ORIGINAL ARTICLE

CLINICAL AND BIOCHEMICAL PROFILE OF LEAN BODY WEIGHT TYPE 2 DIABETICS, NORMAL WEIGHT AND OBESE DIABETICS

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ABSTRACT: BACKGROUND: Diabetes is a group of metabolic disorders with a phenomenal increase in developing countries like India.¹ When we compare the clinical profile in developed countries we find there is a remarkable difference in developing countries. In Asia the proportion of lean diabetics are relatively more when compared to developed countries.² Hence it is worth comparing the clinical and biochemical profile in lean diabetic, normal and obese type 2 diabetic patients in our population.³

OBJECTIVE: To study and compare the clinical profile in lean type 2 diabetic patients compared to normal and obese diabetics by age, sex, family history and anthropometry. We also compared the biochemical profile in lean type 2 diabetic patients with normal and obese diabetics by estimation of blood glucose, urea, serum creatinine, glycosylated hemoglobin and lipid profile.

MATERIALS AND METHODS: Observational study of 1070 patients was conducted in our hospital between June 2011 to July 2013. We have selected patients aged 30 years and older diabetics from outpatient and inpatient departments of our hospital and compared age, sex, family history, anthropometry, blood glucose, urea, serum creatinine, glycosylated hemoglobin and lipid profile.

RESULTS: There is a statistical significant relationship between age, FBS and BMI. Lean diabetic patients were more in the age group between 41 to 50, whereas there is no statistical significant relationship between sex, HbA1C, diastolic blood pressure, HDL and BMI. There is a statistical significant relationship between family history, skin fold thickness, waist hip ratio, systolic blood pressure, total cholesterol, triglycerides and BMI. PPBS and LDL were statistically significant in normal weight diabetics. We also found there is a significant relationship between pulmonary tuberculosis and lean diabetics.

CONCLUSION: Majority of type 2 diabetic patients in our population are having normal weight with lean body weight diabetics contributing to 10.6% which is a relatively a greater proportion when compared to developed countries.⁴,⁵ Lean diabetics have more severe fasting hyperglycemia, poor metabolic control and are prone for infections like pulmonary tuberculosis. Most of the lean diabetic patients required insulin much earlier than other group of diabetics.

KEYWORDS: Lean diabetics, Fasting hyperglycemia, Body mass index.

INTRODUCTION: Diabetes mellitus is characterized by impaired insulin secretion, insulin resistance, excessive hepatic glucose production, abnormal fat & protein metabolism and a constellation of chronic complications.⁶,⁷,⁸ It is a worldwide health crisis. The prevalence has risen dramatically over the past two decades, from an estimated 30 million cases in 1985 to 382 million in 2013 with 46% of diabetics go undiagnosed. Based on current trends, it is predicted that 592 million individuals will have diabetes by year 2035. The Incidence of diabetes is showing an alarming rise in developing countries, particularly in India. 60-80% of diabetics in developed countries were obese, whereas in India we find that clinical profile of diabetes is different.⁹ Most of the patients attending our diabetic outpatient department are not obese as defined by existing parameters such as BMI.
Interestingly, almost 80% of our Type 2 diabetic patients are non-obese where as 60% to 80% of diabetics in western countries are obese. There is a wide spectrum in the presentation, treatment & complications among different groups of diabetics. Hence it is worth studying and comparing profiles of lean, normal weight & obese type 2 diabetics.

**MATERIALS AND METHODS:** We conducted an observational study in 1070 patients with type 2 diabetes mellitus who were attending our outpatient department as well as inpatients in our hospital from June 2011 to July 2013.

**SELECTION OF CASES:** Cases included in the study were adults aged above 30 and above having T2 DM. Those thousand and seventy patients were divided into three groups based on Body Mass Index (BMI).

- Group A: BMI <18.5Kg/m² (Lean Body Weight Type 2 DM).
- Group B: BMI 18.5-24.9Kg/m² (Normal Weight Type 2 DM).
- Group C: BMI >25 Kg/m² (Obese Type 2 DM).

**Exclusion Criteria;** for cases,
1. Presence of active pulmonary tuberculosis history.
2. Presence of other chronic illnesses that could affect body weight like chronic liver and chronic kidney disease.
3. Type 2 Diabetes patients with Age of onset less than 30 years.
4. History wise, particularly in lean patients those who were normal or obese at the time of presentation, now lost the body weight significantly after type 2 Diabetes mellitus detection.
5. Patient with history of Cancer, cachexia and HIV.

A careful detailed history was taken from each person, i.e. age of onset, duration, any positive family history, dietary pattern, presenting complaints–at the time of diagnosis etc. Detailed examination was done for all the 1070 patients to find out various complications and biochemically, blood glucose (Both fasting and postprandial), blood urea, serum creatinine, HbA1C were analysed in all the three groups.

**METHODS:**
1. Height (In meter), Weight (In kg) measured in all patients and BMI (Body Mass Index) was calculated based on the formula BMI=Wt in Kg/(HT).²²
2. Waist hip Ratio (W/H Ratio),²² ‘Waist Circumference’ measured at midpoint between the costal margin and anterior superior iliac spine. Hip Measurement taken as maximum diameter at the greater trochanter. Waist/Hip Ratio (WHR) was calculated in each case. Waist Hip ratio was considered abnormal if >0.95 for males and >0.8 for females.
3. Skin Fold Thickness (SFT):²² Skin Fold Thickness was measured at standard sites such as the Biceps, Triceps, infra scapular, and supra iliac region using a Harpenden Caliper or similar device. Triceps skin fold midway between acromion process and olecranon process was used in our study.

Fasting, postprandial glucose, HbA1C, fasting lipid profile and other relevant investigations were done in each case.
Definitions and Cut Off values for the study;

1. Body Mass Index (BMI):
   - 18.5-24.9 (kg/m2) – normal value
   - < 18.5 (kg/m2) – lean body weight
   - 25 (kg/m2) – obese body weight

Waist Hip Ratio: 12
   - > 0.8 – is taken as abnormal value in female.
   - >0.95 in male as abnormal value.

Skin Fold Thickness (SFT) 12 (in mm):
   - > 12.5 – abnormal in male.
   - > 16.5 – abnormal in female.

Fasting Hyperglycemia (FBS):13
   - It means 8 hours of fasting overnight and abnormal if more than 126mg%

Post prandial Hyperglycemia (PPBS):13
   - Measured at 2 hours after the meals and abnormal if more than 200 mg%

Lipid Profile:14
   - Test was done after 8 hours overnight fasting.

Normal Value Range;
   - Total cholesterol 150-200 mg%.
   - Triglyceride 75-150 mg%.
   - HDL 30-60 mg%.
   - VLDL 20-40 mg%.
   - LDL<100 mg%.

HbA1C – Glycosylated Hemoglobin; It was measured by high performance liquid Chromatography:
   - <6.5-normal.
   - 5.7-6.4 - pre diabetic.
   - >6.5-diabetic.

Ethical Committee Approval; The present study was approved by the Ethical committee of our hospital.

Statistical Analysis: Statistical Analysis of data was done by using the software statistical percentage for social science for Windows (Ver-17).

   Frequencies, Percentages, Range, Median, Mean, S.D. and 'p' values were calculated using this package.
OBSERVATION AND RESULTS: A total of 1070 patients were selected after excluding the patients using the exclusion criteria mentioned above. Initially they were divided into three groups based on BMI.

| AGE GROUP | Count | LEAN | NORMAL | OBESE | Total |
|-----------|-------|------|--------|-------|-------|
| <= 40 YEARS | 9     | 107  | 19.0%  | 19.3% | 192   |
| 41 - 50 YEARS | 45    | 190  | 33.7%  | 35.1% | 373   |
| 51 - 60 YEARS | 30    | 136  | 24.1%  | 13.2% | 218   |
| > 60 YEARS    | 29    | 131  | 23.2%  | 32.3% | 287   |
| **Total**     | 113   | 564  | 100.0% | 100.0%| 1070  |

Table 1. Age wise distribution of various groups of diabetic patients

Out of the total 1070 patients, 113 diabetics (10.6%) were belonging to lean group.

Figure 1. This diagram represents Age wise distribution of various groups of diabetic patients.

There is statistical significant relationship between age and BMI. Lean patients are more in the age group between 41-50 years (p value of 0.001).
There is no statistical significant relationship between sex and BMI.

**Family History and BMI:**

| FAMILY HISTORY | Count | LEAN | NORMAL | OBESE | Total |
|----------------|-------|------|--------|-------|-------|
| YES            | 48    | 42.5%| 30.0%  | 50.4% | 43.6% |
|否 NO           | 65    | 57.5%| 61.0%  | 49.6% | 56.4% |
| Total          | 113   | 100.0%| 100.0% | 100.0%| 100.0%|

**Table 3. Association of family history in various groups**
Figure 3. Association of family history in various groups

There is statistically significant relationship between family history and BMI. Family history is more in obese group (p value 0.002).

Figure 4. Waist hip ratio in various groups

There is statistical significance between waist hip ratio and BMI. W/H ratio is more in obese group.
Table 5. Skin fold thickness in various groups

Figure 5. Skin fold thickness in various groups.

There is statistical significance between skin fold thickness and BMI. Skin fold thickness is more in obese group.

Table 6. Frequency of infections in various groups of diabetics
Figure 6. Diagram represents association of infections in various groups.

There is a statistical significance between infections and BMI. Infections are more in lean group (p value-0.007).

Fasting blood sugar and BMI.

![Table 7. Blood sugar values (FBS) in various groups](image)

Figure 7. Blood sugar values (FBS) in various groups.
There is a strong statistical significance between FBS and BMI. FBS values are more in the lean group (p value 0.000) when compared to normal & obese diabetics.

Postprandial blood sugar and BMI:

|          | N  | Mean   | Std. Deviation | Std. Error | 95% Confidence Interval for Mean | Lower Bound | Upper Bound | Minimum | Maximum |
|----------|----|--------|----------------|------------|---------------------------------|-------------|-------------|---------|---------|
| LEAN     | 113| 312.63 | 109.520        | 10.303     | 292.21                          | 333.04      |             | 126     | 560     |
| NORMAL   | 564| 363.51 | 160.915        | 6.776      | 350.20                          | 376.82      |             | 128     | 650     |
| OBESE    | 393| 351.60 | 122.603        | 6.184      | 339.44                          | 363.76      |             | 126     | 600     |
| Total    | 1070| 353.76 | 143.655        | 4.392      | 345.15                          | 362.38      |             | 126     | 650     |

*Table 8.* Blood sugar values (PPBS) in various groups.

Figure 8. Blood sugar values (PPBS) in various groups.

![Figure 8](image)

There is statistical significance between PPBS and BMI. PPBS more in normal group (p value 0.002).

Total cholesterol and BMI:

|          | N  | Mean   | Std. Deviation | Std. Error | 95% Confidence Interval for Mean | Lower Bound | Upper Bound | Minimum | Maximum |
|----------|----|--------|----------------|------------|---------------------------------|-------------|-------------|---------|---------|
| LEAN     | 113| 249.15 | 93.069         | 8.755      | 231.80                          | 266.50      |             | 110     | 384     |
| NORMAL   | 564| 228.16 | 75.662         | 3.186      | 221.90                          | 234.42      |             | 110     | 380     |
| OBESE    | 393| 251.80 | 88.401         | 4.459      | 243.03                          | 260.56      |             | 110     | 384     |
| Total    | 1070| 239.06 | 83.194         | 2.643      | 234.07                          | 244.05      |             | 110     | 384     |

*Table 9.* Cholesterol levels in various groups.
**Figure 9.** Cholesterol levels in various groups.

There is a statistical significance between total cholesterol and BMI. Total cholesterol values are more in obese group (p value 0.000).

**Figure 10.** Triglyceride levels in various groups.

| TGL | N   | Mean | Std. Deviation | Std. Error | 95% Confidence Interval for Mean | Lower Bound | Upper Bound | Minimum | Maximum |
|-----|-----|------|----------------|------------|---------------------------------|-------------|-------------|---------|---------|
| LEAN| 113 | 217.10| 76.052         | 7.154      |                                | 202.92      | 231.27      | 94      | 380     |
| NORMAL| 564 | 228.00| 73.310         | 3.087      |                                | 221.94      | 234.07      | 95      | 327     |
| OBESE| 393 | 237.96| 70.593         | 3.561      |                                | 230.96      | 244.96      | 94      | 380     |
| Total| 1070| 230.51| 72.847         | 2.227      |                                | 226.14      | 234.88      | 94      | 380     |

**Table 10.** Triglyceride levels in various groups.
There is statistical significance between TGL and BMI. TGL levels are more in obese group (p value 0.013).

**LDL cholesterol and BMI:**

|          | N  | Mean  | Std. Deviation | Std. Error | Lower Bound | Upper Bound | Minimum | Maximum |
|----------|----|-------|----------------|------------|-------------|-------------|---------|---------|
| LEAN     | 113| 169.64| 75.096         | 7.064      | 155.64      | 183.63      | 40      | 320     |
| NORMAL   | 564| 210.84| 92.207         | 3.883      | 203.21      | 218.46      | 40      | 340     |
| OBESE    | 393| 164.41| 94.178         | 4.751      | 155.07      | 173.75      | 40      | 320     |
| Total    | 1070| 189.43| 93.991         | 2.873      | 183.80      | 195.07      | 40      | 340     |

**Table 11.** LDL values in various groups

**Figure 11.** LDL levels in various groups.

There is statistical significance between LDL and BMI. LDL values are more in normal group (p value 0.000).

**HDL cholesterol and BMI**

|          | N  | Mean  | Std. Deviation | Std. Error | Lower Bound | Upper Bound | Minimum | Maximum |
|----------|----|-------|----------------|------------|-------------|-------------|---------|---------|
| LEAN     | 113| 31.17 | 7.536          | .709       | 29.76       | 32.57       | 14      | 45      |
| NORMAL   | 564| 32.60 | 7.673          | .298       | 32.01       | 33.18       | 14      | 45      |
| OBESE    | 393| 34.30 | 7.222          | .364       | 33.58       | 35.01       | 14      | 45      |
| Total    | 1070| 33.07 | 7.241          | .221       | 32.63       | 33.50       | 14      | 45      |

**Table 12.** HDL values in various groups
**Figure 12.** HDL levels in various groups.

There is no statistical significance between HDL and BMI.

**VLDL cholesterol and BMI**

| VLDL  | N   | Mean | Std. Deviation | Std. Error | 95% Confidence Interval for Mean | Minimum | Maximum |
|-------|-----|------|----------------|------------|---------------------------------|---------|---------|
| LEAN  | 113 | 42.57| 14.109         | 1.327      | 39.94 - 45.20                   | 20      | 65      |
| NORMAL| 584 | 36.88| 13.147         | 0.554      | 35.79 - 37.96                   | 20      | 65      |
| OBESE | 393 | 40.35| 11.465         | 0.578      | 39.21 - 41.49                   | 20      | 65      |
| Total | 1070| 38.75| 12.822         | 0.392      | 37.99 - 39.52                   | 20      | 65      |

**Table 13.** VLDL values in various groups

**Figure 13.** VLDL levels in various groups.
There is statistical significance between VLDL and BMI. VLDL more in obese group (p value 0.000).

SYSTOLIC BP and BMI:

| SBP   | N   | Mean | Std. Deviation | Std. Error | Lower Bound | Upper Bound | Minimum | Maximum |
|-------|-----|------|----------------|------------|-------------|-------------|---------|---------|
| LEAN  | 113 | 142.21| 37.886         | 3.564      | 135.15      | 149.27      | 90      | 224     |
| NORMAL| 584 | 148.93| 31.086         | 1.309      | 146.36      | 151.50      | 90      | 220     |
| OBESE | 393 | 183.74| 34.342         | 1.732      | 180.33      | 187.14      | 90      | 224     |
| Total | 1070| 161.01| 37.363         | 1.142      | 158.76      | 163.25      | 90      | 224     |

**Table 14.** Systolic blood pressure values in various groups

There is statistical significance between systolic blood pressure and BMI. Systolic BP more in obese group

**DIASTOLIC BP and BMI:**

| DBP   | N   | Mean | Std. Deviation | Std. Error | Lower Bound | Upper Bound | Minimum | Maximum |
|-------|-----|------|----------------|------------|-------------|-------------|---------|---------|
| LEAN  | 113 | 93.80| 16.431         | 1.546      | 90.73       | 96.86       | 60      | 120     |
| NORMAL| 584 | 93.76| 18.148         | .764       | 92.25       | 95.26       | 60      | 120     |
| OBESE | 393 | 91.91| 14.956         | .754       | 90.43       | 93.39       | 60      | 120     |
| Total | 1070| 93.08| 18.089         | .516       | 92.07       | 94.09       | 60      | 120     |

**Table 15.** Diastolic blood pressure values in various groups

Figure 14. Systolic blood pressure values in various groups.

Fig. 14

There is statistical significance between systolic blood pressure and BMI. Systolic BP more in obese group
**Figure 15.** Diastolic blood pressure values in various groups.

There is no statistical significance between DBP and BMI.

![DBP with BMI](image1)

**Table 16.** HbA1c values in various groups

| BMI * HBA1c Crosstabulation | HBA1c     |          |          |          |          |          |
|-----------------------------|-----------|----------|----------|----------|----------|----------|
|                             | 6.5 - 7.5 | 7.5 - 9.0 | > 9.0    | Total    |          |          |
| LEAN                        | 48        | 37       | 28       | 113      | 100.0%   |          |
| % within BMI                | 42.5%     | 32.7%    | 24.6%    | 100.0%   |          |          |
| NORMAL                      | 197       | 248      | 119      | 564      | 100.0%   |          |
| % within BMI                | 34.9%     | 44.0%    | 21.1%    | 100.0%   |          |          |
| OBESE                       | 136       | 166      | 91       | 393      | 100.0%   |          |
| % within BMI                | 34.6%     | 42.2%    | 23.2%    | 100.0%   |          |          |
| Total                       | 381       | 451      | 236      | 1070     | 100.0%   |          |
| % within BMI                | 35.6%     | 42.1%    | 22.2%    | 100.0%   |          |          |

**Figure 16.** HbA1C values in various groups.

There is no statistical significance between HbA1C and BMI.
DISCUSSION: Diabetes Mellitus is an age old affliction of man and is the most common metabolic disorder all over the World. The incidence of Diabetes is showing an alarming rise in developing countries, particularly in India. Most of the diabetics in developed countries are obese. However in India we have a significant number of diabetics who are either normal weight or even underweight (lean).

Our study included thousand seventy patients. Among 1070 patients, 778 are males and 292 are females. Majority of patients that is 564 patients (52.7%) belong to normal weight, 393 patients (36.7%) belong to obese and 113 patients (10.6%) belong to lean body weight.

1. Age: In our study, we found that there is particular age group for lean diabetics. There is statistical significance between age and BMI. 39.8% of lean diabetics belong to 41-50 years of age, 33.7% of normal weight patients between 41 and 50 years, and 35.1% of obese patients belong to 41-50 years of age group.

2. Sex: There is no statistical significant relationship exist between sex and BMI in our study as male preponderance is noted in all groups.

3. Family History: There is statistical significance between family history and BMI. Family history of diabetes is present only in 42.5% of lean diabetics, when compared to 39% in normal weight and 50.4% in obese diabetics. So there is less incidence of family history present among normal weight diabetics.

4. Waist Hip Ratio and BMI: There is a linear increase in number of patients having abnormal Waist Hip ratio with increase in BMI. Statistical significance present with BMI and waist hip ratio. Among 1070 patients studied, obese people predominantly have abnormal Waist Hip ratio. Even though 10.6% (113) of diabetic's patients are lean based on BMI, 18 among them are having abnormal Waist hip ratio. So, Waist hip ratio is a better indicator than BMI for assessment of obesity. Skin fold thickness also increases as the BMI increases.

Infections: In our study, 50.4% of lean patients with type 2 diabetes presented with infections as compared to 39.7% in normal and 34.4% in obese patients. Values are statistically significant (p value = 0.007). Majority of the lean diabetics in our study group presented with infections especially pulmonary tuberculosis.

Glycemic Control: Lean diabetics have more severe hyperglycemia with poor metabolic control. Lean persons have higher fasting blood sugar (mean 282.99) levels than obese and normal weight type 2 diabetes patients. Postprandial values are higher in normal type 2 DM patients. In lean patients about 25% people have HbA1C >9 as against 21% and 23% in normal weight & obese diabetics.

Lipid Profile: Regarding lipid profile of type 2 diabetes patients, lean diabetics have low triglycerides (mean 217) when compared to normal (mean 228) and obese (mean 237) which is statistically significant. Lean group has low VLDL (mean 33.27) compared to normal (mean 36.88) and obese (mean 40.35) which is also statistically significant. Total cholesterol values in obese
diabetics are more (mean 251.80) as compared to normal (mean 228.16) and (249.15) in lean patients. LDL value in normal weight diabetics (mean 210.84) is more as compared to lean diabetics (mean 169.64) and in obese diabetics (mean 164.41). HD values and different groups are not statistically significant.

Our study has limitations, as it was hospital based in the tertiary care setting. Incidence of complications might be higher compared to general population or primary care setting and it was an observational study. We did not do insulin level assay, C peptide levels and GAD Antibodies in our lean diabetics due to financial constraints.

In conclusion, type 2 diabetic patients need not always obese. Majority (52.7%) belongs to normal weight and significant number (10.6%) of patients are lean in our study. Thus, lean body type 2DM patients appear to be a distinct variety and a great deal of emphasis is to be given on its clinical profile and natural history.

CONCLUSION: Majority of type 2 diabetes patients in our population are having normal weight (52.7%) and lean body weight (10.6%). Lean diabetics have more severe hyperglycemia and poor metabolic control. They are more prone for infections. Hence we conclude that early initiation of insulin in lean type 2 diabetics is expected to achieve good glycemic control and to prevent future complications.

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