https://doi.org/10.46389/rjd-2024-1650
www.rjdnmd.org

Rom J Diabetes Nutr Metab Dis
2024; volume 31, issue 3, pages 264–274

Original Article

Diagnostic accuracy of different anthropometric indicators for detecting lipid profile alterations in the Peruvian population

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Received: 2 May 2024 / Accepted: 20 August 2024

Abstract

Dyslipidemias are prevalent cardiovascular risk factors in Latin America. This study aimed to assess the diagnostic accuracy of anthropometric indicators in detecting lipid profile alterations in Peruvian individuals. A diagnostic test study with secondary analysis of the PERU MIGRANT study was conducted using index tests based on waist circumference and skinfold thickness. Outcomes included hypercholesterolemia, low HDL-c, elevated triglycerides, and high total cholesterol to HDL-c ratio (TC/HDL-c). Receiver operating characteristic curves and area under the curve (AUC) were assessed with optimal cutoff points determined by the Youden index, stratified by sex. A number of 972 participants were included. Waist circumference showed the highest AUC for hypercholesterolemia (0.65 in women, 0.67 in men). The waist-to-height ratio showed the highest AUC for elevated triglycerides (AUC: 0.66). For low HDL-c, waist-to-hip ratio in women (AUC: 0.62) and waist-to-height ratio in men (AUC: 0.65) performed best. Waist-to-height ratio demonstrated AUCs ≥0.70 for elevated TC/HDL-c ratio in both sexes, with waist circumference having an AUC of 0.71 in men. Waist-based tests demonstrated moderate to high diagnostic capabilities for lipid alterations, particularly for elevated TC/HDL-c ratio. Further research is needed to confirm these findings.

Keywords: dyslipidemia, waist circumference, skinfold thickness, ROC curve.

Introduction

Cardiovascular diseases (CVD) represent a global public health challenge due to the significant impact on mortality rates and the diminished quality of life they entail [1]. In Latin America alone, CVD accounted for over 2500 disability-adjusted life years (DALYs) standardized by age in 2020 [1]. Moreover, among the myriad of cardiovascular risk factors, dyslipidemia emerges as a noteworthy independent risk factor [2], with prevalence rates of 34% and 48% for hypercholesterolemia and low levels of high-density lipoprotein cholesterol (HDL-c), respectively, in Latin American populations, [3]. Within this context, low-cost, accessible tools for detecting lipid profile abnormalities and assessing cardiovascular risk, such as anthropometric indicators, may play a critical role [4].

Previous research has reported that different body fat and fat distribution anthropometric indicators are related to altered lipid profiles [5, 6]. For instance, Corvos *et al.* (2018) reported a significant association between body mass index (BMI) and total cholesterol (TC), triglycerides (TG), and HDL-c [5]. Similarly, Gonzáles Sandoval *et al.* (2014) observed significant correlations between BMI and waist circumference (WC) with different lipid profile components [6]. However, there is a scarcity of diagnostic accuracy studies analyzing the performance of anthropometric indicators in detecting lipid profile alterations.

Existing evidence suggests that BMI, WC, waist-to-hip ratio (WHR), and waist-to-height ratio (WHtR) exhibit acceptable diagnostic performances for detecting altered levels of lipid profile components and cardiovascular disease [4, 7–10]. However, the diagnostic accuracy and cutoff points vary depending on the studied population and the methodology used. This highlights the importance of considering multiple anthropometric measures together for a more precise evaluation tailored to the specific study population, particularly in the Latin American population, considering the lack of studies within this ethnic group. Additionally, measurement of other low-cost anthropometric indicators, such as skinfold thickness, could be diagnostically useful, given the significant association between certain skinfold thicknesses with plasma TG and HDL-c [11].

Altogether, this emphasizes the need for a comprehensive approach considering multiple anthropometric measures to evaluate cardiovascular risk factors associated with dyslipidemias. Further research is essential to refine these measures and strengthen their clinical utility in identifying cardiovascular risk factors [4, 8]. Therefore, this study aimed to explore the diagnostic accuracy of different anthropometric indicators for determining alterations in the lipid profile among the adult Peruvian population.

Material and methods

Study design

Analytical cross-sectional study using the PERU MIGRANT database study (primary study), conducted by “CRÓNICAS Center of Excellence in Chronic Diseases” between 2007 and 2008. The primary study aimed to assess differences in cardiovascular risk factors among urban, rural, and urban-rural migrant populations.

Population and sample

The original study population included residents of San José de Secce (a rural Andean area in Ayacucho) and Pampas de San Juan de Miraflores (an urban area in Lima, the capital of Peru). Participants aged 30 years or older, without mental illnesses or pregnancy, were selected through simple random sampling based on censuses conducted in 2006 and 2007. Details regarding selection criteria, evaluated variables, sample size, and participation rates are previously published in the protocol of the original study [12]. For the present study, participants with missing values in the index tests and outcome variables were excluded. Finally, 972 participants were included in the data analysis for this study.

Variables and measures

Hypercholesterolemia, low HDL-c, elevated plasma TG, and high CT/HDL-c ratio were the response variables. Hypercholesterolemia was defined as ≥200 mg/dl of TC [13] and low HDL-c as <40 mg/dl in males and <50 mg/dl in females [14]. Plasma TG ≥150 mg/dl [13, 14] and a CT/HDL-c ratio ≥4.5 [15] were considered elevated. The inclusion of the latter indicator was based on its reported association as a predictor of cardiovascular events [15] and arterial stiffness [16].

Different anthropometric indicators based on waist circumference and skinfold thickness were examined as index tests. Sex-specific cutoff points were determined for each index test and further classified as high or low. All analyzed anthropometric indices are shown in Table 1.

Laboratory measurements

Laboratory evaluations were conducted by trained personnel. Venous samples were collected in the morning after a minimum fasting period of 8 hours. Levels of TC, TG, and HDL-c were determined in serum using an automated Cobas® Modular Platform analyzer with reagents supplied by Roche Diagnostics. Glucose and basal insulin were measured in plasma and whole blood, respectively. Glucose measurement was performed using the enzymatic colorimetric technique (GOD-PAP; modular P-E/Roche-cobas, Grenzach-Wyhlen, Germany), and insulin measurement was conducted using electrochemiluminescence (modular P-E/Roche-cobas).

Table 1: Assessed anthropometric index test.

Index text based on:	Desciption
Waist circumference	
Waist circumference (cm)	Measured at the lower rib and crest mid-distance
Waist to hip ratio	Waist (cm)/hip (cm)
Waist to hieght ratio	Waist (cm)/height (cm)

Table 1: Continued.

Index text based on:	Desciption
Skinfold thickness	
Biceps (mm)	Skinfold thickness at the bicipital site
Triceps (mm)	Skinfold thickness at the tricipital site
Supraspinal (mm)	Skinfold thickness at the supraspinal site
Subscapular (mm)	Skinfold thickness at the subscapular site
Upper limb (mm)	Sum of biceps + triceps skinfolds (mm)
Trunk (mm)	Sum of supraspinal + subscapular skinfolds (mm)
Sum of skinfold (mm)	Sum of all 4 site skinfolds

Anthropometric measurements

Waist circumference was measured at the midpoint between the lower rib and the iliac crest using a SECA 201 anthropometric tape designed to measure waist circumference with a precision of 1 mm. Height was measured with the participant in the Frankfurt plane with an accuracy of 0.1 cm using a stadiometer and standard stools. Weight was recorded with an accuracy of 0.05 kg, with the individual wearing light clothing using an electronic scale (SECA model 940). BMI was calculated using the formula (Weight/Height in meters^2). Waist-to-hip and waist-to-height ratios were obtained by dividing waist circumference by hip and height circumferences, respectively, in centimeters.

Four skinfold thicknesses (biceps, triceps, subscapular, supraspinal, and their combined sum) were measured by a fieldworker using a Holtain Tanner/Whitehouse caliper calibrated to 0.2 mm. All skinfold thicknesses were measured in triplicate within a measurement circuit. Ensuring no consecutive measurement of the same skinfold thickness avoided potential biases. The average of the three measurements for each skinfold thickness was calculated and used for subsequent estimations. Measurement standardization was based on the average of monthly observations conducted by the same observer before the study. Each fieldworker performed duplicate measurements on at least 10 subjects.

Covariates

Age in years, BMI in kg/m^2, migration group, smoking status, alcohol consumption, physical activity level, education level, socioeconomic status, history of hypertension, history of diabetes mellitus, and insulin resistance were considered covariates. Regarding the migration group, individuals born and residing in Ayacucho were classified as rural, those born and residing in Lima as urban, and those born in Ayacucho but residing in Lima at the time of data collection as migrants. Responses for smoking and alcohol consumption were reported using an adapted version of the WHO STEPS questionnaire [17], while physical activity levels were defined following the International Physical Activity Questionnaire (IPAQ) protocol [18]. Hypertension was defined as systolic blood pressure ≥140 mm Hg or diastolic blood pressure ≥90 mm Hg or by self-report of antihypertensive medication or previous diagnosis [19]. Diabetes mellitus was defined as fasting plasma glucose ≥126 mg/dl or glycosylated hemoglobin ≥6.5% or self-report of antidiabetic medication or previous diagnosis.

Statistical analysis

STATA v17.0 was used for analysis. Descriptive analyses included frequencies and percentages for categorical variables and medians with interquartile ranges (25th to 75th percentiles) for numerical variables. Bivariate analysis was conducted using the chi-square test for categorical variables and the Mann-Whitney test for numerical variables. The diagnostic accuracy of each anthropometric index was evaluated using receiver operating characteristic (ROC) curves and the corresponding area under the curve (AUC). ROC curves were stratified by sex. Sensitivity, specificity, positive and negative predictive values were calculated. Optimal cutoff points specific to each anthropometric index according to sex were determined using the Youden index.

Ethical considerations

The original study was approved by the Universidad Peruana Cayetano Heredia ethics committee (Code 60014). Participants were provided with a detailed explanation of

https://doi.org/10.46389/rjd-2024-1650

Table 2: Sample characteristics and bivariate analysis by sex.

Characteristics	Total n (%)	Female (n=518) n (%)	Male (n=454) n (%)	p**
Age*	47 (38–56)	46 (38–55)	47 (39–56)	0.759
BMI (kg/m²)*	25.9 (23.2–28.9)	26.9 (23.6–30.4)	25.2 (22.7–27.6)	<0.001
Migration Group				
Rural	197 (20.27)	103 (52.28)	94 (47.72)	
Migrant	579 (59.57)	308 (53.2)	271 (46.8)	0.898
Urban	196 (20.16)	107 (54.59)	89 (45.41)	
Educational level				
None/Incomplete primary	320 (32.99)	232 (72.5)	88 (27.5)	
Complete primary	148 (15.26)	76 (51.35)	72 (48.65)	<0.001
High School	502 (51.75)	210 (41.83)	292 (58.17)	
Socioeconomic status				
Low	340 (34.98)	197 (57.94)	143 (42.06)	
Middle	323 (33.23)	182 (56.35)	141 (43.65)	0.002
High	309 (31.79)	139 (44.98)	170 (55.02)	
Smoking				
No	863 (88.79)	499 (57.82)	364 (42.18)	<0.001
Yes	109 (11.21)	19 (17.43)	90 (82.57)	
Alcohol intake				
Low	888 (91.36)	507 (57.09)	381 (42.91)	<0.001
High	84 (8.64)	11 (13.1)	73 (86.9)	
Physical activity level				
Low	249 (25.83)	137 (55.02)	112 (44.98)	
Moderate	282 (29.25)	179 (63.48)	103 (36.52)	<0.001
High	433 (44.92)	198 (45.73)	235 (54.27)	
Hypertension				
No	768 (79.01)	395 (51.43)	373 (48.57)	0.024
Yes	204 (20.99)	123 (60.29)	81 (39.71)	
Diabetes Mellitus				
No	915 (94.14)	485 (53.01)	430 (46.99)	0.473
Yes	57 (5.86)	33 (57.89)	24 (42.11)	
Insulin resistance				
No	798 (82.1)	394 (49.37)	404 (50.63)	<0.001
Yes	174 (17.9)	124 (71.26)	50 (28.74)	
Anthropometric index text				
Based on WC*				
WC (cm)	85.82 (78.5–93.5)	85.2 (76.7–94.6)	86.3 (80.2–93.3)	0.031
WHR	0.92 (0.87–0.97)	0.89 (0.84–0.94)	0.95 (0.91–0.99)	<0.001
WtHR	0.55 (0.51–0.60)	0.57 (0.52–0.64)	0.54 (0.50–0.58)	<0.001

Table 2: Continued.

Characteristics	Total n (%)	Female (n=518) n (%)	Male (n=454) n (%)	p**
Based on skinfolds*				
Biceps (mm)	7.8 (5.1–13.5)	11.7 (7.5–18.3)	5.3 (4.0–7.4)	<0.001
Triceps (mm)	19.1 (11.3–31.1)	27.8 (18.5–36.7)	11.6 (8.5–17.3)	<0.001
Supraspinal (mm)	25.3 (16.8–31.9)	27.6 (19.2–33.7)	22.1 (14.3–29.3)	<0.001
Subscapular (mm)	18.5 (13.5–25.7)	21.8 (16.3–28.3)	16 (11.3–20.4)	<0.001
Upper limb (mm)	27.3 (16.9–44.6)	40.5 (26.9–54.8)	17.3 (12.5–25.6)	<0.001
Trunk (mm)	44.4 (31.3–56.9)	50.8 (35.5–60.6)	38.4 (25.8–49.5)	<0.001
The sum of skinfold (mm)	71.9 (50.8–101.0)	92.5 (63.5–115)	57.5 (38.9–76.6)	<0.001
Lipid profile outcomes*				
Total cholesterol (mg/dl)	181 (156–208)	183 (157–212)	178 (154–204)	0.249
Triglycerides (mg/dl)	130 (91–185)	128 (90–182)	132.5 (94–190)	0.315
HDL-c (mg/dl)	42 (36–50)	44 (37–51)	41 (36–48)	<0.001
TC/HDL-c ratio	4.21 (3.4–5.2)	4.11 (3.36–5.17)	4.3 (3.48–5.30)	0.042
Hypercholesterolemia				
No	670 (68.93)	342 (51.04)	328 (48.96)	0.036
Yes	302 (31.07)	176 (58.28)	126 (41.72)	
Elevated triglycerides				
No	586 (60.29)	316 (53.92)	270 (46.08)	0.626
Yes	386 (39.71)	202 (52.33)	184 (47.67)	
Low HDL-c				
No	416 (42.8)	157 (37.74)	259 (62.26)	<0.001
Yes	556 (57.2)	361 (64.93)	195 (35.07)	
High TC/HDL-c ratio				
No	562 (57.82)	313 (55.69)	249 (44.31)	0.079
Yes	410 (42.18)	205 (50.00)	205 (50.00)	

Note: WC – waist circumference; WHR – Waist-hip ratio; WtHR – Waist to height ratio; TC/HDL-c – Total cholesterol/HDL-cholesterol ratio; * – Median (p25 to p75). Medians were compared with the Mann-Whitney test. ** – Assessed with Chi-square of independence test.

the study's purpose, and informed consent was obtained. Ethical standards of the Helsinki Declaration were adhered to. As this study involved secondary analysis using openly accessible data [20], there was no direct interaction with participants, thus avoiding potential risks.

Results

Out of the total participants in the original study (n=989), 17 subjects were excluded due to missing values in index tests (n=16) and outcomes (n=1). Finally, 972 participants were included.

The median age was 47 years. The female sex represented 53%, and almost two-thirds belonged to the rural-urban migrant group. Regarding lifestyle, smoking and alcohol intake were low prevalent (11.21% and 8.64%, respectively). The prevalence of hypercholesterolemia, elevated triglycerides, low HDL-c levels, and high CT/HDL-c ratio was 31.07%, 39.71%, 57.2%, and 42.18%, respectively. Bivariate analysis revealed that age, plasma TC, and TG did not differ statistically between sexes.

https://doi.org/10.46389/rjd-2024-1650

Similarly, all other characteristics, except for the migration group, history of diabetes mellitus, elevated triglycerides, and high TC/HDL-c ratio, were associated with sex (Table 2).

Regarding the diagnostic accuracy analysis for hypercholesterolemia, waist circumference exhibited the highest AUC in women, with a sensitivity and specificity of 84.1% and 45.0%, respectively. For men, both waist circumference and upper limb skinfolds had the highest AUC (sensitivity and specificity of 64.3%, 70.4% and 66.7% and 67.4%, respectively). In the case of elevated triglycerides, the waist-to-height ratio had the highest AUC in both women and men (Table 3). For detecting low HDL-c levels, the waist-to-hip ratio in women (sensitivity: 62.60%; specificity: 60.50%) and waist-to-height ratio in men (sensitivity: 70.8%; specificity: 59.80%) performed best. For detecting a high TC/HDL-c ratio, the index test with the highest performance was the waist-to-height ratio in women (sensitivity: 78.5%; specificity: 60.40%), while in men, both waist-to-height ratio (sensitivity: 81.00%; specificity: 61.40%) and waist circumference (sensitivity: 82.40%; specificity: 59.40%) showed the highest performances (Table 4).

Table 3: Diagnostic accuracy of anthropometric index tests for hypercholesterolemia and elevated plasma triglycerides, stratified by sex.

	Hypercholesterolemia					
	Cutoff	AUC (CI 95%)	S (%)	Sp (%)	PPV (%)	NPV (%)
Female						
Based on WC						
WC (cm)	80.78	0.65 (0.61–0.68)	84.10	45.00	44.00	84.60
WHR	0.84	0.62 (0.59–0.65)	93.20	31.30	41.10	89.90
WtHR	0.53	0.64 (0.61–0.68)	87.50	40.90	43.30	86.40
Based on skinfold						
Biceps (mm)	9.73	0.62 (0.58–0.66)	78.40	46.20	42.90	80.60
Triceps (mm)	18.23	0.61 (0.58–0.65)	91.50	31.30	40.70	87.70
Supraspinal (mm)	24.17	0.6 (0.56–0.64)	77.80	42.40	41.00	78.80
Subscapular (mm)	25.03	0.63 (0.59–0.68)	56.30	70.50	49.50	75.80
Upper limb (mm)	41.57	0.62 (0.58–0.67)	64.20	59.90	45.20	76.50
Trunk (mm)	45.63	0.61 (0.57–0.66)	75.00	47.70	42.40	78.70
The sum of skinfold (mm)	88.23	0.64 (0.6–0.68)	72.20	56.10	45.80	79.70
Male						
Based on WC						
WC (cm)	88.9	0.67 (0.63–0.72)	64.30	70.40	45.50	83.70
WHR	0.96	0.65 (0.60–0.70)	66.70	63.40	41.20	83.20
WtHR	0.55	0.66 (0.61–0.71)	69.80	61.90	41.30	84.20
Based on skinfold						
Biceps (mm)	6.03	0.66 (0.61–0.71)	62.70	68.90	43.60	82.60
Triceps (mm)	10.83	0.56 (0.52–0.60)	19.80	92.10	49.00	74.90
Supraspinal (mm)	18.23	0.66 (0.62–0.70)	86.50	44.50	37.50	89.60
Subscapular (mm)	16.17	0.65 (0.60–0.70)	70.60	59.50	40.10	84.10
Upper limb (mm)	18.97	0.67 (0.62–0.72)	66.70	67.40	44.00	84.00
Trunk (mm)	43.58	0.65 (0.60–0.70)	58.70	71.00	43.80	81.80
The sum of skinfold (mm)	63.7	0.66 (0.61–0.71)	59.50	71.60	44.60	82.20

Table 3: Continued.

	Elevated triglyceride					
	Cutoff	AUC (CI 95%)	S (%)	Sp (%)	PPV (%)	NPV (%)
Female						
Based on WC						
WC (cm)	85.75	0.65 (0.61–0.69)	66.80	63.30	53.80	74.90
WHR	0.89	0.65 (0.61–0.69)	67.30	62.00	53.14	74.80
WtHR	0.57	0.66 (0.62–0.70)	68.80	63.30	54.50	76.00
Based on skinfold						
Biceps (mm)	8.37	0.59 (0.56–0.63)	83.20	35.40	45.20	76.70
Triceps (mm)	33.23	0.58 (0.54–0.62)	45.00	70.90	49.70	66.90
Supraspinal (mm)	22.63	0.58 (0.55–0.62)	78.20	38.60	44.90	73.50
Subscapular (mm)	24.23	0.62 (0.57–0.66)	54.00	69.00	52.70	70.10
Upper limb (mm)	39.1	0.59 (0.55–0.64)	63.40	55.10	47.40	70.20
Trunk (mm)	35.7	0.60 (0.56–0.63)	86.60	33.20	45.30	79.50
The sum of skinfold (mm)	102.73	0.60 (0.55–0.64)	49.50	6.90	51.30	68.40
Male						
Based on WC						
WC (cm)	83.82	0.65 (0.61–0.69)	79.30	51.10	52.50	78.40
WHR	0.94	0.65 (0.61–0.70)	75.50	54.80	53.30	76.70
WtHR	0.55	0.66 (0.62–0.71)	65.80	66.70	57.30	74.10
Based on skinfold						
Biceps (mm)	4.77	0.62 (0.58–0.67)	73.90	50.40	50.40	73.90
Triceps (mm)	10.5	0.53 (0.49–0.56)	14.70	90.40	50.90	60.80
Supraspinal (mm)	17.57	0.62 (0.58–0.66)	81.00	43.70	49.50	77.10
Subscapular (mm)	13.9	0.63 (0.59–0.68)	77.20	49.60	51.10	76.10
Upper limb (mm)	17.73	0.62 (0.58–0.67)	62.00	62.20	52.80	70.60
Trunk (mm)	31.7	0.64 (0.60–0.68)	82.10	45.20	50.50	78.70
The sum of skinfold (mm)	56.37	0.63 (0.59–0.68)	66.80	59.60	53.00	72.50

Note: AUC – Area under the curve; WC – waist circumference; WHR – Waist-hip ratio; WtHR – Waist to height ratio; S – sensitivity; Sp – specificity; PPV – positive predictive value; NPV – negative predictive value; CI – confidence interval 95%.

Discussion

Waist circumference-based tests exhibited the highest diagnostic accuracy in both sexes for all outcomes.

For hypercholesterolemia, WC exhibited the best diagnostic performance in both sexes, with an AUC of 0.65 and 0.67 for women and men, respectively. These results align with a systematic review reporting similar diagnostic performances for WC in cardiovascular disease [7]. This association underscores the link between central obesity and the onset of dyslipidemias [21, 22]. Furthermore, in men the combined assessment of triceps and biceps skinfolds exhibited an AUC comparable to that of WC. Notably, the triceps skinfold demonstrated the highest specificity among all measured skinfolds, potentially contributing to the enhanced AUC compared to individual measures. Nonetheless, interpreting these outcomes requires caution, as central visceral and subcutaneous adiposity, rather than peripheral subcutaneous fat, correlates more closely with cardiovascular risk [23].

 https://doi.org/10.46389/rjd-2024-1650

In both sexes, the WtHR demonstrated moderate diagnostic capacity, with an AUC of 0.66 for elevated plasma triglycerides. These findings are consistent with studies conducted in adult populations in Austria (AUC: 0.67), China (AUC: 0.69), and among Asian populations (AUC: 0.67) [9, 24, 25], albeit lower than those reported in adults in Pakistan (AUC=0.75) [10]. Notably, the latter study excluded participants with diabetes mellitus and arterial hypertension, differing from the population studied in our research, which included individuals with metabolic disorders.

Regarding low HDL-c, the WtHR in men (AUC: 0.65) and the WHR in women (AUC: 0.62) exhibited the highest diagnostic capacity. These findings align with those reported in the adult Peruvian population (AUC: 0.64 for WtHR in men and AUC: 0.59 for WHR in women) [26].

Similar diagnostic performances have been reported in Hispanic and Asian populations [24, 27]. Given the high prevalence of low HDL-c in Latin America [3, 28], the integration of these anthropometric measures into clinical practice holds significant value.

Table 4: Diagnostic accuracy of anthropometric index tests for low HDL-c and high TC/HDL-c ratio, stratified by sex.

	Low HDL-c					
	Cut-off	**AUC (CI 95%)**	**S (%)**	**Sp (%)**	**PPV (%)**	**NPV (%)**
Female						
Based on WC						
WC (cm)	85.35	0.60 (0.55–0.64)	55.40	63.70	77.80	38.30
WHR	0.88	0.62 (0.57–0.66)	62.60	60.50	78.50	41.30
WtHR	0.55	0.59 (0.55–0.64)	68.40	49.70	75.80	40.60
Based on skinfold						
Biceps (mm)	7.23	0.56 (0.52–0.60)	81.40	29.90	72.80	41.20
Triceps (mm)	11.53	0.53 (0.50–0.56)	95.30	10.80	71.10	50.00
Supraspinal (mm)	26.73	0.55 (0.50–0.6)	56.80	52.90	73.50	34.70
Subscapular (mm)	20.37	0.56 (0.51–0.61)	60.70	51.00	74.00	36.00
Upper limb (mm)	35.77	0.55 (0.50–0.60)	60.10	49.70	73.30	35.10
Trunk (mm)	43.33	0.55 (0.51–0.60)	67.90	42.70	73.10	36.60
The sum of skinfold (mm)	71.83	0.55 (0.51–0.59)	71.70	38.20	72.80	37.00
Male						
Based on WC						
WC (cm)	84.23	0.64 (0.60–0.68)	75.40	52.50	54.40	73.90
WHR	0.95	0.61 (0.57–0.66)	65.60	56.40	53.10	68.50
WtHR	0.54	0.65 (0.61–0.70)	70.80	59.80	57.00	73.10
Based on skinfold						
Biceps (mm)	5.13	0.6 (0.55–0.64)	66.20	53.70	51.80	67.80
Triceps (mm)	10.2	0.53 (0.50–0.56)	17.40	88.80	54.00	58.80
Supraspinal (mm)	17.83	0.60 (0.56–0.64)	76.90	43.20	50.50	71.30
Subscapular (mm)	14.17	0.62 (0.57–0.66)	73.30	50.20	52.60	71.40
Upper limb (mm)	16.47	0.58 (0.54–0.63)	63.60	52.90	50.40	65.90
Trunk (mm)	31.7	0.61 (0.57–0.65)	78.50	43.60	51.20	72.90
The sum of skinfold (mm)	51.53	0.61 (0.56–0.65)	71.30	49.80	51.70	69.70

Table 4: Continued.

	High TC/HDL-c ratio					
	Cutoff	**AUC (CI 95%)**	**S (%)**	**Sp (%)**	**PPV (%)**	**NPV (%)**
Female						
Based on WC						
WC (cm)	81.88	0.69 (0.66 – 0.73)	83.90	54.60	54.80	83.80
WHR	0.89	0.68 (0.64 – 0.72)	75.10	61.00	55.80	78.90
WtHR	0.56	0.70 (0.66 – 0.73)	78.50	60.40	56.50	81.10
Based on skinfold						
Biceps (mm)	13.37	0.65 (0.61 – 0.69)	60.00	69.60	56.40	72.70
Triceps (mm)	33.23	0.60 (0.56 – 0.65)	61.50	59.40	49.80	70.20
Supraspinal (mm)	23.83	0.62 (0.58 – 0.66)	79.50	44.40	48.40	76.80
Subscapular (mm)	23.67	0.66 (0.61 – 0.70)	60.00	71.20	57.70	73.10
Upper limb (mm)	43.80	0.64 (0.60 – 0.68)	61.00	67.10	54.80	72.40
Trunk (mm)	47.40	0.64 (0.60 – 0.68)	73.70	55.00	51.70	76.10
The sum of skinfold (mm)	81.80	0.64 (0.60 – 0.68)	76.60	51.10	50.60	76.90
Male						
Based on WC						
WC (cm)	84.23	0.71 (0.67 – 0.75)	82.40	59.40	62.60	80.40
WHR	0.93	0.69 (0.65 – 0.73)	81.50	57.00	60.90	78.90
WtHR	0.53	0.71 (0.67 – 0.75)	81.00	61.40	63.40	79.70
Based on skinfold						
Biceps (mm)	4.83	0.68 (0.64 – 0.72)	78.50	57.00	60.10	76.30
Triceps (mm)	10.07	0.56 (0.53 – 0.59)	18.00	93.60	69.80	58.10
Supraspinal (mm)	16.17	0.69 (0.65 – 0.72)	90.20	47.00	58.40	85.40
Subscapular (mm)	14.43	0.70 (0.66 – 0.74)	79.00	61.00	62.50	77.90
Upper limb (mm)	13.83	0.68 (0.64 – 0.72)	87.40	48.20	58.30	82.80
Trunk (mm)	31.70	0.70 (0.66 – 0.73)	87.30	51.80	59.90	83.20
The sum of skinfold (mm)	44.70	0.70 (0.66 – 0.73)	89.30	4.80	59.40	84.90

Note: AUC – Area under the curve; WC – waist circumference; WHR – Waist-hip ratio; WtHR – Waist to height ratio; S – sensitivity; Sp – specificity; PPV – positive predictive value; NPV – negative predictive value; CI – confidence interval 95%.

The TC/HDL-c ratio, known for its atherogenic properties, has shown a robust predictive capacity for atherosclerotic cardiovascular disease [15, 16, 29]. It is highly correlated with the total number of LDL particles and can outperform LDL-c as a predictor of cardiovascular events, especially when LDL-c values are within normal or low ranges [29].

Moreover, as it can be derived at no additional cost from conventional lipid profiles, it proves to be clinically useful and practical in resource-limited settings [29]. The most promising results for this outcome were observed in men for WC and WtHR and in women for WtHR, all with an AUC ≥0.70. These tests showed a sensitivity close to 80% in women and even higher in men. Given the high TC/HDL-c ratios among Latin Americans, the use of these markers with their corresponding cutoff points is relevant [28]. Therefore, a cutoff point of 0.56 for the WtHR in women is proposed. For

 https://doi.org/10.46389/rjd-2024-1650

men, cutoff points of 84.23 cm for WC and 0.53 for the WtHR are suggested.

The study had limitations to consider. Participants were from rural and urban areas originally selected to represent various population groups, so results may not directly apply to the broader Peruvian population. Skinfold measurement technical errors were not reported in the PERU MIGRANT study. However, anthropometric measurements were standardized and taken in triplicate by the same fieldworker [12]. On the other hand, the use of standardized techniques for measuring components of the lipid profile stands out as a strength. Likewise, internationally accepted cutoff points were used for categorizing dyslipidemias.

Conclusion

The high prevalence of dyslipidemias in Latin America, along with their significant contribution to the burden of cardiovascular disease, underscores the need for low-cost indicators with good diagnostic performance. In this context, anthropometric measures, especially those based on waist circumference, prove invaluable in detecting lipid profile abnormalities, as evidenced by the findings of this study, where moderate to high diagnostic accuracy of anthropometric measures based on waist circumference for various lipid profile abnormalities was observed. It highlighted the diagnostic performance of the waist-to-height ratio in women and waist circumference and waist-to-height ratio in men for an elevated total cholesterol/HDL-c ratio. Further research is needed to confirm and validate these findings.

Acknowledgments

The authors express their gratitude to CRONICAS Center of Excellence in Chronic Diseases for making the PERU MIGRANT study database publicly available.

Conflict of interest

The authors declare no conflict of interest.

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