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Assessment of the Relationship between Lipid Parameters and Obesity Indices in Non-Diabetic Obese Patients: A Preliminary Report

Authors' Contribution:
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Statistical Analysis C
Data Interpretation D
Manuscript Preparation E
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Background: The aim of this cross-sectional study was to examine the relationship between obesity and lipid markers.





Material/Methods: We divided 66 non-diabetic adult obese patients (mean age: 55.8±11.6 years) into 3 groups according to body mass index (BMI). All patients were measured for waist circumference (WC), hip circumference (HC), body mass index (BMI), waist-to-hip ratio (WHR), waist-to-height ratio (WHtR), body adiposity index (BAI), and visceral adiposity index (VAI). Serum levels of total cholesterol (TC), high-density lipoprotein cholesterol (HDL-C), low-density lipoprotein cholesterol (LDL-C), and triglycerides (TG) were determined, and lipid indices TC/HDL, LDL/HDL, and TG/HDL were also estimated.

Results: TC and LDL-C in Group III were lower than in Group I (5.0±1.0 vs. 6.0±1.0 mmol/L, and 2.9±0.9 vs. 3.8±1.2 mmol/L; $p<0.05$ for both). Negative correlations were found between: BMI and TC, LDL, and HDL ($r=-0.291$; $r=-0.310$, $r=-0.240$, respectively); and WC, WHR, VAI, and HDL ($r=-0.371$, $r=-0.296$, $r=-0.376$, respectively). Positive correlations were found between WC, WHR, and TG/HDL ($r=0.279$, $r=0.244$, respectively) and between VAI and: TC ($r=0.327$), TG ($r=0.885$), TC/HDL ($r=0.618$), LDL/HDL ($r=0.480$), and TG/HDL ($r=0.927$).

Conclusions: Obesity is associated with lipid disturbances, especially with HDL-C reduction, in obese non-diabetic patients. VAI is strongly related to lipid profile and thus may be the most valuable obesity index in obese patients with dyslipidemias.

MeSH Keywords: **Dyslipidemias • Obesity • Therapeutics**

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Background

Obesity is a common metabolic disease world-wide and dyslipidemias among the most common metabolic disorders associated with obesity [1–7]. Obesity is often described by classical parameters such as body mass index (BMI), waist circumference (WC), and waist-to-hip ratio (WHR) [1–3,7,8]. Some authors indicate relationships between these obesity parameters and lipid profile [9–11]. Results of meta-regression analysis of prospective, randomized studies showed that WHR and WC may play important roles in assessment of increased risk of cardiovascular (CV) events [12].

In recent years, attention has been drawn to new obesity indices (e.g., waist-to-height ratio (WHtR), visceral adiposity index (VAI), and body adiposity index (BAI), which also take into account adipose tissue distribution [13–16]. Results of the some recently published studies suggest that WHtR, the newer obesity index, may be helpful for assessing risk of metabolic complications, including dyslipidemia, and it may also be a predictor of cardiovascular events in obese patients [1,8,16–20]. Nevertheless, there is little data about the associations between other newer obesity indices (e.g., VAI and BAI) and lipid profile in obese patients. Therefore, the aim of this study was to examine the relationship between obesity parameters or indices (BMI, WC, WHR, WHtR, BAI, VAI) and serum lipid levels of total cholesterol (TC), low-density lipoprotein cholesterol (LDL-C), high-density lipoprotein cholesterol (HDL-C), triglycerides (TG), and lipid indices such as TC/HDL-C, LDL-C/HDL-C, and TG/HDL-C ratios in obese non-diabetic patients.

Material and methods

Patient characteristics

This cross-sectional study was conducted in a population of 66 consecutively enrolled obese non-diabetic patients (BMI ≥ 30 kg/m²) with mean age of 55.8 \pm 11.6 years, including 40 women (mean age 57.5 \pm 10.8 years) and 26 men (mean age 53.3 \pm 12.3 years) treated in the Outpatient Department of Hypertension and Lipid Disorders of WAM University Hospital in Lodz, Poland. Patients with fasting hyperglycemia ≥ 5.6 mmol/l (100 mg/dl) underwent a glucose tolerance test (75 g) to exclude diabetes mellitus (DM). Patients with DM, pregnancy, cancer, acute stroke, acute hepatic or renal diseases and acute cardiovascular events or with history of abdominal surgery, which could have an impact on abdominal fat distribution, were excluded from the study. Patients with psychiatric disorders receiving antipsychotic agents that might impact appetite and lead to weight gain were also excluded.

Based on calculated BMI values, patients were divided into 3 groups according to their obesity level: Group I consisted

of patients with obesity class I with BMI of 30.0–34.9 kg/m²; Group II consisted of patients with obesity class II with BMI of 35.0–39.9 kg/m²; and Group III consisted of patients with obesity class III with BMI ≥ 40 kg/m².

The study was conducted after receiving approval from the Bioethics Committee of the Medical University of Lodz, resolution no. RNN/105/10/KB. Written informed consent was obtained from all participants.

Measurements

All the patients underwent a complete blood count, lipid and liver profile, TSH, glucose, renal function indices (BUN and creatinine), and general urinalysis. The serum LDL-C level was calculated based on Friedewald's formula (in mmol/l):

$$(\text{LDL-C}) = \text{TC} - (\text{HDL-C}) - (0.45 \times \text{TG}) \quad [21].$$

Measurements accurate to within 0.1 kg were made of body mass, and measurements accurate to within 0.5 cm were made of height, WC, and HC. WC was measured at mid-distance between the last rib and the iliac crest, while HC was measured at the level of the greater trochanter. Based on these measurements, the following body mass-related indices were calculated using the following formulas:

1. BMI = body mass (kg) / [height (m)]²
2. WHR = WC (cm) / HC (cm)
3. WHtR = WC (cm) / height (cm)
4. VAI
men VAI = [WC / 39.68 + (1.88 × BMI)] × (TG / 1.03) × (1.31 / HDL);
women VAI = [WC / 36.58 + (1.89 × BMI)] × (TG / 0.81) × (1.52 / HDL).
5. BAI = [hip circumference (cm) / height (m)]^{1.5} – 18 [13–15,18].

In addition, based on the lipid profile results obtained, the following lipid metabolism indices were calculated:

1. TC/HDL-C ratio – values >5 indicate increased cardiovascular risk;
2. LDL-C/HDL-C ratio – increased cardiovascular risk with values >3 ;
3. TG/HDL-C ratio – increased cardiovascular risk with values ≥ 3 [21,22].

Statistical analysis

The results are presented as mean values with standard deviation (normality of distribution was tested using the Shapiro-Wilk test). Significance of differences between groups was assessed using the t-test for independent samples, and in the case of multiple comparisons (more than 2 study groups), univariate analysis of variance (ANOVA) was applied with subsequent

Table 1. Clinical characteristics of patient groups by obesity level.

Clinical data	Group I n (%)	Group II n (%)	Group III n (%)	All N (%)
Group size	33 (100.0)	17 (100.0)	16 (100.0)	66 (100.0)
Age (years)	55.5±11.7	55.0±10.7	57.4±12.1	55.8±11.6
Female	20 (60.6)	10 (58.8)	10 (62.5)	40 (60.6)
Hypertension	26 (78.8)	14 (82.4)	15 (93.8)	55 (83.3)
Ischemic heart disease	9 (27.3)	4 (23.5)	5 (31.3)	18 (27.3)
Myocardial infarction	4 (12.1)	3 (17.6)	0	7 (10.6)
Heart failure	10 (30.3)	8 (47.1)	7 (43.8)	25 (37.9)
Glucose intolerance/fasting hyperglycemia	21 (63.6)	9 (52.9)	10 (62.5)	40 (60.6)
Chronic kidney disease	3 (9.1)	3 (17.6)	3 (18.8)	9 (13.6)
Hepatic disease	2 (6.1)	4 (23.5)	3 (18.8)	9 (13.6)
Cerebral stroke	2 (6.1)	1 (5.9)	0	3 (4.5)
Cerebral arterial insufficiency	2 (6.1)	0	0	2 (3.0)
Hyperuricemia	9 (27.3)	6 (35.3)	5 (31.3)	20 (30.3)
Gout	1 (3.0)	2 (11.8)	1 (6.3)	4 (6.1)
Total dyslipidemias (except hypo-HDL-C)	31 (93.0)	16 (94.1)	13 (81.3)	60 (90.9)
Hypercholesterolemia LDL-C	17 (51.5)	7 (41.2)	5 (31.3)	29 (43.9)
Mixed hyperlipidemia	12 (36.4)	5 (29.4)	7 (43.8)	24 (36.4)
Hypocholesterolemia HDL-C	4 (12.1)	5 (29.4)	4 (25.0)	13 (19.7)
Hypertriglyceridemia	2 (6.1)	4 (23.5)	1 (6.3)	7 (10.6)
Tobacco smoking	5 (15.2)	1 (5.9)	1 (6.3)	7 (10.6)
Statin treatment	17 (51.5)	9 (52.9)	5 (31.3)	31 (47.0)
Fibrate treatment	2 (6.1)	2 (11.8)	0	4 (6.1)
Statin + fibrate combined treatment	2 (6.1)	0	1 (6.3)	3 (4.5)
Omega-3 fatty acids	7 (21.2)	2 (11.8)	4 (25.0)	13 (19.7)
Ezetimibe treatment	3 (9.1)	0	0	3 (4.5)

use of *post-hoc* multiple comparison tests (Tukey's test). For statistical analysis of discontinuous results, the chi-squared test was used. Values of $p < 0.05$ were assumed to be statistically significant.

To assess the relationship and correlation between obesity indices and lipid metabolism parameters, Pearson's linear correlation analysis was used, along with a linear regression model with a 95% confidence interval.

Results

Clinical characteristics of the study subjects are shown in Table 1. There were no statistically significant differences in clinical characteristic between compared groups (Table 1). Among persons enrolled in the study, the largest group consisted of dyslipidemic patients, accounting for 90.9% of the general study population, while hypercholesterolemia was present in 43.9%, mixed hyperlipidemia in 36.4%, and hypertriglyceridemia in

Table 2. Obesity and lipids parameters in the patients' groups.

Parameter	Group I n=33	Group II n=17	Group III n=16
WC (cm)	105.3±6.9	**113.1±7.4	**123.9±11.4^^
WHR	0.94±0.07	0.96±0.10	0.95±0.08
WHtR	0.63±0.04	**0.68±0.05	**0.76±0.05^^
BMI (kg/m ²)	32.5±1.2	**37.0±1.3	**42.8±2.8^^
BAI	34.6±4.6	38.0±5.3	**47.2±6.7^^
VAI	1.9±0.9	2.2±1.5	2.3±1.0
TC (mmol/l)	6.0±1.5	5.4±1.2	*5.0±1.0
HDL-C (mmol/l)	1.4±0.3	1.4±0.3	1.3±0.3
LDL-C (mmol/l)	3.8±1.2	3.1±0.8	*2.9±0.9
TG (mmol/l)	1.6±0.7	1.8±1.5	1.7±0.6
TC/HDL-C	4.3±1.0	3.9±1.0	4.0±1.0
LDL-C/HDL-C	2.7±0.9	2.3±0.7	2.3±0.8
TG/HDL-C	1.2±0.6	1.4±1.1	1.4±0.5

P given as mean values ±SD; vs. group I: * p<0.05, ** p<0.01; vs. group II: ^ p<0.05, ^^ p<0.01. WC – waist circumference; BMI – body mass index; WHR – waist-to-hip ratio; WHtR – waist-to-height ratio; BAI – body adiposity index; VAI – visceral adiposity index; TC – total cholesterol; HDL-C – high-density lipoprotein cholesterol; LDL-C – low-density lipoprotein cholesterol; TG – triglycerides.

Table 3. Correlation coefficients between obesity indices and lipid measurements in obese (n=66) patients.

Indices	TC	LDL-C	HDL-C	TG	TC/HDL-C	LDL-C/HDL-C	TG/HDL-C
BMI	-0.291*	-0.310**	-0.240*	0.068	-0.050	-0.116	0.172
WC	-0.233	-0.201	-0.371**	0.131	0.095	0.043	0.279*
WHR	-0.054	-0.011	-0.296*	0.134	0.174	0.156	0.244*
WHtR	-0.127	-0.127	-0.104	0.052	-0.006	-0.033	0.113
BAI	-0.061	-0.107	0.170	-0.057	-0.148	-0.165	-0.085
VAI	0.327**	0.212	-0.376**	0.885**	0.618**	0.480**	0.927**

Pearson's linear correlation coefficients are given; * p<0.05, ** p<0.01. WC – waist circumference; BMI – body mass index; WHR – waist-to-hip ratio; WHtR – waist-to-height ratio; BAI – body adiposity index; VAI – visceral adiposity index; TC – total cholesterol; HDL-C – high-density lipoprotein cholesterol; LDL-C – low-density lipoprotein cholesterol; TG – triglycerides.

10.6% of subjects (Table 1). In addition, 19.7% of patients had low HDL-C levels. Hypertension was diagnosed in 83.3% patients from the whole study population (Table 1).

Obesity and lipid parameters obtained from the patients are presented in Table 2. Patients from Group III had greater mean WC compared to Group II and I (Table 2). Patients in obesity Class II also had greater mean WC than in Group I. Mean WHtR, BMI, and BAI values were higher in Group III compared to Group II and Group I (Table 2). Higher mean WHtR and BMI

were observed in Group II compared to Group I (Table 2). Mean serum TC and LDL-C in Group III were significantly lower than in Group I (Table 2).

Negative significant correlations were found in the whole study population between: BMI and TC, LDL-C, HDL-C; WC, WHR, VAI and HDL-C (Table 3). By contrast, positive significant correlations were found between WC, WHR, and TG/HDL-C, as well as between VAI and: TC, TG, TC/HDL-C, LDL/HDL-C, and TG/HDL-C (Table 3).

Discussion

Lipid disorders were the most frequent concomitant disorders in our study population. The high incidence of dyslipidemia in obese patients was also shown in 2 large Polish epidemiological studies – LIPIDOGRAM 2004 and WOBASZ [23,24]. Interestingly, the group of patients with Class III obesity had lower mean serum levels of TC and LDL-C compared with patients from the other 2 groups, and this difference was statistically significant when compared to the patients with Class I obesity. This result was not related to lipid-lowering treatment because of lack of statistically significant differences between compared groups. Similar results were obtained in the study LIPIDOGRAM 2004, where higher serum levels of TC, LDL-C, and TG were found in overweight people compared with the obese [25]. On the other hand, the negative correlations observed in our study between BMI, WC, and LDL-C might have resulted from a lower LDL-C level in patients with morbid obesity as previously observed by others [26–28]. Hu et al. found a 2-phase relationship between BMI, WC, and LDL-C levels, especially in women [27]. Increase in BMI and WC values initially resulted in increases in LDL-C levels, subsequently leading to reductions in the most obese persons [27].

In Native Americans, increase in LDL-C levels was positively correlated with BMI only for the first 3 quartiles, then this relationship was reversed [26]. The authors suggest that increase in adipose tissue in this population may decrease LDL-C levels in 2 ways: through increased activity of LDL-C receptors in adipose tissue or because of diluting the circulating pool of LDL-C through the increased circulating blood volume in more obese people [26]. It must also be noted that levels of small, dense LDL (sdLDL) fractions, as in our study, were not measured and a preponderance of sdLDL induced by insulin resistance can lead to significant reductions in LDL-C [6,11].

Many available studies suggest a correlation between obesity and lipid indices. Howard et al. concluded, based on results of clinical studies, that the relationship between BMI and LDL-C serum levels is complex and depends on numerous factors such as age or sex [26]. It was demonstrated that higher LDL-C levels were seen in young (20–44 years of age) obese women, and were positively correlated with BMI [26]. The authors did not observe significant differences between patients from different obesity classes with regards to levels of HDL-C and TG [26]. In the Strong Heart Study conducted in 773 women and 739 men of Native American origin, Hu et al. found significant negative correlation between BMI and HDL-C in women [27]. WC values were positively correlated with serum TG levels and negatively correlated with HDL-C levels, and the relation between WC and assessed lipid fraction levels in women was much stronger than in the case of BMI [27]. In men, positive correlations were observed between BMI, WC, and TG

levels, as well as a negative correlation between BMI, WC, and HDL-C levels, although, in contrast with women, the strength of correlation was comparable for both obesity parameters [27].

Data obtained from the available literature suggest that increasing BMI results in decreasing HDL-C levels and increasing TG levels [26,29]. These studies, however, were conducted in general populations rather than selected groups of patients with obesity. These observations are also supported by the results of a study conducted in 1518 adult Peruvians, where the authors found a very strong negative correlation between BMI, VAI, and the HDL-C fractions, as well as a positive correlation with TG; however, this was irrespective of gender [16]. We also found a negative correlation between BMI, WC, WHR, and HDL-C, but not with TG. Similar findings were observed in the Prospective Epidemiological Study of Myocardial Infarction (PRIME) and by Mojiminiyi et al. [28,30].

The negative correlation between WC and HDL-C levels observed in our study is supported by results presented by Hu et al.; however, unlike the present authors, no statistically significant correlation between BMI, WC, and TG was found, although a similar tendency was present [27]. The above-mentioned negative correlation between WC and HDL-C was also reported by Chehrei et al. in 750 non-obese people [31]. The results of our study suggest that obesity, especially abdominal obesity, is significantly associated with dyslipidemia, which manifests itself mainly with reductions in HDL-C. It is especially evident with the VAI index, which demonstrated the strongest correlation with TG and HDL-C levels and with the lipid indices TC/HDL-C, LDL-C/HDL-C, and TG/HDL-C. This is not surprising, however, given the fact that the VAI formula includes both the HDL-C and TG levels.

The positive correlation observed in our study between WHR and TG/HDL-C ratio is supported by results obtained by Marrotta et al., who demonstrated a similar relationship in obese people [22].

Results of our study demonstrate a relationship between some selected obesity indices, especially those pertaining to visceral obesity, and lipid parameters. This is especially the case with new, recently proposed obesity indices, such as VAI, WHtR, and BAI, which have been investigated in only a few studies to date [1,13–16]. One strength of this study is that there is relatively little information on obese patients grouped according to obesity level, especially among the morbidly obese (BMI ≥ 40 kg/m²). Most studies have assessed the relationship between obesity indices and lipid metabolism parameters in the general population, and sometimes in non-overweight or healthy people. Nevertheless, our study has certain limitations, such as small patient groups. Therefore, we could not assess the possible age and sex dependent differences.

We also cannot exclude that different comorbidities could also impact the results.

Conclusions

Obesity is associated with lipid disturbances, especially with HDL-C reduction, in obese non-diabetic patients. VAI is strongly

related with lipid profile and thus may be the most valuable obesity index in obese patients with dyslipidemias.

Statement

This paper was written independently; no company or institution supported it financially. No professional writer was involved in the preparation of this analysis.

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