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Trabajo Original

Obesidad y síndrome metabólico

Weight-adjusted waist index predicts metabolic syndrome in Caucasian patients with obesity

El índice de cintura ajustado al peso predice el síndrome metabólico en pacientes caucásicos con obesidad

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Abstract

Background and aims: the usefulness of the weight-adjusted waist index (WWI) among persons with metabolic syndrome (MS) has not been previously evaluated. The objective of this study was to evaluate the ability of WWI to predict MS in a Caucasian population with obesity.

Methods*:* we conducted a cross sectional study in 2162 Caucasian patients with obesity. Anthropometric data (weight, height, body mass index [BMI], waist circumference, [WWI]), bioimpedanciometer parameters (total fat mass [FM], skeletal muscle mass [SMM] and skeletal muscle mass index [SMMi]), blood pressure, presence of MS and biochemical parameters were recorded and compared by tertiles of WWI.

Results: a total of 1,176 subjects had MS (54.4 %) and 986 did not show MS (45.6 %). Compared with the lowest WWI category Q1 (< 11.24 cm/ √kg), the prevalence of MS increased in the logistic regression model adjusted by sex and age in the Q3 group (OR = 2.53, 95 % CI = 1.71-3.23; $p = 0.001$). In addition, the prevalence of MS was higher in the Q3 group than in Q2 (OR = 1.65, 95 % CI = 1.25-2.17; $p = 0.005$). Finally, the prevalence of MS in Q2 was higher than in the Q1 group (OR = 1.21, 95 % CI = 1.06-3.11; $p = 0.01$). The area under the curve (AUC) to assess the ability of WWI to identify MS showed values of 0.811 (0.687-0.871; $p = 0.001$). The cut-off point according to the Youden index was 11.59, with sensitivity and specificity of 70 % and 93.4 %, respectively.

Conclusion: we described a good accuracy of WWI to identify MS an independent association between WWI in Caucasian patients with obesity.

Keywords:

Metabolic syndrome. Obesity. Weight-adjusted waist index.

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Statement of ethics: this study protocol was reviewed and approved by the HCVUA Committee, approval number No. 6/2021. Written Informed consent was obtained from all individual participants included in the study.

Consent to participate statement: a signed informed consent was obtained from all participants. This research complies with the guidelines for human studies in accordance with the World Medical Association Declaration of Helsinki.

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Data availability statement: all data generated or analyzed during this study are included in this article. Further enquiries can be directed to the corresponding author.

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Resumen

Antecedentes y objetivos: la utilidad del índice de cintura ajustado al peso (ICAP) entre personas con síndrome metabólico (SM) no se ha evaluado previamente. El objetivo de este estudio fue evaluar la capacidad de ICAP para predecir la SM en una población caucásica con obesidad.

Métodos: realizamos un estudio transversal en 2,162 pacientes caucásicos con obesidad. Los datos antropométricos (peso, altura, índice de masa corporal (IMC), circunferencia de la cintura, ICAP), parámetros del bioimpedanciómetro (masa grasa total [MG], la masa de músculo esquelético [MME] y el índice de masa de músculo esquelético [iMME]), la presión arterial, la presencia de SM y los parámetros bioquímicos se registraron y compararon por terciles del ICAP.

Resultados: un total de 1176 sujetos tenían SM (54,4 %) y 986 no presentaban SM (45,6 %). En comparación con la categoría más baja del ICAP, Q1 (< 11,24 cm/ √kg), la prevalencia de SM aumentó en el modelo de regresión logística ajustado por sexo y edad en el grupo Q3 (OR = 2,53, IC 95 % = 1,71-3,23; $p = 0,001$). Además, la prevalencia del SM fue mayor en el grupo Q3 que en el Q2 (OR = 1,65, IC 95 % = 1,25-2,17; $p = 0,005$). Finalmente, la prevalencia de SM en el grupo Q2 fue mayor que en el grupo Q1 (OR = 1,21, IC 95 % = 1,06-3,11; $p = 0,01$). El área bajo la curva (AUC) para evaluar la capacidad del ICAP para identificar la SM mostró valores de 0,811 (0,687-0,871; $p = 0,001$). El punto de corte según el índice de Youden fue 11,59, con sensibilidad y especificidad del 70 % y el 93,4 %, respectivamente.

Conclusión: describimos una buena precisión del ICAP para identificar el SM, y una asociación independiente entre ICAP en pacientes caucásicos con obesidad.

Palabras clave:

Síndrome metabólico. Obesidad. Índice de cintura ajustado al peso.

INTRODUCTION

Obesity is defined as excess of body fat; this fact is a well-known risk factor for various entities including dyslipidaemia, diabetes *mellitus* type 2, hypertension, non-alcoholic fatty liver disease, metabolic syndrome and cardiovascular diseases (1). In this context, body mass index (BMI) is the most widely used measure of obesity (2). Many studies showed a linear association between BMI and risk of diabetes *mellitus*, hypertension and cardiovascular diseases (3,4). Despite, inverse or inconsistent associations between BMI and mortality have resulted in the "obesity paradox" (5,6). Some physiopathological explanations for this paradox have been implied (7,8). Moreover, some authors have implied the limitation of BMI as a real measure of obesity, as this marker does not differentiate between fat mass and lean mass (9).

On the other hand, waist circumference (WC) has been indicated as a more accurate body adiposity index for the prediction of metabolic disorders than BMI, it has a good correlation with abdominal fat imaging and excellent association with mortality and cardiovascular risk factors (10,11). Moreover, WC is correlated with BMI, and it is limited as an independent measure of BMI. Moreover, the 'Obesity Paradox' has also been described when waist circumference (WC) is used as an obesity index (12). A novel adiposity index called the weight-adjusted waist index (WWI) was described in 2018 as a new obesity anthropometric index (13). BMI cannot distinguish between muscle and fat mass, but WWI can better distinguish both components and mainly shows the problem of central obesity independent of total body weight (14). A lot of evidence confirmed that the value of WWI is a useful risk factor for heart failure, hyperuricemia, abdominal aortic calcification, diabetes *mellitus* type 2 and urinary albumin excretion (15-18). However, the relationship of WWI with metabolic syndrome (MS) has not been investigated. Metabolic Syndrome (MS) is a constellation of risk entities related with obesity; including glucose intolerance or diabetes *mellitus*, abdominal obesity, hyperlipidemia and high blood pressure levels (19). MS therefore marks patients with high cardiovascular risk and it is necessary to identify them with a simple methodology in routine clinical practice.

Thus, the objective of this study was to evaluate the ability of WWI to predict MS in a Caucasian population with obesity.

PATIENTS AND METHODS

SUBJECTS

Caucasian patients with obesity living in our Health Area in western Castile and Leon, Spain, were included in the study from January 2020 to December 2022. The participants were selected through convenience sampling. Patients were recruited consecutively upon arrival at our Nutrition Unit for assessment of their obesity. In all 2,162 adults of both genders, aged 18 year and older with obesity were recruited. Recruited patients signed a consent form. The protocol complies with the Declaration of Helsinki as well as with local institutional guidelines. The Ethics Committee (code of registration 03/2020) approved it.

The inclusion criteria for this study were the following; obesity assessed as body mass index (BMI) ≥ 30 kg/m^2 and age above 18 years. Exclusion criteria were the next; presence of any associated condition (e.g., chronic kidney disease (glomerular filtration ≤ 45 ml/min), chronic liver disease (Child stage B or C), heart failure (ventricular excretion fraction ≤ 50 %), malignant tumours, history of alcoholism, use of medications that potentially influenced weight or metabolic parameters (statins, fibrates and drugs to treat diabetes *mellitus*), inability to walk or being bedridden.

The evaluated parameters of the present study included; anthropometric data (weight, height, body mass index [BMI], waist circumference, weight-adjusted waist index [WWI]), bioimpedanciometer parameters (total fat mass [FM], skeletal muscle mass [SMM] and skeletal muscle mass index [SMMi]), blood pressure and biochemical assessment. During the basal visit, 15 ml of venous blood after an 8 hour overnight fast were obtained and aliquoted in ethylenediaminetetraacetic acid EDTA-coated tubes. All patients recorded their daily dietary intake and physical activity. Finally, patients with three or more of the criteria listed in the text were considered as having metabolic syndrome, as defined using the Adult Treatment Panel III (ATPIII) criteria (19): elevated fasting glucose or treatment for diabetes *mellitus*, elevated tri-

glycerides (> 150 mg/dl) or treatment for hyperlipidemia, low HDL-cholesterol < 40 mg/dl (males) or < 50 mg/dl (females), elevated systolic or diastolic blood pressure (> 130/85 mmHg or antihypertensive treatment) and increased waist circumference (> 88 cm, females or > 102 cm, males).

ANTHROPOMETRIC PARAMETERS, BLOOD PRESSURE AND LIFESTYLE PARAMETERS

Height, weight and waist circumference were measured using standardized techniques, while the patients were wearing only light clothing. Weight was measured to the nearest 0.1 kg using a digital scale (Omrom, LA, CA, USA). Stature was measured bare footed to the nearest 0.5 cm using a stationary stadiometer (Omrom, LA, CA, USA). Waist circumference was measured at the nearest 0.1 cm just above the ilium with a flexible tape (Omrom, LA, CA). Weight and stature were used to calculate BMI; weight in kilograms divided by height in squared meters. Weight-adjusted waist index (WWI) was calculated with the following formula; waist circumference in centimeters divided by square root of weight. Subjects were divided into three groups based on WWI tertiles. WWI tertiles were defined as follows: < 11.24 cm/√kg (Q1), ≥ 11.24 and < 11.92 cm/√kg (Q2), ≥ 11.92 cm/√kg (Q3).

Total fat mass (FM) and skeletal muscle mass (SMM) were obtained by bioelectrical impedance analysis with an accuracy of 50 g (20) (EFG BIA 101 Anniversary, Akern, It). SMMi (skeletal muscle mass index) was obtained by dividing SMM by squared height. Blood pressure was measured using a standard sphygmomanometer (Omrom, LA, CA, USA). Systolic and diastolic blood pressures were measured two consecutive times on the right arm after 10 minutes rest, and average of the two measures was calculated.

BIOCHEMICAL PROCEDURES AND ADIPONECTIN

All samples were measured in our central laboratory. Glucose, insulin, C-reactive protein (CRP), total cholesterol, HDL-cholesterol and triglyceride were measured according to the manufacturer using the COBAS INTEGRA 400 analyser (Roche Diagnostic, Basel, Switzerland). LDL-cholesterol was calculated using Friedewald equation (LDL cholesterol = total cholesterol - HDL cholesterol-triglycerides / 5) (21). Based on glucose and insulin levels, homeostasis model assessment for insulin resistance (HOMA-IR) was obtained using these values (glucose (mml/L) x insulin (UI/L) / 22.5) (22). Adiponectin, interleukin-6 and leptin were measured by enzyme immunoassay (ELISA) (R&D systems, Inc., Minnesota, USA) (23).

STATISTICAL ANALYSIS

Data analysis was performed using IBM SPSS Statistical Package for Social Sciences, version 24.0 (SPSS Statistics, IBM, Armonk, NY, USA). Sample size was calculated to detect significant statistical correlation between WWI and MS criteria with 90 % power and 5 % significance (n = 2000). Continuous data were expressed as mean ± standard deviation. An independent t test was used to compare factors with continuous variables between two groups for parametric variables and Mann-Whitney test for non-parametric variables. ANOVA for continuous variables among tertiles of WWI was used. Chi-squared test or Fischer exact test, as appropriated, was used to compare categorical variables. Spearman's or Pearson's correlation analysis were used to explore the relationship among WWI with other parameters. Multiple logistic regression models were used to estimate odds ratios (ORs) and 95 % confidence intervals (CIs) in order to examine the relationship between MS and WWI. The receiver operating characteristic (ROC) curve and the area under the ROC curve (AUC) were used to assess the ability of WWI to identify MS. And the cutoff points were elucidated by two methods: the area under the curve (AUC) that had the best specificity and sensitivity values for the test in question, and the Youden Index as (sensitivity + specificity) - 1). p-values below 0.05 were considered statistically significant.

RESULTS

A total of 2,162 subjects with obesity were recruited, 927 males (42.9 %) and 1,235 females (57.1 %) with an average age of 50. 2 ± 10.3 years. A total of 1,176 subjects had MS (54.4 %) and 986 did not show MS (45.6 %).

Table I summarizes the clinical and anthropometric details of the study population according to WWI categories. Compared with the subjects in the lower WWI tertile (< 11.24 cm/√kg) Q1, those in the higher WWI categories (Q2) (≥ 11.24 and < 11.92 cm/√kg) and (Q3) 11.92 cm/√kg) had higher values of BMI, weight, fat mass and systolic blood pressure. And vice versa, the subjects in Q2 and Q3 groups compared with subjects in Q1 group had lower muscle mass and muscle mass index.

Table II shows the biochemical parameters of the study population. Compared with the subjects in the lower WWI category (< 11.24 cm/√kg) Q1, those in the higher WWI tertiles (Q2) (≥ 11.24 and < 11.92 cm/√kg) and (Q3) (11.92 cm/√kg) had higher values of fasting glucose, triglycerides, insulin, HOMA-IR, leptin, interleukin-6 and CRP levels. And vice versa, the subjects in Q2 and Q3 groups compared with subjects in Q1 group had higher adiponectin levels.

Table III displays the correlation analysis of WWI with biochemical and anthropometric parameters. WWI values were positive correlated with BMI, weight, WC, FM, glucose, insulin, HOMA-IR, triglycerides, interleukin-6, CRP and leptin levels. Moreover, WWI values were negative correlated with SMM, SMMi, phase angle and leptin levels.

Table IV summarizes the percentage of each MS criteria and the total MS percentage in each tertile groups of WWI. Percentage of MS, central obesity, hypertriglyceridemia, hypertension and hyperglycaemia were higher in groups (Q2) (≥ 11.24

and < 11.92 cm/√kg) and (Q3) (11.92 cm/√kg) than group (Q1) (< 11.24 cm/√kg). Percentage of low HDL-cholesterol levels were similar among tertile groups. Patients with 0 or 1 criteria's of MS were 53.1 % in Q1 group, 30.7 % in Q2 group and 19.9 % in Q3 group ($p = 0.003$). Finally, compared with the lowest WWI category Q1 (< 11.24 cm/√kg), the prevalence of MS increased in the logistic regression model adjusted by sex and age in Q3 group (OR = 2.53, 95 % CI = 1.71-3.23; $p = 0.001$). In addition, the prevalence of MS was higher in Q3 group than Q2 (OR = 1.65, 95 % CI = 1.25-2.17; $p = 0.005$). Finally, prevalence of MS in Q2 was higher than Q1 group (OR = 1.21, 95 % CI = 1.06-3.11; $p = 0.01$), too.

The ROC curve of the WWI index for MS is shown in figure 1. The area under the curve (AUC) according ATPIII criteria showed values of 0.811 (0.687-0.87: $p = 0.001$). The cut-off point according to the Youden index was 11.59, with sentivity and specificity of 70 % and 93.4 %, respectively, and a positive likelihood ratio of 10.4 and negative likelihood ratio of 0.34.

Table I. Clinical and anthropometric parameters of the study participants by weight-adjusted waist index in tertiles (mean ± SD)

Parameters	< 11.24 cm/√kg (Q1)	≥ 11.24 and < 11.92 cm/√kg (Q2)	≥ 11.92 cm/√kg (Q3)	*p*-value
Gender (female/male) (*n*)	412/309	413/308	410/311	0.45
Age (years)	41.5 ± 5.3	50.1±5.2	58.1±5.1	0.01
BMI (kg/m^2)	34.8 ± 1.5	37.3 ± 1.7	40.1 ± 2.4	0.01
Weight (kg)	95.1 ± 2.0	98.4 ± 3.0	99.8 ± 1.7	0.02
Fat mass (kg)	44.4 ± 9.0	43.3 ± 9.1	45.3 ± 8.4	0.03
Skeletal muscle mass (kg)	39.2 ± 1.1	38.4 ± 1.2	37.4 ± 1.4	0.02
Skeletal muscle mass index (kg/m^2)	14.8 ± 0.3	14.0 ± 0.1	13.1 ± 0.9	0.02
WC (cm)	103.6 ± 11.1	114.3 ± 10.7	124.3 ± 9.3	0.01
SBP (mmHg)	125.7 ± 12.0	130.5 ± 8.0	134.5 ± 8.1	0.04
DBP (mmHg)	80.3 ± 4.1	82.2 ± 3.1	82.6 ± 4.0	0.41

BMI: body mass index; DBP: diastolic blood pressure; SBP: systolic blood pressure; WC: waist circumference.

Table II. Biochemical parameters of the study participants by weight-adjusted waist index in tertiles (mean ± SD)

Parameters	< 11.24 cm/√kg (Q1)	≥ 11.24 and < 11.92 cm/√kg (Q2)	≥ 11.92 cm/√kg (Q3)	*p*-value
Fasting glucose (mg/dl)	97.9 ± 3.1	102.1 ± 2.1	111.1 ± 2.3	0.01
Total cholesterol (mg/dl)	196.2 ± 21.8	202.9 ± 19.8	202.3 ± 12.8	0.24
LDL-cholesterol (mg/dl)	119.7 ± 18.9	121.7 ± 12.9	120.7 ± 13.1	0.29
HDL-cholesterol (mg/dl)	52.6 ± 3.1	53.4 ± 4.0	52.5 ± 3.2	0.28
Triglycerides (mg/dl)	120.7 ± 11.0	129.9 ± 12.0	135.4 ± 9.0	0.03
Insulin (UI/l)	14.6 ± 1.2	15.9 ± 1.1	17.7 ± 2.1	0.02
HOMA-IR	3.4 ± 0.8	4.0 ± 0.4	4.8 ± 0.2	0.03
Leptin (ng/ml)	56.9 ± 9.8	69.8 ± 8.7	91.9 ± 7.9	0.01
Adiponectin (ng/ml)	22.9 ± 0.9	17.4 ± 0.7	13.9 ± 0.9	0.01
Interleukin-6 (pg/ml)	1.4 ± 0.8	2.1 ± 0.7	4.4 ± 1.1	0.01
CRP (mg/dl)	3.3 ± 1.3	4.2 ± 0.8	6.3 ± 0.9	0.03

HOMA-IR: homeostasis model assessment.

Table III. Correlation analysis between weight-adjusted waist index, bioelectric impedance and biochemical parameters

Anthropometric parameters and blood pressure	Weight-adjusted waist index	Biochemical parameters	HOMA-IR
BMI (kg/m^2)	$r = 0.277$, $p = 0.01$	Glucose (mg/dl)	$r = 0.337$, $p = 0.59$
Weight (kg)	$r = 0.361$, $p = 0.002$	Insulin (MUI/L)	*$r = 0.299$, $p = 0.001$*
Waist circumference (cm)	$r = 0.676$, $p = 0.001$	HOMA-IR	*$r = 0.329$, $p = 0.003$*
Fat mass (kg)	$r = 0.191$, $p = 0.02$	Triglycerides (mg/dl)	*$r = 0.174$, $p = 0.012$*
Skeletal muscle mass (kg)	*$r = -0.24$, $p = 0.005$*	Adiponectine (ng/ml)	*$r = -0.210$, $p = 0.005$*
Skeletal muscle mass index (kg/m^2)	*$r = -0.27$, $p = 0.003$*	Leptin (ng/ml)	*$r = 0.182$, $p = 0.02$*
Systolic blood pressure	*$r = 0.19$, $p = 0.001$*	CRP (ng/m)	*$r = 0.230$, $p = 0.01$*
Phase angle	*$r = -0.14$, $p = 0.001$*	Interleukin-6	*$r = 0.218$, $p = 0.02$*

BMI: body mass index; CRP: C-reactive protein; HOMA-IR: homeostasis model assessment.

Table IV. Metabolic syndrome and components of metabolic syndrome percentages by weight-adjusted waist index in tertiles

Parameters	< 11.24 cm/√kg (Q1),	≥ 11.24 and < 11.92 cm/√kg (Q2)	≥ 11.92 cm/√kg (Q3)	*p*-value
Percentage of MS	29.8 %	48.7 %	64.4 %	0.001
Percentage of central obesity	60.6 %	90.0 %	99.5 %	0.001
Percentage of hypertriglyceridemia	6.5 %	10.2 %	12.8 %	0.02
Low HDL cholesterol	32.3 %	34.3 %	33.2 %	0.53
Percentage of hypertension	32.3 %	46.3 %	59.4 %	0.001
Percentage of hyperglycaemia	10.8 %	19.0 %	35.5 %	0.001

MS: metabolic syndrome. The criteria cutoff points included: central obesity (waist circumference > 88 cm in females and > 102 cm in males), hypertension (systolic BP > 130 mmHg or diastolic BP > 85 mmHg or specific treatment), hypertriglyceridemia (triglycerides > 150 mg/dl or specific treatment) or hyperglycaemia (fasting plasma glucose > 110 mg/dl or drug treatment for elevated blood glucose). Statistical differences between groups established when p < 0.05.

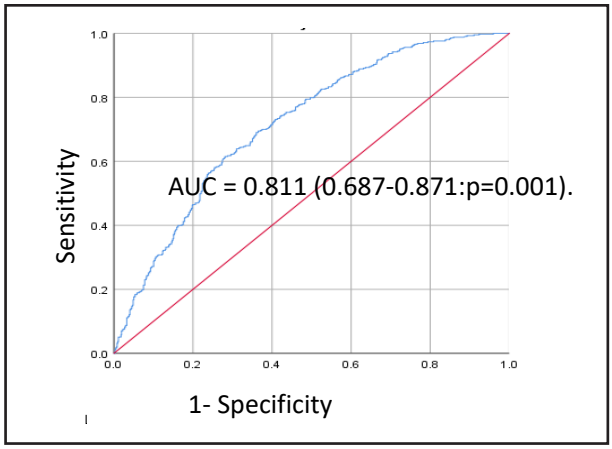

Figure 1.
ROC curve.

DISCUSSION

In this cross-sectional study among Caucasian patients with obesity older than 18 years, we confirmed that the prevalence of metabolic syndrome (MS) increased with the weight-adjusted waist index (WWI) tertiles and that there was a significant correlation between WWI and some anthropometric and biochemical parameters in these patients.

A lot of evidence confirms that obesity increases the risk of hypertension, diabetes *mellitus* type 2, hyperlipemia, cardiovascular disease and metabolic syndrome (24). Several studies reported the predictive value of BMI as an important indicator of obesity is limited in that it is unable to of distinguishing between fat mass and muscle mass (25). For all this, it is necessary to identify an adiposity index with the accuracy to predict the risk of metabolic disorders associated to obesity to decrease future cardiometabolic mortality in these subjects. As a novel adiposity index, WWI, which is easier to estimate, is an important predictor of morbidity which has been joined to cardiometabolic disease (13). To our knowledge, this is the first investigation examining the association between WWI and prevalence of MS. WWI has been previously evaluated in a huge range of diseases, such as hyperuricemia, albuminuria, hypertension, heart hypertrophy and abdominal aortic calcification (14-18).

Our present results reinforce the effectiveness of WWI as a novel marker of central obesity to predict MS in Caucasian patients with obesity. Some hypotheses have been implied to explain the positive association between BMI and Metabolic syndrome. Firstly, the increment of WWI may reflect the alteration of adipose tissue; this fact causes an increase in immune cell infiltration, proinflammatory cytokines, and producing insulin resistance and lipid disorders (26). Secondly, obesity is related with increased inflammatory markers as our study shows with CRP and IL-6, this inflammatory status is directly associated with insulin resistance. Other pathways, such as NK-kB, JNK and alteration in adipokine levels (high leptin and low adiponectin) have been implied in these pathogenic processes (27-30). In our design, we reported a direct correlation of IL-6, CRP, leptin with WWI, and secondarily WWI with insulin resistance (HOMA-IR). These results are in agreement with the hypotheses presented previously. Perhaps, this new anthropometric index reflects the visceral adipose tissue of the body, based on waist standardized with body weight in the equation. Until now, there have been no studies on the recognition capability for MS in Caucasian subjects with obesity. Our study found a cut-off point (WWI = 11.59) to determine the presence of MS with a high specificity and a medium sensitivity. This high specificity characterizes the WWI's ability to detect the absence of MS in subjects with obesity and the medium sensitivity value characterizes the WWI's ability to detect MS in subjects with obesity, too.

Besides, WWI could be an indicator of muscle and fat composition. Measurement of muscle mass has become increasingly important as a measure of body composition and health status in patients with obesity (31). However, determination of muscle mass without a special device (bioelectrical impedance, computerized axial tomography, Dual X-ray Absorptiometry, nuclear magnetic resonance and so on) is difficult. Similar to previous studies on WWI in non-Caucasian populations, our results presented indicate that WWI is a good tool to differentiate muscle and fat mass in obesity populations (32).

In addition, previous studies have confirmed that WWI had correlation with some biochemical parameters such as albuminuria (17) and uric acid (18). In one of these studies (17), the inflection point of WWI was 10.93, with a high correlation of albuminuria with WWI in this point. This cut-off point is close to our point (11.59) to detect MS. On the other hand, in our study we have detected a positive correlation with CRP, leptin and IL-6, and a negative one with adiponectin, these being the first data in the literature demonstrating this correlation with WWI. These data are consistent with the WWI relationship with visceral fat mass and insulin resistance.

The limitations of our study are as follows: firstly, the design has been realized only in Caucasian subjects with obesity and metabolic syndrome, so the data are not generalizable to other ethnicities, overweight subjects, or other patients with obesity and without MS. Secondly, the investigation as a cross-sectional design does not allow any inference causality. Thirdly, the subjects came from a single center. Some strengths of our study are the large sample size and that the representation of both genders was similar.

In conclusion, we described a good accuracy of WWI to identify MS in Caucasian patients with obesity. WWI is positive related with inflammatory markers such as CRP, IL-6 and leptin. Furthermore, WWI can be a useful intervention tool to decrease MS incidence. We can consider the changes in WWI values to determine the effectiveness of body weight control and intervention programs. WWI is an easy tool to monitor risk of MS without the need for a blood draw for glucose or lipid determination as is necessary to determine MS, or the need to measure blood pressure. For all of this, WWI may serve as an effective and simple anthropometric index in clinical practice.

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