RESEARCH PAPER

Nutritional and Biochemical Profile differences between Metabolic Dysfunction-Associated Fatty Liver and Non-fatty Liver patients

Anmayee Nanda[1], Dr Suryamani Patro[2]*, Tanmayee Mousumee Maharana[3], Dr Sambit Das[4], Namrata Behera[5], Swagatika Sahoo[6]

[1]Phd Research Scholar, Department of Homescience, Ramadevi Women's University, ORCID: 0009-0008-1541-3605 Mail: anmayeenanda@gmail.com
[2*]Associate Professor, Ramadevi Women's University, Department of Homescience, Mail: suryamanipatro@rdwu.ac.in ORCID: 0009-0001-1334-1926
[3]PhD Scholar, Department of Home Science, Rama Devi Women's University, Vidya Vihar, Bhubaneswar. ORCID: 0009-0009-0302-9371 Mail: mousumeetanu94@gmail.com
[4]MD(Medicine) ,DM (Endocrinology, PGIMER, Chandigarh), FACE. Professor &Head, Department of Endocrinology, KIMS Medical College and Superspeciality Hospital, Bhubaneswar.
Senior Consultant Endocrinologist, Endeavour Clinic, Endocrinology, ORCID: 0000-0001-5983-0453, Mail: drsambitendocrine@gmail.com
[5]Research Scholar, Endeavour Clinic Mail: namratabehera1302@gmail.com, ORCID:0009-0003-6947-7544
[6]Qualifications - Msc Home science Working area - Clinical Dietitian at Dr. Sambit Das Endeavour Clinic, Nayapalli, Bhubaneswar Mail- swagatikas531@gmail.com

Abstract
MAFLD, or metabolic dysfunction-associated fatty liver disease, is a highly prevalent disease in individuals with type 2 diabetes mellitus (T2DM) and is influenced by metabolic, dietary and lifestyle factors. This baseline assessment was a prospective interventional cohort study that compared clinical, biochemical, eating behavior, nutritional knowledge, and Mediterranean diet adherence profiles in adults with T2DM with and without MAFLD. The total number of participants was 300, each with 150 participants. A structured questionnaire and clinical/laboratory records were used to collect data. Group differences were assessed using multivariate logistic regression, chi-square tests, and descriptive statistics. Participants with MAFLD had higher BMI, FBS, PPBS, HbA1c, triglycerides, LDL cholesterol, AST, ALT, and ALP, and lower HDL cholesterol than Non-MAFLD participants. BMI, triglycerides and HbA1c were positive predictors of MAFLD, while HDL was negative. Nutritional knowledge score had a substantial correlation with MAFLD status, while eating habit score and Mediterranean diet adherence were not substantially linked to MAFLD status. Based on these findings, it may be advisable to combine metabolic assessment with nutrition-literacy and lifestyle evaluation when using MAFLD risk profiling in T2DM.

Keywords- Metabolic dysfunction-associated fatty liver disease; Type 2 diabetes mellitus; Dietary habits; Eating behavior; Nutritional knowledge; Mediterranean diet adherence

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1. Introduction

Metabolic diseases are a major global health concern and are strongly influenced by dietary transition, physical inactivity, adiposity, and adverse cardiometabolic risk profiles. Their global burden has increased substantially over the past two decades, emphasizing the need for integrated strategies that address both clinical metabolic markers and modifiable lifestyle factors (Chew et al., 2023). This burden revolves around type 2 diabetes mellitus (T2DM) as it is marked by insulin resistance, defective 8-cell functioning, sustained hyperglycemia, and multisystem metabolic disregulation (DeFronzo et al., 2015). Fatty liver disease is especially noteworthy among the hepatic complications of this metabolic phenotype since it is one of the most common in people with T2DM and can potentially deteriorate hepatic and cardiometabolic outcomes.

Individuals with T2DM are at increased risk of fatty liver disease. A meta-analysis and systematic review of the literature showed that the prevalence of non-alcoholic fatty liver disease and steatohepatitis is high in patients with T2DM and that this population is clinically at risk of hepatic steatosis and progressive liver disease (Younossi et al., 2019). The metabolic dysfunction-associated fatty liver disease (MAFLD) was proposed to highlight the metabolic nature of fatty liver disease, instead of identifying it as the absence of alcohol consumption or other liver conditions (Eslam et al., 2020). Even though the terminology has changed to steatotic liver disease that is associated with metabolic dysfunction, the essence of the idea is that fatty liver reflects systemic metabolic dysfunction in the liver (Younossi et al., 2024). Here, insulin resistance, dyslipidemia, obesity, inflammation, and cardiovascular risk are strongly linked with fatty liver disease (Powell et al., 2021).

*Author for Correspondence: suryamanipatro@rdwu.ac.in

T2DM and fatty liver disease have a two-way relationship. The resistance to insulin enhances hepatic lipid accumulation through stimulating adipose tissue lipolysis, supplying free fatty acids to the liver, and de novo lipogenesis in the liver. In turn, hepatic steatosis may further impair glucose regulation and systemic metabolic control (Tilg et al., 2017). This mutualistic connection underpins the opinion that MAFLD is not a liver-specific disease but a subset of a larger range of metabolic imbalance on a systemic level (Zhao et al., 2024). Thus, lifestyle-related exposures such as dietary patterns, eating habits, physical activity, mental well-being, nutrition knowledge, and the overall dietary quality should be assessed among T2DM patients with and without MAFLD.

Dietary pattern is one of the most important modifiable factors influencing hepatic and metabolic health. Dietary consumption can influence the level of hepatic fat by the total energy consumption, the macronutrient mix, the quality of foods, the time of meals, and the ratio of the protective and harmful food groups (Riazi et al., 2019). The dietary patterns also affect insulin sensitivity, lipid metabolism, inflammation, body weight, and the total risk in cardiometabolism (Li et al., 2023). Fatty liver disease has been associated with unhealthy dietary practices, especially the high intake of refined carbohydrates, saturated fats, energy-dense foods, and low-quality foods (Al-Dayyat et al., 2018). Carbohydrate and fat diets have the potential to modify hepatic lipid metabolism by regulating de novo lipogenesis, fatty acid oxidation, and intrahepatic triglyceride levels (Parry & Hodson, 2017).

Lifestyle change is the key approach to the treatment and avoidance of fatty liver disease. Systematic review evidence suggests that lifestyle interventions can be useful in fatty liver disease, and behavioral change plays a crucial role in managing the disease (Fernández et al., 2022). The interventions are particularly applicable to patients with both fatty liver disease and T2DM due to the similar mechanisms of these conditions that comprise insulin resistance, obesity, and lipid metabolism disorders (Prabhakar and Bhuvaneswari, 2021). Sedentary behavior and physical activity exacerbate the metabolic risk through decreased energy expenditure, impaired glucose regulation, and obesity and cardiometabolic dysfunction (Park et al., 2020). On the other hand, regular exercise has positive impacts on liver-related and metabolic outcomes in fatty liver disease (Wang et al., 2020). Aerobic and resistance exercises can enhance hepatic fat, insulin sensitivity, and cardiometabolic performance, complemented by physiological mechanisms (Hashida et al., 2017).

Quality of diet may also be measured by following the set healthy eating trends. The Mediterranean diet is deemed cardiometabolically protective, as it stresses limits processed foods and saturated fats and includes fish, fruits, vegetables, whole grains, legumes, nuts, and olive oil. The Mediterranean diet has also been linked to fatty liver-related outcomes among participants with metabolic syndrome as a dietary quality index and is a useful tool in MAFLD studies (Montemayor et al., 2022). Its applicability to high-risk groups, such as people with T2DM and fatty liver disease, due to cardiometabolic advantages is further supported by cardiovascular prevention research (Estruch et al., 2018). Along with the quality of diet, nutritional knowledge and awareness of diseases can also affect food preferences, compliance with lifestyle, and preventive practices. Recent research on MAFLD knowledge and attitudes indicates that knowledge-related variables can influence disease risk perceptions and lifestyle change participation (Al Tawil et al., 2024). Although The number of studies has increased focusing on individual dietary and metabolic determinants, limited studies have concurrently assessed eating habit score, nutritional knowledge score, Mediterranean diet adherence, and metabolic-biochemical profile within the same population of people with T2DM and MAFLD. This gap is significant because MAFLD is likely to be affected by a combination of metabolic, nutritional, and behavioral factors. Therefore, the present study compared clinical, anthropometric, biochemical, eating behavior, nutritional knowledge, and Mediterranean diet adherence profiles among adults with T2DM with and without MAFLD. The specific objectives of the study were:

- To compare baseline clinical, anthropometric and biochemical profiles between individuals with MAFLD and Non-MAFLD.
- To compare Dietary behaviour and nutritional knowledge between individuals with MAFLD and Non-MAFLD.

2. Materials and Methods

2.1 Study Design and Setting

This hospital-based comparative cross-sectional study was conducted in selected diabetic care units of both government and private hospitals in Bhubaneswar, Odisha. These healthcare facilities cater to a heterogeneous population from urban and peri-urban areas of Bhubaneswar, as well as patients referred from different districts of Odisha and neighbouring states.

The study was initiated in July 2024 and was conducted over a period of six months, from July 2024 to December 2024. Participants were recruited from the outpatient diabetic and hepatology clinics of the selected hospitals according to predetermined inclusion and exclusion standards.

2.2 Study population and sample size

A total of 300 adult patients diagnosed with Type 2 Diabetes Mellitus (T2DM) were recruited for the study and categorized into two groups. The MAFLD group consisted of 150 adult patients with T2DM who had fatty liver disease linked to metabolic disorders and the control group consisted of 150 adult patients with T2DM without fatty liver disease.

Ultrasonography was used to confirm the MAFLD status and was supported by pertinent clinical and biochemical criteria. Outpatient diabetic and hepatology clinic registers of the selected government and private hospitals in Bhubaneswar, Odisha were used to recruit participants via clinic registers and predetermined eligibility criteria. The chosen sample size was deemed to be sufficient to provide meaningful comparison of nutritional, lifestyle, anthropometric, and biological characteristics between the two populations because of feasibility and patient availability at the time of the study.

Inclusion Criteria

Patients were included in the study if they met the following criteria:

- Adult patients aged 20–70 years diagnosed with Type 2 Diabetes Mellitus for more than one year.
- Patients classified into MAFLD or Non-MAFLD groups based on ultrasonographic findings supported by relevant clinical and biochemical criteria.
- Patients willing to provide written informed consent and able to provide required dietary, lifestyle, medical history, and eating behavior information.

Exclusion Criteria

Patients were excluded from the study if they met any of the following criteria:

- Patients with Type 1 Diabetes Mellitus, pregnancy/lactation, severe systemic illness, chronic kidney disease, or other metabolic/endocrine disorders affecting study outcomes.
- Patients with viral hepatitis, alcoholic liver disease, significant alcohol consumption, or other chronic liver diseases unrelated to MAFLD.
- Patients unwilling to provide written informed consent or unable to comply with study procedures and provide required clinical, dietary, and lifestyle information.

2.3 Nutritional and Biochemical Evaluation

All enrolled subjects underwent a complete baseline health profile assessment including a detailed nutritional, anthropometric, clinical and biochemical evaluation. The clinical assessment consisted of diabetes-related history, duration of Type 2 Diabetes Mellitus, current treatment pattern, use of oral hypoglycemic agents, insulin use, routine health check-up practices, relevant medical history and ultrasonographic findings for MAFLD classification. Clinical information was collected to understand the disease status, treatment history and liver related diagnostic profile of participants. Demographic details, medical history, eating behavior, nutritional knowledge and adherence to Mediterranean diet were recorded using a structured pre-tested proforma. Data was collected by conducting in-person interviews, printed questionnaire forms and using digital Google Forms. All modes of data collection had similar instructions to facilitate consistency and minimize the variation of responses.

Anthropometric assessment included height and weight measurement. Weight in kilograms divided by height in meters squared (kg/m2) yields the body mass index (BMI). MAFLD status was confirmed using ultrasonographic findings supported by relevant clinical and biochemical criteria.

Biochemical parameters were obtained from recent hospital records or verified laboratory reports from certified diagnostic centers. The parameters included fasting blood glucose (FBS), postprandial blood glucose (PPBS), glycated hemoglobin (HbA1c), triglycerides, Aspartate aminotransferase (AST), alanine aminotransferase (ALT), alkaline phosphatase (ALP), low-density lipoprotein cholesterol (LDL-C), and high-density lipoprotein cholesterol (HDL-C).

Eating behavior was assessed using an eating habit score based on the frequency of negative eating habits. The score was categorized into three groups: participants scoring 0–1 were classified as having good eating habits, those scoring 2–3 were classified as having fair eating habits, and those scoring 4–6 were classified as having poor eating habits. This classification was used to compare eating behavior categories between MAFLD and Non-MAFLD participants. A Mediterranean diet was used to gauge adherence to the diet adherence score and categorized into low, medium, and high adherence levels. Scores from 0–9 were considered low adherence, scores from 9.1–11 were considered medium adherence, and scores from 11.1–16 were considered high adherence. This classification was used to evaluate adherence to a Mediterranean-style dietary pattern among MAFLD and Non-MAFLD participants. Nutritional knowledge was assessed using a 16-item nutritional knowledge score. The questions covered basic concepts related to balanced diet, macronutrients, healthy food choices, and glycemic control. The total score was categorized as good, fair, or poor nutritional knowledge. Scores from 0–7 were considered good, scores from 7–10 were considered fair, and scores of 11 and above were considered poor nutritional knowledge. The categorized score was used to compare nutritional knowledge distribution according to MAFLD status.

2.4 Data Management and Statistical Analysis

All data gathered were coded and cleaned and keyed into an appropriate Microsoft Excel database. One observation was each filled questionnaire. The data was verified to be complete, internally consistent, had no missing values, no duplicates, and potential data entry errors before statistical analysis. The numerically coded categorical variables included MAFLD status, eating habit score category, nutritional knowledge score category, and Mediterranean diet adherence category.

Analysis of data was done using Python statistical libraries. The categorical variables were summarized using descriptive statistics like frequencies and percentages. The continuous variables were represented as mean and standard deviation of normally distributed data and as median and interquartile range of non-normally distributed data, where appropriate

Continuous variables were evaluated in terms of distribution and then suitable statistical tests were chosen. The independent t-test was used to compare the MAFLD and Non-MAFLD groups in terms of normally distributed continuous variables with the Welch t-test.

The mann whitney u test was used to test variables that failed to satisfy the normality assumptions. The Chi-square test was used to identify associations between MAFLD status and categorical variables, including eating habit score category, nutritional knowledge score category, and Mediterranean diet adherence category.

The multivariate logistic regression analysis was conducted to determine independent predictors of the MAFLD status with the adjustment of selected metabolic and clinical variables. Where relevant, odds ratios, 95% confidence and p-values were reported. The p-value below 0.05 was regarded as statistically significant.

2.5 Ethical Considerations

The study was carried out in line with the ethical guidelines for research involving human participants. The Institutional Authority and Institutional Ethics Committee gave formal approval prior to the initiation of data collection. To ensure the rights, safety, dignity and privacy of the participants were protected throughout the study, the study protocol, recruitment process, informed consent process, data collection methods and confidentiality measures were reviewed . All eligible participants were fully informed of the purpose of the study, study procedures, voluntary nature of participation, confidentiality safeguards and their right to withdraw from the study at any time without penalty before enrolment.

Written informed consent was obtained from each participant before enrolment. Personal identifiers were removed from the analytical dataset to maintain confidentiality. All clinical, dietary, lifestyle, and biochemical data were used only for academic and research purposes. No invasive or harmful procedures were performed as part of the dietary and behavioral assessment, and participant privacy was maintained throughout the study.

3. Results

The present study analyzed data from 300 adult patients with Type 2 Diabetes Mellitus (T2DM), including 150 participants diagnosed with MAFLD and 150 Non-MAFLD controls. All participants completed clinical, nutritional, and biochemical evaluations, and complete datasets were available for statistical analysis.

3.1 Baseline Clinical, Biochemical, and Medical Profile

Table 1 presents the baseline clinical and biochemical characteristics of MAFLD and Non-MAFLD participants. Participants with MAFLD had significantly higher BMI, fasting blood glucose, postprandial blood glucose, HbA1c, triglycerides, LDL cholesterol, AST, ALT, and ALP levels compared with Non-MAFLD participants. HDL cholesterol was significantly lower in the MAFLD group. These findings indicate that participants with MAFLD had a less favorable metabolic and hepatic profile than those without MAFLD.

Table 1. Baseline Demographic, Medical, Clinical, Anthropometric, and Biochemical Profile of MAFLD and Non-MAFLD Participants

Variable	Category/Unit	Non-MAFLD (n = 150)	MAFLD (n = 150)
Demographic profile			
Age	20–40 years	73 (48.67%)	66 (44.00%)
	41–60 years	66 (44.00%)	60 (40.00%)
	Above 60 years	11 (7.33%)	24 (16.00%)
Gender	Male	34 (22.67%)	56 (37.33%)
	Female	116 (77.33%)	94 (62.67%)
Marital status	Married	85 (56.67%)	97 (64.67%)
	Unmarried	51 (34.00%)	39 (26.00%)
	Separated	14 (9.33%)	14 (9.33%)
Medical history			
Treatment type	Allopathy	117 (78.00%)	124 (82.67%)
	Ayurveda	17 (11.33%)	14 (9.33%)
	Homeopathy	16 (10.67%)	12 (8.00%)
Taking OHA	Yes	86 (57.33%)	88 (58.67%)
	No	50 (33.33%)	44 (29.33%)
	Maybe/Not sure	14 (9.33%)	18 (12.00%)
Taking insulin	Yes	39 (26.00%)	39 (26.00%)
	No	111 (74.00%)	111 (74.00%)
Routine check-up	Yes	100 (66.67%)	111 (74.00%)
	No	50 (33.33%)	39 (26.00%)
Duration of diagnosis	≤1 year	27 (18.00%)	20 (13.33%)
	1–5 years	69 (46.00%)	77 (51.33%)
	5–10 years	32 (21.33%)	38 (25.33%)
	>10 years	22 (14.67%)	15 (10.00%)
Clinical profile			

Fatty liver on abdominal ultrasound	No	150 (100.00%)	0 (0.00%)
	Yes	0 (0.00%)	150 (100.00%)
Ultrasound impression	Grade I fatty liver	0 (0.00%)	114 (76.00%)
	Grade II fatty liver	0 (0.00%)	28 (18.67%)
	Grade III fatty liver	0 (0.00%)	8 (5.33%)
Anthropometric and biochemical profile			
BMI	kg/m²	28.86 ± 2.43	31.66 ± 2.87
FBS	mg/dL	170.57 ± 22.53	193.11 ± 28.48
PPBS	mg/dL	248.54 ± 34.16	293.25 ± 40.13
HbA1c	%	9.06 ± 0.86	9.91 ± 0.84
Triglycerides	mg/dL	259.53 ± 46.70	303.42 ± 54.48
LDL-C	mg/dL	147.99 ± 20.40	162.66 ± 21.41
HDL-C	mg/dL	37 (35–40)	33 (30–36)
AST	U/L	60.31 ± 11.93	84.19 ± 18.48
ALT	U/L	71.05 ± 14.43	92.63 ± 19.83
ALP	U/L	142.39 ± 20.02	164.55 ± 23.28

Note: Categorical variables are presented as frequency (%). Continuous variables are presented as mean ± SD, except HDL-C, which is presented as median (interquartile range).

Table 1 presents the baseline demographic, clinical, anthropometric, and biochemical profile and medical history of participants with and without MAFLD. In the demographic profile, younger participants aged 20–40 years were slightly more common in the Non-MAFLD group, whereas participants above 60 years were more frequent in the MAFLD group. This indicates that advancing age may be associated with a greater burden of fatty liver disease among patients with T2DM. The gender distribution showed a higher proportion of males in the MAFLD group compared with the Non-MAFLD group, while females were more common in both groups overall. This pattern suggests that male participants may have a relatively greater susceptibility to MAFLD,

possibly because of differences in central adiposity, metabolic risk, and lipid distribution. With respect to marital status, married participants were more frequent in the MAFLD group, whereas unmarried participants were more frequent in the Non-MAFLD group. This difference may reflect lifestyle-related influences such as dietary routine, household food practices, physical activity, and body weight patterns.

Regarding medical history, most participants in both groups were receiving allopathic treatment, with slightly higher allopathic treatment use among MAFLD participants. Use of oral hypoglycemic agents was similar between the groups, and insulin use was identical in both groups. Routine check-up was reported more frequently among MAFLD participants, which may reflect greater healthcare contact after detection of fatty liver disease or related metabolic complications. The most common duration of diabetes diagnosis in both groups was 1–5 years, although the MAFLD group had a relatively higher proportion of participants with 1–5 years and 5–10 years of diabetes duration. Ultrasonography confirmed fatty liver only among MAFLD participants, with Grade I fatty liver being the most common ultrasound impression, followed by Grade II and Grade III fatty liver.

The anthropometric and biochemical profile showed a clear unfavorable metabolic and hepatic pattern among MAFLD participants. The MAFLD group had higher BMI, fasting blood sugar, postprandial blood sugar, HbA1c, triglycerides, LDL cholesterol, AST, ALT, and ALP levels compared with the Non-MAFLD group, while HDL cholesterol was lower among MAFLD participants. These findings suggest that MAFLD among patients with T2DM is associated with greater adiposity, poorer glycemic control, a more adverse lipid profile, and higher liver enzyme levels. Overall, the table indicates that MAFLD is not only a hepatic condition but also reflects a broader metabolic disturbance in patients with T2DM.

3.2 Multivariate Logistic Regression Predicting MAFLD Status

Multivariate logistic regression analysis identified BMI, triglycerides, and HbA1c as significant positive predictors of MAFLD status, while HDL cholesterol showed a protective association. HbA1c demonstrated the strongest association, suggesting that poor long-term glycemic control was strongly linked with MAFLD. Age and gender were not statistically significant after adjustment for metabolic variables. The overall model was significant, with a Pseudo R^2 of 0.479.

Table 2. Multivariate Logistic Regression Predicting MAFLD Status

Predictor	Odds Ratio (OR)	95% CI	p-value	Interpretation
BMI	1.36	1.19–1.55	<0.001	Positive predictor
Triglycerides	1.013	1.007–1.020	<0.001	Positive predictor

HbA1c	3.09	1.98–4.80	<0.001	Strong positive predictor
HDL cholesterol	0.74	0.67–0.82	<0.001	Protective factor
Age	—	—	>0.05	Not significant
Gender	—	—	>0.05	Not significant

3.3 Dietary Profile and Nutritional knowledge score among MAFLD and Non-MAFLD Participants

Participants' dietary profiles were assessed according to three main indicators: eating habit score, Mediterranean diet adherence score and nutritional knowledge score. Parameters were used to evaluate the behavioral and knowledge aspects of the diet in participants with and without MAFLD. This comparison helped to establish whether participants with MAFLD differed from Non-MAFLD participants on the following: routine eating practices, adherence to a healthy dietary pattern, and knowledge of basic nutritional principles related to diabetes and liver health.

Eating habit scores were categorized into good, fair, and poor based on the frequency of negative eating behaviors. Poor eating habits were more common among MAFLD participants than Non-MAFLD participants. Good eating habits were seen in 49.3% of Non-MAFLD participants and 40.7% of MAFLD participants. This suggests that the proportion of good dietary habits was relatively higher in non-MAFLD subjects. Conversely, fair eating habits were more common in MAFLD participants (39.3% of MAFLD participants vs. 33.3% of Non-MAFLD participants). Poor eating habits were also marginally higher in MAFLD participants, with 20.0% of the MAFLD group versus 17.3% of the Non-MAFLD group. These results indicate a descriptive trend that less favorable eating behavior was more frequently observed among participants with MAFLD (Fig. 1).

We assessed the adherence of the participants to the Mediterranean diet to understand how much the participants followed a dietary pattern characterized by healthier food choices, such as fruits, vegetables, whole grains, pulses, nuts, healthy fats, and low intake of processed and high-fat foods. Compliance was classified as low, medium and high. The leading category in both study groups was low adherence, which means most of the participants did not strongly adhere to a Mediterranean style dietary pattern. Low adherence was observed in 58.00% of Non-MAFLD and 59.33% of MAFLD participants. Medium adherence was observed in 42.00% of Non-MAFLD and 40.00% of MAFLD participants. There was almost no high adherence in the study population; only one patient in the MAFLD group had high adherence. This pattern indicates that protective dietary behaviors as reflected by the Mediterranean diet score were generally low in both groups irrespective of MAFLD status.

Nutritional knowledge was assessed by a categorized score, which reflected participants' knowledge of balanced diet, macronutrients, healthy food choices, and dietary practices related to glycemic control. Nutritional knowledge was classified as good, fair or poor. Good nutritional knowledge was more prevalent in Non-MAFLD participants, while fair and poor nutritional knowledge were more common in MAFLD participants. This indicates that the participants without MAFLD had relatively better nutrition-related awareness than the participants with MAFLD. This difference may be relevant to understanding dietary behavior in patients with T2DM, because nutritional knowledge may affect food choice, portion control, meal planning, and adherence to dietary advice. In general, Fig. 1 shows that Non-MAFLD participants had a relatively better dietary and nutritional knowledge profile, while MAFLD participants tended to have fair or poor eating habits and lower nutritional knowledge.

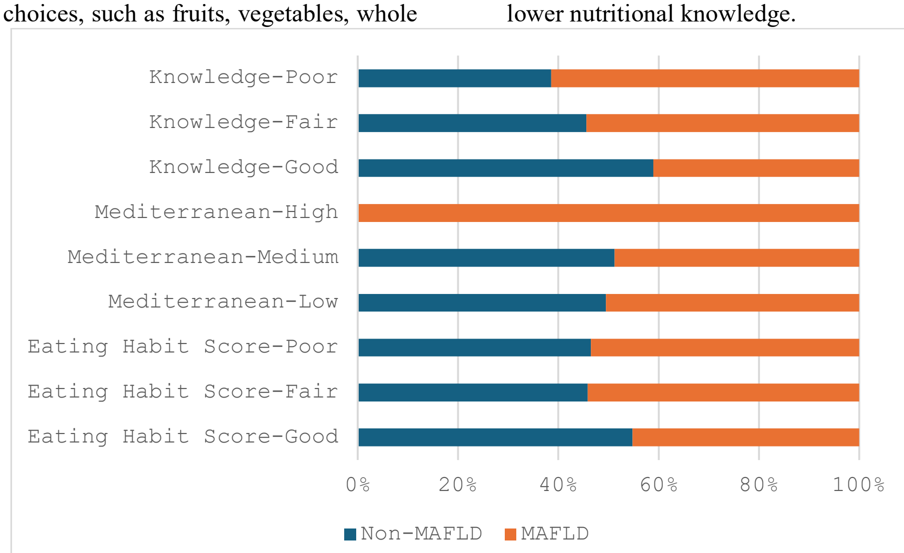

Figure 1: Dietary profile and Nutritional Knowledge score

3.4 Association of Dietary Factors with MAFLD Status

Chi-square analysis was used to examine the association of dietary factors with MAFLD status. Nutritional knowledge score was significantly associated with MAFLD status, whereas eating habit score and Mediterranean diet adherence were not significantly associated.

Table 3. Association of Dietary Factors with MAFLD Status

Variable	χ^2	df	p-value	Interpretation
Eating habit score	2.281	2	0.320	Not significant
Mediterranean diet score	0.771	2	0.680	Not significant
Nutritional knowledge score	7.943	2	0.019	Significant

Only nutritional knowledge score showed a statistically significant association with MAFLD status ($\chi^2 = 7.943$, df = 2, p = 0.019). Eating habit score was not significantly associated with MAFLD status ($\chi^2 = 2.281$, df = 2, p = 0.320), although descriptive differences showed poorer eating habit categories among MAFLD participants. Mediterranean diet adherence was also not significantly associated with MAFLD status ($\chi^2 = 0.771$, df = 2, p = 0.680). These findings suggest that nutritional knowledge differed significantly between MAFLD and Non-MAFLD participants, while eating habit score and Mediterranean diet adherence showed descriptive but not statistically significant differences.

4. Discussion

The current baseline analysis was conducted in a prospective interventional cohort comparing clinical, anthropometric, biochemical, eating behavior, nutritional knowledge, and Mediterranean diet adherence profiles of T2DM patients with and without MAFLD. The results indicate that participants with MAFLD had a more unfavorable metabolic and hepatic profile, with higher BMI, poorer glycemic status, higher triglycerides and LDL cholesterol, lower HDL cholesterol, and higher liver enzyme levels. Multivariate logistic regression also confirmed BMI, triglycerides, and HbA1c as positive predictors of MAFLD status, while HDL cholesterol showed a protective association. Among the selected dietary and nutritional variables, nutritional knowledge score was the only factor significantly associated with MAFLD status. The present findings suggest that, in T2DM, MAFLD is strongly influenced by metabolic dysfunction and may also be related to modifiable behavioral factors, although not all lifestyle variables reached statistical significance.

The poorer metabolic parameters observed in the MAFLD group are consistent with the current concept of MAFLD as a hepatic expression of systemic metabolic dysfunction. Eslam et al. (2020) highlighted that MAFLD is not a diagnosis based on exclusion but is characterized by metabolic dysregulation, while Zhao et al. (2024) explained that MAFLD is a component of overall metabolic disturbance. This metabolic-hepatic relationship is supported by the results of the current study, such as an increase in BMI, HbA1c, triglycerides, LDL, AST, ALT, and ALP in MAFLD participants. The results of the regression are especially significant as they show that glycemic burden, adiposity, and dyslipidemia are still one of the most important factors influencing the status of MAFLD. Poor long-term glycemic control may be a significant marker of hepatic-metabolic risk in adults with T2DM, as HbA1c showed the strongest association.

The eating habit score appeared to be a useful composite behavioral indicator. Good eating habit scores were more frequent among Non-MAFLD participants, whereas fair and poor eating habit scores were more frequent among MAFLD participants. However, this association was not statistically significant. This descriptive pattern suggests that unfavorable eating behavior may be more common among participants with MAFLD. This observation is biologically plausible because dietary composition and eating behavior may contribute to hepatic fat accumulation through de novo lipogenesis, fatty acid oxidation, and triglyceride storage, as suggested by Parry and Hodson (2017).

The clinically relevant descriptive pattern was also exhibited by mental health. Non-MAFLD group had more participants who exercised 3-5 times per week and those who exercised high-intensity exercises, whereas the MAFLD group had more participants who exercised more than five times per week and with longer duration. This trend could be a lifestyle modification following diagnosis, not long-term preventive measures of participants having MAFLD. The frequency of exercise did not significantly predict MAFLD status and suggests that more specific measures of exercise such as duration, intensity, sedentary time and whether exercise was initiated before or after diagnosis should be used in future studies. However, the clinical significance of physical activity is still significant since Wang et al. (2020) and Hashida et al. (2017) identified exercise interventions as effective in enhancing liver and metabolic outcomes of fatty liver disease.

The clinically relevant descriptive pattern was also exhibited by mental health. The MAFLD participants had poorer mental health and the Non-MAFLD participants had better mental health. This difference was not statistically significant, but it is still significant since the psychological distress can affect food preferences, exercise, sleep habits, motivation, and compliance with treatment. Park et al. (2020) stated that inactive and inefficient lifestyles are associated with metabolic risk, and bad mental health can additionally decrease compliance with lifestyle interventions.

Nutritional knowledge was the most significant lifestyle-associated result. Nutritional knowledge about good was higher in Non-MAFLD participants and fair and poor nutritional knowledge were higher in MAFLD participants. The status of MAFLD was significantly correlated with nutritional knowledge score, implying that nutrition literacy might be linked with disease-related behaviour in T2DM. This result aligns with the study by Al Tawil et al. (2024), who found that knowledge and attitudes towards MAFLD can affect the perception of risk, patient engagement, and preventive behavior. Lack of nutritional knowledge could lead to an impaired knowledge of dietary glycemic control, portion control, dietary quality of fats, liver-related dietary risk, and balanced diet practices.

The compliance with Mediterranean diet was low in both groups and very low compliance was observed among participants. Mediterranean diet score did not have a significant association with MAFLD status. Nevertheless, the finding is still clinically relevant since the lack of variability in adherence can decrease the possibility of identifying statistical differences among groups. Mediterranean diet adherence has been reported to be important in fatty liver disease among patients with metabolic syndrome (Montemayor et al., 2022) and has broader cardiometabolic benefits (Estruch et al., 2018). In the present population, Mediterranean-style dietary recommendations may need to be culturally adapted according to local foods, affordability, staple grains, cooking methods, and food preferences.

The study has several strengths, including equal MAFLD and Non-MAFLD group sizes, inclusion of clinical and biochemical markers, and assessment of eating behavior, nutritional knowledge, and Mediterranean diet adherence in the same T2DM population. However, some limitations should be acknowledged. Since this article reports baseline findings, causal relationships cannot be inferred. Lifestyle and behavioral factors were self-reported and may be affected by recall bias or social desirability bias. Mediterranean diet adherence was low in both groups, which may have limited the ability to detect differences between MAFLD and Non-MAFLD participants. In addition, the hospital-based setting may limit the generalizability of the findings to broader community populations. Future longitudinal studies should explore whether nutritional knowledge, eating behavior, and Mediterranean diet adherence predict changes in metabolic, hepatic, and intervention-related outcomes over time.

5. Conclusion

A prospective interventional cohort baseline evaluation was conducted to assess eating habit score, nutritional knowledge score, and adherence to the Mediterranean diet among adults with T2DM with and without MAFLD. The results suggest that MAFLD participants had a less desirable nutritional and behavioral profile, along with a more unfavorable metabolic and hepatic profile. The metabolic basis of MAFLD in T2DM was supported by higher BMI, poorer glycemic control, adverse lipid profile, and elevated liver enzyme levels among MAFLD participants compared with Non-MAFLD participants. Nutritional knowledge score was the main dietary and nutritional variable significantly associated with MAFLD status. Good nutritional knowledge was more common among Non-MAFLD participants, whereas fair and poor nutritional knowledge were more common among MAFLD participants. This indicates that nutritional knowledge may be a potentially modifiable factor in MAFLD risk and lifestyle management. Eating habit score and Mediterranean diet adherence score were not statistically significant, but they showed clinically relevant descriptive patterns. Non-MAFLD participants had a higher proportion of good eating habit scores, whereas MAFLD participants showed higher proportions of fair and poor eating habit scores. Adherence to the Mediterranean diet was also low in both groups, indicating limited adoption of protective dietary patterns. To sum up, the present paper recommends that MAFLD risk assessment in T2DM patients should be based not only on metabolic testing but also on assessment of nutritional knowledge, eating habits, and culturally appropriate dietary counselling. Nutritional education should be prioritized as an intervention component in routine care for diabetes and fatty liver disease.

6. Recommendations

Nutritional education is recommended to be incorporated in the normal clinical practice of T2DM patients with and without MAFLD. Practical dietary education, meal timing, controlling the size of portions, the quality of carbohydrates, fibre, reducing saturated fat, and avoiding sugary and processed foods should be the focus of counselling. Clinicians ought to evaluate eating behavior based on structured scores and not general dietary history. The counselling of physical activity ought to involve frequency, duration, intensity and regularity, as well as the distinction between habitual physical activity and the new post-diagnosis lifestyle. Lifestyle counselling should include mental health screening since mental distress can influence diet, activity, sleep, motivation and compliance with treatment. The principles of the Mediterranean diet must be culturally oriented towards local food practices with a strong focus on whole grains, pulses, vegetables, fruits, nuts, seeds, healthy fats, and minimal consumption of processed food. Longitudinal designs should be employed in future research to shed light on whether nutritional knowledge and eating behavior affect the progression of MAFLD in the long term.

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