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**Original Research Article**

# Association of lipid accumulation product index and conicity index in predicting systolic and diastolic blood pressures in hypertensive patients: a hospital based study

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## ABSTRACT

**Background:** An epidemiological association between adiposity and hypertension has been well established. However, not all obese individuals develop hypertension, possibly due to variations in fat distribution. The present study aimed to evaluate the relationship of the lipid accumulation product (LAP) index with systolic and diastolic blood pressures in newly diagnosed hypertensive patients. Visceral fat accumulation is known to influence mean blood pressure levels, and indices like LAP and conicity index (CI) may serve as better indicators of central adiposity compared to body mass index (BMI) and waist circumference (WC).
**Methods:** This observational cross-sectional study included 40 Indian patients attending the medicine OPD of a tertiary care centre in North India between July 19 and September 19, 2019. Blood pressure, WC, and serum triglyceride levels were measured, and LAP and Conicity indices were calculated. Correlations between these parameters were analysed statistically.
**Results:** Among the participants, 62.5% were females and 37.5% males, with a mean age of 50.02±8.48 years (median: 49.5 years). A strong positive correlation was found between serum triglyceride levels and LAP index (r=0.867, p<0.001) and a moderate positive correlation with CI (r=0.326, p=0.040). Pulse pressure also showed a moderate positive correlation with LAP index (r=0.341, p=0.031).
**Conclusions:** LAP and Conicity indices are promising, simple, and effective measures of visceral adiposity and may help in predicting hypertension risk and guiding clinical assessment.

**Keywords:** Adiposity, Conicity index, Hypertension, LAP index

## INTRODUCTION

Hypertension is a major public health problem and important area of research due to its high prevalence all around the globe. According to a report by ICMR 2018, adult hypertension prevalence has shown a drastic increase in the past three decades in urban as well as rural areas. It is estimated that 16% of ischaemic heart disease, 21% of peripheral vascular disease, 24% of acute myocardial infarctions and 29% of strokes are attributed to hypertension, which is a significant count increase in non-communicable diseases caused by hypertension. Complications of hypertension also include aneurysm, kidney failure, amputation, hypertensive retinopathy and blindness. An epidemiological link between adiposity and hypertension development has been firmly established. However, many obese patients still remain normotensive despite significant adiposity due to differences in adipose tissue distribution.[1]

Fat in our body is distributed in two main compartments with different metabolic characteristics: subcutaneous adipose tissue (SAT) and visceral adipose tissue (VAT) and it is VAT which is hormonally active.[2] VAT is also associated with increased cytokine production and insulin resistance. Persistently higher short- and long-term mean blood pressure levels is associated with excess visceral fat accumulation, accounting for 26% in male and 28% in female cases of hypertension.[3] Therefore, simple quantitative assessment of visceral obesity for evaluating potential risk and providing accurate prognosis is what need of the day. Techniques for measuring visceral adiposity vary in accessibility, specificity, accuracy and ability to quantify. As visceral obesity is associated with increased degree of insulin resistance and further progression of hypertension and it`s complications, it is of great importance to identify methods that quantify adipose tissue accurately and specifically. Current techniques of assessment of adiposity range from simple, indirect methods like BMI to crude cross-sectional imaging technique like computed tomography (CT scan) which directly measure visceral fat volume. CT scan and magnetic resonance imaging (MRI) are most accurate methods but being costly these are inaccessible in primary care settings and are not suitable for use by general public.[2] CT scan also owns radiation exposure hazards.

LAP index, a new novel central obesity indicator, was developed from population-based frequency plots of adult WCs and circulating triglyceride concentrations.[4] Soon after that a number of studies was done to use this visceral fat index in predicting risk of diseases that increase morbidity and mortality in today`s world. Positive association with LAP index has been documented with cardiovascular diseases (CVD), CVD in polycystic ovarian syndrome in women, metabolic syndrome (MtS), MtS in liver diseases, diabetes mellitus and predicting insulin resistance, intracranial atherosclerotic stenosis and hyperuricemia.[5] Also, a study on what effect dietary modification and lipid accumulation have on blood pressure changes in women was studied.[6] In continuation of these studies, focus of our present study was to check what effect, after changes in LAP index have on both systolic and diastolic blood pressures in newly diagnosed hypertensive patients in our tertiary care centre.

LAP index is a simple and effective indicator than BMI and WC.[2,7,8] It is also advantageous as it`s a gender-based formula, therefore, how its association changes in male and female can also be assessed. Use of LAP index for prediction of hypertension or MtS has been previously done in different Chinese and Japanese population, but currently, there is a lack of such study amongst hypertensive individuals of Indian population.[9-13]

Another new simpler index proposed for measurement of visceral fat is CI. In 1991, Rodolfo Valdez proposed the CI to assess obesity and body fat distribution, on the grounds that central rather than general obesity is associated with CVD. A study in 2015, to determine the performance of five central obesity indices to best predict 10-year cardiovascular (CV) events, concluded that CI showed the most discriminatory power in estimation of a 10-year CV risk.[14] Also, a study by Almeida and cols. assessed the association between abdominal obesity and cardiovascular risk in women and showed that the CI was the indicator with the best performance in the discrimination of coronary heart disease risk.[15] Until now, many studies have been done to predict blood pressure changes or risk of hypertension in middle-aged or post-menopausal women and found a positive correlation of CI with systolic and diastolic blood pressures.[16-18] Also, a study in young girls found similar result. But till now no study was done to establish it as a common predictor of hypertension in both male and female. So, we tried to compare and analyse between the values of C index of male and female. Also, there are some recent studies which are unable to conclude CI as a strong predictor of hypertension which will also be checked in our study.[19] Hence, the present study was carried with the study subjects from our tertiary care centre OPD with an aim to highlight possible associations between these two central obesity indices and systolic and diastolic blood pressure changes. This is also an effort to include LAP index and CI with potential value in clinical application to come up in regular use in clinics.

## METHODS

### *Study setting*

The study was conducted in outpatient department of medicine in our tertiary care health centre of North India.

### *Study type*

This was hospital based observational, cross-sectional study.

### Study period

Study was conducted from 19 July 2019 to 19 September 2019.

### *Study population*

Newly diagnosed patients at outpatient department of medicine were selected for this study.

### *Sample size*

Forty patients (15 male and 25 female-as it is a gender-based study) were selected in this study.

### *Case selection method*

Consecutive study participants satisfying eligibility criteria and voluntarily willing to participate in the study.

### *Inclusion criteria*

Newly diagnosed cases of hypertension based on new American College of Cardiology (ACC) and American Heart Association (AHA) guidelines with age: >40 years were included in study.

***Exclusion criteria***

Diagnosed cases of secondary hypertension, Diabetes mellitus and any of its complication or endocrinopathies, Pregnancy, on any drug therapy for hypertension, hyperlipidaemia, history of abusive smoking from past 6 months or more, abusive alcohol consumption exceedingly more than 14 pegs per week in case of men and more than 7 pegs per week in case of women (1 peg=approximately 30 mL), any comorbid illnesses (cardiorespiratory, hepatic, renal, significant central nervous system illness).

***Case definition***

According to new guidelines by ACC/AHA: Stage 1 hypertension: Systolic blood pressure between 130-139 or diastolic blood pressure between 80-89; stage 2 hypertension: Systolic blood pressure at least 140 or diastolic blood pressure at least 90 mm Hg.

***Methodology***

All subjects were recruited after obtaining approval from institutional ethics committee (IEC). Patients who satisfied the eligibility criteria for the study were included in the study as subjects from the medicine outpatient department and their confidentiality were maintained. Patient was explained in detail about the purpose and importance of study. Patients were recruited in the study only after obtaining informed and written consent. They were subjected to a detailed history, physical examination-including anthropometric measurements, clinical examination and laboratory tests. All these data obtained was entered in a predesigned proforma. Using these data LAP index and CI has been calculated. Clinical data collection blood pressure: Blood pressure was measured by using aneroid sphygmomanometer. Measured in patients in sitting position, using cuff of appropriate sizes for normal and obese patients, with hand being supported at the level of heart. 3 successive values were taken with a gap of 10 minutes and mean of these 3 readings were calculated to determine the average blood pressure.

*Anthropometric data collection*

*Height:* Height was measured in erect position without shoes to the nearest 0.5 centimetre.

*Weight:* Weight was measured with minimal clothing without shoes to nearest 0.1 kilogram.

*WC:* WC (to the nearest 0.5 centimetre) was taken as circumferential measurement midway between anterior superior iliac spine and lower coastal margin at umbilical level, at the end of gentle expiration in the upright position.

*Lab data parameters*

All tests recommended for a routine investigation in hypertensives was done during OPD check-up and the available laboratory data was utilized for the present study. These included fasting plasma glucose (FPG), liver and kidney function tests (LFT and KFT), uric acid, electrolytes, total cholesterol, triglycerides, complete blood count (CBC), urine analysis, 12 lead ECG.

Using the data collected above, following values were calculated using the formulas given below.

*LAP index*

An index of abdominal obesity calculated from WC and TyG levels where, WC (Waist circumference) is measured in centimetre (cm) and TyG (Triglycerides) is measured in mmol/L.[4] For males: LAP=[WC-65]×TyG, for females: LAP=[WC-58]×TyG. Since laboratory reports express TyG in mg/dL, we divided the value by conversion factor 88.57 to convert it to mmol/L.[20]

*CI index*

An index of abdominal obesity that was developed based on a model of geometric reasoning.[21]

CI=WC (m)/[0.109×√Bodyweight (kg)/height (m)}]
Where 0.109 is a constant.

## RESULTS

A total of 40 Indian patients who visited medical OPD of our tertiary care centre from 19 July 2019 to 19 September 2019 fulfilling the selection criteria were enrolled into this study after taking written and informed consent. Among the study subjects, majority of them (62.5%) were females and rest were (37.5%) males. The 50% of the study subjects belonged to the age category of 40-49 years, 32.5% were in 50-59 years and 17.5% were >60 years age group. The mean age of study subjects was 50.02±8.48 years (median age-49.5 years). Table 1 shows the clinical characteristics of the study subjects (n=40).

When calculated LAP index for 40 patients was divided into 3 significant groups, it was observed that 52.5% people's LAP index lay in the range of 51-100 and next larger constituting group was with 37.5% having less than or equal to 50. The 10% subjects are having LAP value >101 (Table 2). Among males, 40% people had LAP values less than or equal to 50 and 60% people had LAP values in the range of 51-100. Among females we observed 48% are having LAP index in the range 51-100 and 38% are having less than or equal to 50. This result in female cannot be stated as significant because male and female sex ratio is different. The 71.4% of study subjects in the age group of 40-49 years and 61.5% in the age group of 50-59 years are having LAP index more than 51. Whereas in the age group of >60 years majority of subjects (71.4%) are having LAP index less than 51.

When calculated CI for 40 patients was divided into 3 significant groups, it was observed that 50% people are having CI in the range of 1.3-1.4 and 40% of subjects are having value more than 1.4 (Table 3). Among both the groups, majority of males (93.3%) and females (88%) are having CI more than 1.3. 95% of study subjects in the age group of 40-49 years, 84.6% of 50-59 years and 85.7% of >60 years are having CI more than or equal to 1.3.

When patients were stratified according to mean systolic blood pressure, 57.5 %, 30% and 12% had blood pressure in the range of 130-144 mmHg, 145-159 mmHg and >160 mmHg respectively. Considering mean diastolic blood pressure 52.5%, 37.5% and 10% had blood pressure in the range of 80-89 mmHg, 90-99 mmHg and >100 mmHg respectively. Table 4 shows bivariate Pearson's Correlation of Anthropometric and Biochemical profile with Central obesity indices LAP index and CI.

Scatter diagram (Figure 1) between LAP index and serum triglycerides shows strong positive correlation between both of them. Scatter diagram (Figure 2) shows strong positive correlation between CI and serum triglycerides. Scatter diagram (Figure 3) between LAP index and WC shows moderate positive correlation between 2.

Scatter diagram (Figure 4 and 5) shows weak positive correlation of LAP index with mean systolic blood pressure and CI with mean systolic blood pressure respectively. There was weak negative correlation seen between LAP index and mean diastolic blood pressure and between CI and mean diastolic blood pressure. Moderate positive correlation was seen between LAP index and pulse pressure and moderate negative correlation was seen between CI and heart rate.

**Table 1: Clinical characteristics of the study subjects, (n=40).**

| Parameters | Mean±SD | Median | Min-Max (Range) |
|---|---|---|---|
| **Age (in years)** | 50.02±8.48 | 49.5 | 40-74 |
| **Weight (kg)** | 64.85±0.97 | 65.5 | 45-113 |
| **Height (cm)** | 157.23±12.10 | 155 | 140-188.9 |
| **WC (cm)** | 97.47±10.32 | 97.5 | 76-119 |
| **Mean systolic pressure** | 146±11.12 | 142.95 | 132-176.6 |
| **Mean diastolic pressure** | 89.60±7.64 | 89.3 | 80-110 |
| **Mean blood pressure** | 108.80±7.13 | 108.5 | 98.3-132.2 |
| **Pulse pressure** | 55.64±11.61 | 54 | 33.3-85.3 |
| **Heart rate** | 83.87±14.38 | 82 | 50-125 |
| **Total cholesterol** | 187.15±36.08 | 184 | 131-315 |
| **Serum triglycerides** | 148.4±73.08 | 132 | 70-400 |
| **LAP index** | 64.10±38.17 | 52.99 | 10.80-175 |
| **CI** | 1.39±0.08 | 1.39 | 1.17-1.57 |

**Table 2: LAP index in study subjects.**

| LAP index | N | Percentage (%) |
|---|---|---|
| **≤50** | 15 | 37.5 |
| **51-100** | 21 | 52.5 |
| **≥101** | 4 | 10 |
| **Total** | 40 | 100 |

**Table 3: CI in study subjects.**

| CI | N | Percentage (%) |
|---|---|---|
| **<1.3** | 4 | 10 |
| **1.3-1.4** | 20 | 50 |
| **> 1.4** | 16 | 40 |
| **Total** | 40 | 100 |

**Table 4: Bivariate Pearson's correlation of anthropometric and biochemical profile with central obesity indices LAP in**

| Parameters | LAP index | | CI | |
|---|---|---|---|---|
| | R value | P value | R value | P value |
| **Age (in years)** | -0.173 | 0.287 | 0.158 | 0.329 |
| **Weight (kg)** | 0.129 | 0.426 | 0.283 | 0.077 |
| **Height (cm)** | -0.268 | 0.094 | 0.133 | 0.413 |
| **WC (cm)** | 0.473 | 0.002 | 0.683 | 0.000 |

Continued.

| Parameters | LAP index | | CI | |
|---|---|---|---|---|
| | R value | P value | R value | P value |
| **Mean systolic blood pressure** | 0.207 | 0.201 | 0.038 | 0.814 |
| **Mean diastolic blood pressure** | -0. 151 | 0.352 | -0.225 | 0.163 |
| **Mean blood pressure** | 0.024 | 0.882 | -0.102 | 0.532 |
| **Pulse pressure** | 0.341 | 0.031 | 0.259 | 0.106 |
| **Heart rate** | -0.169 | 0.296 | -0.365 | 0.02 |
| **Total cholesterol** | 0.238 | 0.139 | 0.347 | 0.028 |
| **Serum triglycerides** | 0.867 | 0.000 | 0.326 | 0.40 |
| **CI** | 0.518 | 0.000 | | |
| **LAP** | | | 0.518 | 0.000 |

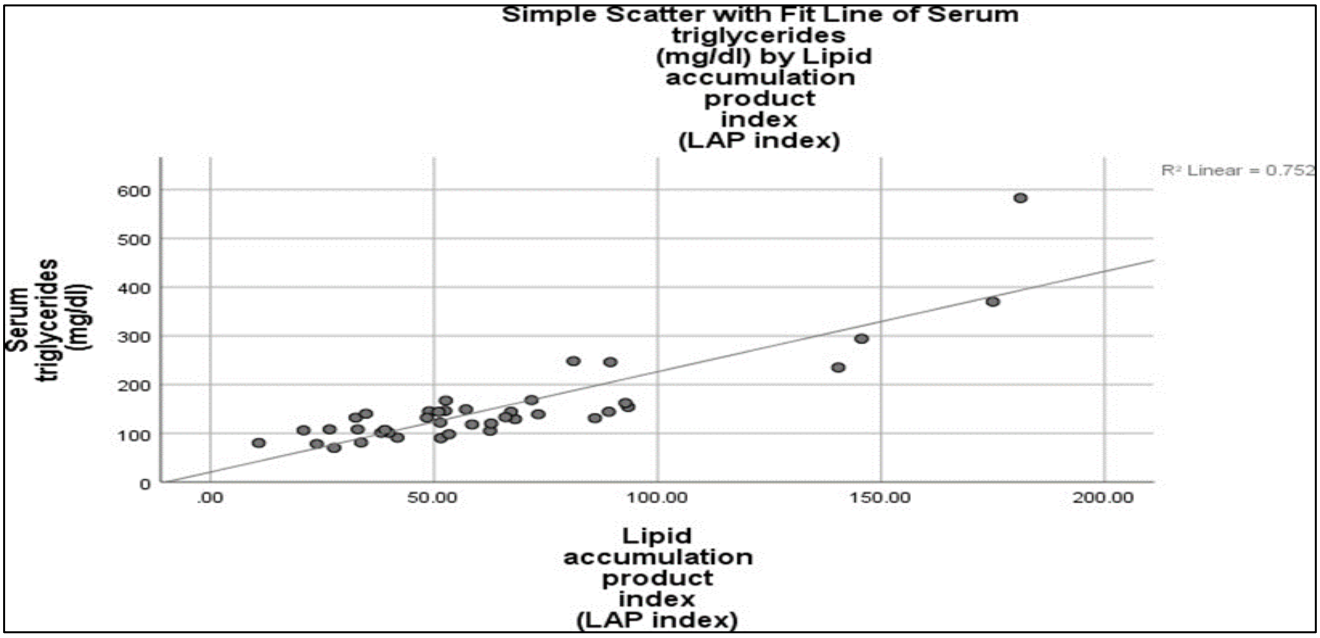


**Figure 1: Scatter diagram between LAP index and serum triglycerides.**

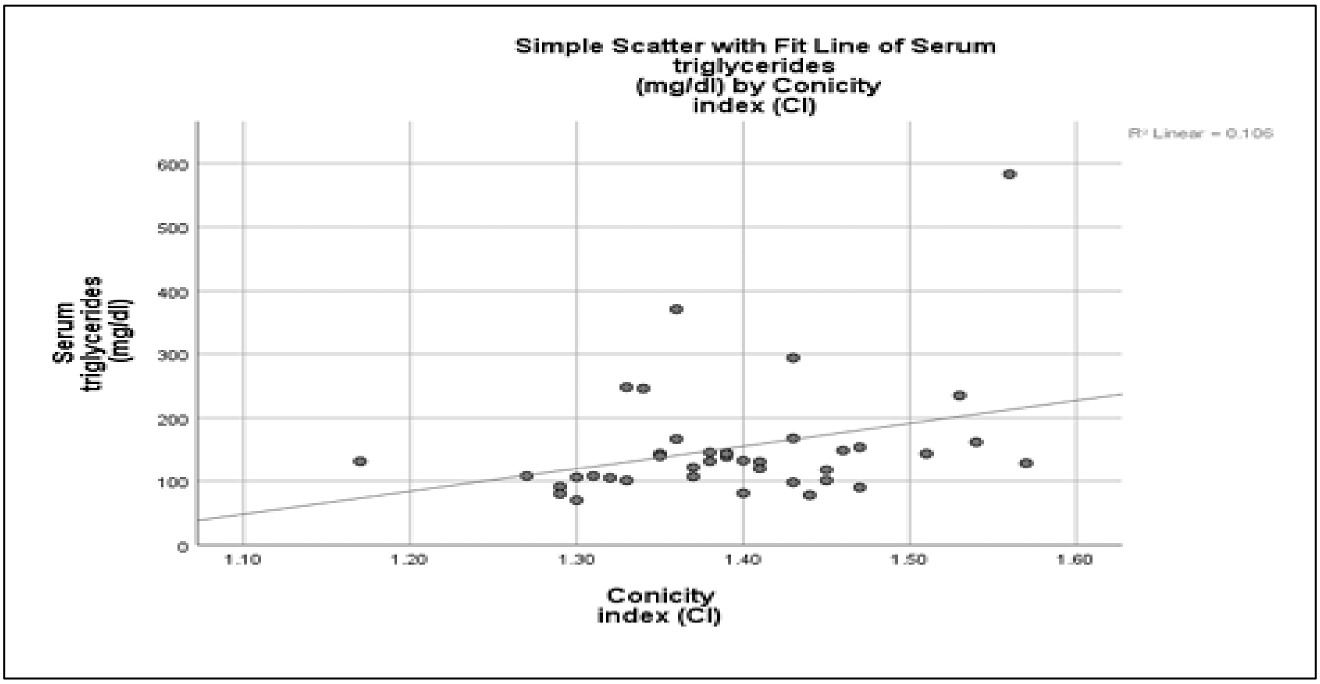


**Figure 2: Scatter diagram between CI and serum triglycerides.**

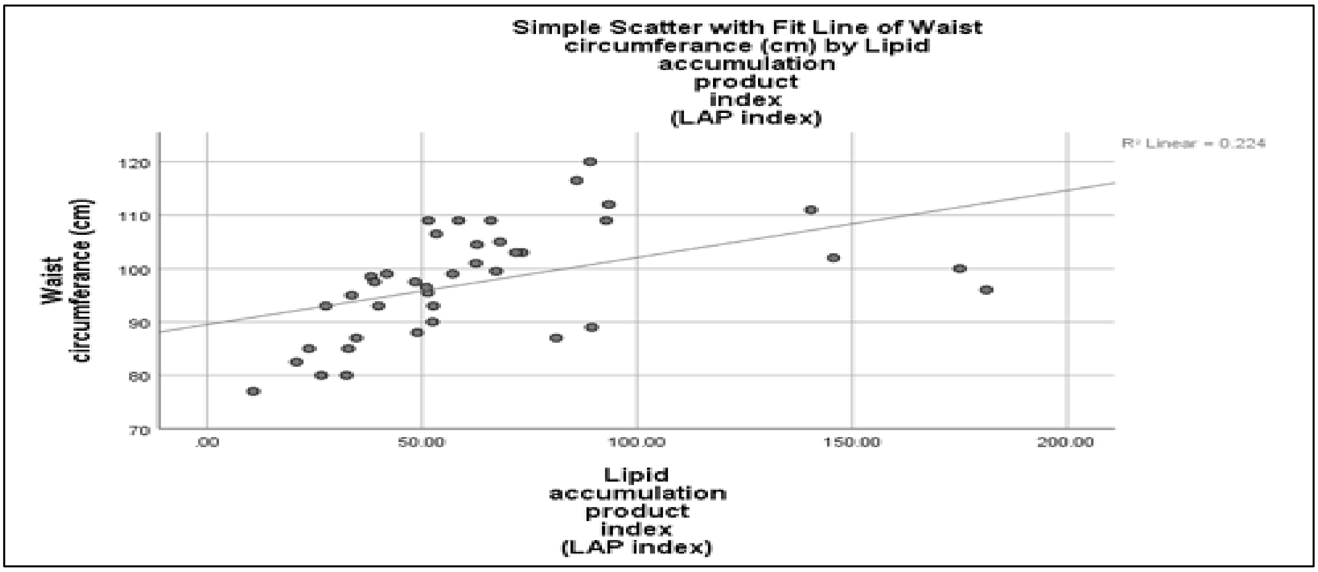


**Figure 3: Scatter diagram between LAP index and waist circumference.**

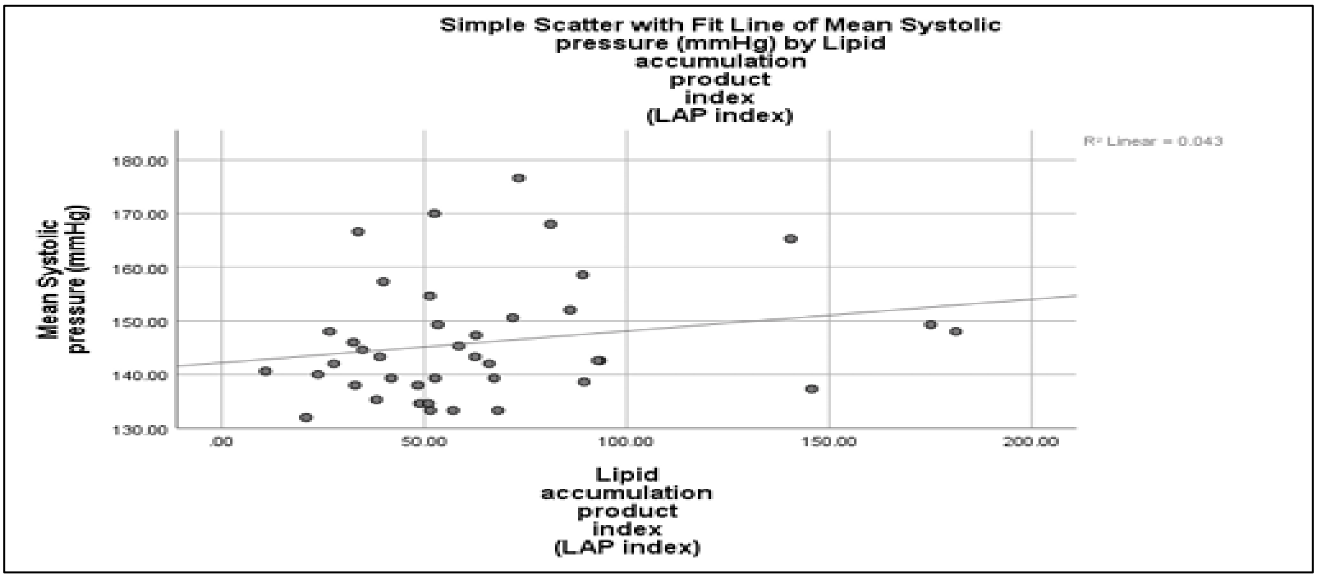


**Figure 4: Scatter diagram between LAP index and mean systolic blood pressure.**

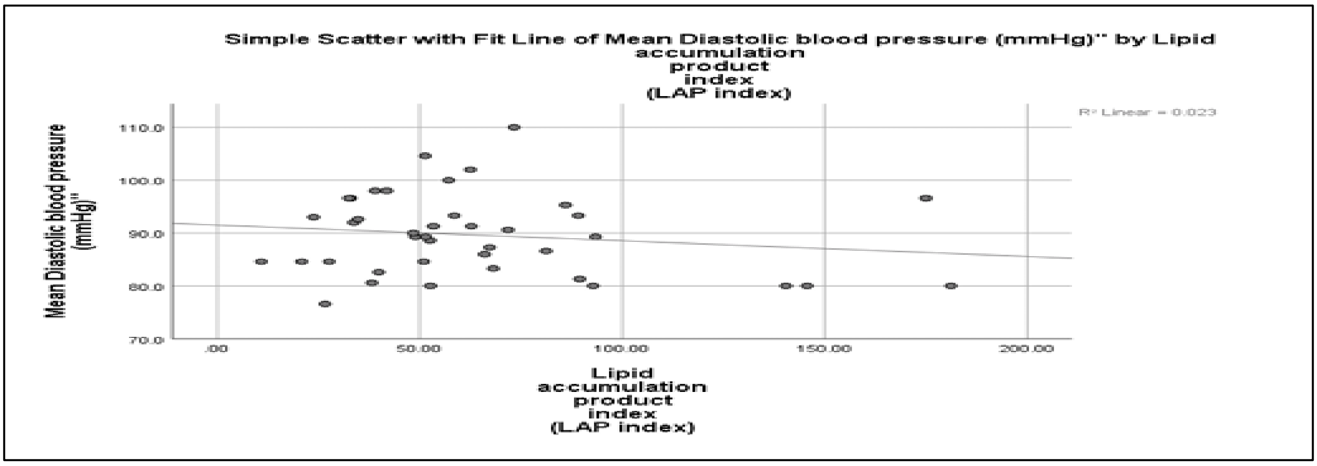


**Figure 5: Scatter diagram between LAP index and mean diastolic blood pressure.**

## DISCUSSION

This hospital based cross-sectional study conducted in our tertiary care center, with 40 OPD subjects, which were enrolled and investigated as per a pre-defined Performa in the study period from July-September 2019. Report was prepared in MS word 2019 and data of the study was compiled in a master chart prepared in MS excel 2019. Statistical analysis was performed using SPSS version 26.0 software.

The key finding of our study is strong positive correlation of serum triglyceride levels with LAP index ($r=0.867$, $p=0.000$) and moderate positive correlation with CI ($r=0.326$, $p=0.40$), which is consistent with the results found by Mantzoros et al.[22] This can be a useful inference and can indirectly prove its relation with hypertension. Dyslipidemia or hyperlipidemia accelerate the process of atherosclerosis which further increase incidence of hypertension. If hyperlipidemia is correlated with LAP Index, then indirectly it is related to hypertension which we could not conclude in our study strongly because of many limitations.

Study by Mantzoros et al showed CI to be indicator of risk for hyperlipidemia in Western populations, while WHR proved to be a better than CI predictor of triglyceride concentrations in this population of healthy premenopausal Greek women. Also, a moderate positive correlation of waist circumference with LAP index ($r=0.473$, $p=0.002$) and CI ($r=0.683$, $p=0.000$) is found, which justifies many studies done in past to prove that waist circumference measurement is a useful tool for adiposity measurement.

Moderate positive correlation between pulse pressure and LAP index ($r=0.341$, $p=0.031$), which is consistent with the results by Wakabayashi.[13] A moderate negative correlation of heart rate and CI ($r=-0.365$, $p=0.020$) was also found in our study, which is a new finding and needs future studies on larger sample size to prove its significance.

Weak positive correlation of LAP index with mean systolic blood pressure ($r=0.207$, $p=0.201$) and weak negative correlation with mean diastolic blood pressure ($r=-0.151$, $p=0.352$), but it is not significant. Our finding of correlation of LAP index with systolic blood pressure is consistent with many studies, but we could not prove its significance level due to a small sample size, which were proved earlier in studies where they took about 35,000 subjects and about 2000 subjects respectively.[9,13] Negative correlation of LAP index with diastolic blood pressure is new finding in our study.

Similarly, weak positive correlation of CI with mean systolic blood pressure ($r=0.038$, $p=0.814$), which is consistent with the study by Schembovski Jr et al in his study on post-menopausal women in Brazil, Shidfar et al, Andrade et al and Mehmood et al.[16-18] And there's weak negative correlation of CI with mean diastolic blood pressure ($r=-0.225$, $p=0.163$), but again it is not significant and a new finding, which is limitation of our study. Jian Song, in his study found that there was a significant increase in hypertension risk with LAP levels in the fourth quartile (LAP value>61.7) as compared with the bottom quartile (LAP value<61.7) which is also consistent with our studies, as 62.5% of our study subjects are having LAP value ≥51.[12] We can also conclude that both male (60%) and female (64%) have equal prevalence of having high LAP value.

The strengths of our study were that this was the first study done to find out association taking 2 central obesity indices with systolic and diastolic blood pressure in Indian sub-population. Many direct and indirect results were concluded in our study even with small sample size and with very strict exclusion criteria. Our study had some limitations such as small sample size, a hospital based cross sectional study and we did not have controls to compare the result of cases. Also, Indian diet and environmental conditions are different from other Asian and European countries, in which similar conclusive studies were done.

## CONCLUSION

This study shows that the LAP index and Conicity Index are associated with systolic and diastolic blood pressure. Although the sample size was small, both indices demonstrated a strong positive correlation with serum triglyceride levels ($p<0.001$), supporting their metabolic significance. Waist circumference correlated significantly with both LAP index and Conicity Index, while pulse pressure showed a moderate positive correlation with LAP index and heart rate showed a moderate negative correlation with Conicity Index. These findings suggest that LAP index and Conicity Index are simple and potentially useful clinical markers of central obesity; however, larger studies are required to validate their routine clinical application.

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*Ethical approval: The study was approved by the Institutional Ethics Committee*

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