

Original Research Article

Comparison of body mass index and lipid accumulation product as a better indicator of metabolic syndrome

Yashavanth H. S., Bharath M. S.*

Department of Medicine, Bangalore Medical College and Research Institute, Bengaluru, Karnataka, India

Received: 18 February 2017

Accepted: 28 March 2017

*Correspondence:

Dr. Bharath M. S.,

E-mail: bharath.kornic@gmail.com

Copyright: © the author(s), publisher and licensee Medip Academy. This is an open-access article distributed under the terms of the Creative Commons Attribution Non-Commercial License, which permits unrestricted non-commercial use, distribution, and reproduction in any medium, provided the original work is properly cited.

ABSTRACT

Background: Metabolic syndrome (MS) is defined to be cluster of metabolic interrelated risk factors of such as obesity, elevated blood pressures, glucose metabolism disturbances and dyslipidemia. "Lipid accumulation product" (LAP) – is a simple and novel index based on a combination of an anthropometric dimension and a metabolic dimension.

Methods: One hundred patients with metabolic syndrome were included in study. Data was collected through a prepared proforma which included various parameters related to history, thorough clinical examination, and laboratory parameters. Further the patients were assessed for the body mass index (BMI) and lipid accumulation product (LAP). BMI and LAP then correlated with metabolic syndrome.

Results: Our present study is conducted among the population meeting the IDF criteria of MS, with a mean age of 54.52 ± 12.65 years and female predominance (54%). 72% and 62% of the study group had Diabetes Mellitus and Hypertension respectively. The mean BMI in our study is 29.04 ± 5.11 kg/m² with 25% of the population are non-obese. The average LAP value in our present study is 111.51 ± 59.71 cm mmol/l and shown increasing trend with increasing age. LAP had a mean value of 85.19 cm mmol/l, 118.52 cm mmol/l and 122.37 cm mmol/l in the study population satisfying 3/5, 4/5 and 5/5 criteria of Metabolic Syndrome respectively. This shows LAP ($P < 0.001$) has better correlation with MS when compared to BMI ($P < 0.001$) in ANOVA test. In our present study, the presence of diabetes mellitus resulted in significant elevated LAP values i.e. 85.10 ± 31.40 cm mmol/l among non-diabetics to 121.78 ± 64.92 cm mmol/l among diabetics, which is of statistical significance (p value 0.005).

Conclusions: LAP showed strong positive correlation with metabolic syndrome and it also positively correlated with increasing number of components of metabolic syndrome. LAP found to be better predictor of MS than BMI.

Keywords: BMI, LAP, MS

INTRODUCTION

Metabolic syndrome, a constellation of cardiometabolic disease risk factors has become pandemic. It occurs as a result of interaction of genetics, environmental factors and life style choices.

The concept of Metabolic Syndrome is perhaps the most significant development in the management of

cardiovascular diseases. Prior to this, Physicians often treated diabetes, hypertension or dyslipidemia as separate diseases and did not really consider the impact of treatment of one of these conditions on the other co-existing conditions. The American Heart Association reported a meteoric rise of coronary artery disease morbidity and mortality in India. In the last 3 decades, coronary heart disease prevalence in India has increased by 300%. It has been predicted that cardiovascular

disease will increase rapidly in India and to have more than half of the cases of cardiovascular disease in the world in the next fifteen years. The cost of cardiovascular diseases is estimated to cost 215.6 billion dollars. It is possible to prevent or delay metabolic syndrome, mainly with lifestyle changes. So, an early screening and detection with help to check the development of metabolic syndrome and thus the cardiovascular mortality and morbidity.¹

Body Mass Index (BMI) is one of the largely used screening tool in identification of metabolic syndrome. It is calculated using weight and height and is given by a formula, weight in kilograms divided by height in meter-square but BMI fails to distinguish between body fat and muscle mass and thus has its drawbacks in predicting metabolic syndrome.²

Lipid Accumulation product (LAP) a novel and simple index of central lipid accumulation based on a combination of waist circumference (WC) and serum triglycerides (TG). Thus, it uses a physical and a simple laboratory parameter to predict the metabolic syndrome. It has given utmost importance to WC which is considered to be an integral and predominant determinant of cardiovascular outcomes. Thus LAP can be applied easily on a day today clinical practice to predict MS. At present, there are very limited number of studies from India regarding LAP as a screening tool for MS and its comparison with BMI in predicting MS.^{3,4}

METHODS

Source of data

Patients attending the outpatient and inpatient department at hospital attached to Bangalore medical college and research institute.

Method of collection of data

- Study design: Observational cross sectional study
- Study period: 2 Years
- Sample size: 100 cases

Inclusion criteria

- Patients with metabolic syndrome (IDF criteria⁵) (Table 1).
- Age more than 18 years
- Hypolipidemic drug naive

Exclusion criteria

- Age less than 18 years
- Patients with abdominal distension secondary to pathological cause
- Patients who are pregnant
- Patients on lipid lowering agents

Table 1: Metabolic syndrome (IDF criteria).⁵

Waist circumference	>90 cm in men; > 85 cm in women (south Indians)
And two or more of the following	
Fasting triglycerides	> 150 mg/dl
HDL cholesterol	<40 mg/dl (men) or <50mg/dl (women)
Blood pressure	>130 mmHg systolic or >85 mmHg diastolic or previous diagnosis or specific medication for hypertension
Fasting plasma glucose	>100 mg/dl or previously diagnosed type 2 diabetes

Sample procedure

Written informed consent was obtained after explaining the purpose and method of the study

Examination: selected patients will be thoroughly examined; anthropometric measurements like waist circumference, BMI and blood pressure are measured.

Investigations: Lipid profile, Fasting blood sugar and Post-prandial blood sugar.

Further the patients will be assessed for the following

The waist circumference (WC) of each participant was measured using a non-elastic measuring tape, to the nearest 0.1cm. WC was measured midway between the lowest rib and the superior border of the iliac crest at the end of normal. Fasting circulating serum triacylglycerol (TAG), total cholesterol and HDL-C concentrations were measured using the enzymatic colorimetric methods.

Fasting blood glucose levels were determined by the hexokinase method. The blood pressures of the participants were measured, using a mercury sphygmomanometer and appropriate cuff sizes.

Body mass index: weight in kilograms/ height in square meters

The weight of each subject was measured using a Calibrated weighing balance, to the nearest 0.1kg, with the subject wearing light clothes and no shoes. Height was measured with a measuring tape fastened to a vertical rod, and with the subject standing on bare feet, to the nearest 0.1cm. BMI is further classified as per the following table; (Table 2).

LAP (lipid accumulation product)

LAP was calculated using WC and fasting TG level using the following formula for men and women respectively

LAP = (WC- 65) X TG for men

LAP = (WC-58) X TG for women.⁷

Table 2:Body mass index.

Classification of overweight and obesity by BMI for Asian Indians ⁶	
Category	BMI
Underweight	<18.5 kg/m ²
Normal weight	≥18.5 to 22.9 kg/m ²
Overweight	≥23.0 to 24.9 kg/m ²
Obesity	≥25 kg/m ²
Obesity Class I	25.0 to 29.9 kg/m ²
Obesity Class II	30.0 to 34.9 kg/m ²
Obesity Class III[severe, extreme, or morbid obesity]	≥35 kg/m ²

Analysis of data

Statistical methods

Descriptive and inferential statistical analysis has been carried out in the present study. Results on continuous measurements are presented on Mean±SD (Min-Max) and results on categorical measurements are presented in Number (%).

Significance is assessed at 5 % level of significance. The following assumptions on data is made,

Assumptions

- Dependent variables should be normally distributed.
- Samples drawn from the population should be random, Cases of the samples should be independent

Analysis of variance (ANOVA) has been used to find the significance of study parameters between three or more groups of patients, Student t test (two tailed, independent) has been used to find the significance of study parameters on continuous scale between two groups (Inter group analysis) on metric parameters.

Chi-square/ Fisher Exact test has been used to find the significance of study parameters on categorical scale between two or more groups.

Significant figures

- + Suggestive significance (P value: 0.05<P<0.10)
- Moderately significant (P value: 0.01<P≤0.05)
- ** Strongly significant (P value: P≤0.01)

Statistical software

The Statistical software namely SAS 9.2, SPSS 15.0, Stata 10.1, MedCalc 9.0.1, Systat 12.0 and R environment ver.2.11.1 were used for the analysis of the data and Microsoft word and Excel have been used to generate graphs, tables etc.

RESULTS

In this study 100 Subjects with metabolic syndrome were evaluated. BMI and LAP were also derived for the same patients and their correlation with metabolic syndrome has been studied.

Our present study is conducted among the population meeting the IDF criteria of MS, with a mean age of 54.52±12.65 years and female predominance (54%) (Table 3). 72% and 62% of the study group had Diabetes Mellitus and Hypertension respectively (Table 4 and 5).

The mean BMI in our study is 29.04±5.11 kg/m² with 25% of the population are non-obese [Table 6]. The average LAP value in our present study is 111.51±59.71 cm mmol/l and shown increasing trend with increasing age [Table 7]. LAP had a mean value of 85.19 cm mmol/l, 118.52 cm mmol/l and 122.37 cm mmol/l in the study population satisfying 3/5, 4/5 and 5/5 criteria of Metabolic Syndrome respectively [Table 8]. This shows LAP (P<0.001) has better correlation with MS when compared to BMI (P<0.001) in ANOVA test [Table 8].

In our present study the presence of diabetes mellitus resulted in significant elevated LAP values i.e.85.10±31.40 cm mmol/l among non-diabetics to 121.78±64.92 cm mmol/l among diabetics, which is of statistical significance (p value 0.005). LAP values positively correlated with increasing number of components of metabolic syndrome. Thus we found that LAP is the parameter with the strongest predictive accuracy for MS.

Table 3: Age distribution of patients studied.

Age in years	No. of patients	%
<30	1	1.0
30-40	16	16.0
41-50	24	24.0
51-60	29	29.0
61-70	24	24.0
>70	6	6.0
Total	100	100.0

Mean ± SD: 54.52±12.65

In this study majority of the population were in the age group of 51-60 years, followed by between 41-50 years and 61-70 years. Which compromised 77% of all the subjects, with a mean age of 54.52 years (Table 3).

28% of the subjects were non-diabetics compared to 72% diabetics, with majority of them having beyond 5 years (25%). Prevalence of Diabetes is almost equal in both the sexes (Table 4).

Prevalence of Hypertension in the study population was 62% and majority of the population had beyond 5 years.

Relatively equal prevalence of Hypertension was noted in either of the sexes (Table 5).

Table 4: Incidence of DM in patients studied.

DM	Gender		Total (n=100)
	Female (n=54)	Male (n=46)	
No	15 (27.8%)	13 (28.3%)	28 (28%)
Yes	39 (72.2%)	33 (71.7%)	72 (72%)
<6 months	3 (5.6%)	3 (6.5%)	6 (6%)
6-12 months	6 (11.1%)	5 (10.9%)	11 (11%)
1-2 years	5 (9.3%)	5 (10.9%)	10 (10%)
2-5 years	11 (20.4%)	9 (19.6%)	20 (20%)
>5 years	14 (25.9%)	11 (23.9%)	25 (25%)

Table 5: Incidence of HTN in patients studied.

HTN	Gender		Total (n=100)
	Female (n=54)	Male (n=46)	
No	21 (38.9%)	17 (37%)	38 (38%)
Yes	33 (61.1%)	29 (63%)	62 (62%)
<6 months	2 (3.7%)	4 (8.7%)	6 (6%)
6-12 months	3 (5.6%)	5 (10.9%)	8 (8%)
1-2 years	5 (9.3%)	6 (13%)	11 (11%)
2-5 years	8 (14.8%)	5 (10.9%)	13 (13%)
>5 years	15 (27.8%)	9 (19.6%)	24 (24%)

Of the study population 25% (13% females and 12% males) did not have obesity even in the presence of metabolic syndrome (Table 6).

Table 6: BMI (kg/m²) distribution in patients studied.

BMI (kg/m ²)	Gender		Total
	Female	Male	
<18.5	0 (0%)	0 (0%)	0 (0%)
18.5-22.9	5 (9.3%)	7 (15.2%)	12 (12%)
23-24.9	8 (14.8%)	5 (10.9%)	13 (13%)
25-29.9	17 (31.5%)	15 (32.6%)	32 (32%)
>30	24 (44.4%)	19 (41.3%)	43 (43%)
Total	54 (100%)	46 (100%)	100 (100%)

Majority of the females had a LAP values distributed between 75-125 cm mmol/l. whereas it is less than 100 for males (Table 7).

Table 7: LAP distribution in patients studied.

LAP (in cm mmol/l)	Gender		Total
	Female	Male	
<75	7 (13%)	16 (34.8%)	23 (23%)
75-100	18 (33.3%)	14 (30.4%)	32 (32%)
100-125	16 (29.6%)	5 (10.9%)	21 (21%)
>125	13 (24.1%)	11 (23.9%)	24 (24%)
Total	54 (100%)	46 (100%)	100 (100%)

Table 8: Comparison of clinical variables according to criteria of metabolic syndrome.

Variables	Metabolic syndrome criteria			Total	P value
	3 criteria	4 criteria	5 Criteria		
Age in years	52.92±15.41	52.35±10.90	57.05±11.80	54.52±12.65	0.220
Height (cm)	158.31±8.98	157.94±11.29	158.84±8.66	158.42±9.54	0.922
Weight (kg)	76.35±12.15	73.55±9.79	68.77±12.29	72.22±11.86	0.026*
Waist Circumference (cm)	103.42±10.89	97.87±18.20	103.12±10.86	101.57±13.66	0.193
BMI (kg/m ²)	30.35±4.59	30.41±5.21	27.27±4.89	29.04±5.11	0.009**
LAP	85.19±53.95	118.52±58.90	122.37±60.06	111.51±59.71	0.030*

ANOVA test: Spearman Correlation: BMI vs Metabolic syndrome $r_s = -0.299$, $P < 0.001^{**}$; LAP vs Metabolic syndrome $r_s = 0.314$, $P < 0.001^{**}$

This shows LAP has better correlation when compared to BMI in ANOVA test. Where, SD more matters since the LAP is more spread than the BMI (Table 8).

DISCUSSION

Metabolic syndrome is a clinical complex, which predicts and predisposes to the occurrence of cardiovascular morbidity and mortality in the population. It has a linear correlation with the advancing age. It is possible to screen, assess and stratify the population at high risk of

cardiovascular related morbidity and mortality and thus to revert the correctable factors in the high-risk group. In order to screen the general population several conventional parameters have been used, namely BMI, Waist circumference, waist to hip ratio etc.⁸ For long period BMI was considered to be an indicator of MS and cardiovascular risk. With the introduction of newer index like LAP and BMI's failure to differentiate adipose mass from muscle mass- the credibility of BMI has been questioned.

LAP is an ideal screening tool derived from a combination of clinical parameter and a biochemical parameter i.e. Waist circumference and Fasting Triglyceride level respectively. Waist circumference itself serve as an independent risk factor for cardiovascular diseases and combining it with TG levels will further increases its reliability. Being the two independent components in the accepted definition of metabolic syndrome; LAP is considered as an upcoming index.⁹

In the current study, the correlation of BMI and LAP with MS and thus the cardiovascular risk has been assessed and compared among the patients presenting in the department of Medicine, Bangalore Medical College and Research Institute. Study was conducted among patients with Metabolic Syndrome and the salient characteristics of our study are:

LAP values found to be positively correlating with the number of MS criteria satisfied in the population. LAP had a mean value of 85.19 cm mmol/l, 118.52 cm mmol/l and 122.37 cm mmol/l in the study population satisfying 3/5, 4/5 and 5/5 criteria of metabolic syndrome respectively.

Total cholesterol (p value: 0.018) and HDL (p value 0.021) showed moderate correlation with LAP. BMI (p value: 0.091) and Weight (p value: 0.083) showed mild positive correlation with LAP.

Hamsaveena et al showed that the Mean LAP values in women with normal blood glucose is 22.74 cm mmol/l, in women with impaired glucose tolerance it is 48.18 cm mmol/l and that in women with Diabetes Mellitus is 66.84 cm mmol/l.¹⁰ Mean LAP values are found to be high in impaired glucose tolerance group and significantly higher in diabetic group compared to normal group.¹¹

Even in present study the presence of diabetes mellitus resulted in significant elevated LAP values i.e. 85.10 ± 31.40 cm mmol/l among non-diabetics to 121.78 ± 64.92 cm mmol/l among diabetics, which is of statistical significance (p value 0.005). Presence of diabetes, has negative correlation with HDL levels (p value: 0.092).

Even though Age, Height and weight circumference did not show any correlation with the presence of metabolic syndrome, LAP showed statistically significant positive correlation with MS. With the LAP values more widespread, found to have better correlation than the BMI. And also, the LAP values even found to be correlating with the number of MS criteria satisfied in the population.

CONCLUSION

LAP showed strong positive correlation with Metabolic Syndrome and thus can be used as screening too. LAP found to have much better correlation than BMI in predicting metabolic syndrome. LAP values positively correlated with increasing number of components of metabolic syndrome.

Funding: No funding sources

Conflict of interest: None declared

Ethical approval: The study was approved by the institutional ethics committee

REFERENCES

1. Cornier MA, Dabelea D, Hernandez TL, Lindstrom RC, Steig AJ, Stob NR et al. The metabolic syndrome. *Endocr Rev.* 2008;29:777-822.
2. Kahn HS. The "lipid accumulation product" performs better than the body mass index for recognizing cardiovascular risk: a population-based comparison. *BMC Cardiovascular Disorders.* 2005;5-26.
3. Taverna MJ, Marinez-Larrad MT, Frechtel GD, Serrano-Rios M. Lipid accumulation product: a powerful marker of metabolic syndrome in healthy population. *European J Endocrinology.* 2011;164: 559-67.
4. Yang C, Guo ZR, Hu XS, Zhou ZY, Wu M. A prospective study on the association between lipid accumulation product or body mass index and diabetes. *Zhonghua Liu Xing Bing Xue Za Zhi.* 2010;31:5-8.
Eckel RH. The Metabolic Syndrome. In: Dennis L. Kasper, Dan L Longo, Stephen L. Hauser, Anthony S Fauci, J. Larry Jameson, Joseph Loscalzo, eds. *Harrison's principle of internal medicine.* 19th ed. New York, NY:Mcgraw-Hill; 2015:2440-54.
5. Shashank R Joshi. Disorders of Adipose Tissue and Obesity. In: Yash Pal Munjal, A.K. Agarwal, Pritam Gupta, Sandhya A. Kamath, Milind Y. Nadkar, R.K. Singal, eds. *API textbook of Medicine.* 9th edition. New Delhi: The Association of physicians of India; 2012:1275-78.
6. Kahn HS. The lipid accumulation product is better than BMI for identifying diabetes. *Diabetes Care.* 2006;29:151-3.
7. National Cholesterol Education Program (NCEP). Third Report of the National Cholesterol Education Program Expert Panel on Detection, Evaluation, and Treatment of High Blood Cholesterol in Adults (Adult Treatment Panel III) final report. *Circulation* 2002;106:3143-421.
8. Bruna Angelo Vieira, Patricia Sauer, Aline Marcadenti, Carla Haas Piovesan. Association between LAP Index (lipid accumulation product) and metabolic profile in hospitalized patients. *Nutr Hosp* 2015;31(6):2771-4.

9. Hamsaveena, Shalini M, Cariappa KB. Lipid Accumulation Product as a Novel Index to Predict Diabetes in Women. *RES J Pharm Biol Chem SCI* 2014;5(2):760-63.
10. Bozorgmanesh M, Hadaegh F, Azizi F. Diabetes prediction, lipid accumulation product, and adiposity measures; 6-year follow-up: Tehran lipid and glucose study. *Lipids Health Dis*. 2010;9:45.
11. XinGao, Guiyan Wang, Aili Wang, Tan Xu, Weijun Tong, Yonghong Zhang. Comparison of lipid

accumulation product with body mass index as an indicator of hypertension risk among Mongolians in China. *Obesity Research and Clinical Practice*. 2013;7:e308-314.

Cite this article as: Yashavanth HS, Bharath MS. Comparison of body mass index and lipid accumulation product as a better indicator of metabolic syndrome. *Int J Adv Med* 2017;4:728-33.