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A study on prevalence of non-alcoholic fatty liver disease in diabetes mellitus

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Abstract

NAFLD is commonly associated with Type 2 diabetes mellitus in clinical practice it is overlooked despite the significant clinical implications of NAFLD in Type 2 diabetes mellitus. Non-Alcoholic Fatty Liver Disease (NAFLD) in association with Type 2 Diabetes Mellitus (T2DM) can significantly increase the risk and severity of both conditions. Peripheral insulin resistance serves as a central mechanism in the pathogenesis of NAFLD and T2DM alike. The estimated prevalence of NAFLD in individuals with T2DM ranges from 70% to 75%. Patients diagnosed with both NAFLD and T2DM tend to have a poorer prognosis, with the mortality rate due to cirrhosis being notably higher in diabetic patients compared to the general population. This study was done to estimate the prevalence of NAFLD in diabetes mellitus.

The term MASLD formally MAFLD will now be MASLD (Metabolic dysfunction - associated steatotic liver disease [51] MAFLD was defined as the presence of SLD with overweight/obesity (BMI > 25 kg/m^2), T2DM or presence of metabolic dysregulation. MASLD was defined as SLD with atleast one cardiometabolic risk factor without excessive alcohol intake [51]. This new nomenclature defined by multisociety Delphi process and proposed by a panel of expert will help to differentiate people with pure MASLD from those MetALD (Metabolic liver disease associated with alcohol [51].

Methods: This cross-sectional observational study was conducted in both the outpatient and inpatient settings of the Department of General Medicine at Al-Ameen Medical College Hospital, Vijayapura, over a period of 18 month (July 2023 to December 2024). A total of 96 patients diagnosed with Type 2 Diabetes Mellitus (T2DM) or Type 1 DM on insulin therapy, who met the inclusion and exclusion criteria, were enrolled in the study.

The inclusion criteria were based on the American Diabetes Association (ADA) guidelines[18], which define diabetes as a fasting plasma glucose level of ≥126 mg/dL, a 2-hour postprandial blood glucose level of ≥200 mg/dL, or an HbA1C level of ≥6.5%. Patients were excluded if they had a history of alcohol consumption, tested positive for HIV, HCV, or HBsAg, or were on medications known to cause steatohepatitis, such as steroids, methotrexate, and estrogen-containing preparations. The sample size (n = 96) was obtained using Statulator software, based on an anticipated prevalence of Metabolic Dysfunction-Associated Steatotic Liver Disease (MASLD) among diabetic patients of 51.3%[17], with a 95% confidence level and 10% absolute precision.

Results: In our study of 96 diabetic patients, the majority (38.5%) were aged 21–40 years, with no significant age or gender differences (male-to-female ratio: 1.08:1). The overall prevalence of MASLD was 51.0%, with no statistically significant gender association. Obesity was significantly more common in MASLD patients (52.0%) than non-MASLD patients (19.7%) ($P < 0.01$), and BMI was significantly higher in the MASLD group. Central obesity markers, including waist circumference and waist-hip ratio, showed strong associations with MASLD in both males and females ($P < 0.001$). Additionally, liver enzymes (SGOT, SGPT, ALP) were significantly elevated in MASLD patients (40.8%) compared to non-MASLD patients (12.7%) ($P < 0.01$), highlighting their potential diagnostic value.

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Conclusion: MASLD is highly prevalent among diabetic patients, with obesity and dyslipidemia identified as major contributing factors, and liver function tests proving useful for early diagnosis. The study highlights the significance of metabolic parameters such as BMI, waist circumference, and lipid profile in the development of MASLD and supports existing evidence that MASLD independently contributes to liver dysfunction and metabolic complications in diabetics. Although no statistically significant gender difference in MASLD prevalence was observed, male patients demonstrated a higher tendency toward central obesity and associated metabolic changes. These findings underscore the importance of early screening and timely intervention to prevent the progression of MASLD in individuals with diabetes.

Keywords: Non-Alcoholic Fatty Liver Disease; Diabetes Mellitus; Prevalence; MASLD - (Metabolic Dysfunction - Associated Steatotic Liver Disease

1. Introduction

Metabolic Dysfunction-Associated Steatotic Liver Disease (MASLD) describes a broad spectrum of liver conditions, ranging from simple steatosis to non-alcoholic steatohepatitis (NASH), cirrhosis, and hepatocellular carcinoma, occurring in the absence of significant alcohol consumption (defined as <20–40 g/day)[1]. The hallmark of MASLD is the accumulation of macrovesicular fat in more than 5% of hepatocytes without notable necroinflammation or fibrosis. MASLD has become the most common cause of chronic liver disease in Western countries[1]. It is frequently associated with diabetes mellitus, with studies indicating a prevalence of MASLD in 60% to 76% of diabetic patients and NASH in approximately 22%[2,3].

In India, the prevalence of diabetes mellitus has increased from 7% in 2009 to 8.9% in 2019[4]. Diabetes mellitus, a multisystemic disease, is now increasingly linked to metabolic dysfunction-associated steatotic liver disease (MASLD), previously known as MASLD. MASLD and type 2 diabetes mellitus (T2DM) often coexist, with a prevalence of MASLD reported at 59.67% among T2DM patients, and exceeding 70% in obese individuals with T2DM. As most patients with MASLD are asymptomatic, its true prevalence is likely underestimated[5].

MASLD encompasses a pathological spectrum from simple steatosis (NAFL) and NASH to fibrosis and cirrhosis, without excessive alcohol intake (<30 g/day for men and <20 g/day for women)[6]. Its strong association with obesity, insulin resistance, T2DM, and dyslipidemia supports the view that MASLD represents the hepatic manifestation of metabolic syndrome[6]. MASLD includes conditions ranging from simple steatosis, NASH, cirrhosis, to hepatocellular carcinoma[7]. The pathogenesis of MASLD involves insulin resistance and compensatory hyperinsulinemia, leading to disrupted lipid metabolism, hepatic triglyceride accumulation, or beta-cell dysfunction in T2DM patients[8]. Risk factors for NASH, in addition to T2DM, include hypercholesterolemia, hypertriglyceridemia, metabolic syndrome, polycystic ovary syndrome, sleep apnea, and hypothyroidism[9].

MASLD was virtually unknown three decades ago, but it has now emerged as a leading cause of chronic liver disease worldwide, in both developed and developing nations[10,11]. Approximately 25% of individuals with MASLD develop NASH, and of these, about 20% may progress to cirrhosis[10]. Elevated alanine aminotransferase (ALT) levels, over twice the normal limit, are observed in about 20% of children with T2DM, frequently due to MASLD[12]. This can result in adverse outcomes such as increased mortality due to cirrhosis[13]. MASLD is now widely recognized as part of the metabolic syndrome cluster[14] and has become a significant global health concern. The coexistence of MASLD and T2DM increases the risk of cardiovascular events, further emphasizing the importance of early detection and lifestyle modifications as essential components of MASLD management, regardless of diabetic status[15,16].

Given these considerations, a systematic study to evaluate the prevalence of MASLD in patients with diabetes mellitus is essential. Such a study can help fill existing research gaps and improve understanding of the epidemiology of NASH. Therefore, the present study was undertaken to determine the prevalence of MASLD in individuals with T2DM and to examine its association with central obesity and lipid profile. Specifically, the study aims to assess the prevalence of non-alcoholic fatty liver disease in patients with diabetes mellitus, and to evaluate its association with both central obesity and general obesity, defined as BMI >25.

Aims

To assess the prevalence and associated factors of Metabolic Dysfunction-Associated Steatotic Liver Disease (MASLD) in patients with diabetes mellitus.

Objectives

- To determine the prevalence of non-alcoholic fatty liver disease among patients with diabetes mellitus.
- To evaluate the association between central obesity and the presence of non-alcoholic fatty liver disease.
- To evaluate the association between general obesity (BMI >25) and the presence of non-alcoholic fatty liver disease.

2. Materials and Methods

This cross-sectional observational study was conducted in both the outpatient and inpatient settings of the Department of General Medicine at Al-Ameen Medical College Hospital, Vijayapura. The study period extended over 18 months, from July 2023 to December 2024. The study population included patients diagnosed with diabetes mellitus—either Type 1 patients on insulin therapy or Type 2 patients of any duration—who were admitted to the general medicine ward or attending the outpatient department. A total of 96 patients who fulfilled the inclusion and exclusion criteria were selected for the study.

The sample size was determined based on an anticipated prevalence of Metabolic Dysfunction-Associated Steatotic Liver Disease (MASLD) among diabetic patients of 51.3% 17, with a 95% confidence level and 10% absolute precision. The calculation was performed using Statulator software. The formula used was:

$n = (z*p*q)/d2.\ 17$

where Z is the Z statistic at the desired level of confidence, p is the estimated prevalence, q is 100-p, and d is the absolute error. Based on this formula, the required sample size was found to be 96.

Patients were included in the study if they had Type 2 diabetes mellitus of any duration. Diabetes was defined according to the American Diabetes Association (ADA) guidelines as one or more of the following: a fasting plasma glucose (FBS) of ≥126 mg/dL, a 2-hour postprandial blood glucose (PPBS) of ≥200 mg/dL, or an HbA1C level of ≥6.5%.18

Exclusion criteria included patients with a history of alcohol consumption, those seropositive for HIV (ELISA), anti-HCV antibody, or HBsAg, and patients who were on medications known to induce steatohepatitis, such as steroids, amiodarone, oral contraceptive pills, estrogen-containing preparations, and methotrexate.

All eligible participants were informed about the nature and purpose of the study, and written informed consent was obtained before enrollment. Data were collected using a structured proforma designed for the study (Annexure IIH). Each participant underwent a detailed medical history and thorough clinical examination, including vital signs and systemic examination focusing on the abdomen, respiratory system, and central nervous system. Blood samples were obtained either during hospital admission or outpatient visits for the assessment of fasting lipid profile, liver function tests, fasting and postprandial blood glucose levels, HbA1C, HIV status, anti-HCV antibody, HBsAg, and prothrombin time.

Ultrasonography of the abdomen and pelvis was performed in all participants to assess the presence of fatty liver. In addition, anthropometric measurements such as height and weight were recorded for all patients, and Body Mass Index (BMI) was calculated. Participants were classified based on the World Health Organization (WHO) Southeast Asia classification of BMI.18

2.1. Statistical Analysis

Data entry was performed using Microsoft Excel and the statistical analysis was conducted using SPSS software version 25.0. A p-value less than 0.05 was considered statistically significant. The statistical tests applied included the Chi-square test, Student's t-test, Analysis of Variance (ANOVA), and Pearson's correlation coefficient to evaluate relationships between variables.

3. Results

Table 1 Age and gender wise distribution of patients

Age in years	Males		Females		Total	
	No.	%	No.	%	No.	%
21—40	19	38	18	39.1	37	38.5
41—60	15	30	15	32.6	30	31.3
61—80	16	32	11	23.9	27	28.1
>80	0	0.0	2	4.4	2	2.1
Total	50	100.0	46	100.0	96	100.0
Mean ± SD	48.64 ± 17.32		49.77 ± 15.75		49.17 ± 16.42	
P-value	t = 0.331 P = 0.742, NS					

NS= not significant, S=significant, HS=highly significant

Study observed that: majority of type 2 DM patients 37 (38.5%) were belongs to the age group of 21—40 years, followed by 30 (31.3%) of patients were belongs to the age group of 41—60 years, 27 (28.1%) of patients were belongs to the age group of 61-80 years. And 2 (2.1%) of patients belong to >80 years. Minimum age of patient was 23 years and maximum age of patient was 82 years. There was statistically no significant difference of mean age in male and females (P>0.05)

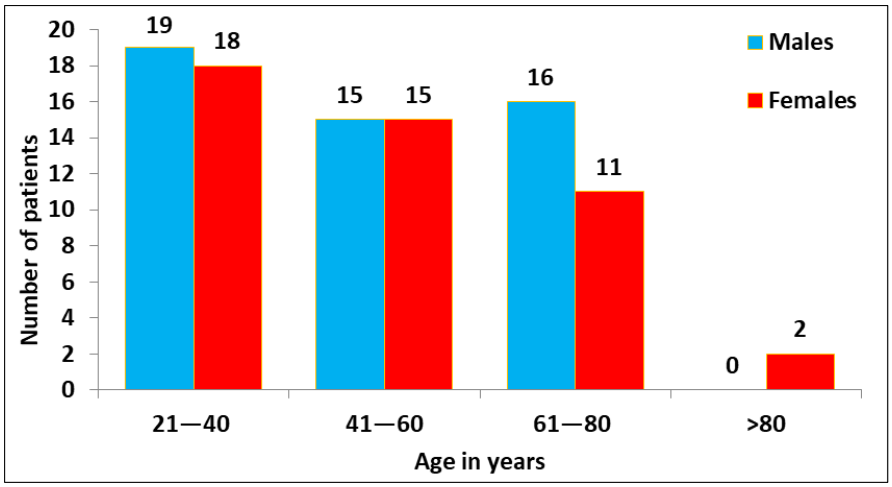

Figure 1 Multiple bar diagram represents age and gender wise distribution of patients

Table 2 Gender wise distribution of patients

Gender	Number of patients	Percentage
Males	50	52.1
Females	46	47.9
Total	96	100.0

Study observed that; Male patients were 50 (52.1%) and 46 (47.9%) of patients were females. Male to Female ratio was 1.08:1

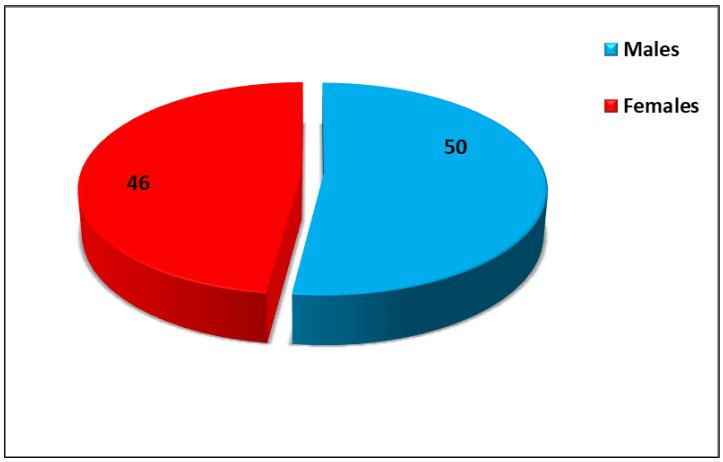

Figure 2 Pie chart represents gender wise distribution of patients

Graph-1 illustrates that there were 50 male patients, accounting for 52.1% of the total, while 46 patients were female, making up 47.9% of the total. The male to female ratio was calculated to be 1.08:1.

Table 3 Prevalence of Metabolic Dysfunction-Associated Steatotic Liver Disease (MASLD) and diabetes mellitus

Patients	**Males**		**Females**		**Total**	
	No.	%	No.	%	No.	%
DM with MASLD	24	48	25	54.3	49	51.0
DM without MASLD	26	52	21	45.7	47	49.0
Total	50	100.0	46	100.0	96	100.0
P-value	$X^2 = 0.386$ P = 0.534, NS					

NS= not significant, S=significant, HS=highly significant

The study prevalence of Metabolic Dysfunction-Associated Steatotic Liver Disease (MASLD) was 51.0%. It has been observed that there were 24 (48.0%) males and 25 (54.3%) females in individuals DM with MASLD, while there were 26 (52.0%) males and 21 (45.7%) females in individuals DM without MASLD. There was statistically no significant difference in the distribution of MASLD patients among gender (P>0.05)

Bar chart shows prevalence of Metabolic Dysfunction Associated Steatotic Liver Disease (MASLD) and diabetes mellitus

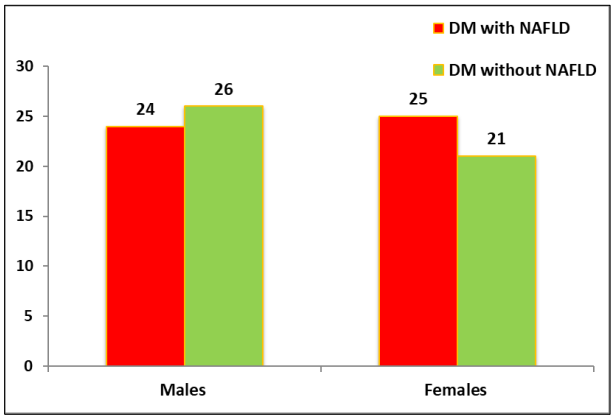

Figure 3 Prevalence of Metabolic Dysfunction-Associated Steatotic Liver Disease (MASLD) and diabetes mellitus

Table 4 Association of MASLD with BMI

BMI	MASLD		Non-MASLD		Total	
	No.	%	No.	%	No.	%
Underweight < 18.5	0	0.0	0	0.0	0	0.0
Normal weight (18.5--22.9)	0	0.0	2	4.2	2	2.1
Overweight (23.0--24.9)	24	48.0	35	76.1	59	61.5
Obese-I (25.0--29.9)	13	26.0	7	15.2	20	20.8
Obese II (>30)	12	24.0	3	6.5	16	16.6
Total	49	100.0	47	100.0	96	100.0
X^2 teat, P-value	X^2 = 12.019, P = 0.007, HS					

NS= not significant, S=significant, HS=highly significant

Analysis of MASLD cases and (non-MASLD) controls with respect to body mass index (BMI) 52.0% of cases were obese while in the non-MASLD group obesity was noticed in 19.7%. Study reveals that; the mean BMI was observed high in MASLD patients as compare to non-MASLD patients which was statistically highly significant (P<0.01)

Bar diagram represents association of MASLD with BMI

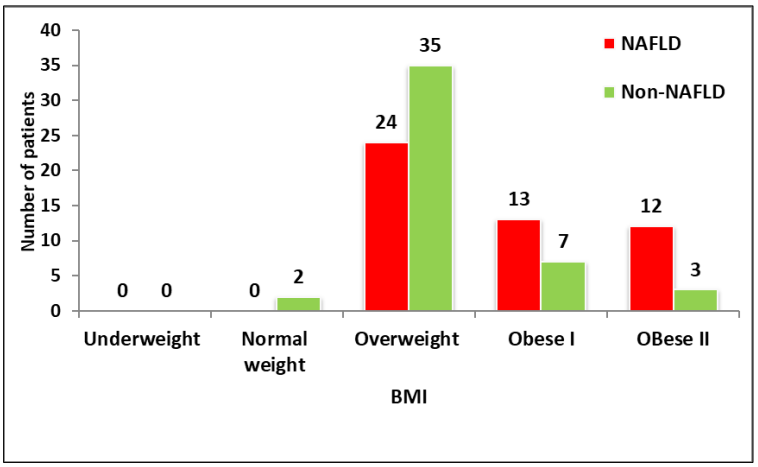

Figure 4 Association of MASLD with BMI

Table 5 Association of MASLD and Non-MASLD with waist circumference in males

Waist circumference	MASLD		Non-MASLD		Total	
	No.	%	No.	%	No.	%
< 94.9	0	0.0	10	38.5	10	20.0
95—101.9	18	75.0	16	61.5	34	68.0
>102	6	25.0	0	0.0	6	12.0
Total	24	100.0	26	100.0	50	100.0
X^2 teat, P-value	X^2 = 16.063, P = 0.0032, HS					

NS= not significant, S=significant, HS=highly significant

Study reveals that; waist circumference ≥ 102 were observed 25.0% of male patients in MASLD and waist circumference ≥102 were observed 0.0% of male patients in non-MASLD. There was statistically highly significant association of waist circumference in male patients with MASLD and Non MASLD (P<0.001).

Bar diagram represents association of MASLD and Non-MASLD with waist circumference in males

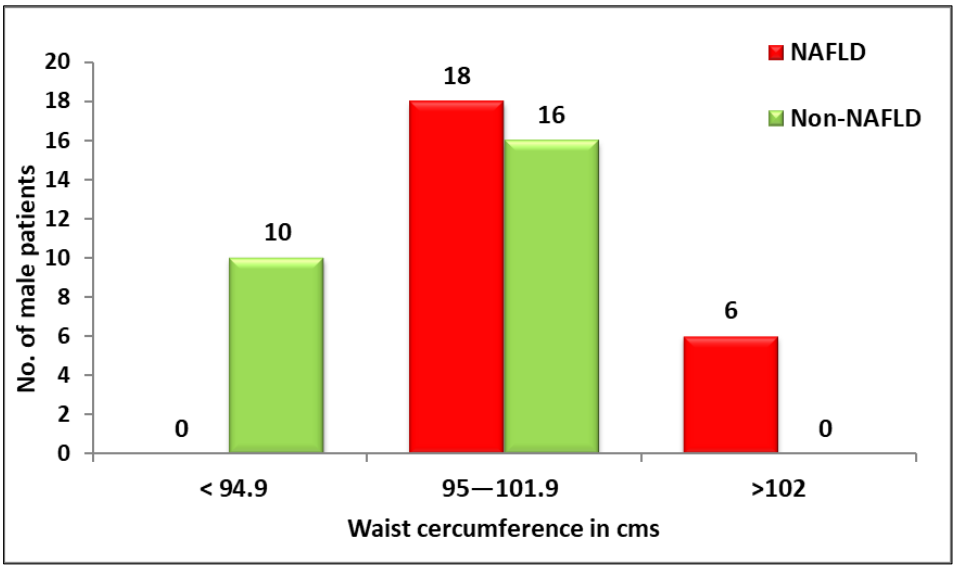

Figure 5 Association of MASLD and Non-MASLD with waist circumference in males

Table 6 Association of MASLD and Non-MASLD with waist circumference in females

Waist circumference	**MASLD**		**Non-MASLD**		**Total**	
	No.	%	No.	%	No.	%
< 80.9	0	0.0	7	33.3	7	15.2
81—89.9	19	76.0	13	61.9	32	69.6
≥ 90	6	24.0	1	4.8	7	15.2
Total	25	100.0	21	100.0	46	100.0
X^2 teat, P-value	X^2 = 11.435, P = 0.0033, HS					

NS= not significant, S=significant, HS=highly significant

Study reveals that; waist circumference ≥ 90 were observed 24.0% of female patients in MASLD and waist circumference ≥ 90 were observed 15.2% of female patients in non-MASLD. There was statistically highly significant association of waist circumference in female patients with MASLD and Non MASLD (P<0.001).

Bar diagram represents association of MASLD with waist circumference in females

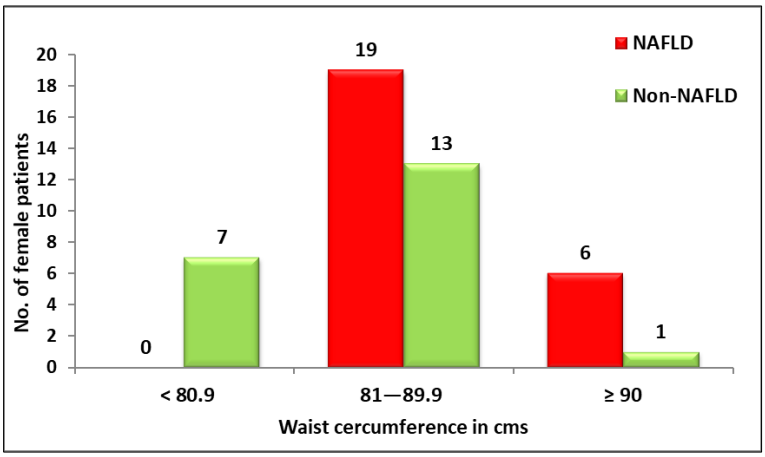

Figure 6 Association of MASLD with waist circumference in female

Table 7 Association of MASLD Non-MASLD with waist hip ratio in males

Waist hip ratio	MASLD		Non-MASLD		Total	
	No.	%	No.	%	No.	%
< 0.95	1	4.2	15	57.7	16	32.0
0.96—1.0	16	66.7	11	42.3	27	54.0
>1	7	29.1	0	0.0	7	14.0
Total	24	100.0	26	100.0	50	100.0
X^2 teat, P-value	X^2 = 20.128, P = 0.00004, HS					

NS= not significant, S=significant, HS=highly significant

Study reveals that; waist hip ratio > 1 were observed 29.1% of male patients in MASLD and waist hip ratio > 1 were observed 0.0% of male patients in non-MASLD. There was statistically highly significant association of waist hip ratio in male patients with MASLD and Non MASLD (P<0.001).

Bar diagram represents association of MASLD with waist hip ratio in males

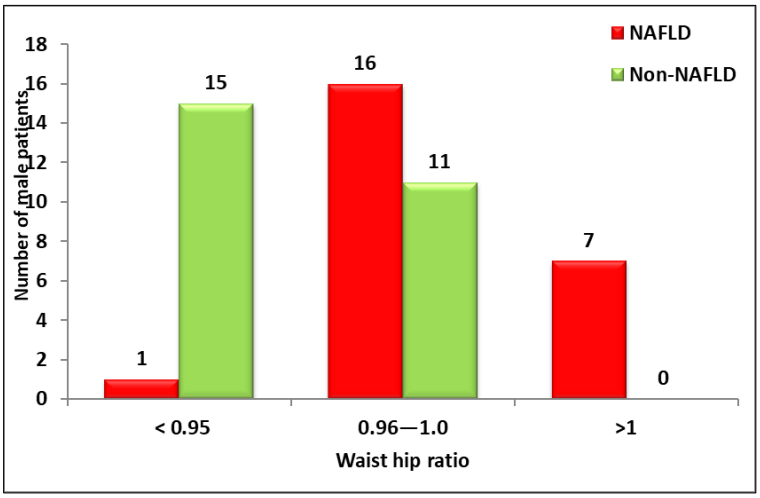

Figure 7 Association of MASLD with waist hip ratio in males

Table 8 Association of MASLD and Non-MASLD with waist hip ratio in females

Waist hip ratio	MASLD		Non-MASLD		Total	
	No.	%	No.	%	No.	%
< 0.80	0	0.0	8	38.1	8	17.4
0.81—0.84	19	76.0	13	61.9	32	69.6
> 0.84	6	24.0	0	0.0	6	13.0
Total	25	100.0	21	100.0	46	100.0
X^2 teat, P-value	X^2 = 14.889, P = 0.00058, HS					

NS= not significant, S=significant, HS=highly significant

Study reveals that; waist hip ratio > 0.84 were observed 24.0% of female patients in MASLD and waist hip ratio > 0.84 were observed 0.0% of female patients in non-MASLD. There was statistically highly significant association of waist hip ratio in female patients with MASLD and Non MASLD (P<0.001).

Bar diagram represents association of MASLD with waist hip ratio in females

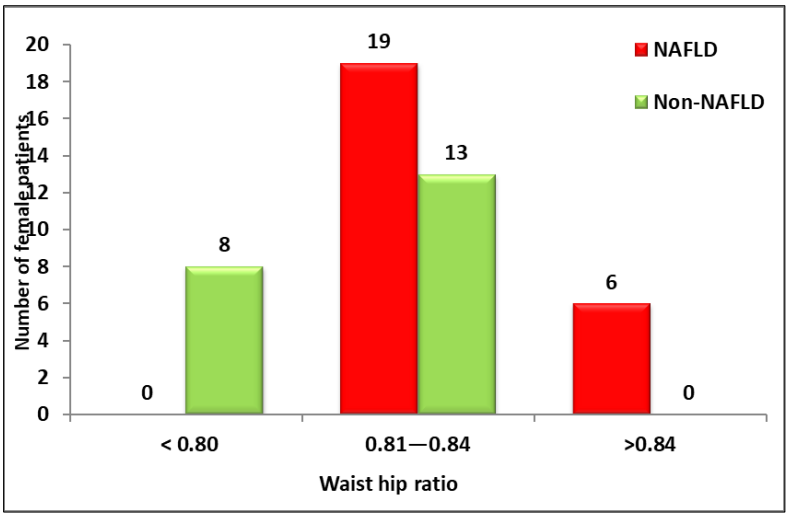

Figure 8 Association of MASLD with waist hip ratio in females

Table 9 Association of MASLD and Non-MASLD with Hb% level

Hb% level		MASLD (49)		Non-MASLD (47)		X^2 teat, P-value
		No	%	No	%	
Males	< 13.0%	10	41.7	11	42.3	X^2 = 0.023, P = 0.962, NS
	≥ 13.0%	14	58.3	15	57.7	
Females	< 12.0%	8	33.3	7	26.9	X^2 = 0.019, P = 0.971, NS
	≥ 12.0%	16	66.7	19	73.1	

Study reveals that; there was statistically no significant difference in the distribution of Hb% level in males and females between MASLD and Non-MASLD (P>0.05)

Multiple bar diagram represents association of MASLD and Non-MASLD with Hb% level

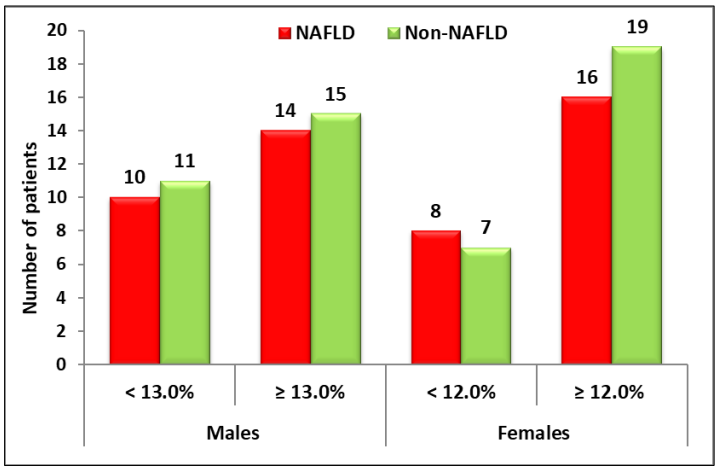

Figure 9 Association of MASLD and Non-MASLD with Hb% level

Table 10 Association of MASLD and Non-MASLD with HbA1c% level

HbA1c% level		MASLD (49)		Non-MASLD (47)		X^2 teat, P-value
		No	%	No	%	
Males	6.5 - 7.5%	5	20.8	16	61.5	X^2 = 8.488, P = 0.0035, HS
	> 7.5%	19	79.2	10	38.5	
Females	6.5 - 7.5%	6	24	15	71.4	X^2 = 10.347, P = 0.0013, HS
	> 7.5%	19	76	6	28.6	

Study reveals that; there is statistically higher significant association of HbA1c level in males and females bewtween MAFLD and Non-MAFLD (P<0.01). HbA1c levels observed in MAFLD males and females patiet=nts as compared to non-MASLD patients of males and females.

Multiple bar diagram represents association of MASLD and Non-MASLD with HbA1c% level

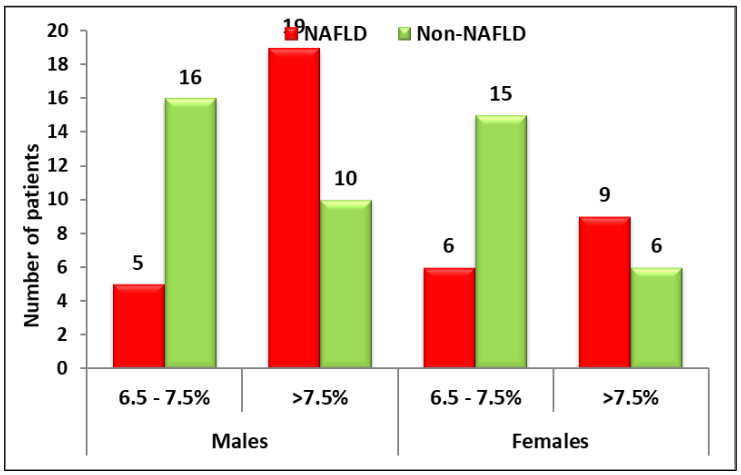

Figure 10 Association of MASLD and Non-MASLD with HbA1c% level

4. Discussion

The present study showed that the majority of T2DM patients were aged 21-40 years (38.5%), followed by 41-60 years (31.3%) and 61-80 years (28.1%), with only 2.1% over 80 years old. The youngest patient was 23 years old, and the oldest was 82 years old. No statistically significant difference in mean age was found between males and females (P > 0.05).

A study done by Patel H et al The mean age of the patients with T2DM was 51.81±9.87 years. The frequency of patients with MASLD was more in the age group of 50-59years. No significant difference was found between age and disease by statistical analysis. The prevalence of MASLD to be 10.51% which increased with advancing age (38%) and longer duration of diabetes (49%). Results were statistically significant.17

A study done by Afaf Merza Mohamed, et al.19 showed that the mean age of the patients was 59.0 ± 12.0 years and most were women (n = 235; 61.5%).A meta-analysis of 35,599 T2DM patients reported a pooled MASLD prevalence of 59.67%, with significant associations between MASLD and male gender, obesity, hypertension, dyslipidemia, and chronic kidney disease.

A cross-sectional study done by Sinha A et al 20 assessed 132 T2DM patients for MASLD. Anthropometry and lipid estima tions were done in all the individualsThe mean age was 49.03 ± 12.79 years, ranges 22–75 years. The median duration of T2DM was six years

Similarly, a study by Cho et al. 21 reported that MASLD prevalence in T2DM patients was highest in those aged 50-70 years, with a global prevalence of 55-70% in this group, and noted a gradual decline after age 70.

Our study revealed that 52.1% of the participants were male, while 47.9% were female, resulting in a male-to-female ratio of 1.08:1.

A retrospective cross-sectional study investigated a random sample of patients who were treated for T2DM during 2018 at non-communicable disease clinics in primary health centers in Bahrain. Female 61.5% and Male 38.5%.22

Research by Sinha and Bankura conducted in Eastern India also highlighted male predominance in MASLD among type 2 diabetes mellitus patients. However, their study indicated an even larger male-to-female ratio, differing significantly from the near-parity ratio (1.08:1) found in the current study. A total of 132 patients were enrolled in the study of which 55% patients were male and 45% patients were female.20

In a study showed that there was about 62 were males (63.9%) and 35 were females (36%) with male to female sex ratio of 1.8:1. 23

Our study revealing a prevalence rate of 51.0%. Gender distribution among individuals with DM and MASLD showed 24 males (48.0%) and 25 females (54.3%), whereas among those with DM but without MASLD, there were 26 males (52.0%) and 21 females (45.7%). Statistical analysis indicated no significant difference in MASLD prevalence based on gender (P > 0.05).

In the Study of Prevalence of Metabolic Dysfunction-Associated Steatotic Liver Disease (MASLD) in Type 2 Diabetes Patients in India (SPRINT), a prevalence rate of 56.5% was reported among 924 type 2 diabetes mellitus (T2DM) patients. The study found a higher prevalence in females (60%) compared to males (54.3%). 24

A study done by Mohan et al 25 revealed that a 32.0% prevalence of MASLD in an urban South Indian population. Amon g subjects with diabetes, the prevalence was higher at 54.5%. Similarly, Sinha A et al 20 the prevalence of MASLD is higher in males (54.6%) compare to females (45.4%).

Our study showed that the prevalence of Metabolic Dysfunction-Associated Steatotic Liver Disease (MASLD) in the study was 51.0%. The data shows that among individuals with diabetes mellitus (DM) and MASLD, there were 24 (48.0%) males and 25 (54.3%) females. In contrast, among individuals with DM but without MASLD, there were 26 (52.0%) males and 21 (45.7%) females. The analysis revealed that there was no statistically significant difference in the distribution of MASLD patients based on gender (P>0.05).

In a study by Patel H et al 17 showed that 36% had BMI >25kg/m2. The prevalence of obesity (BMI >25kg/m2) in patients with MASLD was 92.2%, as compared to 86.11% in non-MASLD patients. Whereas, 59% patients with MASLD had a BMI that was above normal (27.79±2.31), compared to 35% of patients without MASLD (24.28±3.14) that had higher BMI which is statistically significant (p< 0.0001). BMI was associated as marker of obesity which is strongly correlation with presence of fatty liver disease. Moreover, Similar to Shobhaluxmi et al, studies where BMI was 30.17±3.92 in patients with MASLD and 23.7±2.55 in patients without MASLD which was statistically significant with p value of 0.03.26

Most of the patients were either overweight or obese, 103 (30.5%) and 197 (58.3%); respectively. Only 37 (10.9%) had normal BMI and only one patient was underweighted. Accordingly, BMI was found to be the independent risk factor for fatty liver (p=0.005). Moreover, BMI was the independent risk factor for fatty liver.22

Our study revealed that 25.0% of male patients with MASLD had a waist circumference ≥ 102 cm, while none (0.0%) of the male patients without MASLD exhibited a waist circumference ≥ 102 cm. This difference was statistically significant (P < 0.001), suggesting a strong association between increased waist circumference and the presence of MASLD among male diabetic patients.

Moreover, research focusing on the prevalence of MASLD in type 2 diabetes mellitus patients revealed that 64% of diabetic patients had MASLD, with a higher prevalence among males (65.62%) than females (34.38%). This study also highlighted that central obesity, indicated by increased waist circumference, was prevalent among MASLD patients, reinforcing the association between central obesity and MASLD in diabetic population.17

A 2024 systematic review and meta-analysis by Kumar et al. 27 estimated the pooled prevalence of MASLD among Indian adults at approximately 38.6%, with a significantly higher prevalence in high-risk groups such as those with diabetes mellitus (DM). This aligns with our study's focus on diabetic patients, where MASLD prevalence is expected to be elevated due to shared pathophysiological mechanisms like insulin resistance and visceral fat accumulation. Similarly, a 2024 study from South India by Balasubramanian et al.28 reported a 57% prevalence of MASLD among type 2 diabetes mellitus (T2DM) patients in the eastern region, reinforcing the high burden of MASLD in diabetic populations.

The statistically significant association (P < 0.001) between waist circumference ≥ 102 cm and MASLD in our male diabetic patients echoes findings from recent Indian literature. A 2024 cross-sectional study by Mukherjee et al. 29 in North Bihar reported that T2DM patients with MASLD had significantly higher waist circumference (37 inches vs. 33 inches in controls, P < 0.001), with 73.6% of newly diagnosed T2DM patients exhibiting MASLD. This study emphasized waist circumference as a practical anthropometric marker for screening MASLD in diabetic populations. Similarly, a South Indian study by Singh et al. 30 noted that waist circumference cutoffs of 89 cm for men were predictive of MASLD, though our study's higher threshold (≥ 102 cm) may reflect a more severe metabolic phenotype in our diabetic cohort.

Our study reveals a significant association between elevated waist circumference and the presence of Metabolic Dysfunction-Associated Steatotic Liver Disease (MASLD) in female patients. Specifically, 24.0% of female patients with MASLD exhibited a waist circumference ≥90 cm, compared to 15.2% of female patients without MASLD, with this difference being statistically significant (P<0.001).

A 2024 study by Mukherjee et al. 29 in North Bihar found that T2DM patients with MASLD had significantly higher waist circumference (37 inches vs. 33 inches in controls, P < 0.001), with 73.6% of newly diagnosed T2DM patients exhibiting MASLD. Although not gender-stratified, their emphasis on waist circumference as a screening tool supports our results. In contrast, a South Indian study by Singh et al. 30 proposed a lower waist circumference cutoff of 80 cm for women as predictive of MASLD in the general population. 70

Our study showed that there was a significant association between elevated waist-to-hip ratio (WHR) and the presence of Metabolic Dysfunction-Associated Steatotic Liver Disease (MASLD) in female patients. Specifically, 24.0% of female patients with MASLD exhibited a WHR greater than 0.84, while none of the female patients without MASLD had a WHR exceeding this threshold, indicating a statistically significant difference (P<0.001).

Amarapurkar et al. 31 also reported a higher prevalence among men compared to women (24.6% v. 13.6%). Li et al. 72 in their meta-analysis of Asian studies also reported a higher prevalence among men compared to women (37.11% [95% CI 35.04–39.24] v. 22.67 [95% CI 20.61–24.88]). However, the relationship between gender and MASLD is believed to be diametrically divided between either gender in several studies, some studies showing a preponderance of women while others show a preponderance of men in prevalence.

Inverse-Variance Weighted (IVW) analysis demonstrated a positive association between a higher waist-hip ratio and an elevated risk of MASLD. Specifically, an increase in waist-hip ratio by one standard deviation correlated with a 61% increase in the risk of MASLD (OR = 1.61; 95%CI: 1.08–2.41; P = 0.02). 32

A study done by Vagurmekar PA et al 33 showed that the WHR was also significantly associated with MASLD (p=0.003). BMI and WHR were found to be significantly associated with MASLD.

For instance, a study by Jayasudha et al. 34 demonstrated that simple anthropometric parameters, including WHR, are effective in predicting MASLD in Indian adults. The study reported an optimal WHR cut-off point of 0.87 for women, which is slightly higher than our threshold of 0.84, but still indicative of central obesity's role in MASLD development

Similar to BMI, Waist circumference and W/H ratio also had direct relationship with the diagnosis of MASLD. Even grades of MASLD were also correlated with these parameters.

This correlation was also found in other studies like AK Agharwal et al 35. (p-value 0.033) and Giorgio Bedogni et al 77 (p value 0.001). All these studies also had statistically significant, as of our study.

Our study showed that 20 out of 49 MASLD patients (40.8%) had elevated levels of SGPT (ALT), SGOT (AST), and ALP, compared to 6 out of 47 non-MASLD patients (12.7%), with a statistically highly significant difference ($P < 0.01$). This suggests a strong association between MASLD and elevated liver enzymes in diabetic patients, particularly when all three enzymes are considered.

A study by Kumar et al.36 reported that 38% of diabetic MASLD patients had elevated SGPT/SGOT, attributing this to insulin resistance-driven hepatic inflammation. Their findings corroborate the current results, reinforcing the role of metabolic dysfunction in MASLD progression.

A multicenter study on Prevalence of Metabolic Dysfunction-Associated Steatotic Liver Disease (MASLD) in type 2 diabetes patients in India (SPRINT) involved 924 type 2 diabetic patients across 101 cities in India, identifying 56.5% with MASLD based on elevated aminotransferase levels (NHANES III criteria). Mean AST and ALT levels in MASLD patients were 54.8 ± 36.1 IU/L and 55.6 ± 39.8 IU/L, respectively, with 65.3% having elevation of both AST and ALT. ALP levels were not reported, limiting direct comparison with the present study.37

A cross-sectional study on Prevalence of elevated liver enzymes and its relationship with type 2 diabetes mellitus in North Indian adults included 612 participants (386 T2DM, 226 controls), measuring ALT, AST, and ALP. Showed that the Diabetic subjects with MASLD had significantly higher ALT, AST, and GGT, but no significant difference in ALP levels compared to those without MASLD. This study supports elevated ALT and AST in MASLD but does not align with the present study findings focus on ALP elevation.38

A study on Liver enzymes in patients diagnosed with non-alcoholic fatty liver disease in Veracruz. Reported that among 40 MASLD patients, 72.5% had elevated ALT, 25% had elevated AST, and 45% had elevated ALP. Whereas it suggests that ALP elevation can occur in MASLD, with 45% prevalence, though overlap with ALT and AST was not detailed.39

Elevation of Liver enzymes raise in SGOT, SGPT were seen in MASLD cases, indicating deranged Liver function. We had minimal raise in Liver enzyme levels in Majority of cases of MASLD. This finding was comparable to similar liver function derangements from other studies described by Reid et al 40 and Cortez-Pinto et al.41 There was

significant difference observed in values of liver function test like SGOT, SGPT and ALP The enzyme elevation directly proportional to the extent of Liver involvement. In study by AK Agharwal et al,42 Giorgio Bedogni et al 43, Giovanni et al 44, statistically significant correlation was found between SGOT, SGPT, ALP values and occurrence of MASLD as of our study.

Our study showed that there was no statistically significant difference in hemoglobin levels between males and females with and without MASLD ($P>0.05$). This finding suggests that hemoglobin levels may not serve as a distinguishing factor for MASLD in diabetic populations.

A study by Ding et al. 45 reported that hemoglobin levels were significantly higher in MASLD patients with young-onset type 2 diabetes mellitus, particularly in males and overweight/obese individuals. This contrasts with the current study, which found no significant gender-based differences in hemoglobin levels.

Juárez-Hernández et al. 46 observed elevated hemoglobin levels in MASLD patients, suggesting a potential protective role of hemoglobin as an antioxidant. This finding diverges from the current study's results, which did not identify hemoglobin as a significant marker for MASLD.

A Mendelian randomization study by Zhu et al. 47 highlighted a positive correlation between hemoglobin levels and MASLD risk, emphasizing the role of hematological markers in MASLD pathogenesis. However, the current study's focus on a diabetic cohort may explain the lack of significant findings regarding hemoglobin levels.

Our study reveals a statistically significant and robust association ($P < 0.01$) between HbA1c levels and Metabolic Dysfunction-Associated Steatotic Liver Disease (MASLD) status, observed in both male and female participants. A notably higher proportion of MASLD patients, regardless of gender, exhibited HbA1c levels exceeding 7.5%, compared to their non-MASLD counterparts. These findings strongly indicate that poor glycemic control is more prevalent among individuals with MASLD, emphasizing the pivotal role of metabolic dysfunction in the disease's pathogenesis.

These results corroborate the findings from Lin TC et al48, whose study demonstrated that the mean HbA1c level was significantly elevated in the MASLD group (5.51%) compared to the non-MASLD group (5.38%) ($P < 0.05$). Moreover, a positive trend was identified, wherein higher HbA1c values were associated with an increased prevalence of MASLD. Specifically, individuals in Group 4 (HbA1c ≥ 5.6%) showed a significantly higher risk of developing MASLD compared to those in Group 1 (HbA1c < 5.2%). Logistic regression analysis further supported these findings, revealing that participants in Groups 3 and 4 (HbA1c ≥ 5.4%) had significantly elevated odds of developing MASLD relative to Group 1. Even after adjusting for confounding variables, such as age and body mass index (BMI), the association remained significant for Group 3 (OR = 2.050, $P < 0.0001$), reinforcing the hypothesis that modest elevations in HbA1c contribute independently to MASLD risk.

Similarly, another study reported a statistically significant association between elevated HbA1c levels and MASLD, with a Pearson chi-square value of 11.265 and a P-value of 0.01.49 Notably, 80% of individuals with HbA1c ≥ 9.0% had MASLD, in contrast to just 12.5% of those with HbA1c < 6.5%. This stepwise increase supports a dose–response relationship, further validating that poor glycemic control serves as a key, independent risk factor in the development of MASLD.

In contrast, a separate analysis involving 437 individuals revealed that while the mean HbA1c was slightly higher in the fatty liver group (7.2 ± 1.2%) compared to the non-fatty liver group (6.9 ± 1.2%), this difference did not reach statistical significance ($P = 0.066$).50 While not statistically conclusive, the observed trend towards higher HbA1c levels in fatty liver patients underscores the potential link between suboptimal glycemic control and hepatic steatosis. These cumulative findings underscore the critical relationship between HbA1c levels and liver disease, pointing to the importance of early glycemic management in preventing or mitigating the progression of MASLD and similar hepatic conditions.

Our study assessed the prevalence of MASLD in Type 2 Diabetes Mellitus (T2DM) patients and found that 51.0% had MASLD, with the majority aged 21–40 years and a male-to-female ratio of 1.08:1; while gender did not significantly affect MASLD prevalence ($P > 0.05$), obesity showed a strong association ($P < 0.01$), with 52.0% of MASLD patients being obese, and significantly higher waist circumference, waist-hip ratio (especially in males, $P < 0.001$), and elevated liver enzymes (SGOT, SGPT, ALP) indicating hepatic involvement ($P < 0.01$). Our study also showed that there was no statistically significant difference in hemoglobin levels between males and females with and without MASLD ($P>0.05$).

4.1. Limitations

- The study was conducted in a single-center setting, which may limit the generalizability of findings.
- The sample size was relatively small, potentially affecting statistical power.
- The study relied on non-invasive diagnostic criteria for MASLD, without histopathological confirmation through liver biopsy.
- Lack of dietary and lifestyle assessment data to correlate with MASLD prevalence.
- Cross-sectional design prevents establishing a causal relationship between MASLD and metabolic abnormalities.

5. Conclusion

MASLD is highly prevalent among diabetic patients, with obesity and dyslipidemia identified as major contributing factors, and liver function tests proving useful for early diagnosis. The study highlights the significance of metabolic parameters such as BMI, waist circumference, and lipid profile in the development of MASLD and supports existing evidence that MASLD independently contributes to liver dysfunction and metabolic complications in diabetics. Although no statistically significant gender difference in MASLD prevalence was observed, male patients demonstrated a higher tendency toward central obesity and associated metabolic changes. These findings underscore the importance of early screening and timely intervention to prevent the progression of MASLD in individuals with diabetes.

Compliance with ethical standards

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Disclosure of conflict of interest

No conflict of interest to be disclosed.

Statement of ethical approval

The study was approved by the Institutional Ethical Committee.

Statement of informed consent

Informed consent was obtained from all individual participants included in the study.

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[18] World Health Organization, International Association for the Study of Obesity, International Obesity Task Force. The Asia-Pacific perspective: redefining obesity and its treatment. Sydney: Health Communications Australia; 2002. p. 20. Table 2.3: Co-morbidities risk associated with different levels of BMI and suggested waist circumference in adult Asians

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