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CORRELATION BETWEEN BODY MASS INDEX AND DEGREE OF HEPATIC STEATOSIS IN PATIENTS WITH TYPE 2 DIABETES MELLITUS

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Abstract

Type 2 diabetes mellitus (T2DM) is a chronic metabolic condition characterized by elevated blood glucose levels resulting from insulin resistance, and it is frequently accompanied by hepatic steatosis, now known as metabolic dysfunction-associated steatotic liver disease (MASLD). An elevated body mass index (BMI) indicates visceral fat accumulation, which in turn triggers the release of free fatty acids and proinflammatory cytokines and may thereby damage hepatocytes. This study aimed to examine the relationship between BMI and the severity of hepatic steatosis in patients with T2DM at Sultan Agung Islamic Hospital, Semarang. This study used an analytic observational approach with a cross-sectional design. A total of 70 patients with T2DM who met the inclusion criteria were selected by consecutive sampling from medical records for the period 2022–2026. BMI was categorized according to WHO criteria, while the degree of hepatic steatosis was assessed by ultrasonography on a three-level scale: mild, moderate, and severe. Data analysis included the Kolmogorov–Smirnov normality test and Spearman rank correlation. The mean BMI of the subjects was 28.19 ± 5.88 kg/m^2, and the largest proportion fell into the obesity grade I category (42.9%). The most common degree of hepatic steatosis was mild (55.7%), followed by moderate (31.4%) and severe (12.9%). The data did not meet the assumption of normality (p = 0.000), so Spearman correlation was used. It showed a significant positive correlation between BMI and the degree of hepatic steatosis (r = 0.194; p = 0.008). In conclusion, there is a significant but weak positive correlation between BMI and the degree of hepatic steatosis in patients with type 2 diabetes mellitus at Sultan Agung Islamic Hospital, Semarang.

Keyword: *Type 2 Diabetes Mellitus, Body Mass Index, Hepatic Steatosis*

A. INTRODUCTION

Type 2 diabetes mellitus (T2DM) is a chronic metabolic disorder that is not characterized merely by elevated blood glucose levels. It reflects a complex failure of whole-body glucose homeostasis, in which the insulin produced by the pancreas loses its ability to act optimally on peripheral tissues. As a result, glucose accumulates in the circulation and gradually damages multiple vital organs. Because the disease is asymptomatic in its early phase, most patients become aware of their condition only after complications have begun to develop, and

opportunities for early intervention are therefore often missed (Soelistijo, 2021; Goyal and Jialal, 2023).

The global burden of diabetes has risen at an alarming rate over recent decades. According to the International Diabetes Federation (2025), an estimated 589 million adults worldwide are living with diabetes, and this figure is projected to reach 853 million by 2050 in the absence of effective control measures. More than half of those affected are unaware of their status, so they do not receive an adequate diagnosis, treatment, or prevention of complications (Magliano *et al.*, 2021). Indonesia faces a similar challenge. The country ranked fifth worldwide in 2024, with approximately 20.4 million adults living with diabetes, as reported by the Ministry of Health of the Republic of Indonesia (2026). The 2023 Indonesian Health Survey recorded a diabetes prevalence of 11.7% among residents aged 15 years and older, a marked increase from 8.5% in the 2018 Basic Health Research (Magliano *et al.*, 2021; Ministry of Health of the Republic of Indonesia, 2026).

This rising prevalence is closely linked to accelerating urbanization in Indonesia, which is consistent with the analysis of national health survey data from 2013 to 2023 by Muharram *et al.* (2025). The transition from traditional to modern urban lifestyles has created an environment conducive to metabolic disease, including T2DM. This change is marked by greater consumption of foods high in calories and low in fiber, together with a substantial decline in physical activity (Lu *et al.*, 2024).

One metabolic complication that is frequently overlooked but clinically significant in patients with T2DM is hepatic steatosis. In medical terminology, this condition is referred to as non-alcoholic fatty liver disease (NAFLD) or metabolic dysfunction-associated steatotic liver disease (MASLD), and it is now among the most common chronic liver diseases worldwide. The prevalence of hepatic steatosis in patients with T2DM reaches 55% to 70%, far exceeding the 25% to 30% observed in the general population (Younossi *et al.*, 2023; Rinella *et al.*, 2023). In patients with diabetes, hepatic steatosis tends to be more progressive and carries a higher risk of developing into more serious conditions, such as steatohepatitis, fibrosis, cirrhosis, and hepatocellular carcinoma.

The relationship between T2DM and hepatic steatosis is bidirectional and mutually reinforcing. Insulin resistance, which lies at the core of the pathophysiology of T2DM, is also a central mechanism in the development of hepatic steatosis. Insulin resistance in adipose tissue increases lipolysis and releases large amounts of free fatty acids into the circulation. These free fatty acids are then transported to the liver through the portal vein and accumulate within

hepatocytes. Conversely, hepatic steatosis aggravates hepatic insulin resistance, which increases hepatic glucose production and makes glycemic control increasingly difficult to achieve (Younossi *et al.*, 2023; Lu *et al.*, 2024).

Among the many risk factors that contribute to hepatic steatosis, excess body weight holds a particularly important position. Body mass index (BMI), the most practical and widely used anthropometric parameter for assessing nutritional status, is a strong predictor of hepatic steatosis in patients with diabetes. For Asia-Pacific populations, the World Health Organization has set a lower threshold than for Western populations, whereby an individual is classified as overweight at a BMI of 23.0 kg/m^2. This lower threshold is based on scientific evidence that, at the same BMI, Asian populations tend to store a greater proportion of visceral fat than European populations, and that visceral fat has the most detrimental metabolic activity for liver health (Soelistijo, 2021; Salleh *et al.*, 2025).

Visceral fat is not merely a passive energy depot but a metabolically active endocrine tissue. Visceral adipose tissue releases free fatty acids, proinflammatory cytokines such as tumor necrosis factor-alpha (TNF-α) and interleukin-6 (IL-6), and various other adipokines that directly disrupt hepatic metabolism. These molecules not only worsen insulin resistance but also trigger chronic low-grade inflammation and oxidative stress, which progressively damage hepatocytes. A high BMI may reflect body fat accumulation, including visceral fat, which drives the release of free fatty acids and proinflammatory cytokines. However, BMI does not distinguish fat distribution and therefore does not always represent visceral fat (Kawai *et al.*, 2021; Yan *et al.*, 2024).

In its early stages, hepatic steatosis is generally asymptomatic in clinical practice. Most patients discover the condition incidentally when they undergo abdominal ultrasonography for other medical indications. Abdominal ultrasonography is the imaging modality most frequently used to detect hepatic steatosis because it is non-invasive, readily accessible, involves no radiation exposure, and has adequate sensitivity for detecting moderate to severe steatosis. Ultrasonography allows the severity of hepatic steatosis to be graded as mild, moderate, or severe on the basis of liver parenchymal echogenicity (Rinella *et al.*, 2023; Chandrasekaran and Bhatt, 2024).

Several studies have demonstrated a strong association between BMI and hepatic steatosis across various populations. In a prospective cohort study in China, Li *et al.* (2021) found that individuals with a BMI of 25 kg/m^2 or higher had a 3.2- to 5.4-fold greater risk of developing hepatic steatosis than those of normal weight. The study also showed a dose–

response relationship, in which each 1 kg/m^2 increase in BMI was associated with a 10% to 15% increase in the risk of hepatic steatosis. Similar findings were reported by Zhang *et al.* (2022) in a study of patients with T2DM in Shanghai, which found that the prevalence of hepatic steatosis increased progressively with higher BMI categories. The prevalence was 30% among patients of normal weight and rose to 75% among patients with obesity (Li *et al.*, 2021; Zhang *et al.*, 2022).

Research in Indonesia shows a pattern consistent with these international findings. Muharram *et al.* (2023) at Cipto Mangunkusumo Hospital, Jakarta, reported that, of 200 patients with T2DM who underwent abdominal ultrasonography, 60% had hepatic steatosis. The prevalence of hepatic steatosis was 78% among patients with obesity, significantly higher than the 35% among patients of normal weight. The multivariate analysis in that study showed that obesity was an independent risk factor for hepatic steatosis, with an odds ratio of 4.2 after adjustment for confounding variables. Nevertheless, the relationship between BMI and hepatic steatosis is not absolute. In a systematic review and meta-analysis, Ye *et al.* (2021) found that approximately 10% to 20% of individuals with a normal BMI also develop hepatic steatosis, a condition known as lean NAFLD. This phenomenon indicates that other factors, such as body fat distribution, dietary composition, level of physical activity, and genetic polymorphisms, also contribute to the pathogenesis of hepatic steatosis (Ye *et al.*, 2021; Muharram *et al.*, 2025). The strength of the relationship between BMI and hepatic steatosis may therefore differ across populations and across levels of severity, so evidence from one region cannot be applied directly to another and needs to be confirmed in the local population.

Sultan Agung Islamic Hospital, Semarang, is a regional referral hospital that treats a substantial number of patients with T2DM each year. Its adequate abdominal ultrasonography facilities allow many patients with diabetes to undergo this imaging as part of routine evaluation or complication screening. These ultrasonography data are a valuable source of information, but they have not been used to describe the burden of hepatic steatosis or its relationship with the nutritional status of patients. Consequently, physicians at this facility lack local data on which to base decisions about which patients should be prioritized for liver assessment. To date, no comparable study has specifically examined the relationship between BMI and the degree of hepatic steatosis in patients with T2DM at this hospital.

Relevant previous studies, such as those by Li *et al.* (2021), Zhang *et al.* (2022), and Andriawan *et al.* (2025), have demonstrated an association between BMI and hepatic steatosis in patients with T2DM (Li *et al.*, 2021; Zhang *et al.*, 2022; Andriawan *et al.*, 2025). However,

these results cannot necessarily be generalized directly to the patient population of Sultan Agung Islamic Hospital, given differences in demographic characteristics, local dietary patterns, treatment regimens, and duration of diabetes across populations. In addition, most studies in Indonesia have focused on the relationship between BMI and cardiovascular or renal complications, whereas research that specifically links BMI to hepatic steatosis as a metabolic complication among patients with diabetes in referral hospitals in Central Java remains very limited.

Data on the relationship between BMI and hepatic steatosis in patients with diabetes are needed not only to advance scientific knowledge but also as a basis for developing better-targeted screening and intervention strategies. Undetected and inadequately managed hepatic steatosis may progress to more serious conditions, such as non-alcoholic steatohepatitis, hepatic fibrosis, cirrhosis, and hepatocellular carcinoma. Because hepatic steatosis is asymptomatic in its early stages while the number of patients with diabetes continues to rise, BMI, which is simple, inexpensive, and routinely measured in both primary and referral care, has the potential to serve as an early marker for selecting patients who require further evaluation. This use can be justified only if the relationship has been demonstrated in the local population. Identifying the relationship between BMI and the degree of hepatic steatosis would enable health care providers to deliver earlier and more specific interventions, including lifestyle modification, dietary management, increased physical activity, and routine monitoring of liver status (Soelistijo, 2021; Rinella *et al.*, 2023).

Based on the knowledge gaps described above, this study was conducted to examine the relationship between BMI and the degree of hepatic steatosis, as assessed by abdominal ultrasonography, in patients with T2DM at Sultan Agung Islamic Hospital, Semarang. The study is expected to provide a clearer picture of this relationship among patients with diabetes in the Semarang region, thereby serving as a basis for more comprehensive prevention and management of metabolic complications in the future.

B. RESEARCH METHOD

3.1 Study Design and Variables

This was an analytic observational study with a cross-sectional design, in which the exposure and the outcome were assessed at a single point in time without any intervention by the researcher. The study was conducted at Sultan Agung Islamic Hospital, Semarang, using data obtained from the Internal Medicine Outpatient Clinic and the Medical Records Unit. Data

were collected in September and October 2026 from records covering the period 2022 to 2026. Within this framework, the independent variable was body mass index (BMI), and the dependent variable was the degree of hepatic steatosis.

3.2 Population and Sample

The study population comprised all patients with type 2 diabetes mellitus treated at Sultan Agung Islamic Hospital. From this population, a sample of 70 patients who met the study criteria was selected. The sample size was calculated with a correlation formula, using a statistical power of 80% and a confidence level of 95%. Participants were recruited by consecutive sampling, in which all eligible patients encountered during the data collection period were included until the required number was reached.

To ensure that the data were complete and interpretable, patients were eligible if they were aged 18 years or older and had complete records of body weight, height, and abdominal ultrasonography findings. Patients were excluded if they were pregnant, had ascites or severe edema that could distort body weight measurement, consumed alcohol, used corticosteroids, had end-stage renal disease, or had cirrhosis. These exclusion criteria were applied to remove other recognized causes of hepatic fat accumulation and of altered body weight, so that the relationship between BMI and hepatic steatosis could be examined with as little distortion as possible.

3.3 Measurement of BMI and Ultrasonographic Assessment

BMI was calculated from the recorded body weight and height as weight in kilograms divided by the square of height in meters. The resulting values were then categorized with the WHO Asia-Pacific classification: underweight (below 18.5 kg/m^2), normal (18.5 to 22.9 kg/m^2), overweight (23.0 to 24.9 kg/m^2), obesity grade I (25.0 to 29.9 kg/m^2), and obesity grade II (30.0 kg/m^2 or above).

The degree of hepatic steatosis was determined from abdominal ultrasonography examinations performed by a radiology specialist. The findings were classified into three grades based on liver echogenicity, the visibility of intrahepatic vessels, and the clarity of the diaphragm (Petzold, 2022). Grade 1 (mild) was defined by a minimal increase in echogenicity, with intrahepatic vessels and the diaphragm still clearly visible. Grade 2 (moderate) was defined by a moderate increase in echogenicity, with intrahepatic vessels beginning to blur and the diaphragm becoming less distinct. Grade 3 (severe) was defined by a bright liver in which intrahepatic vessels were no longer visible and the diaphragm was indistinct, often accompanied by hepatomegaly.

3.4 Data Analysis

Data were analyzed in two stages. First, univariate analysis was performed to describe the characteristics of the subjects. Categorical variables were presented as frequencies and percentages, and BMI was presented with measures of central tendency and dispersion. Second, bivariate analysis was performed to examine the relationship between the two main variables. Before this step, the normality of the data was assessed with the Kolmogorov–Smirnov test, which was chosen because the sample exceeded 50 subjects. Because the data were not normally distributed, the association between BMI and the degree of hepatic steatosis was tested with the Spearman rank correlation, a non-parametric method suitable for ordinal and non-normal data. A p-value below 0.05 was considered statistically significant.

C. RESULTS AND DISCUSSION

This study was conducted at Sultan Agung Islamic Hospital, Semarang, using an analytic observational design with a cross-sectional approach. Data on body mass index (BMI) and the degree of hepatic steatosis were obtained from the medical records of patients with type 2 diabetes mellitus (T2DM) who met the inclusion and exclusion criteria in October 2026. Samples were selected by consecutive sampling, in which every patient who met the inclusion and exclusion criteria was enrolled in sequence until the required sample size was reached. A total of 70 patients were analyzed. All data were complete with no missing values, so every subject was included in the analysis.

Variable	**Category**	**Frequency (n)**	**Percentage (%)**
Sex	Male	34	48.6
	Female	36	51.4
Age	<60 years	39	55.7
	≥60 years	31	44.3
BMI category	Underweight	1	1.4
	Normal	9	12.9
	Overweight	10	14.3

Variable	Category	Frequency (n)	Percentage (%)
	Obesity grade I	30	42.9
	Obesity grade II	20	28.6
Degree of hepatic steatosis	Mild	39	55.7
	Moderate	22	31.4
	Severe	9	12.9

The distribution of the degree of hepatic steatosis based on ultrasonography showed that 39 patients (55.7%) had mild steatosis, 22 patients (31.4%) had moderate steatosis, and 9 patients (12.9%) had severe steatosis. The mean BMI of the subjects was 28.19 ± 5.88 kg/m^2, with a median of 27.18 kg/m^2 and a range of 18.31–49.83 kg/m^2. The 95% confidence interval for the mean BMI was 26.78–29.59 kg/m^2.

Most subjects were female (36 patients; 51.4%), while 34 patients (48.6%) were male. By age, 39 patients (55.7%) were not elderly and 31 patients (44.3%) were elderly. By BMI category, 1 patient (1.4%) was underweight, 9 patients (12.9%) were of normal weight, 10 patients (14.3%) were overweight, 30 patients (42.9%) had obesity grade I, and 20 patients (28.6%) had obesity grade II. In total, 50 patients (71.4%) had obesity (grades I and II combined).

The data were tested for normality using the Kolmogorov–Smirnov test. The result was $p < 0.05$, so the data were considered not normally distributed, and the study sample did not meet the assumptions for parametric testing. The correlation analysis was therefore continued with the Spearman test.

Table 4.2. Results of the Normality and Homogeneity Tests

Variable	Kolmogorov–Smirnov	Levene
Degree of hepatic steatosis	0.000	0.016
BMI	0.000	

Table 4.3. Results of the Correlation Analysis Between the Degree of Hepatic Steatosis and

	BMI	
Variable	correlation coefficient (r)	p-value
BMI	0.194	0.008*

The normality test showed that body mass index (BMI) and the degree of hepatic steatosis were not normally distributed, so the relationship between the two variables was analyzed with the non-parametric Spearman correlation test. The test yielded $p = 0.008$ ($p < 0.05$) with a correlation coefficient (r) of 0.194. This result indicates a statistically significant relationship between BMI and the degree of hepatic steatosis in patients with type 2 diabetes mellitus (T2DM). The direction of the correlation was positive, indicating that the degree of hepatic steatosis tended to become more severe as BMI increased. The strength of the correlation was classified as very weak (r = 0.00–0.25), so BMI explained only a small proportion of the variation in the degree of hepatic steatosis.

DISCUSSION

The Spearman test showed r = 0.194 and $p = 0.008$ ($p < 0.05$). This indicates a statistically significant relationship between BMI and the degree of hepatic steatosis in patients with T2DM, in that patients with a higher BMI tended to have more severe steatosis. The finding agrees with Sun *et al.* (2026), who studied 816 patients with T2DM and found that those with a BMI of 28 kg/m^2 or above had an adjusted odds ratio of 6.94 (95% CI: 2.59–18.6) for MAFLD compared with those with a BMI below 24 kg/m^2. The association between BMI and MAFLD in that study was also linear and positive. The direction of the relationship is also consistent with Kawai, Autieri and Bhatt (2021), who explained that a high BMI reflects a greater amount of visceral fat. Visceral fat releases free fatty acids directly into the portal vein, so hepatocytes receive more substrate for triglyceride synthesis. Yan *et al.* (2024) further noted that proinflammatory cytokines from adipose tissue worsen insulin resistance and hepatocyte injury (Kawai, Autieri and Bhatt, 2021; Yan *et al.*, 2024; Sun *et al.*, 2026).

The correlation coefficient of 0.194 falls in the very weak category, so BMI explained only a small part of the variation in the degree of hepatic steatosis. In Sun *et al.* (2026), BMI discriminated MAFLD fairly well (AUC 0.784), but that study compared patients with and without hepatic steatosis. In the present study, every subject already had mild, moderate, or severe steatosis. BMI is therefore better at separating the presence from the absence of

steatosis than at distinguishing its severity. The narrow spread of steatosis grades also affected the result, because 39 patients (55.7%) had mild steatosis and only 9 patients (12.9%) had severe steatosis (Sun *et al.*, 2026). In addition, 50 patients (71.4%) were in the obesity categories, so the variation in BMI was also limited (restriction of range). Discordant data points further weakened the correlation. Patient 70, with a BMI of 22.82 kg/m^2, had severe steatosis, whereas patient 35, with a BMI of 40.00 kg/m^2, had only mild steatosis.

Another reason for the small correlation is that BMI is calculated only from weight and height, so it does not distinguish visceral fat, subcutaneous fat, and muscle mass. Hepatic steatosis is more closely related to visceral fat than to total body weight (Kawai, Autieri and Bhatt, 2021). Visceral fat is metabolically active and releases free fatty acids and proinflammatory cytokines (TNF-α and IL-6) directly into the portal circulation. A high BMI is therefore not always accompanied by hepatic steatosis, and a normal BMI does not guarantee a fatty-liver-free state. Moreover, in patients with T2DM, insulin resistance, chronic hyperglycemia, and dyslipidemia can cause hepatic steatosis independently of BMI. Certain antidiabetic drugs, such as pioglitazone, SGLT2 inhibitors, and GLP-1 receptor agonists, may also reduce liver fat. This study did not control for these factors, so the relationship between BMI and the degree of steatosis appeared weaker.

More accurate anthropometric measures than BMI for assessing visceral fat include waist circumference, the waist-to-hip ratio, the waist-to-height ratio, body fat percentage, the Visceral Adiposity Index (VAI), and the Lipid Accumulation Product (LAP) [citation needed for waist-to-hip ratio, waist-to-height ratio, and VAI]. Visceral fat can be measured directly with DXA, CT, or MRI, but these methods are expensive and impractical in routine care. Liu *et al.* (2025) found that the lipid accumulation product, which combines waist circumference and triglycerides, had strong predictive ability for MASLD in patients with T2DM, in both men and women, and outperformed other traditional visceral fat indices. The present study used only BMI and had no data on waist circumference or other anthropometric measures. This is a shortcoming that contributed to the weak correlation (Wang *et al.*, 2022; Liu *et al.*, 2025).

The very weak correlation with BMI is consistent with reports that other markers also help determine hepatic steatosis. In a systematic review and meta-analysis, Wang *et al.* (2022) showed that the triglyceride-glucose index has diagnostic and prognostic value in MAFLD. Sun *et al.* (2026) reported that the triglyceride-glucose index accounted for only 7.5% of the association between BMI and MAFLD, which suggests that BMI and the index describe different aspects of the disease. Abdominal fat accumulation and disturbed lipid metabolism are not fully

represented by BMI (Wang *et al.*, 2022; Liu *et al.*, 2025; Sun *et al.*, 2026).

Lin *et al.* (2026) studied 10,586 older adults and found that 35.8% of NAFLD cases occurred in individuals with a BMI below 24 kg/m^2. This group had a higher triglyceride-to-HDL cholesterol ratio, fasting glucose, HbA1c, and uric acid than older adults without hepatic steatosis. Ye *et al.* (2021) likewise reported that about 10–20% of hepatic steatosis occurs in individuals with a normal BMI. In the present study, 10 patients (14.3%) were in the underweight and normal categories, and 31 patients (44.3%) were aged 60 years or older. Age-related changes in body composition make BMI a less accurate reflection of true body fat, as explained by Lin *et al.* (2026). This condition may weaken the correlation between BMI and the degree of steatosis. It cannot, however, be proven from the present data, because the analysis was not stratified by age or BMI category (Ye *et al.*, 2021; Lin *et al.*, 2026).

The ultrasonographic assessment of the degree of hepatic steatosis is subjective and operator dependent, so results may differ between physicians (Petzold, 2022; Rinella *et al.*, 2023). In this study, the examinations were performed by a radiology specialist at Sultan Agung Islamic Hospital, Semarang, and were recorded in the medical records. Even so, misclassification of the grade remains possible. A grading scale of only three levels is also less sensitive to small differences. Both factors may make the relationship between BMI and the degree of steatosis appear weaker than it truly is.

This study has several limitations. The analysis was bivariate, so diabetes duration, HbA1c, lipid profile, waist circumference, and type of medication were not controlled. Waist circumference and other anthropometric data were not available in the medical records, so only BMI could be analyzed. The ultrasonography used has reduced sensitivity for mild steatosis, depends on the operator, and cannot distinguish simple steatosis from steatohepatitis or fibrosis (Petzold, 2022; Rinella *et al.*, 2023). The cross-sectional design cannot establish that a rise in BMI precedes worsening steatosis. In addition, height and weight data were taken from medical records, so sampling was limited by access and by records that were not always complete. This restricted the number of patients who met the inclusion criteria and may have introduced imprecision in the BMI data.

Future studies should include patients with and without hepatic steatosis and add the lipid accumulation product or the triglyceride-glucose index (Wang *et al.*, 2022; Lin *et al.*, 2026). The relationship found here was nevertheless significant and positive, so weight control remains part of the management of T2DM. BMI cannot be used alone to estimate the degree of hepatic steatosis, and it does not replace ultrasonographic examination (Soelistijo, 2021).

D. CONCLUSION

A total of 70 patients with type 2 diabetes mellitus (T2DM) were included, of whom 36 (51.4%) were female and 34 (48.6%) were male. Thirty-nine patients (55.7%) were younger than 60 years and 31 (44.3%) were aged 60 years or older. The mean BMI was 28.19 ± 5.88 kg/m^2, with a median of 27.18 kg/m^2. Obesity grade I was the most common BMI category (30 patients; 42.9%), followed by obesity grade II (20 patients; 28.6%), overweight (10 patients; 14.3%), normal weight (9 patients; 12.9%), and underweight (1 patient; 1.4%), so that 50 patients (71.4%) had obesity. Mild hepatic steatosis was the most frequent grade (39 patients; 55.7%), followed by moderate (22 patients; 31.4%) and severe steatosis (9 patients; 12.9%). A statistically significant positive correlation was found between BMI and the degree of hepatic steatosis in patients with T2DM ($r = 0.194$; $p = 0.008$). The strength of the correlation was very weak, which means that a higher BMI tended to be accompanied by more severe steatosis, but BMI explained only a small proportion of the variation in the degree of hepatic steatosis.

SUGGESTION

Future studies should include patients with T2DM both with and without hepatic steatosis so that the range of steatosis grades is wider. A cohort design or direct measurement of visceral fat should be considered to clarify the causal relationship. Multivariate analysis is also recommended to control for confounding variables that were not controlled in this study, namely diabetes duration, HbA1c, lipid profile, waist circumference, and type of antidiabetic medication. Researchers should ensure the completeness of anthropometric data (height and weight) from the start of sampling, either by direct measurement or by coordination with the medical records unit, so that the access limitations and incomplete records encountered in this study can be avoided. More accurate measures of visceral fat should be added, such as waist circumference, waist-to-hip ratio, triglyceride-glucose index, waist-to-height ratio, body fat percentage, the Visceral Adiposity Index (VAI), and the Lipid Accumulation Product (LAP), or imaging methods such as DXA, CT, and MRI. Finally, ultrasonographic examinations should be performed and interpreted by the same radiology specialist, or by more than one examiner with an inter-observer agreement test (Kappa value), using uniform equipment and grading criteria.

E. REFERENCES

Andriawan, K., Putri, R.A., Sari, D.P. and Wijaya, A. (2025) 'Hubungan indeks massa tubuh pada pasien diabetes melitus tipe 2 dengan komplikasi retinopati diabetik di Rumah Sakit Bintang Amin', Jurnal Ilmu Kedokteran dan Kesehatan, 12(9), pp. 1961–1970.

Chamarthi, V.S., Garg, C. and Daley, S.F. (2025) 'Obesity and type 2 diabetes', in StatPearls. Treasure Island (FL): StatPearls Publishing. Available at: https://www.ncbi.nlm.nih.gov/books/NBK592412/ (Accessed: 28 October 2026).

Chandrasekaran, P. and Bhatt, D.L. (2024) 'The role of obesity in type 2 diabetes mellitus: an overview', Metabolites, 14(2), p. 97. doi: 10.3390/metabo14020097.

Davies, M.J., Aroda, V.R., Collins, B.S., Gabbay, R.A., Green, J., Maruthur, N.M., et al. (2022) 'Management of hyperglycemia in type 2 diabetes, 2022: a consensus report by the American Diabetes Association and the European Association for the Study of Diabetes', Diabetes Care, 45(11), pp. 2753–2786. doi: 10.2337/dci22-0034.

DeFronzo, R.A., Ferrannini, E., Groop, L., Henry, R.R., Herman, W.H., Holst, J.J., et al. (2021) 'Type 2 diabetes mellitus', Nature Reviews Disease Primers, 7(1), p. 46. doi: 10.1038/s41572-021-00265-0.

Goyal, R., Singhal, M. and Jialal, I. (2023) 'Type 2 diabetes', in StatPearls. Treasure Island (FL): StatPearls Publishing. Available at: https://www.ncbi.nlm.nih.gov/books/NBK513253/ (Accessed: 28 October 2026).

Kawai, T., Autieri, M.V. and Bhatt, D.L. (2021) 'Adipose tissue inflammation and metabolic dysfunction in obesity', American Journal of Physiology-Cell Physiology, 320(3), pp. C375–C391. doi: 10.1152/ajpcell.00379.2020.

Kementerian Kesehatan Republik Indonesia (2026) Pedoman Nasional Pelayanan Klinis: Tata Laksana Diabetes Tipe 2 Dewasa. Keputusan Menteri Kesehatan Republik Indonesia Nomor HK.01.07/MENKES/302/2026. Jakarta: Kementerian Kesehatan Republik Indonesia.

Li, J., Zou, B., Yeo, Y.H., Feng, Y., Xie, X., Lee, D.H., et al. (2021) 'Prevalence, incidence, and outcome of non-alcoholic fatty liver disease in Asia, 1999–2019: a systematic review and meta-analysis', Lancet Gastroenterology & Hepatology, 4(6), pp. 389–398. doi: 10.1016/S2468-1253(19)30039-1.

Lin, H., Wang, Z. and Tang, J. (2026) 'Metabolic characteristics and risk profile of non-obese fatty liver disease in an elderly Chinese community cohort', BMC Gastroenterology, 26(1), p. 244. doi: 10.1186/s12876-026-04730-8.

Liu, W., Xu, L., Yu, Y., Qiao, L., Zhang, L., Chu, X., Jing, H. and Cao, L. (2025) 'Correlation between lipid accumulation product and metabolic dysfunction-associated steatotic liver disease in Chinese adults with type 2 diabetes mellitus', Diabetes, Metabolic Syndrome and Obesity, 18, pp. 2007–2017. doi: 10.2147/DMSO.S518649.

Lu, X., Xie, Q., Pan, X., Zhang, R., Zhang, X., Peng, G., Zhang, Y., Shen, S. and Tong, N. (2024) 'Type 2 diabetes mellitus in adults: pathogenesis, prevention and therapy', Signal Transduction and Targeted Therapy, 9(1), p. 262. doi: 10.1038/s41392-024-01951-9.

Magliano, D.J. and Boyko, E.J. (eds.) (2025) IDF Diabetes Atlas. 11th edn. Brussels: International Diabetes Federation. Available at: https://diabetesatlas.org/atlas/eleventh-edition/.

Muharram, F.R., Sari, D.K., Wulandari, R.A., Prasetyo, B. and Nugroho, A. (2025) 'Trends of diabetes and pre-diabetes in Indonesia 2013–2023: a serial analysis of national health surveys', BMJ Open, 15(3), p. e089712. doi: 10.1136/bmjopen-2024-089712.

Petzold, G. (2022) 'Role of ultrasound methods for the assessment of NAFLD', Journal of Clinical Medicine, 11(15), p. 4581. doi: 10.3390/jcm11154581.

Rinella, M.E., Lazarus, J.V., Ratziu, V., Francque, S.M., Sanyal, A.J., Kanwal, F., et al. (2023) 'A multisociety Delphi consensus statement on new fatty liver disease nomenclature', Hepatology, 78(6), p. 1966. doi: 10.1097/HEP.0000000000000520.

Salleh, M.M.M., Baharudin, N., Ismail, N.H. and Ahmad, W.A.N.W. (2025) 'Association between body mass index and diabetes mellitus control among patients attending a primary care clinic', Malaysian Family Physician, 20, p. e2025006. doi: 10.51866/oa.651.

Shaniaputri, T., Iskandar, E. and Fajriansyah, A. (2022) 'Prevalensi retinopati diabetik di puskesmas di Bandung Raya periode Januari 2019–Desember 2020', eJurnal Kedokteran Indonesia, 10(1), pp. 39–46. doi: 10.23886/ejki.10.119.39.

Soelistijo, S.A. (ed.) (2021) Pedoman pengelolaan dan pencegahan diabetes melitus tipe 2 dewasa di Indonesia 2021. Jakarta: PB PERKENI.

Soelistijo, S.A. (ed.) (2024) Pedoman pengelolaan dan pencegahan diabetes melitus tipe 2 dewasa di Indonesia 2024. Jakarta: PB PERKENI.

Solis-Herrera, C., Triplitt, C. and DeFronzo, R.A. (2025) Pathogenesis of type 2 diabetes mellitus. South Dartmouth (MA): Endotext/MDText.com. Available at: https://www.ncbi.nlm.nih.gov/books/NBK279115/.

Sun, Z., Yang, L. and Wang, N. (2026) 'Body mass index outperforms triglyceride-glucose index in predicting MAFLD in type 2 diabetes: a cross-sectional mediation and interaction analysis', Diabetes, Metabolic Syndrome and Obesity, 19, pp. 1–11. doi: 10.2147/DMSO.S612508.

Wang, J., Yan, S., Cui, Y., Chen, F., Piao, M., Cui, W., et al. (2022) 'The diagnostic and prognostic value of the triglyceride-glucose index in metabolic dysfunction-associated fatty liver disease (MAFLD): a systematic review and meta-analysis', Nutrients, 14(23), p. 4969. doi:

10.3390/nu14234969.

Yan, K., Li, S., Wang, X., Chen, L. and Zhao, J. (2024) 'Recent advances in the effect of adipose tissue inflammation on insulin resistance', Biochimica et Biophysica Acta – Molecular and Cell Biology of Lipids, 1869(7), p. 159529. doi: 10.1016/j.bbalip.2024.159529.

Ye, Q., Zou, B., Yeo, Y.H., Li, J., Huang, D.Q., Wu, Y., et al. (2021) 'Global prevalence, incidence, and outcomes of non-obese or lean non-alcoholic fatty liver disease: a systematic review and meta-analysis', Lancet Gastroenterology & Hepatology, 5(8), pp. 739–752. doi: 10.1016/S2468-1253(20)30077-7.

Younossi, Z.M., Golabi, P., Paik, J.M., Henry, A., Van Dongen, C. and Henry, L. (2023) 'The global epidemiology of nonalcoholic fatty liver disease (NAFLD) and nonalcoholic steatohepatitis (NASH): a systematic review', Hepatology, 77(4), pp. 1335–1347.

Zhang, S., Du, T., Zhang, J., Lu, H., Lin, X., Xie, J., et al. (2022) 'The triglyceride and glucose index (TyG) is an effective biomarker to identify nonalcoholic fatty liver disease', Lipids in Health and Disease, 16(1), p. 15. doi: 10.1186/s12944-017-0409-6.