (341.2)	0.546
Total MET minutes per week	1318.7 (1183.2)	1370.0 (1180.0)	1351.4 (1175.0)	0.840

Statistical significance was set at $P < 0.05$.
Abbreviations: MET: Metabolic equivalent of task; kcal: Kilocalorie

As outlined in Table 6, Figure 2 reflects the differences in the intensity of reported physical activity by sex in terms of MET minutes. Females surpassed males in moderate-intensity physical activity.

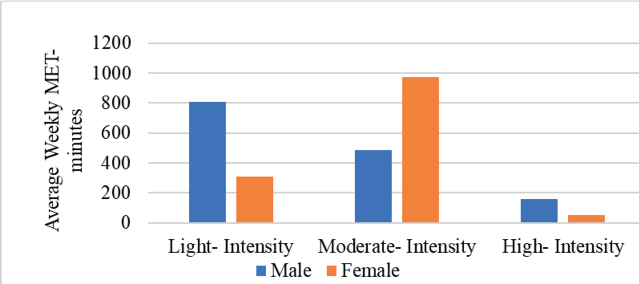

Figure 2: Distribution of average MET minutes acquired from the 7-day PAR form

DISCUSSION

The rate that MASLD has been increasing at worldwide is unprecedented and is becoming more widely known as a lifestyle disease. The relationship between MASLD and dietary habits, physical activity, and other risk factors among populations has been researched extensively but has not been done on Arab adults living in Qatar. This study found a significant association between snacking and BMI as an indicator of MASLD. This study also showed a significant association between dietary habits including excluded meals, meal timings, and eating out on some MASLD biochemical indicators. The results of this cross-sectional study also showed that all participants have sufficient dietary diversity. There was a notable difference in physical activity between sexes, with females engaging more in moderate-intensity physical activity compared to males.

Some relationships between certain dietary habits and MASLD indicators were found. First, the significant association between BMI and snacking observed in this study aligns with findings from Yari et al., who reported that frequent consumption of nutrient-poor snacks such as sugar-sweetened beverages, biscuits, candy, and other processed foods compared to those who snacked on fruit or vegetables, increases the risk of MASLD development, mediated through an increase in weight [26]. Participants among the Iranian population who had these unhealthy snacking habits had a two-fold increased risk of developing MASLD [26].

Consuming snacks high in calories, refined carbohydrates, and unhealthy fats increases the caloric intake, leading to extra stored fat that accumulates in the liver [26]. An excess influx of fructose from processed foods containing high fructose corn syrup is a great substrate for uncontrolled and irreversible lipogenesis in the liver, also contributing to excessive fat production ,hepatic steatosis, and low-grade inflammation [26]. Snacking too frequently may disrupt the body's ability to utilize nutrients from the previous meal and may lead to meal skipping, causing a frequent snacking pattern [27]. Therefore, snacks should be chosen mindfully, as snacks higher in whole grains, fruit, and vegetables are better than processed foods, but portion control should also be implemented to avoid a surplus in energy intake from snacks [27].

The relationship between meal skipping and triglycerides found in our study further underscores the metabolic importance of regular meal patterns. Our study showed that breakfast was the most skipped meal of the day. Breakfast has long been regarded as the most important meal, and observational studies have shown that skipping breakfast was associated with obesity, CVD, insulin resistance, and MASLD [28]. Consuming a well-balanced breakfast has been associated with improved satiety, reducing the likelihood of over-eating throughout the day [28]. It can also promote a healthier eating pattern [29]. Additionally, observational studies have demonstrated that breakfast consumption leads to improved post-prandial glycemia and insulin sensitivity [28]. However, evidence on the impact of breakfast on MASLD and cardiometabolic health remains conflicting. For instance, a randomized control trial conducted by Wei et al. found that participants with MASLD who were on a time-restricted eating pattern showed no difference in outcomes such as weight loss, blood pressure, lipid profile, and intrahepatic fat than those with energy restriction alone [30]. This suggests that the macronutrient composition and energy intake during the morning may be more important than whether breakfast is consumed or skipped. On the other hand, a systematic review and meta-analysis including seven randomized control trials analyzed the impact of skipping breakfast on body composition and some cardiometabolic risk factors [31]. While skipping breakfast was found to reduce overall body weight in five studies, it did not affect body fat percentage. Of the three studies that analyzed cholesterol levels, skipping breakfast led to a significant increase in LDL cholesterol, but did not result in changes in other biochemical parameters [31].

Our study revealed a positive association between the timing of the first meal and metabolic parameters related to MASLD, including fasting blood sugar level, cholesterol levels, and LDL levels. Additionally, we observed an inverse association between last meal timing and HDL levels. These findings align with existing evidence from observational studies which suggest that earlier eating windows rather than later at night may be beneficial for cardiometabolic health [28]. Late-night eating, found in those who have an evening chronotype, causes a misalignment within the body's natural circadian rhythm and has been linked to insulin resistance and altered lipid metabolism [32]. Teixiera et al.'s systematic review supports these findings, reporting that earlier meal timings were associated with healthier dietary habits such as reduced processed food intake and lower consumption of late-night meals and snacks, and reports a higher prevalence of obesity among individuals who consumed the majority of their calories later in the day [32].

The relationship between chronotype, meal timings, and metabolic health remains complex and conflicting among epidemiological studies. Most cross-sectional studies have reported a higher BMI among individuals with a late chronotype, which is associated with later meal timing and disrupted circadian alignment. For example, in people with T2DM, late-night eating was associated with having a delayed breakfast, suggesting that breakfast may play a role in mediating the relationship between morning or evening chronotype preference [33]. Additionally, evening chronotypes tend to engage in unhealthy dietary behaviors, such as consuming more calorie-dense snacks, skipping breakfast, and eating fewer fruits and vegetables. These behaviors, combined with reduced sleep duration and quality, contribute to poor metabolic outcomes [33]. This pattern may be explained by diminished self-control as the day progresses, making it more challenging to choose healthier food choices [34]. Another study found that individuals who deflated their first their first meal of the day (eating after 10:00 AM) had higher intakes of sucrose and saturated fat later in the day, particularly on weekends, reinforcing the idea that meal timing impacts the dietary quality and metabolic health [34]. Chronotype can be affected by shift work as well. In fact, a study done on nurses who worked night shift mostly complained of weight gain as their personal health problem[35].

The human circadian rhythm plays an essential role in energy metabolism. This cycle may be disrupted due to sleep or meal timing irregularity and may lead to obesity and metabolic disorders [33]. While the master circadian clock resides in the brain, the liver also has its circadian rhythm which plays a critical role in metabolic regulation [28]. Our findings reflect this, suggesting that meal timing may influence liver function, particularly in the breakdown, storage, and release of nutrients [28].

The present study identified a positive association between eating out and elevated triglycerides, which aligns with findings from another research. Lachat et al. conducted a systematic review of cross-sectional studies and found that individuals who ate outside the home were higher in fat contact and total energy intake compared to foods prepared at home [36]. Similarly, Robinson et al. estimated the energy content of an average of 50 restaurants found in the United Kingdom (UK) [37]. They found that the mean energy content per main meal was 977 (95% CI: 973-983) kilocalories (kcal), and only 9% of the restaurants met the UK's health recommendation of less than 600 kcal per main meal [37]. Lastly, a study conducted by Han found that the risk of developing MASLD when eating at home-cooked meals was less than when eating out (OR 1.25; CI: 1.006-1.552) [38]. Eating out has been becoming more prevalent, especially with delivery gaining more popularity than dining in or takeaway. Portion sizes in restaurants are much larger than portions prepared at home [39]. This surplus of energy intake may lead to weight gain and hepatic steatosis [38]. Over-eating leads to increased insulin released into the bloodstream, peripheral fat breakdown, and the release of more fatty acids [38]. Insulin itself also increases the synthesis of fat in the liver, adding to hepatic steatosis and leading to MASLD [38]. Food from outside is also usually higher in saturated fat and refined carbohydrates, which may increase triglycerides and reduce HDL levels [38]. These dietary behaviors highlight the importance of encouraging home-cooked meals and healthier eating practices to reduce the risk of MASLD.

Dietary diversity, assessed using the FGC score, offers a quick glimpse of adherence to nutritional guidelines. An FGCS score above 42 for wealthier countries is considered indicative of adequate dietary diversity. While all adults in the study met this criterion, certain food groups fell short of meeting the Qatar Dietary Guidelines (QDG) [40], Compared to the QDG, adults did not meet the requirements of vegetables as it was reported that only 44.7% participants reported consuming vegetables daily. Regarding fruit, 57.4% of participants reported consuming fruit daily, with males consuming more fruit than females. On average, participants reported a low intake of pulses and nuts, averaging only 2.7 times per week. Similarly, a study done in Qatar found that only one-third of participants consumed fruit daily, while less than half consumed vegetables daily[41].

Physical activity is a crucial factor in preventing MASLD and controlling its progression. According to the Qatar National Physical Activity guidelines, individuals should engage in a minimum of 30 minutes of moderate-intensity exercise per day, five days per week to sustain a healthy lifestyle and avoid comorbidities such as MASLD [42]. However, more than half of the people living in Qatar do not engage in any regular physical activity [42]. In our study, women reported engaging in more moderate-intensity physical activity (975 MET minutes) compared to men (487.1 MET minutes). This discrepancy may be due to overestimation. Most women categorized household activities such as cooking, cleaning, and taking care of their children as moderate exercise (MET level of 3), while most men classified work outside of the home as light activity.

As per the World Health Organization (WHO) criteria for the recommended physical activity level for adults [22], the level of physical activity in MET minutes per week can be classified as low (less than 600 MET minutes), moderate (600 to 3,000 MET minutes) and high (more than 3,000 MET minutes). Depending on those criteria, our study found that 33 participants (35.1%) were considered to have a low level of physical activity, 52 participants (55.3%) were considered to have a moderate level of physical activity, and nine participants (9.6%) were considered to have a high level of physical activity. Another study performed on Arab adults living in Qatar also estimated physical activity levels and found a similar distribution of low, moderate, and high levels of physical activity (low=21.7%, moderate: 53.2%, high=24.3%) [41]. Another study found a slightly different distribution of activity levels (low=47.8%, moderate=22.6%, high=29.6%) [43].

Strengths and Limitations

This study has several strengths and limitations. The main strength of this study is that it is the first study done to comprehensively assess dietary habits and diversity, lifestyle, physical activity, and other risk factors among Arab adults diagnosed with MASLD living in Qatar. The use of validated questionnaires to assess dietary diversity and physical activity enhances the reliability and comparability of the findings. However, the study also has limitations. As a cross-sectional design, it can identify the associations but cannot establish causal relationships between the variables studied. Additionally, the small sample size may limit the generalizability of the findings to the broader population, reducing the study's statistical power to detect subtle associations. Future research with larger, longitudinal cohorts is needed to build on these findings and clarify causal pathways.

CONCLUSION

MASLD is a largely environmentally influenced condition that may be reversed through lifestyle modification. This cross-sectional study examined dietary habits, diversity, physical activity, lifestyle behaviors, and other risk factors among Arab patients with MASLD in Qatar. Snacking was positively associated with BMI, a key MASLD indicator, while meal timing was correlated with various biochemical markers, including FBS, cholesterol, LDL, and HDL. Meal skipping, eating out, and triglycerides were also linked to MASLD. Despite high dietary diversity based on FGC scores, some food groups did not meet QDG guidelines. Women reported higher moderate-intensity physical activity than men.

This study highlights the dietary and lifestyle characteristics of Arab adults with MASLD in Qatar, addressing a gap in regional research. While associations were identified, questions of causality remain. Longitudinal studies are needed to explore whether these habits contribute to or result from MASLD, providing insights for clinical dietary interventions and culturally tailored strategies to promote healthy meal patterns.

DECLARATIONS

Ethical approval

The study protocol was approved by the Institutional Review Boards of both Hamad Medical Corporation (HMC) and Qatar University (IRB number QU-IRB 007/2024-EA, Supplementary Material 1).

The study was conducted according to the guidelines of the Declaration of Helsinki.

Our study is part of a larger study entitled "Long noncoding RNAs (lncRNA) as non-invasive biomarkers of Non-alcoholic fatty liver disease (NAFLD)", protocol number MRC-01-21-033. Consent was obtained from participants after explaining the purpose of the study and before starting the data collection.

Consent for publication: The authors permit the publisher to publish the findings of this manuscript.

Availability of data and materials: The data is available in the supplementary files.

Competing interests: The authors declare no competing or conflict of interest.

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Authors' Contributions: RT was responsible for the conception and design of the study and for the development of the methodology.

SE and SG were responsible for the acquisition of the data.

SE, RT, and SG were responsible for the analysis and interpretation of data.

SE, RT, and SG were responsible for drafting, revising, and approving the manuscript.

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