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Nutritional Indicators Correlated with Metabolic Syndrome in Patients with Non-Dialytic Chronic Kidney Disease

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ABSTRACT

The progression of chronic kidney disease (CKD) causes damage that can trigger metabolic syndrome (MS). Obesity is an important risk factor for MS. To evaluate the correlation between nutritional indicators of obesity and MS in patients with non-dialysis CKD. Cross-sectional study. Included patients with CKD under non-dialysis treatment in stages 2, 3A, 3B 4, and 5, of both genders and aged ≥ 18. Sociodemographic, anthropometric, clinical-laboratory, and body composition data were collected. Data analysis was performed by the probability of significance of $p<0.05$, distributed in frequency and percentage. Pearson's correlation was used to evaluate the degree of relationship between the variables. The study was approved by the ethics committee. The study analyzed 188 patients, of whom 50.53% were women, with a prevalence of age 60 years (60.00±11.80). The best correlations were observed with the visceral adiposity index (VAI) and the lipid accumulation product (LAP) with the following variables: Fasting glycemia (r=0.30; p=0.000 versus r=0.31; p=0.002), triglycerides (r= 0.81; p=0.000 versus r=0.82; p= 0.000) and high density lipoprotein (HDL-c) (r= -0.58; p=0.000 versus r= -0.42; p=0.000) respectively. Followed by HDL-c to the indicators waist-hip ratio (WHR) (r= -0.31; p=0.000), neck circumference (NC) (r= -0.31; p=0.000) and sagittal abdominal diameter (SAD) (r= -0.30; p=0.000). The best methods to predict the risks of cardiovascular disease in this population are the VAI and LAP indices.

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INTRODUCTION

Chronic kidney disease (CKD) is defined as the progressive and irreversible decrease in renal function, characterized by the glomerular filtration rate (eGFR) below 60 ml/min/1.73m² for a period equal to or greater than three months.[1] The progressive nature of the disease culminates in hydro electrolytic imbalances, the consequences of which involve metabolic impairments, leading to the development or progression of metabolic syndrome.[2]

Metabolic syndrome (MS) is a set of metabolic disorders that include insulin resistance, increased blood pressure, high triglyceride levels, low-density cholesterol (HDL-c), and obesity (mainly central).[3] The prevalence of MS has increased significantly in recent years. It is estimated that 25% of the adult population have the condition, mainly provided by increased obesity.[4]

Studies indicate that the condition is associated with the development, as well as the progression of CKD[5,6], influenced by factors such as inflammation, insulin resistance, systemic arterial hypertension (SAH), and dyslipidemias that increase the expression of adipokines and inflammatory cytokines that have repercussions on kidney injury.[6]In addition, obesity, considered an important public health problem, has a high prevalence in patients with MS and is associated with complications such as type 2 diabetes, nonalcoholic fatty liver disease, gout[7] and kidney diseases, particularly CKD.[8]

To evaluate and quantify body adiposity, with better precision and practicality, several methods have been proposed. Body Mass Index (BMI), commonly used as a diagnostic criterion for classifying obesity, is not considered as an ideal measure to evaluate fat distribution.[9]However, some anthropometric indices have been developed to classify obesity according to its distribution because current evidence has shown that central obesity is more related to metabolic complications and mortality.[10,11] Studies also indicate that patients with CKD have a higher risk for the development of metabolic disorders and mortality from cardiovascular diseases.[5,8]

Therefore, the early diagnosis of MS in patients with CKD is indispensable to minimize the risks of mortality from CVD.[12] the study aimed to evaluate the correlation between nutritional indicators of obesity and metabolic syndrome in patients with non-dialysis CKD.

MATERIALS AND METHODS

METHODS

Study type

A cross-sectional and analytical study was developed at the Center for The Prevention of Brain Diseases of the University Hospital of the Federal University of Maranhão (CPDR-HUUFMA) encompassing a group of 188 users with CKD. This research is grouped with the project "Association of serum and urinary magnesium levels with body composition and inflammatory markers in patients with chronic non-dialysis kidney disease". The study meets the requirements of Resolution 466/12 of the National Health Council approved research ethics committee under n° 2,727,940.

Study subjects

Non-probabilistic sample, consisting of 188 patients followed by the multidisciplinary team of CPDR-HUUFMA in 2018. We included individuals with CKD undergoing non-dialysis treatment in stages 2, 3A, 3B 4, and 5, of both genders, aged 18 years or older who maintained regular follow-up, by signing the Informed Consent Form (TCLE in Portuguese). The following were not included: pregnant women, individuals with amputation of limbs, neurological disorders or sequelae of stroke, those with cognitive impairment, patients with autoimmune diseases, infectious diseases, cancer, acquired immunodeficiency syndrome, and those with BMI < 18.5 kg/m².

Study Protocol

Demographic, socioeconomic, clinical-laboratory, anthropometric, and body composition data were collected. Lifestyle, blood pressure, medication consumption, and presence of comorbidities that were recorded in their form were also evaluated. The interviews were conducted during the consultation, in order not to cause disorders to the patients.

Venous samples were collected after maximum fasting of 12 hours and included the following dosages: creatinine, lipid profile, and fasting glycemia. The glomerular filtration rate (GFR) was

estimated using the formula derived from the CKD-EPI[13]study, using creatinine as a reference for the calculation.

The anthropometric evaluation was performed by measuring body weight; stature; waist circumference (WC), hip circumference (HC) and neck circumference (NC), and sagittal abdominal diameter (SAD). Bodyweight was obtained was performed with the aid of a calibrated scale (Filizola®, Brazil) with a maximum capacity of 150kg and subdivisions every 100g. Height was obtained with the aid of a portable estadiometer (Alturexata®, Brazil) with a scale from 0 to 220cm and a precision of 0.1cm. Based on these parameters, the body mass index (BMI) was classified, and the criteria proposed by the World Health Organization WHO for adults and Lipschitz for the elderly were adopted[14,15].

WC was measured at the midpoint between the last rib and the iliac crest, using an inelastic measuring tape (Sanny®, Brazil), thus, high or very high-risk values for obesity-related complications for men when WC greater than 94cm and 102cm, respectively, and, for women, when higher than 80cm and 88cm, according to the criteria of the National Cholesterol Education Program [16]. The HC was measured with the patient standing, surrounding the hip in the area of the greater perimeter at the height of the buttocks, passing through the pubic symphysis, parallel to the floor.

NC was measured using an inelastic measuring tape (Sanny®, Brazil), measured at the base of the neck at the height of the cricothyroid cartilage. In the presence of prominence, in men, the measurement was performed below prominence. The cutoff points adopted were ≥34 and ≥ 37 for women and men, respectively, according to criteria of Ben-Noun *et al*.[17]

The SAD comprises the distance between the back and abdomen and was measured in duplicate. For measurement, a portable abdominal calibrator was used, with a subdivision of measurements of 0.1cm (Holtain Kahn Abdominal Caliper®). The measurement was performed with the individual in a supine position and knees flexed. The fixed arm of the calibrator was positioned at the midpoint between the last rib and the iliac crest, at the height between the discs of the lumbar vertebrae four and five (L4 – L5), and then the mobile upper arm of the calibrator was slipped into the upper abdomen until touching it, without compressing it, and at this point, the

reading was performed. The cut-off points that were adopted are: ≥23.1cm for men and ≥21.1cm for women, according to the criteria of Roriz *et al*. [18]

The nutritional indicators used, as well as their respective equations, are presented as shown in Chart 1.

Chart I. Anthropometric indices and respective equations used in the study.

Nutritional Indicators	Equations	References
BMI	Weight (Kg) / height² (m)	19
New BMI	1.3 × (weight (kg)/height (m)^2)	20
WHR	CC (cm) / CQ (cm)	11
WRstt	CC (cm) / height (cm)	21
WI	CC (m) / 0.109√Weight (Kg) /height (m)	10
VAI	Men: WC(cm)/ [39.68 + (1.88 x BMI(kg/m²)] x TG(mmol/l)/ 1.03 x 1.31/ HDL(mmol/l) Women: WC(cm)/ [36.58 + (1.89 x BMI(kg/m²)] x TG(mmol/l)/ 0.81 x 1.52/ HDL(mmol/l)	22
BAI	(HC (cm)/ height (m) x √height) - 18	23
LAP	Men: WC (cm) -65 x TG (mmol/l) Women: WC (cm) -58 x TG (mmol/l)	24
BSI	WC (cm)/ (BMI (kg/m²) $^{0.66}$ × Height (m)$^{0.5}$)	25
BAE	−44.988+(0.503×age(years))+(10.689×gender)+(3.172×BMI(kg/m²))-(0.026×BMI ^{2})+(0.181×BMI×gender)-(0.02×BMI×age) (0.005×BMI ^{2}×gender)+(0.00021×BMI ^{2}×age) In which men=0 and women=1 about gender, and age measurement in years.	26

Body mass index (BMI); new body mass index (New BMI); waist/hip ratio (WHR); waist/height ratio (WRstt); Visceral Adiposity Index (VAI); Body Adiposity Index (BAI); Lipid Accumulation Product (LAP); Body Shape Index (BSI); Body Adiposity Estimator (BAE).

In the evaluation of body composition, air displacement plethysmography (ADP) and electrical bioimpedance (BIA) were used. The ADP consists of a densitometric mean of determining body composition, with the bodyweight obtained through the scale and the body volume provided by the application of gas laws inside two chambers. The device estimates body volume based on Boyle's air displacement law, in which the volume varies inversely with pressure while the temperature remains constant Mccrory*et al*[27]. The estimation was performed using the BOD POD® (BOD POD - COSMED®, Italy).

Initially, the device (BOD POD - COSMED®, Italy) was calibrated, and the individual was informed about the procedure. A specific garment provided by the research (shorts, cap, and sports top for women) was delivered and asked to exchange it, in a place intended for this purpose, for the clothing she was wearing. He was also asked to remove all metal props he was perhaps wearing. Then, initially, the individual was weighed on a scale belonging to the equipment and then asked to enter the measuring chamber and sit, remain motionless during the test, and perform three respiratory incursions, so that the equipment would measure the volume occupied by the patient. Thus, the variations between pressure and volume were measured to determine body density. From this, body composition is measured, specifically the percentage of body fat %BF based on the Siri [28] equation, through the specific software of the equipment itself.

For the analysis of body composition through BIA, the participants were instructed to follow some previous procedures: absolute fasting of four hours; not performing strenuous physical exercises in the 12 hours before the test; do not drink alcohol 48 hours before the test; remove earrings, rings, watches, and metal objects at the time of evaluation. Measurements were performed with individuals in the supine position, with limbs in the abduction and using four electrodes (two placed on the back of the hand and two placed on the back of the foot) on the dominant side. The procedures performed followed the proposed standards for the Jebb and Elia [29] method. A tetrapolar bioimpedance device (Biodynamics BIA 450, Seatle Washington-USA) was used for the examination.

Metabolic syndrome definition

The presence of metabolic syndrome was defined according to the criteria of the Adult Treatment Panel III of the National Cholesterol Education Program (NCEP-ATP III)[30], which requires the presence of three or more of the following clinical conditions: WC> 102cm in men and> 88cm in women; SBP> 130mmHg and/or DBP > 85mmHg or pharmacological treatment for arterial hypertension; HDL-c levels < 40mg /dL in men and < 50mg/dL in women or pharmacological treatment; Fasting glycemia > 100mg/dL or pharmacological treatment for hyperglycemia.

Statistical Analysis

The collected data were stored in a specific database. Descriptive analysis was performed to characterize the patients. Categorical variables were presented using frequencies and percentages and quantitative variables using mean and standard deviation (mean ± SD). The normality of the variables was tested by the Shapiro-Wilk test. The associations between the groups with and without SM were made through the Student t-tests.

To evaluate the association between the variables of interest, the chi-square test was performed. Pearson's or Spearman's correlation coefficient was used to evaluating the degree of relationship between nutritional indicators and cardiometabolic risk factors. The level of significance adopted was 5%. The software used was Stata 14.0.

RESULT AND DISCUSSION

The study evaluated 188 patients, of whom 50.53% were women. The mean age was 60.00±11.80 years; 62.55% received up to 3 minimum wages monthly; 48.13% had completed high school and 51.81% were married. Regarding lifestyle, 6.42% were smokers, 14.97% consumed alcoholic beverages and 48.66% practiced physical activity. Regarding clinical characteristics, 87.23% were hypertensive and 46.28% diabetic (Table 1).

Table I. Sociodemographic, clinical, and lifestyle characteristics of the study population, according to gender.

Variables	**Total**	**Female**	**Male**	***p-value***
	n (%)	n (%)	n (%)	
Age (years)				0.701
< 40	14 (7.44)	7 (7.53)	7 (7.37)	
40 to 59	60 (31.92)	33 (35.48)	27 (28.42)	
≥ 60	114 (60.64)	53 (56.99)	61 (64.21)	
Mean ± SD	60.0±11.8	59.9± 12.3	60.2 ± 11.3	
Income (MW)				0.472
≤1	55 (29.42)	31 (33.70)	24 (25.26)	
>1 to ≤ 3	117 (62.56)	56 (60.87)	61 (64.21)	
>3	16 (8.02)	5 (5.44)	10 (10.53)	
Scholarity				0.174
No scholarity	17(8.56)	12(13.04)	4(4.21)	
Elementary	66(35.29)	31(33.70)	35(36.84)	
High school	90(48.13)	41(44.57)	49(51.58)	
Superior level	15 (8.02)	8(8.70)	7(7.37)	
Smoking				0.171
Yes	12(6.42)	5 (5.43)	7 (7.37)	
Acoholism				**0.000**
Yes	28(14.97)	11(11.96)	17 (17.89)	
Physical exercises				0.985
Yes	91 (48.66)	43 (45.32)	48 (51.63)	
Marital Status				**0.033**
Single	34 (18.18)	22(23.91)	12(12.63)	
Married	98(51.87)	40(43.48)	57(60.00)	
Other	56(29.95)	30(32.61)	26(27.37)	
DM				0.246
Yes	87(46.28)	47 (50.54)	40 (42.11)	
SAH				0.703
Yes	164 (87.23)	82 (88.17)	82 (86.32)	

Minimum wages (MW); systemic arterial hypertension (SAH); diabetes mellitus (DM).

Men, when compared to women, had higher means, with statistical significance, WC (97.71cm vs 93.96cm; p-value=0.031), NC (38.99cm vs 35.39cm; p-value=0.000), WHR (1.0cm vs 0.94cm; p-value=0.000) and IC (1.34cm vs 1.31cm; p-value=0.001).

As for women, they had higher means, with statistical significance, BF BIA (36.95cm vs 26.27cm; p-value=0.000), BF ADP (38.92cm vs 27.56cm; p-value=0.031), BAI (35.49cm vs 27.77cm; p-value=0.020), GFR (40.03cm vs 38.74cm; p-value=0.002), TC (183.69cm vs 161.98cm; p-value=0.000) and HDL-c (51.54cm vs 40.34cm; p-value=0.000). According to biochemical and anthropometric indicators according to sex presented in table 2.

Table II. Biochemical and anthropometric indicators according to sex in patients with non-dialytic chronic kidney disease.

Variable	**Total (188)**	**Female (95)**	**Male (93)**	p-value
	Mean ± SD	Mean ± SD	Mean ± SD	
WC (cm)	95.83±11.84	93.96±12.13	97.71±11.31	**0.031**
NC (cm)	37.21±5.16	35.39±6.16	38.99±3.08	**0.000**
SAD (cm)	21.14±3.16	20.87±3.06	21.42±3.25	0.235
BF (BIA) (%)	31.52±9.00	36.95±6.78	26.27±7.68	**0.000**
BF (ADP) (%)	33.10±9.59	38.92±7.17	27.56±8.17	**0.000**
BMI (Kg/m²)	27.69±4.64	28.33±5.10	27.06±4.07	0.317
New BMI (Kg/m²)	35.99±6.03	36.82±6.63	35.18±5.29	0.317
WHR	0.97±0.09	0.94±0.09	1.00±0.07	**0.000**
WRstt	0.60±0.07	0.61±0.81	0.59±0.06	0.809
TI	1.33±0.08	1.31±0.09	1.34±0.08	**0.001**
VAI	3.15±2.67	3.51±3.22	2.79±1.92	0.648
BAI (%)	31.59±6.05	35.49±5.75	27.77±3.25	**0.020**
Cr (mg/dL)	1.92±1.08	1.63±0.67	2.22±1.31	0.287
GFR (mL/min/1,73m²)	39.38±1.08	40.03±15.86	38.74±15.52	**0.002**
TC (mg/dL)	172.72±48.21	183.69±53.14	161.98±40.31	**0.000**
HDL (mg/dL)	45.88±48.21	51.54±17.93	40.34±12.37	**0.000**
LDL (mg/dL)	93.06±40.09	96.51±45.49	89.72±33.97	0.124
TG (mg/dL)	163.55±77.53	167.48±83.69	159.71±71.23	0.247

Waist circumference (WC); neck circumference (NC); sagittal abdominal diameter (DAS); bioimpedance fat mass (BF BIA); fat mass by air displacement plethysmography (BF ADP); body mass index (BMI); waist/height ratio (WRstt); Taper index (TI); visceral adiposity index (VAI); body adiposity index (BAI); serum creatinine (Cr); glomerular filtration rate (GFR); total cholesterol (TC); high density lipoprotein (HDL-c); low density lipoprotein (LDL-c) and triglycerides (TG).

When researching the association between the studied variables and the presence of MS, it was observed that patients diagnosed with MS had higher mean SBP values (152.08cm vs 141.97cm; p-value=0.002), WC (99, 66cm vs 89.35cm; p-value=0.000), NC (38.12cm vs 35.68cm; p-value=0.001), SAD (22.20cm vs 19.35cm; p-value=0.000), BF BIA (33.10cm vs 28.82cm; p-value=0.002), BF ADP (35.94cm vs 28.20cm; p-value=0.000), BMI (29.08cm vs 25.33cm; p-value=0.000), New BMI (37.81cm vs 32.93cm; p-value=0.000), WHR (0.99cm vs 0.94cm; p-value=0.000), WRstt (0.63cm vs 0.56cm; p-value=0.000), TI (1.35cm vs 1.29cm; p-value=0.039), VAI (4.08cm vs 1.57cm; p-value=0.000), and TG (191.44cm vs 116.55cm; p-value =0.000)). Mean HDL-c were lower in individuals with HDL MS (40.12cm vs 55.60cm; p-value=0.000) (Table 3).

Table III. Characteristics of the population, according to the presence or absence of metabolic syndrome in patients with non-dialytic chronic kidney disease.

	METABOLIC SYNDROME		
	YES (118)	**NO (70)**	
Variable	Mean ± SD	Mean ± SD	p-value
Age	61.30±10.40	57.90± 13.50	0.069
SBP (mmHg)	152.08±21.61	141.97±22.68	**0.002**
DBP (mmHg)	78.52±12.79	78.81±21.94	0.134
WC (cm)	99.66±10.31	89.35±11.52	**0.000**
NC (cm)	38.12±5.75	35.68±3.52	**0.001**
SAD (cm)	22.20±3.00	19.35±2.58	**0.000**
BF (BIA) (%)	33.10±8.22	28.82±9.68	**0.002**
BF (ADP) (%)	35.94±7.88	28.20±10.31	**0.000**
BMI (Kg/m^2)	29.08±4.52	25.33±3.83	**0.000**
New BMI (Kg/m^2)	37.81±5.88	32.93±4.98	**0.000**
WHR	0.99±0.87	0.94±0.88	**0.000**
WRstt	0.63±0.06	0.56±0.07	**0.000**
TI	1.35±0.80	1.29±0.88	**0.039**
VAI	4.08±2.89	1.57±1.08	**0.000**
BAI (%)	32.84±6.08	29.49±5.41	0.076
Cr (mg/dL)	1.84±0.81	2.07±1.42	0.660
GFR (mL/min/1,73m²)	39.22±15.25	39.66±16.44	0.230
TC (mg/dL)	170.35±49.84	176.72±45.41	0.931
HDL (mg/dL)	40.12±13.37	55.60±16.34	**0.000**
LDL (mg/dL)	90.22±40.51	97.91±39.18	0.262
TG (mg/dL)	191.44±72.40	116.55±61.91	**0.000**

Systolic blood pressure (SBP); diastolic blood pressure (DBP); waist circumference (WC); neck circumference (CPESC); sagittal abdominal diameter (SAD); bio impedance fat mass (MG

BIA); fat mass according to air displacement plethysmography (MG ADP); body mass index (BMI); new body mass index (New BMI); waist/hip ratio (WHR); waist/height ratio (WRstt); taper index (TI); visceral adiposity index (VAI); body adiposity index (BAI); serum creatinine (Cr); glomerular filtration rate (GFR); total cholesterol (TC); high density lipoprotein (HDL-c); low density lipoprotein (LDL-c) and triglycerides (TG).

Fasting blood glucose was positively correlated with BMI (r=0.17; p=0.040), new BMI (r=0.17; p=0.040), VAI (r=0.30; p=0.000), LAP (r=0.31; p=0.002), BAE (r=0.18; p=0.003), NC (r=0.24; p=0.004) and SAD (r=0.19; p=0.021). The best correlations with fasting blood glucose were observed with the indicators VAI (r=0.30; p=0.000) and LAP (r=0.31; p=0.002).

As for the lipid profile, represented by the TC, TG, LDL-c and HDL-c fractions. TC was weakly and negatively correlated with WHR (r= -0.19; p=0.010), BSI (r= -0.20; p=0.005) and NC (r= -0.21; p=0.000) and positively with VAI (r=0.20; p=0.007), IAC (r=0.15; p=0.042) and LAP (r=0.24; p=0.001). Serum TG levels were also positively correlated with BMI (r=0.19; p=0.009), new BMI (r=0.19; p=0.009), WRstt (r=0.19; p=0.011), VAI (r=0.81; p=0.000), LAP (r=0.82; p=0.000), BAE (r=0.18; p=0.013), SAD (r=0.27; p=0.002), BF (ADP) (r=0.17; p=0.019) and WC (r=0.19; p=0.011). The anthropometric indicators, VAI (r= 0.81; p=0.000) and LAP (r=0.82; p= 0.000), showed a strong correlation with TG.

Negative and weak correlations of LDL-c with WHR (r=0.19 and p=0.001), BSI (r=0.16; p=0.033), NC (r= -0.18; p=0.016) and WC (r= -0.16; p=0.031). Serum HDL-c levels were negatively correlated with BMI (r= -0.19; p=0.009), new BMI (r= -0.19; p=0.009), WHR (r= -0.31; p =0.000), WRstt (r= -0.17; p= 0.022), VAI (r= -0.58; p=0.000), LAP (r= -0.42; p=0.000), BAE (r= -0.24; p=0.001), NC (r= -0.31; p=0.000), SAD (r= -0.30; p=0.000) and WC (r= -0.29; p=0.000). The WHR (r= -0.31; p=0.000), VAI (r= -0.58; p=0.000) and LAP (r= -0.42; p=0.000), NC (r= -0) indicators .31; p=0.000) and SAD (r= -0.30; p=0.000) showed moderate correlations with HDL-c, as shown in the correlations between anthropometric indicators and cardiometabolic risk factors in table 4.

Table IV. Correlation between anthropometric variables and cardiometabolic risk factors.

Variables	JG	TC	TG	LDL	HDL
BMI (kg/m^2)	0.17**(p=0.040)**	0.02 (p=0.806)	0.19**(p=0.009**)	-0.04(p=0.594)	-0.19**(p=0.009)**
NewBMI(kg/m^2)	0.17**(p=0.040)**	0.02(p=0.806)	0.19**(p=0.009)**	-0.04(p=0.594)	-0.19**(p=0.009)**
WHR	0.16(p=0.060)	-0.19**(p=0.010)**	0.13(p=0.085)	-0.19**(p=0.001)**	-**0.31(p=0.000)**
WRstt	0.16(p=0.050)	-0.03(p=0.635)	0.19**(p=0.011)**	-0.10(p=0.151)	-0.17**(p=0.022)**
VAI	**0.30(p=0.000)**	0.20**(p=0.007)**	**0.81(p=0.000)**	-0.04(p=0.559)	-**0.58(p=0.000)**
BAI (%)	0.07(p=0.419)	0.15**(p=0.042)**	0.09(p=0.196)	0.06(p=0.383)	0.13(p=0.080)
LAP	**0.31(p=0.002)**	0.24**(p=0.001)**	**0.82(p=0.000)**	0.01(p=0.999)	-**0.42(p=0.000)**
BSI	-0.13(p=0.113)	-0.20**(p=0.005)**	-0.07(p=0.325)	-0.16**(p=0.033)**	-0.14(p=0.052)
BAE (%)	0.18**(p=0.003)**	-0.04(p=0.612)	0.18**(p=0.013)**	-0.07(p=0.312)	-0.24**(p=0.001)**
NC (cm) SAD (cm) BF (BIA) (%) BF (ADP) (%) WC (cm)	0.24**(p=0.004)** 0.19**(p=0.021)** 0.05(p=0.534) 0.02(p=0.776) 0.14(p=0.107)	-0.21**(p=0.004)** 0.06(p=0.410) 0.03(p=0.653) 0.09(p=0.223) -0.11(p=0.143)	0.09(p=0.218) 0.27**(p=0.002)** 0.07(p=0.364) 0.17**(p=0.019)** 0.19**(p=0.011)**	-0.18**(p=0.016)** -0.14**(p=0.068)** -0.06(p=0.405) -0.03(p=0.643) -0.16**(p=0.031)**	-**0.31(p=0.000)** -**0.30(p=0.000)** 0.11(p=0.142) 0.11(p=0.149) -0.29**(p=0.000)**

Body Mass Index (BMI); new body mass index (New BMI); waist/hip ratio (WHR); waist/height ratio (RCest); visceral adiposity index (VAI); body adiposity index (BAI); lipid accumulation product (LAP); body shape index (BSI); body adiposity estimator (BAE); fasting glucose (FG); total cholesterol (TC); triglycerides (TG); low density lipoprotein (LDL-c); high density lipoprotein (HDL-c).

In the present study, several nutritional indicators predicting obesity were used to investigate and compare those with better relation to MS in patients with chronic non-dialysis kidney disease. Among these, the VAI and LAP indices stood out for maintaining better correlations with the

cardiometabolic risk factors evaluated. The results corroborate other studies that associate them with more sensitive determinations for MS when compared to other nutritional indices such as BMI, WC, WHR, and WRstt. [31,32]

In this sense, a retrospective design investigation, conducted by Biyik and Guney,[32] with 247 patients with stage 3 to 5 CKD under outpatient follow-up, demonstrated that the LAP and VAI indices showed the best correlations with MS in both genders (r = 0.586 for men *vs* r = 0.455 for women, p <0.001 for both) and (r = 0.558 for men *vs* r = 0.447 for women, p <0.001 for both).

The utility of these two indices proved to be effective in adults, the elderly, women with polycystic ovary syndrome, and more recently in patients with CKD[33,34,35]. Regarding this population, Zhou *et al*[36], based on a multicenter study, concluded that markers of visceral obesity LAP followed by VAI presented higher discriminating values for MS in patients with CKD undergoing dialysis treatment. Both indexes have the advantage of simplicity and low cost, besides being satisfactory in the identification of visceral obesity, one of the main risk factors for MS[7].

Regarding the conformity of nutritional indicators regarding gender, men presented higher averages in WC, NC, WHR, and TI. While, women showed higher averages in BF BIA, BFADP, and BAI. It is known that different sex hormones can affect the distribution of body fat. However, more concise explanations about the disparities in the accumulation and distribution of adiposity in genders have yet to be elucidated.[37]

Patients diagnosed with MS had higher means (SBP, WC, NC, SAD, BF BIA, BFADP, BMI, New BMI, WHR, WRstt, TI, VAI, and TG) and lower mean HDL-c values.[39]MS is characterized by a grouping of risk factors, among which obesity, which is generally associated with the development and progression of MS.[3] Therefore, nutritional indicators predicting obesity function as an important screening tool in the identification of individuals at risk[40]. Those used in the present study showed good association with the presence of MS, except BAI. On the other hand, previous studies have pointed to the BAI as a good predictor index of obesity with positive associations with MS.[41,42,43] Therefore, further studies would be needed for more concise conclusions.

Among the indicators used, those destined to the classification of general obesity are BMI, most often used to assess obesity, because it allows the classification of nutritional status in different stages of life[15,19]; the new BMI proposed to reproduce a better prediction of postoperative complications in colorectal cancer patients when compared to traditional BMI[20]; the TI proposed for the evaluation of obesity and distribution of body adiposity[10]; BAI, BSI and BAE suggested to estimate the percentage of total body fat[23,25,26]. As well as those destined to the classification of central and visceral obesity as WHR traditionally used to measure relative fat distribution by gender[11]; similarly, the WRstt used to classify abdominal obesity in different ethnic groups[21]; The VAI and LAP are indicators of visceral body fat distribution and functionality differentiated by gender[22,24].

Limitations

This study has some limitations, such as (1) cross-sectional design, and cannot infer causality in the results found. (2) this study used the National Cholesterol Education Program (NCEP-ATP III) As a defining criterion for MS, so more studies are needed to determine whether the results are consistent under different criteria.

Advantages

Some advantages in this study stand out, such as the use of more precise techniques, the ADP, considered as the gold standard in the analysis of body composition. In addition, the anthropometric measurements of the participants, applied to the different nutritional indices, were collected by qualified professionals.

CONCLUSION

There is a multiplicity of nutritional variables directed to the analysis of cardiovascular risks in several populations, however, there is no consensus on which would be more applicable in the population of chronic renal patients in the non-dialysis phase. Therefore, the joint use of two or more methods would justify the purpose of more reliable diagnoses.

The results found in this study suggest that the best methods, among the conventional or most recently studied in the literature to predict the risks of cardiovascular diseases in this population, are the VAI and LAP indices.

These indicators can be used as screening methods for the early detection of cardiovascular risks to which the referred population is constantly vulnerable.

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