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# Analyzing Left Ventricular Mass Across Weight and Metabolic Health Categories: Insights from an Observational Study

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**Abstract:** ***Background: Left ventricular (LV) hypertrophy is an established independent cardiovascular risk factor. LV mass is influenced by multiple factors such as race, ethnicity, gender, and the degree of central and peripheral adiposity. This study aims to analyse LV mass via transthoracic echocardiography in individuals with varying weight categories (normal weight, pre-obese, and obese) and metabolic health statuses (metabolically healthy/unhealthy). Methods: An observational study was conducted among 120 patients at Mahatma Gandhi medical college and hospital. Participants were categorized based on their body mass index (BMI) into normal weight, pre-obese, and obese groups. Metabolic health status was assessed, and LV mass was measured using transthoracic echocardiography. Clinical, anthropometric, and biochemical parameters were collected and analysed. Results: Normal weight patients were predominantly aged 61-70 years, while obesity and pre-obesity were most common in the 41-51 years age group. A significant association was found between LV mass and BMI. LV mass in metabolically healthy normal weight, pre-obese, and obese patients were 140.8 ± 20.2, 143.1 ± 25.5, and 159.8 ± 31.1 respectively. Metabolically unhealthy counterparts had LV masses of 154.4 ± 21.2, 178.6 ± 29.4, and 181.45 ± 45.0 respectively. LV mass index showed a significant association with waist circumference and other parameters including age, total cholesterol, triglycerides, HDL, LDL, and hypertension. Conclusion: Metabolic health significantly influences LV mass across all BMI categories. Obesity impacts LV mass independently of metabolic syndrome components, indicating that metabolically healthy obese individuals exhibit subclinical adverse changes in LV mass. Waist circumference is a more accurate predictor of LV mass index than BMI.***

**Keywords:** Metabolically healthy, metabolically unhealthy, LV mass, obesity, cardiovascular risk

## 1. Introduction

Obesity is a growing global health concern, affecting both children and adults. It is replacing traditional public health concerns like undernutrition and infectious diseases as a significant contributor to ill health. Obesity is a key risk factor for chronic and noncommunicable diseases (NCDs), and it is expected to increase mortality rates in developing countries.[1] Obesity affects 39% of the global population above 18 years of age, with 13% being obese. Studies have shown a relationship between obesity and cardiovascular diseases, hypertension, diabetes mellitus, dyslipidaemias, and sleep apnoea syndrome.[2] Obesity is related to disturbances in cardiac structure, such as greater left ventricular mass, greater wall thickness, and larger chamber size. Left ventricular hypertrophy is a strong risk factor for cardiovascular morbidity and mortality. Changes in left ventricular mass and structure with increasing body weight can be partially explained by haemodynamic changes, arterial hypertension, and metabolic and hormonal factors. Medical treatment of hypertension can induce regression in left ventricular hypertrophy, but little is known about the effect of weight reduction on left ventricular mass. Subclinical alterations in left ventricular structure and function according to obesity and metabolic health status.[3]

Obesity has been identified as an independent risk factor of cardiovascular morbidity and mortality. Study of left ventricular mass in obese individuals is an area of active research in current times. However, there is dearth of studies on left ventricular mass in metabolically normal and abnormal obese individual in western India. We intend to study effects of obesity and metabolic health status on left ventricular mass and compare the same with non-obese and pre-obese individuals who are metabolically normal and study the degree of association between LV mass and various factors influencing the same.

## 2. Methods

- **Study design**: Observational Study
- **Study area**: The study was conducted at Mahatma Gandhi medical college and hospital.
- **Study Period**: The study was conducted over a period of 1.5 years (2023-2024).
- **Sampling size**: In absence of any reliable regional data, we assumed moderate effect size of 0.6. With this effect size, about 44 participants per group were required to achieve 80% power allowing for 5% type I error. Based on that 40 obese, 40 pre-obese, and 40 non-obese individuals were included in this study.
- **Study population**: Indoor patients admitted under Cardiology Department

**Inclusion Criteria**: Age >18 years,
Any individual having 3 or > 3 criteria of the five criteria mentioned below:

1) Waist circumference >102 cm in males and >88 cm in female
2) Fasting glucose more than or equal to 100 mg/dl or treated
3) Triglyceride more than or equal to 150 mg/dl or treated
4) HDL cholesterol less than 40 mg/dl or treated
5) Systolic BP >130 mmHg or Diastolic BP >85 mmHg

**Exclusion Criteria:**
Patients with Cerebrovascular stroke and Chronic obstructive airway disease
Clinical, laboratories, anthropometric and echocardiographic data were collected of the selected individuals.

Data was analysed with respect to –
1) Age, gender and BMI.
2) Body composition characteristics as measured by impedance plethysmography.
3) Left ventricular mass

Result will be compared between obese, pre-obese and non-obese groups.

Association between BMI, Age, Gender, Post-menopausal status, Central fat, Metabolic age, Lipids, HbA1C were assessed.
Left ventricular mass was studied using standard formula suggested by Devereux et al. and other standard formulae.

## 3. Results

Obesity and pre-obesity was highest in age group of 41-51 years (44.1% obese patients and 38.2% pre-obese patients). Normal weight patients were highest in 61-70 years age group (54.2%). Majority of normal weight patients (60%) and pre-obese (52.5%) were male. Majority of obese patients (67.5%) were female. Mean BMI in normal weight, pre-obese and obese patients were 21.88, 24.21 and 30.11 respectively. Mean waist circumference in normal weight, pre-obese and obese patients were 83.75 ± 12.31, 92.77± 11.44 and 91.92± 12.68respectively. Mean waist circumference of obese males was 107.6 ± 89.3. Mean waist circumference of obese females was 94.35 + 7.13.

Hypertension was present in 37.5% of normal weight patients, 45% of pre-obese patients, 57.5% of obese patients. Diabetes mellitus II was present in 47.5% of normal weight patients, 52.5% of preobese patients, 57.5% of obese patients. Hypertension and Diabetes mellitus II were present in 27.5% of normal weight patients, 35% of preobese patients, 50% of obese patients. Dyslipidaemia was present in 40% of normal weight patients, 40% of pre-obese patients, 47.5% of obese patients.

Cardiac profile (SBP, DBP, Heart rate, LV mass, LV mass index, RWT) was studied among normal weight, pre-obese and obese patients. All these parameters were in increasing trend from normal weight<pre-obese<obese. But among all these factors, correlation between LV mass and BMI only was significant.

Glycaemic and lipid profile (FBS, HBA1C, T. Cholesterol, HDL Cholesterol, LDL Cholesterol, Triglyceride) was studied among normal weight, pre-obese and obese patients. All these parameters not significant but were in increasing trend from normal weight<pre-obese<obese.

BMI of metabolically healthy normal weight, pre-obese, obese patients was 21.78±0.87, 24.14±0.64, 28.94±5.08 respectively. BMI of metabolically unhealthy normal weight, pre-obese, obese patients was 22±1.01, 24.29±0.62, 31.29±4.87 respectively.

LV Mass in metabolically healthy was 147.92± 26.97 and metabolically unhealthy was 171.48± 38.08 and hence is statistically significant. LV Mass index in metabolically healthy was 104.08 ± 23.08 and metabolically unhealthy was 124.91 ± 24.02 and hence is statistically significant. LV Mass in metabolically healthy normal weight patients is 140.8 ± 20.2. LV Mass in metabolically healthy pre-obese patients is 143.1 ± 25.5. LV Mass in metabolically healthy obese patients is 159.8 ± 31.1. LV Mass in metabolically unhealthy normal weight patients is 154.4 ± 21.2. LV Mass in metabolically unhealthy pre-obese patients is 178.6 ± 29.4. LV Mass in metabolically unhealthy obese patients is 181.45 ± 45.0.

LV Mass index in metabolically healthy normal weight patients is 99.5 ± 18.1. LV Mass index in metabolically healthy pre-obese patients is 103.6 ± 26.1. LV Mass index in metabolically healthy obese patients is 109.1 ± 24.3. LV Mass index in metabolically unhealthy normal weight patients is 124.3 ± 32.6. LV Mass index in metabolically unhealthy pre-obese patients is 121.0 ± 20.6. LV Mass index in metabolically unhealthy obese patients is 129.4 ± 16.1.

LV Mass index in patients with Hypertension alone was 118.9 ± 19.45. LV Mass index in patients with Diabetes alone was 118.77 ± 39.35. LV Mass index in patients with Hypertension and Diabetes both was 124.44 ± 17.66.

Multiple Linear Regression (Backward Method) was performed to understand the relationship between various independent variables Age, BMI, WC, TG, TC, HDL, LDL, DM and HTN with LV Mass and LV Mass Index. Regression model revealed that Total cholesterol, Age, TG, BMI and LDL are statistically significantly associated with LV Mass. It also revealed that Age, HDL, BMI and Waist circumference are statistically significant with LV Mass Index.

Multiple Linear Regression (Backward Method) was performed to understand the relationship between various independent variables Age, HDL, LDL, TG, TC, LVM, LVMI, HTN and DM with BMI and waist circumference. Regression model revealed that LV Mass, Age and HDL are statistically significant with BMI. Regression model revealed that HTN and LV Mass Index are statistically significant with Waist circumference.

**Table 1:** Comparison of clinical characteristic among metabolic phenotypes

| Characteristic | Metabolic Phenotypes | | | | | | P value |
|---|---|---|---|---|---|---|---|
| | MHNW (n=20) | MHO (n=20) | MHPO (n=20) | MUNW (n=20) | MUO (n=20) | MUPO (n=20) | |
| Age | 49.8 ± 13.1 | 48.05 ± 9.41 | 48.8 ± 9.05 | 63.95 ± 6.01 | 53.25 ± 11.82 | 52.8 ± 13.43 | 0.026 |
| Male n (%) | 11 (55%) | 7 (35%) | 8 (40%) | 13 (65%) | 6 (30%) | 13 (65%) | 0.091 |
| BMI kg/m2 | 21.77 ± 0.87 | 28.94 ± 5.08 | 24.14 ± 0.63 | 21.99 ± 1.01 | 31.28 ± 4.87 | 24.29 ± 0.61 | 0.0001 |
| Risk factors, n (%) | | | | | | | |
| HT | 1 (5%) | 5 (25%) | 2 (10%) | 14 (70%) | 18 (90%) | 16 (80%) | 0.0001 |
| DM | 4 (20%) | 4 (20%) | 3 (15%) | 15 (75%) | 19 (95%) | 18 (90%) | 0.0001 |
| Dyslipidaemia | 0 (0%) | 2 (10%) | 3 (15%) | 16 (80%) | 17 (85%) | 13 (65%) | 0.0001 |
| Cardiac Profile | | | | | | | |
| SBP | 116.6 ± 6.32 | 115.4 ± 6.32 | 116.1 ± 5.12 | 124.8 ± 8.39 | 128.2 ± 7.53 | 125.3 ± 8.92 | 0.813 |
| DBP | 77.6 ± 3.92 | 76.7 ± 5.44 | 75.8 ± 4.98 | 81.7 ± 5.03 | 82.6 ± 4.77 | 79.8 ± 4.72 | 0.207 |
| Heart Rate | 78.6 ± 11.24 | 85.0 ± 8.93 | 83.0 ± 10.31 | 78.8 ± 15.29 | 81.2 ± 7.79 | 83.9 ± 9.78 | 0.093 |
| RWT | 0.56 ± 0.05 | 0.56 ± 0.05 | 0.52 ± 0.04 | 0.59 ± 0.07 | 0.55 ± 0.05 | 0.58 ± 0.06 | 0.146 |
| LV mass | 160.3 ± 33.5 | 159.8 ± 31.1 | 143.1 ± 25.5 | 207.8 ± 53.0 | 181.45 ± 45.0 | 178.6 ± 39.4 | 0.0001 |
| Glycaemic & Lipid Profile | | | | | | | |
| FBS | 98.15 ± 21.23 | 94.9 ± 7.35 | 101.75 ± 23.1 | 144.6 ± 54.69 | 121.85 ± 36.17 | 124.15 ± 38.5 | 0.292 |
| HBA1C | 5.52 ± 0.83 | 5.37 ± 0.69 | 5.74 ± 1.18 | 7.02 ± 1.62 | 6.77 ± 1.11 | 6.78 ± 1.51 | 0.758 |
| Total Cholesterol | 168.35 ± 41.69 | 180.55 ± 37.79 | 171.9 ± 37.0 | 180.5 ± 42.45 | 191.7 ± 54.48 | 189.95 ± 44.34 | 0.484 |
| LDL Cholesterol | 101.5 ± 33.0 | 118.2 ± 26.21 | 106.7 ± 26.78 | 106.1 ± 27.68 | 120.1 ± 47.98 | 124.45 ± 28.88 | 0.094 |
| HDL Cholesterol | 52.9 ± 12.0 | 54.3 ± 6.67 | 52.5 ± 10.79 | 38.65 ± 10.72 | 46.95 ± 17.53 | 44.65 ± 7.81 | 0.222 |
| Triglyceride | 90.8 ± 38.35 | 102.05 ± 37.57 | 96.55 ± 50.96 | 150.45 ± 68.88 | 149.85 ± 61.6 | 169.9 ± 110.34 | 0.736 |
| Waist circumference | 76.65 ± 10.34 | 85.25 ± 9.31 | 86.35 ± 11.42 | 90.85 ± 9.9 | 98.6 ± 12.22 | 99.2 ± 7.17 | 0.002 |

## 4. Discussion

Left ventricular (LV) hypertrophy is a known independent risk factor for cardiovascular events such as heart failure, coronary heart disease, and stroke. Reducing LV hypertrophy through medical treatment decreases these risks.[4] While echocardiography has been used for over 40 years to diagnose LV hypertrophy, cardiovascular MRI is now the standard for quantifying LV mass. However, older clinical studies show variability in measurements due to differences in criteria, formulas, and adjustments, complicating comparisons and clinical applications. Additionally, factors like race, ethnicity, gender, adiposity, and metabolic phenotypes further complicate analysis.[5]

This study aimed to explore the relationship between obesity, metabolic health status, and LV mass in adults, assessing how obesity and metabolic syndrome components influence LV mass and LV mass index. We conducted a multivariate analysis of factors affecting LV mass in the overall study population and within different phenotypic groups. Our methodology involved assessing LV mass in 120 adults, categorized into normal weight, pre-obese, or obese according to WHO Asia-Pacific definitions.[6] Participants were also classified as metabolically healthy (meeting ≤1 criterion of Metabolic Syndrome) or unhealthy.[7] Metabolic Syndrome criteria included elevated blood pressure, elevated fasting glucose or HbA1c, elevated triglycerides, low HDL cholesterol, and high waist circumference.[8] In this study, the highest obesity prevalence was among patients aged 41-60 years, with 44.1% in the 41-50 age group and 28.1% in the 51-60 age group. The older age groups (61-70 and >70) had the most normal weight patients. Similarly, Singh S et al.[9] found peak obesity prevalence at 40-49 years for males and at/after 50 years for females. The sample included 40 patients each of normal, pre-obese, and obese subgroups with male/female ratios of 60/40, 52.5/47.5, and 32.5/67.5, respectively.

Undavalli et al.[10] reported higher obesity prevalence in women and individuals aged 41-50 years in rural Andhra Pradesh. Shammi Luhar et al.[11] projected that between 2010 and 2040, the prevalence of overweight and obesity in India will significantly increase, especially among older adults and in rural areas. Chen C et al.[12] found that advanced age correlates with greater LV wall thickness, LV mass, and LV mass index (LVMI).

In this study, 40% of normal weight, 47.5% of pre-obese, and 67.5% of obese patients were female. Males had a higher mean LV mass (167.44±35.82) compared to females (152.45±32.70). Wang SX et al.[13] showed that female metabolic syndrome (MS) patients are at higher risk for concentric and eccentric hypertrophy. Akintoye E et al.[14] found significant racial/ethnic differences in LVMI, with higher values for Blacks and Hispanics compared to non-Hispanic Whites and Chinese, noting stronger associations between LVMI and cardiovascular disease (CVD) in Chinese and Hispanics.

Burchfiel et al.[15] linked the degree of metabolic syndrome clustering to LV mass and wall thickness, influenced by factors like insulin resistance. KK Poppe et al.[16] emphasized that geographic and ethnic variations affect LV mass reference ranges. Manish Bansal et al.[17] noted that Indian subjects have smaller cardiac chambers than Western populations, recommending BSA-indexed values for accurate echocardiography interpretations. In this study, the mean BMI was 21.88 ± 0.93 for the normal group, 24.21 ± 0.62 for the pre-obese group, and 30.11 ± 5.05 for the obese group. Hypertension prevalence increased with BMI: 37.5% in the normal group, 45% in the pre-obese group, and 57.5% in the obese group. Diabetes showed a similar trend, with 47.5% in the normal group, 52.5% in the pre-obese group, and 57.5% in the obese group. Dyslipidaemia was observed in 40% of both the normal and pre-obese groups and 47.5% in the obese group. LV mass and LVMI were significantly higher in the obese group (170.63 ± 39.76) compared to the pre-obese and

normal groups. No significant differences were found in mean SBP, DBP, heart rate, and RWT across BMI groups.

The study indicated that LV mass increases with age and is higher in males than females, with statistical significance. Increased BMI correlates with higher LV mass, regardless of metabolic status, though poor metabolic health status results in greater LV mass increments than obesity alone. Previous studies, such as those by Sutipong J et al.[18], demonstrated that obesity independently increases LVM in normotensive individuals and adds to the effect in hypertensive patients. Gender and obesity influence LVM and LVH prevalence. Rider et al.[19] found that LV hypertrophy in obese individuals is due to increased lean body mass, stroke volume, and visceral fat mass. Lee H-J et al.[20] noted that poor metabolic health status causes more adverse LV structural changes than obesity, with high SBP having the greatest impact. Wang YC et al.[21] concluded that obesity is linked to high LVMI irrespective of Metabolic Syndrome (MetS) presence, but only those with MetS had high RWT, indicating that poor metabolic health status is more strongly associated with LV hypertrophy than obesity alone.

In our study, mean waist circumference (WC) and BMI among normal, pre-obese, and obese patients were 83.75±12.31 cm (21.88±0.93), 92.775±11.44 cm (24.21±0.6), and 91.925±12.68 cm (30.11±1.05), respectively, showing a statistically significant association. Previous research by Pischon et al.[22] demonstrated a 17% increase in mortality risk for men and 13% for women with each 5 cm increase in WC, emphasizing the importance of both BMI and WC in health risk predictions. The Jaipur Heart Watch studies[23] indicated higher rates of obesity in urban versus rural populations in India.

We also analysed left ventricular (LV) mass and LV mass index (LVMI) using established formulas. LVMI, which normalizes LV mass to body surface area (BSA), is more accurate for comparing individuals of different body sizes. Our findings showed that LV mass and LVMI were higher in patients with both hypertension and diabetes compared to those with only one condition, although the differences were not statistically significant. Prior studies, including those by Cuspidi et al.[24] and Seferovic et al.[25], corroborate that LVMI is a critical predictor of cardiovascular risk, particularly in patients with type 2 diabetes, where it may serve as an early marker of myocardial changes associated with hyperglycaemia.

The following table shows comparison of various clinical and echocardiographic parameters in metabolically healthy normal-preobese-obese and metabolically unhealthy normal-preobese-obese individuals of the present study and study by Lee H-Jet et al.[20] which was carried out in south korea and results published in 2019. They studied in 789 subjects (58.8 ±13.0 years, 50.7% males) LV morphology and function with the help of trans esophageal echocardiography in the 6 metabolic subgroups as described above. Their aim was to study relationship obesity and metabolic health status in LV structure. Theirs was a retrospective study between March 2012- June 2016. In contrast, ours was the prospective study of 120 patients presenting for health check-up with the help of trans thoracic echocardiography during the year of COVID pandemic. They demonstrated that obesity in poor metabolic health were associated with high LV mass but not LVEF and poor metabolic health status was related to more adverse LV changes than obesity. Among various components of metabolic syndrome Hypertension showed strongest association with LV mass. In metabolically healthy individuals, obesity was associated with high LV mass. Their findings are confirmative with our findings.

**Table 2:** Comparison between our study and LEE-H et al[20] study

| Characteristic | Metabolic Phenotypes | | | | | | P value |
|---|---|---|---|---|---|---|---|
| | MHNW (n=20) | MUNW (n=20) | MHPO (n=20) | MUPO (n=20) | MHO (n=20) | MUO (n=20) | |
| Age | 49.8 ± 13.1 | 63.95 ± 6.01 | 48.8 ± 9.05 | 52.8 ± 13.43 | 48.05 ± 9.41 | 53.25 ± 11.82 | 0.026 |
| Age ( Lee H-J et al) | 53.8 ± 13.9 | 64.3 ± 12.1 | 53.7 ± 11.7 | 61.7 ± 10.2 | 53.2 ± 15 | 59.6 ± 12.4 | <0.001 |
| BMI kg/m2 | 21.77 ± 0.87 | 21.99 ± 1.01 | 24.14 ± 0.63 | 24.29 ± 0.61 | 28.94 ± 5.08 | 31.28 ± 4.87 | 0.0001 |
| BMI kg/m2 (Lee H-J et al) | 21.4±1.2 | 21.5±1.1 | 24.0±0.6 | 24.1±0.6 | 27.0±2.1 | 27.4±2.0 | <0.001 |
| **Risk factors, n (%)** | | | | | | | |
| HTN | 1 (5%) | 14 (70%) | 2 (10%) | 16 (80%) | 5 (25%) | 18 (90%) | 0.0001 |
| HTN(Lee H-J et al) | 17 (15.3) | 92 (65.7) | 10 (13.2) | 81 (62.3) | 12 (18.2) | 196 (73.7) | <0.001 |
| DM | 4 (20%) | 15 (75%) | 3 (15%) | 18 (90%) | 4 (20%) | 19 (95%) | 0.0001 |
| DM(Lee H-J et al) | 3 (2.7) | 36 (25.7) | 3 (3.9) | 26 (20.0) | 4 (6.1) | 69 (25.9) | <0.001 |
| Dyslipidaemia | 0 (0%) | 16 (80%) | 3 (15%) | 13 (65%) | 2 (10%) | 17 (85%) | 0.0001 |
| Dyslipidaemia (Lee H-J et al) | 6 (5.4) | 36 (25.7) | 2 (2.6) | 40 (30.8) | 2 (3.0) | 85 (37.6) | <0.001 |
| **Cardiac Profile** | | | | | | | |
| SBP | 116.6 ± 6.32 | 124.8 ± 8.39 | 116.1 ± 5.12 | 125.3 ± 8.92 | 115.4 ± 6.32 | 128.2 ± 7.53 | 0.813 |
| SBP(Lee H-J et al) | 121±15 | 134±18 | 120±13 | 131±18 | 123±10 | 136±17 | <0.001 |
| DBP | 77.6 ± 3.92 | 81.7 ± 5.03 | 75.8 ± 4.98 | 79.8 ± 4.72 | 76.7 ± 5.44 | 82.6 ± 4.77 | 0.207 |
| DBP(Lee H-J et al) | 73±12 | 81±11 | 75±10 | 79±11 | 76±8 | 82±12 | <0.001 |
| Heart Rate | 78.6 ± 11.24 | 78.8 ± 15.29 | 83.0 ± 10.31 | 83.9 ± 9.78 | 85.0 ± 8.93 | 81.2 ± 7.79 | 0.093 |
| Heart Rate (Lee H-J et al) | 64.2±8.7 | 69.9±12.0 | 68.3±10.9 | 66.4±12.1 | 65.0±10.2 | 68.9±10.9 | 0.014 |
| RWT | 0.56 ± 0.05 | 0.59 ± 0.07 | 0.52 ± 0.04 | 0.58 ± 0.06 | 0.56 ± 0.05 | 0.55 ± 0.05 | 0.146 |
| RWT (Lee H-J et al) | 0.34±0.04 | 0.36±0.05 | 0.34±0.04 | 0.38±0.04 | 0.36±0.05 | 0.37±0.05 | <0.001 |
| LV mass | 140.8 ± 20.2 | 154.4 ± 21.2 | 143.1 ± 25.5 | 178.6 ± 39.4 | 159.8 ± 31.1 | 181.45 ± 45.0 | 0.0001 |
| LV Mass Index | 99.5 ± 18.1 | 124.3 ± 32.6 | 103.6 ± 26.1 | 121.0 ± 20.6 | 109.1 ± 24.3 | 129.4 ± 16.1 | 0.0002 |
| LV Mass Index(Lee H-J et al) | 78.1±15.2 | 88.9±19.6 | 78.1±15.3 | 91.4±20.3 | 82.6±18.3 | 86.0±17.3 | <0.001 |
| **Glycaemic & Lipid Profile** | | | | | | | |

| Characteristic | Metabolic Phenotypes | | | | | | P value |
|---|---|---|---|---|---|---|---|
| | MHNW (n=20) | MUNW (n=20) | MHPO (n=20) | MUPO (n=20) | MHO (n=20) | MUO (n=20) | |
| FBS | 98.15 ± 21.23 | 144.6 ± 54.69 | 101.75 ± 23.1 | 124.15 ± 38.5 | 94.9 ± 7.35 | 121.85 ± 36.17 | 0.292 |
| FBS(Lee H-J et al) | 98±17 | 122 ±63 | 98±15 | 117±32 | 99±15 | 121±72 | <0.001 |
| HBA1C | 5.52 ± 0.83 | 7.02 ± 1.62 | 5.74 ± 1.18 | 6.78 ± 1.51 | 5.37 ± 0.69 | 6.77 ± 1.11 | 0.758 |
| HBA1C (Lee H-J et al) | 5.5±0.4 | 6.2±1.1 | 5.5±0.4 | 6.1±0.9 | 5.6±0.5 | 6.3±1.2 | <0.001 |
| Total Cholesterol | 168.35± 41.69 | 180.5 ± 42.45 | 171.9 ± 37.0 | 189.95 ± 44.34 | 180.55 ± 37.79 | 191.7 ± 54.48 | 0.484 |
| Total Cholesterol (Lee H-J et al) | 184±33 | 180±48 | 187±31 | 181±41 | 182±33 | 180±41 | 0.847 |
| LDL Cholesterol | 101.5 ± 33.0 | 106.1 ± 27.68 | 106.7 ± 26.78 | 124.45 ± 28.88 | 118.2 ± 26.21 | 120.1 ± 47.98 | 0.094 |
| LDL Cholesterol (Lee H-J et al) | 113±30 | 115±41 | 116±28 | 112±35 | 113±30 | 113±36 | 0.974 |
| HDL Cholesterol | 52.9 ± 12.0 | 38.65 ± 10.72 | 52.5 ± 10.79 | 44.65 ± 7.81 | 54.3 ± 6.67 | 46.95 ± 17.53 | 0.222 |
| HDL Cholesterol (Lee H-J et al) | 58.4±13.4 | 48.7±13.3 | 56.3±9.8 | 47.2±11.4 | 54.1±12.6 | 45.2±10.7 | <0.001 |
| Triglyceride | 90.8 ± 38.35 | 150.45 ± 68.88 | 96.55 ± 50.96 | 169.9 ± 110.34 | 102.05 ± 37.57 | 149.85 ± 61.6 | 0.736 |
| Triglyceride (Lee H-J et al) | 86±33 | 111±57 | 97±35 | 140±84 | 96±28 | 152±125 | <0.001 |
| Waist circumference | 76.65 ± 10.34 | 90.85 ± 9.9 | 86.35 ± 11.42 | 99.2 ± 7.17 | 85.25 ± 9.31 | 98.6 ± 12.22 | 0.002 |

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