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Original Research Article

Clinical and Biochemical Differences among Lean, Normal Weight, and Obese Type 2 Diabetes Patients in a Tertiary Hospital in Northeast India: A Cross-Sectional Study

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Abstract:

Background: In South and Southeast Asia, type 2 diabetes mellitus (T2DM) frequently occurs at lower body mass index (BMI) and is often accompanied by a high burden of complications. However, clinical and biochemical differences across BMI categories remain incompletely characterised in this region. This study compared the profile of lean, normal-weight, and obese T2DM patients attending a tertiary care centre in Northeast India.

Methods: This hospital-based cross-sectional study was conducted at Fakhruddin Ali Ahmed Medical College and Hospital, Barpeta, Assam, from 1 November 2023 to 31 October 2024. A total of 134 adults with T2DM were classified as lean (BMI <18.5 kg/m²), normal weight (18.5–22.9 kg/m²), or obese (>25 kg/m²); patients with overweight BMI (23.0–24.9 kg/m²) and those with major comorbid illnesses affecting weight were excluded. Clinical data, anthropometry, blood pressure, and complications (neuropathy, nephropathy, retinopathy, fatty liver, hypertension) were recorded. Laboratory evaluation included HbA1c and fasting lipid profile. Associations between BMI categories and categorical variables were analysed using the Chi-square test, and continuous variables were compared using one-way ANOVA, with $p<0.05$ considered statistically significant.

Results: Of 134 patients, 40 (29.9%) were lean, 54 (40.3%) normal weight, and 40 (29.9%) obese. Lean patients had significantly higher prevalence of microvascular complications: nephropathy 60% vs 35.2% (normal) vs 20% (obese); neuropathy 65% vs 37% vs 22.5%; and retinopathy 70% vs 38.9% vs 25% (all p=0.0001). In contrast, hypertension (22.5% vs 37% vs 67.5%) and fatty liver (10% vs 13% vs 70%) increased with BMI (p=0.0001). Obese patients had more atherogenic lipid profiles, with significantly higher total cholesterol, triglycerides, LDL, and VLDL, and lower HDL than other groups (p=0.0001). Mean HbA1c was highest in lean patients (9.70±0.95%), followed by obese (8.92±0.28%) and normal-weight patients (7.52±0.22%) (p=0.0001).

Conclusion: Among T2DM patients in this Northeast Indian cohort, lean individuals exhibited poorer glycaemic control and a higher burden of microvascular complications, whereas obese patients had more adverse cardiovascular risk profiles, including hypertension, fatty liver, and dyslipidaemia. These findings highlight the need for vigilant screening for complications across the BMI spectrum and tailored management strategies for both lean and obese T2DM phenotypes.

Keywords: Type 2 diabetes mellitus; Lean diabetes; Body mass index; Microvascular complications; Obesity; Dyslipidaemia; Northeast India

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Introduction

Diabetes mellitus includes a range of metabolic abnormalities characterised by low insulin secretion, resistance to insulin in the body, irregular liver glucose production, and problems with fat and protein metabolism. These can lead to various long-term complications. [1] The prevalence of diabetes is escalating at a concerning rate in developing nations, with India witnessing a particularly sharp increase. [2] According to the International Diabetes Federation, approximately 77 million Indians were affected by Diabetes Mellitus in 2020. [3]

Epidemiological trends over recent decades show that the clinical characteristics and prevalence of type 2 diabetes mellitus (T2DM) in India are quite different from those in Western countries. [4] In Europe and North America, T2DM is mainly linked to obesity. In contrast, many patients in India have

a lean body type. As early as 1965, Tripathy and Kar [5] found that 27% of older adults with diabetes in India were lean. Later studies [6-9] in India have reported the prevalence of lean or low body weight T2DM, defined as having a body mass index (BMI) under 19 kg/m², to be between 1.6% and 26%. The biochemical and clinical features of normal/lean body T2D patients are very different from those of typical type 2 diabetes (T2D) patients. They have a higher incidence of microvascular problems, such as diabetic neuropathy, retinopathy, and nephropathy, and frequently present with more severe hyperglycaemia. [6] Interestingly, a small number of studies have found that lean people with type 2 diabetes have somewhat lower rates of hypertension, dyslipidaemia, and coronary artery disease. [6,10] The subgroup of T2D patients with low or normal BMI has not been well categorised and documented. Instead of insulin resistance, which is evident in the traditional type of diabetes associated with obesity, the primary pathophysiology seems to be inadequate insulin secretion. [11] Numerous studies have shown a connection between early-life poverty, poor nutrition, and lean T2D. Animal models have shown that protein deficiencies in early life can result in a decrease in beta-cell mass, which in turn can lead to inadequate insulin secretion, even if there is no conclusive evidence from human investigations [12,13]. These patients' profiles also diverge from those of latent autoimmune diabetes of adults (LADA), since most lean T2D patients do not exhibit the autoimmune markers of LADA. [6,14]

Given the limited number of existing studies and the heterogeneity of current evidence, we undertook this clinical investigation to systematically characterise the clinical and biochemical profiles of lean individuals with type 2 diabetes mellitus (T2DM), in comparison to those with normal and obese body weight, at a tertiary care centre in Lower Assam.

Methodology: This hospital-based cross-sectional study was conducted at Fakhruddin Ali Ahmed Medical College and Hospital (FAAMCH), Barpeta, Assam, from November 1, 2023, to October 31, 2024, to compare the clinical and biochemical profiles of type 2 diabetes mellitus (T2DM) patients across three BMI-defined groups: lean (<18.5 kg/m²), normal weight (18.5–22.9 kg/m²), and obese (>25 kg/m²). A total of 134 adult patients with a confirmed diagnosis of T2DM were enrolled based on predefined inclusion and exclusion criteria. Patients aged below 18 years, those with comorbidities influencing body weight (e.g., tuberculosis, chronic liver or kidney disease), HIV/AIDS, malignancy, long-term steroid use, or those with BMI in the overweight range (23.0–24.9 kg/m²) were excluded. Written informed consent was obtained from all participants. Data collection included medical and family history, physical examination, anthropometric measurements (height, weight, waist-hip ratio), and blood pressure assessment. Laboratory investigations comprised HbA1c, lipid profile, urine routine, and microalbumin. Diabetic retinopathy and neuropathy were screened using indirect ophthalmoscopy and a 128 Hz tuning fork, respectively, and abdominal ultrasonography was performed to detect fatty liver. Statistical analysis was carried out using IBM SPSS version 26.0, with descriptive statistics used to summarise the data; Chi-square test for associations between BMI categories and categorical variables; and one-way ANOVA for comparing means of continuous variables, with p-values <0.05 considered statistically significant.

Results

134 patients with type 2 diabetes mellitus (T2DM) participated in the study. The group included 74 males (55.2%) and 60 females (44.8%). Based on body mass index (BMI), participants were sorted into three groups: lean (n = 40, 29.9%), normal weight (n = 54, 40.3%), and obese (n = 40, 29.9%). The distribution of BMI categories showed no significant difference between sexes ($\chi^2 = 0.135$, $p = 0.93$). The average age of the study population was 56.02 years (SD = 6.38). The subgroup averages were 55.03 years (SD = 4.55) for the lean group, 55.69 years (SD = 7.47) for the normal group, and 57.48 years (SD = 6.25) for the obese group.

Anthropometric Parameters: The average BMI values across the three groups were as expected: lean (17.30 ± 0.67 kg/m²), normal (20.70 ± 1.16 kg/m²), and obese (27.54 ± 1.42 kg/m²). These differences were statistically significant (ANOVA $F = 859.32$, $p < 0.0001$). Waist-to-hip ratios also varied significantly across groups: lean (0.89 ± 0.01), normal (0.91 ± 0.03), and obese (1.05 ± 0.02), with an overall mean of 0.94 ± 0.07 ($F = 558.28$, $p < 0.0001$).

Diabetes-Related Complications: The prevalence of diabetic complications was strongly associated with BMI categories: Diabetic nephropathy was found in 51 participants (38.1%), with a higher rate in the lean group (60%) compared to the normal (35.2%) and obese (20%) groups. This association between BMI and nephropathy was statistically significant ($\chi^2 = 13.89$, $p = 0.0001$). Diabetic neuropathy affected 55 participants (41.0%). It was most common among lean individuals (65%), followed by normal weight (37%) and obese participants (22.5%), showing a significant association ($\chi^2 = 15.52$, $p = 0.0001$). Diabetic retinopathy was reported in 59 participants (44.0%). It was more common in lean individuals

(70%) than in normal (38.9%) and obese (25%) groups ($\chi^2 = 17.41$, $p = 0.0001$). Hypertension was present in 56 participants (41.8%). Prevalence increased with BMI: 22.5% in lean, 37% in normal, and 67.5% in obese individuals ($\chi^2 = 17.48$, $p = 0.0001$). Fatty liver, identified by abdominal ultrasonography, was seen in 39 participants (29.1%). A much higher percentage of obese individuals (70%) had fatty liver compared to normal (13%) and lean (10%) groups ($\chi^2 = 46.31$, $p = 0.0001$).

Biochemical Parameters: Significant differences in lipid profiles and HbA1C levels were found among BMI categories:

Total cholesterol levels were notably higher in obese participants (229.75 ± 8.32 mg/dL) than in normal (184.91 ± 9.59 mg/dL) and lean individuals (180.00 ± 4.08 mg/dL). The overall mean was 196.83 ± 23.04 mg/dL ($F = 496.74$, $p < 0.0001$). Triglycerides followed a similar trend: lean (141.38 ± 13.25 mg/dL), normal (146.20 ± 4.23 mg/dL), and obese (189.75 ± 8.32 mg/dL) ($F = 367.55$, $p < 0.0001$). HDL cholesterol exhibited the opposite pattern. It was highest in normal weight participants (51.30 ± 2.62 mg/dL), followed by lean (45.65 ± 3.30 mg/dL) and lowest in obese individuals (36.38 ± 1.28 mg/dL) ($F = 394.50$, $p < 0.0001$). LDL cholesterol levels were significantly higher in obese participants (139.75 ± 8.32 mg/dL) compared to normal (107.50 ± 1.85 mg/dL) and lean groups (105.53 ± 6.71 mg/dL) ($F = 435.34$, $p < 0.0001$).VLDL levels also increased with BMI: lean (31.30 ± 1.90 mg/dL), normal (31.98 ± 2.62 mg/dL), and obese (42.28 ± 2.09 mg/dL) ($F = 306.75$, $p < 0.0001$).

The analysis showed clear differences in HbA1c levels among the groups ($F = 184.64$, $p = 0.0001$). The Lean group had the highest average HbA1c level at 9.703% (SD = 0.9472). The Obese group followed this at 8.915% (SD = 0.2797), while the Normal group had the lowest average at 7.524% (SD = 0.2223). The overall average HbA1c was 8.590% (SD = 1.0821).

Discussion

The burden of diabetes is rising steadily in India. The ICMR-INDIAB study, a national population-based survey, found a prevalence of type 2 diabetes in India to be 7.3%, with variation across regions-5.2% in rural areas and 11.2% in urban areas as of 2016. [15] People from Southeast Asia, specifically India, have a unique T2D phenotype; they have a lower body mass index (BMI), a higher body fat percentage, greater insulin resistance, and increased inflammatory markers. Individuals from Southeast Asia develop diabetes 10 to 20 years before individuals from Western populations, on average. [16] Given these features, this population may experience a quicker disease course and a greater risk of diabetes-related complications. Also, several studies report a substantial percentage of Indian T2D patients who are lean or in the normal weight category 17, but these patient groupings are still under-researched.

This study consisted of a cohort of 54 normal, 40 lean and 40 obese patients with type 2 diabetes, the distribution similar to that of a study by Mohan et al. [6] The mean age of patients was 56.02 ±6.38 years. This finding contrasts with data from western population, where diabetes is more common among older adults, highlighting the earlier onset of T2D among Indians. [18] The distribution of normal, lean and obese individuals varied across studies, attributed to different cutoff levels used to describe obesity. In the current study there were 44.8% females and 55.2% males, providing a distribution similar to that described by Mukyaprana et al. [7] and no significant associations with BMI categories were discovered in relation to age or sex, which aligns with findings that gender differences in metabolic risk are the result of multiple factors; poor diet, inactivity, and excessive alcohol intake for both sexes. [19]

This study reveals a greater frequency of microvascular complications in lean individuals with type 2 diabetes. In this study, lean participants with type 2 diabetes showed higher rates of diabetic nephropathy (60%), neuropathy (65%), and retinopathy (70%) compared to those with normal BMI or obesity. Overall, these findings are indicative of a greater risk of complications for lean individuals, with all differences across BMI groups considered statistically significant (P=0.0001). The higher rates of microvascular complications, in lean people with type 2 diabetes in this study, are consistent with previous findings of Barma et al. [20], Mohan et al. [6], and Mukyaprana et al. [7], who also found higher rates of nephropathy, neuropathy, and retinopathy in lean individuals. However, the documented results differ from Faraz [21], who did not find a significant association between BMI and microvascular complications.

Our results demonstrated a statistically significant difference in hypertension prevalence between individuals with type 2 diabetes and normal BMI (37%) and those with lean individuals (22.5%) ($p = 0.0001$), documenting that the highest BMI levels exhibited the highest hypertension prevalence (67.5%). This finding supports the trend that the hypertension rate increases with BMI category. Mohan et al. [6] and Faraz et al. [21] both documented higher rates of hypertension and coronary artery disease in obese patients. There are consistent findings from Barma et al. [20] reporting lower rates of hypertension prevalence among lean subjects with type 2 diabetes. In this study, fatty liver was most prevalent among patients with obesity and type 2 diabetes (70%), with a

significant difference between the BMI groups (p = 0.0001). These findings corroborate those by Lee et al. [22], who documented a greater prevalence of NAFLD in type 2 diabetes patients among those with obesity, and explained that the combination of fatty liver, high blood sugar, obesity, and insulin resistance would significantly increase the risk of type 2 diabetes.

In this study, levels of lipid profile differed substantially in BMI categories (p = 0.0001), with obese individuals having a greater total cholesterol (229.75 ± 8.31), triglycerides level (189.75 ± 8.31), LDL (139.75 ± 8.31), and VLDL (42.28) values than those from the lean and normal weight groups, the findings aligning with other studies. 2,23 On the other hand, HDL levels were highest in the normal group (51.30 ± 2.62) and lowest in the obese group, which could be attributed to high hepatic lipase activity. [24]

The highest mean HbA1c levels were found in lean individuals with type 2 diabetes mellitus (T2DM) at 9.70 ± 0.94. Those in the obese category had lower levels at 8.91 ± 0.27. A significant link was found between HbA1c and body mass index (BMI) categories, shown by a p-value of 0.0001 (P < 0.05). These results match earlier studies by Mohan et al. [6] and Faraz et al. [21], which also reported higher HbA1c levels in lean diabetic individuals compared to those with normal BMI. Conversely, Deng et al. [25] found that obese subjects had higher HbA1c concentrations. They linked this trend to metabolic issues caused by obesity. Extra body fat, especially visceral fat, is a known cause of insulin resistance, which is a key problem in type 2 diabetes (T2DM). Higher levels of free fatty acids (FFAs) in obese individuals disrupt insulin signalling in the liver and muscles. This disruption leads to reduced glucose uptake in tissues and increased glucose production in the liver. As insulin resistance worsens, the pancreas tries to keep up by producing more insulin. However, this workaround often fails over time, resulting in poor blood sugar control and permanently high HbA1c levels.

This research does have several limitations. The study design was cross-sectional and non-randomised, limiting the ability to make causal inferences, as the possibility of selection bias exists. The sample size was calculated based on a national prevalence estimate, but the true prevalence in our region could differ. This is a single-centre study, and thus it may not extend to larger population-based practice generalizability. The exclusion of patients with chronic illnesses and separating those with a slight overweight BMI classification (23–24.9 kg/m²) may limit application. The researchers cannot avoid the proximity of recall bias in self-reporting. Despite self-reporting, the study did not follow up with a repeat data collection and did not include key potential lifestyle, environmental, genetic, and/or behavioural factors related to the patient's health condition, such as diet, physical activity, and medication use. A further limitation for interpretation is that the study used only routine investigations.

Conclusion

To summarise, this study found significant differences in clinical features, complications, and biochemical parameters between type 2 diabetes mellitus (T2DM) patients with different body mass index (BMI) categories. Lean T2DM patients had a higher prevalence of microvascular complications, including nephropathy, neuropathy, and retinopathy, while obese patients had higher hypertensive complications and fatty liver.

Obese participants had an adverse lipid profile, including significantly elevated total cholesterol, triglycerides, LDL, and VLDL, and blunted HDL. NT-proBNP levels were associated significantly with BMI, although this finding contradicts prior reports.

Overall, body weight plays an important role in the clinical course and metabolic profile of T2DM, and lean patients have an increased risk of microvascular complications, while obese patients exhibit poorer metabolic control and additional comorbidities.

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