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Evaluation of the Relationship Between Metabolic Syndrome, Visceral Adiposity Index and Lipid Accumulation Product in Patients with Obesity

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ABSTRACT

Objective: Visceral adiposity index (VAI) and lipid accumulation product index (LAPI) are the new methods to determine the visceral adiposity and to predict the cardiometabolic risks in patients with. In this study, it was aimed to determine whether VAI or LAPI could be a predictor for metabolic syndrome (MS) in obesity, and to evaluate their relationship with other biochemical and anthropometric parameters.

Methods: All patients who were admitted to the obesity outpatient clinic for the first time in January-February 2020 were included in the study. Age, gender, height, weight, body mass index, waist circumference (WC), hip circumference, waist/hip (W/H) ratio, biochemical parameters, and degree of hepatosteatosis were recorded. The presence of MS was determined according to the National Cholesterol Education Program Adult Treatment Panel-III criteria. VAI and LAPI were calculated according to fixed formulations. Results were evaluated by SPSS.

Results: A total of 49 subjects, (48 females), with obesity were included in the study. Thirty-two patients (65.3%) had MS. In the MS (+) group, fasting blood glucose (FBG), insulin resistance (HOMA-IR) and triglyceride (TG) levels, VAI, LAPI, diabetes mellitus and hypertension ratios were higher than the group with MS (-). A positive correlation was observed between VAI and LAPI. There was a positive correlation between the VAI and the TG value, and a negative correlation between the VAI and high density lipoprotein value. A positive correlation was observed between LBU and TG, FBG, HOMA-IR, WC, W/H ratios.

Conclusion: It is important to determine the comorbidities in obesity on a timely manner and to make the necessary interventions. With a simple formulation, VAI and LAPI can predict important health risks accompanying obesity.

Keywords: Obesity, metabolic syndrome, visceral adiposity index, lipid accumulation product index

INTRODUCTION

Obesity prevalence is increasing day-by-day in our country. It is a serious cause of morbidity and mortality, and puts a heavy burden on the health system. Therefore, it is vital to reveal the effects of obesity at an early stage and to take necessary precautions against the pathologies accompanying the obesity, as well as the treatment of it (1,2).

Perhaps the most important parameter to be evaluated in obesity is the visceral adiposity. Visceral adipose tissue has been shown to cause cardio-metabolic pathologies, and the visceral adiposity index (VAI) is valuable in determining the risk for these diseases. VAI can now be measured using methods such as bioelectrical impedance analysis, dual energy X-ray absorptiometry, computed tomography, and magnetic resonance. However, since these

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J Acad Res Med 2021;11(1):56-61

methods are not practical, they bring costs and some of them are not available in every hospital/obesity center, new methods are needed to determine visceral adiposity (1-3).

VAI and lipid deposition product index (LAPI) are also new methods used in this subject. Both are essentially mathematical models calculated by anthropometric data, and are used to show visceral adiposity, adipose dysfunction, insulin resistance (HOMA-IR), metabolic dysfunction, and cardio metabolic risk. Thus, with a simple formulation, they can predict the significant accompanying health risks and help take early action (4,5).

In this study, it was aimed to evaluate the relationship between VAI and LAP in patients with and without metabolic syndrome (MS) in obesity, and to determine whether they could be a predictor of MS, as well as to evaluate their relationship with other biochemical parameters, anthropometric measurements, and hepatosteatosis.

METHODS

All patients who were admitted to the obesity outpatient clinic for the first time in January-February 2020 were included in the study. Age, gender, height, weight, body mass index (BMI), waist circumference (WC), hip circumference (HC), waist/hip ratio (WHR), biochemical parameters [fasting blood glucose (FBG), triglyceride (TG), high density lipoprotein (HDL), HOMA-IR], degree of hepatosteatosis (detected by abdominal ultrasonography), blood pressure arterial (TA) value, presence of diabetes mellitus (DM) and hypertension (HT) were recorded. Presence of MS was determined according to National Cholesterol Education Program Adult Treatment Panel-III (NCEP-ATP-III) criteria. VAI and LAPI were calculated according to the fixed formulations (Table 1, 2). The results were analyzed on SPSS.

The study was conducted in accordance with the 1964 Helsinki Declaration. Ethics committee approval was obtained from the University of Health Sciences Turkey, İstanbul Training and Research Hospital Ethics Committee (approval number: 2254, tarih: 27.04.2020) and informed consent was obtained from the patients.

Table 1. VAI Formulation for male and female patients

- Male VAI : $\left[\frac{WC\ (cm)}{\left\{39.68+(1.88\times BMI\left(\frac{kg}{m^2}\right))\right\}}\right] \times \left[\frac{TG(mmol/l)}{1.03}\right] \times \left[\frac{1.31}{HDL(mmol/l)}\right]$
- Female VAI : $\left[\frac{WC\ (cm)}{\left\{36.58+(1.89\times BMI\left(\frac{kg}{m^2}\right))\right\}}\right] \times \left[\frac{TG(mmol/l)}{0.81}\right] \times \left[\frac{1.52}{HDL(mmol/l)}\right]$

VAI: Visceral adiposity index, WC: waist circumference, BMI: body mass index, TG: triglyceride, HDL: high density lipoprotein

Table 2. LAPI Formulation for male and female patients

Male LAPI = [waist (cm)-65] × TG concentration (mmol/L)
Female LAPI = [waist (cm)-58] × TG concentration (mmol/L)

LAP: lipid accumulation product index, TG: triglyceride

Statistical Analysis

In the descriptive statistics of the data; mean, standard deviation, median lowest, highest, frequency and ratio values were used. The distribution of variables was measured with the Kolmogorov-Simonov test. Mann-Whitney U test and Independent Sample test were used in the analysis of quantitative independent data. Chi-square test was used in the analysis of categorical data, and Fisher's exact test was used when chi-square test conditions were not met. SPSS 26.0 program was used in the analysis.

RESULTS

A total of 49 people, 48 females and 1 male, with obesity were included in the study. Thirty-two patients (65.3%) had MS. The mean and median values of the data for the parameters are shown on Table 3.

Age, gender distribution, height, weight, WC, HC, WHR, BMI values of the patients with and without MS did not show a significant difference ($p>0.05$). In the group with MS (+), FBG, HOMA-IR and TG levels, VAI, LAPI, DM and HT ratios were significantly higher ($p<0.05$) than the group with MS (-). HDL values and hepatosteatosis degrees of the patients in the group with and without MS did not show a significant difference ($p>0.05$) (Table 4, Figure 1).

Significant positive correlation ($p<0.05$) was observed between the visceral adipocyte index and lipid deposition product. There was a significant positive correlation ($p<0.05$) between visceral adipocyte index and TG value, and a significant negative correlation ($p<0.05$) between visceral adipocyte index HDL value. There was no significant correlation ($p>0.05$) between VAI and age, FBG, HOMA-IR, BMI, WC, HC, WHR (Table 5).

A significant positive correlation ($p<0.05$) was observed between lipid deposition product and TG, FBG, HOMA-IR, WC, WHR values. There was no significant correlation ($p<0.05$) with age, HDL, BMI, and HC (Table 5).

The age, gender distribution, height and weight values of the patients in the group with hepatosteatosis grade (0-1) and grade (2-3) did not differ significantly ($p>0.05$). The BMI of the patients in the group with hepatosteatosis grade (2-3) was significantly higher ($p<0.05$) than the patients in the hepatosteatosis grade (0-1) group. WC, HC, WHR, FBG, HOMA-IR, TG, HDL, VAI, LAPI values, DM, HT, MS ratios values did not differ significantly ($p>0.05$) in the group with hepatosteatosis grade (0-1) and grade (2-3) (Table 6).

DISCUSSION

Obesity is the abnormal accumulation of fat in the body that poses a health risk (6). Most of the adipose tissue consists of white adipocytes, although there are also beige/brown adipocytes in humans. The white adipose tissue responsible for energy storage is mainly located under the skin. However, when visceral steatosis causes ectopic steatosis in the liver, heart and muscles, it causes low-level chronic inflammation, HOMA-IR, and consequently metabolic complications, in addition to cardiovascular diseases (7,8).

J Acad Res Med 2021;11(1):56-61

Table 3. General data of the parameters investigated

		Min-Max	Median	Mean ± SD/ (n, %)
Age		20.0-64.0	51.0	49.1±10.8
Gender	Female	-	-	48 (98.0%)
	Male	-	-	1 (2.0%)
Height		117.0-177.0	160.0	160.0±8.9
Weight		67.0-134.0	97.0	99.6±18.3
Body mass index		28.8-53.3	39.1	38.7±6.4
Waist circumference		90.0-132.0	113.0	113.0±9.5
Hip circumference		106.0-167.0	130.0	130.1±12.2
Waist/hip ratio		0.7-1.0	0.9	0.9±0.1
Fasting blood glucose		79.0-187.0	99.0	105.0±21.5
HOMA-IR		0.1-7.6	2.5	2.6±1.5
Visceral adipocyte index		1.7-19.0	5.3	6.0±3.2
Lipid accumulation product		1792.0-18148	8250.0	8382.6±3563.4
Triglyceride		56.0-349.0	150.0	152.0±59.5
HDL		38.0-102.0	50.0	53.0±12.2
Diabetes	(-)	-	-	38 (77.6%)
	(+)	-	-	11 (22.4%)
HT	(-)	-	-	39 (79.6%)
	(+)	-	-	10 (20.4%)
Hepatosteatosis	0-1	-	-	17 (34.7%)
	2-3	-	-	32 (65.3%)
Hepatosteatosis grade	0	-	-	4 (8.2%)
	1	-	-	13 (26.5%)
	2	-	-	28 (57.1%)
	3	-	-	4 (8.2%)
Metabolic syndrome	(-)	-	-	17 (34.7%)
	(+)	-	-	32 (65.3%)

Min: minimum, Max: maximum, SD: standard deviation, HOMA-IR: insulin resistance, HDL: high density lipoprotein, HT: hypertension

MS is one of the diseases accompanying obesity. NCEP-ATP-III criteria are commonly used for identification purposes. Increase in WC, being diagnosed with TA or under HT treatment, high BG or being under DM treatment, high TG and low HDL are the diagnostic criteria. It is important to screen these criteria in individuals with obesity and to take the necessary precautions in the presence of MS in order to prevent obesity-related morbidity and mortality (8,9). In our study, MS is present in two-thirds of the patients, and FBG, HOMA-IR, TG level, VAI and LAPI were found to be high in this group.

VAI and LAPI are also new methods that have been used to determine visceral adiposity. It is a formulation that uses simple anthropometric measurements such as WC and BMI and biochemical parameters such as TG and HDL. Fixed values vary for men and women (5).

VAI was positively correlated with peripheral glucose use in euglycemic and hyperinsulinemic clamp studies. Many studies have been published showing that it is associated with type 2 DM, MS, cardiovascular diseases and polycystic ovary syndrome (10). In our study, in the group with MS, VAI was found to be higher than the group without MS and correlated with atherogenic dyslipidemia profile. However, no relationship was found between HOMA-IR and BMI. It has led to the thought that VAI has a stronger relationship with the diagnostic combination of the parameters that constitute the MS, rather than a single effect. As a matter of fact, different studies have shown the relationship between VAI and MS in support of this idea (11,12).

The LAPI is based on a formulation using WC and TG level. It was found to be more effective than BMI and WC in reflecting HOMA-IR and predicting cardiovascular disease risk (4,13). It is associated with glucose/insulin homeostasis and dietary pattern as well as anthropometric data and is an inexpensive alternative to indirect visceral adiposity measurement method (14). In the study conducted by Chiang and Koo (15), LAPI was seen to predict MS. Similarly, in our study, LAPI was found to be high in patients with MS.

VAI is usually high in hepatosteatosis, but there are studies showing that it is not directly related to steatosis and has poor diagnostic power in this regard. WC is seen as a stronger predictor for liver fattening (16,17). Although the degree of hepatosteatosis was found to be associated with BMI in our study, the MS was not found to be associated with VAI or LAPI in parallel with these data. However, it is thought that VAI may be a marker for adipose tissue dysfunction, especially in the absence of MS (18).

Study Limitations

The limited number of patients and the fact that the same parameters were not examined in individuals without obesity are the limitations of this study.

CONCLUSION

In individuals with obesity, VAI and LAPI are associated with MS and the parameters that constitute MS. It can be calculated with a simple formulation and can be used as a practical tool in determining the level of inflammation, adipocyte dysfunction, and the metabolic and cardiovascular risks.

Ethics Committee Approval: The study was approved by the University of Health Sciences Turkey, İstanbul Training and Research Hospital, Clinic Research Ethics Committee (approval number: 2254, date: 27.04.2020).

Informed Consent: Informed consent was obtained from the patients.

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J Acad Res Med 2021;11(1):56-61

Table 4. Parameters investigated according to the presence of metabolic syndrome

		Metabolic syndrome (+)		Metabolic syndrome (-)		p	
		Mean ± SD/(n, %)	Median	Mean ± SD/(n, %)	Median		
Age		50.0±10.0	51.5	47.2±12.5	48.5	0.518	m
Gender	Female	31 (96.9%)	-	17 (100.0%)	-	1.000	X²
	Male	1 (3.1%)	-	0 (0.0%)	-		
Height		159.8±9.8	160.0	160.4±7.3	160.0	0.591	m
Weight		99.8±20.0	93.6	99.3±15.0	102.0	0.934	t
Body mass index		38.7±7.0	38.2	38.6±5.2	39.9	0.964	t
Waist circumference		113.6±10.4	113.5	111.9±7.9	113.0	0.556	t
Hip circumference		128.7±12.6	126.0	132.8±11.2	130.0	0.260	t
Waist/hip ratio		0.9±0.1	0.9	0.8±0.1	0.9	0.059	t
Fasting blood glucose		110.8±24.3	100.0	94.1±6.8	95.0	0.012	m
HOMA-IR		3.0±1.5	3.0	1.7±1.1	1.4	0.003	t
Visceral adipocyte index		6.8±3.4	6.3	4.6±2.4	3.8	0.026	t
Lipid accumulation product		9329.1±3448.3	8970.0	6600.9±3145.1	5170.0	0.009	t
Triglyceride		168.9±56.9	173.0	120.2±51.8	109.0	0.005	t
HDL		53.1±13.0	49.5	52.6±10.7	51.0	0.897	t
Diabetes	(-)	21 (65.6%)	-	17 (100.0%)	-	0.006	X²
	(+)	11 (34.4%)	-	0 (0.0%)	-		
HT	(-)	22 (68.8%)	-	17 (100.0%)	-	0.010	X²
	(+)	10 (31.3%)	-	0 (0.0%)	-		
Hepatosteatosis grade	0	2 (6.3%)	-	2 (11.8%)	-	0.487	X²
	1	8 (25.0%)	-	5 (29.4%)	-		
	2	20 (62.5%)	-	8 (47.1%)	-		
	3	2 (6.3%)	-	2 (11.8%)	-		

m: Mann-Whitney U test, X²: chi-square test, t: Independent Sample t-test, HOMA-IR: insulin resistance, HDL: high density lipoprotein, HT: hypertension, SD: standard deviation

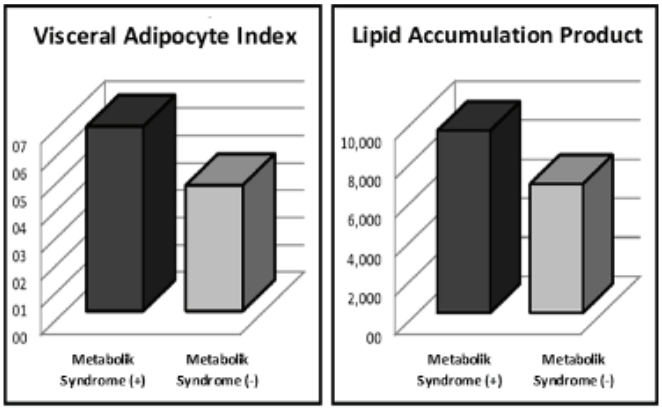

Figure 1. MS and VAI-LAPI box plot
MS: metabolic syndrome, VAİ: visceral adiposity index, LAPI: lipid accumulation product index

Table 5. VAI, LAP and research parameters

	Visceral adipocyte index		Lipid accumulation product	
	r	p	r	p
Lipid accumulation product	0.835	0.000	-	-
Age	0.046	0.755	0.137	0.355
Triglyceride	0.924	0.000	0.915	0.000
HDL	-0.603	0.000	-0.222	0.125
Fasting blood sugar	0.268	0.063	0.339	0.017
HOMA-IR	0.182	0.211	0.290	0.044
Body mass index	-0.208	0.152	0.116	0.429
Waist circumference	-0.037	0.800	0.372	0.009
Hip circumference	-0.160	0.274	0.069	0.636
Waist/hip ratio	0.227	0.117	0.389	0.006

Spearman Correlation.
HDL: high density lipoprotein, HOMA-IR: insulin resistance

J Acad Res Med 2021;11(1):56-61

Table 6. Hepatosteatosis and research parameters

		Hepatosteatosis grade (0-1)		Hepatosteatosis grade (2-3)		p	
		Mean±SD (n, %)	Median	Mean ± SD/(n, %)	Median		
Age		48.7±10.4	50.0	49.3±11.2	51.0	0.746	m
Gender	Female	16 (94.1%)	-	32 (100.0%)	-	0.347	X^2
	Male	1 (5.9%)	-	0 (0.0%)	-		
Height		161.6±8.1	160.0	159.2±9.4	160.0	0.916	m
Weight		94.5±14.7	93.0	102.4±19.6	101.5	0.153	t
Body mass index		36.1±4.7	35.1	40.0±6.8	40.0	0.038	t
Waist circumference		110.4±7.1	112.0	114.4±10.4	113.0	0.159	t
Hip circumference		128.9±12.4	126.0	130.7±12.3	131.0	0.633	t
Waist/hip ratio		0.9±0.1	0.9	0.9±0.1	0.9	0.415	t
Fasting blood glucose		111.8±29.8	101.0	101.4±14.8	98.0	0.333	m
HOMA-IR		2.5±1.3	2.4	2.6±1.6	2.6	0.934	t
Visceral adipocyte index		6.1±4.0	4.6	6.0±2.8	6.0	0.903	t
Lipid accumulation product		7509.0±3576.1	7198.0	8846.7±3524.2	9247.0	0.214	t
Triglyceride		145.4±68.3	131.0	155.6±55.1	157.0	0.572	t
HDL		50.6±10.0	50.0	54.2±13.1	51.0	0.337	t
Diabetes	(-)	11 (64.7%)	-	27 (84.4%)	-	0.116	X^2
	(+)	6 (35.3%)	-	5 (15.6%)	-		
HT	(-)	12 (70.6%)	-	27 (84.4%)	-	0.254	X^2
	(+)	5 (29.4%)	-	5 (15.6%)	-		
Metabolic syndrome	(-)	7 (41.2%)	-	10 (31.3%)	-	0.487	X^2
	(+)	10 (58.8%)	-	22 (68.8%)	-		
Hepatosteatosis grade	0	4 (23.5%)	-	0 (0.0%)	-	0.000	X^2
	1	13 (76.5%)	-	0 (0.0%)	-		
	2	0 (0.0%)	-	28 (87.5%)	-		
	3	0 (0.0%)	-	4 (12.5%)	-		
	ı	-	-	-	-		

m: Mann-Whitney U test, X^2: chi-square test, t Independent Sample t-test, SD: standard deviation, HOMA-IR: insulin resistance, HDL: high density lipoprotein, HT: hypertension

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J Acad Res Med 2021;11(1):56-61

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