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ORIGINAL RESEARCH

Waist-to-hip ratio cut-off points for overweight and obesity in Peruvian population

Puntos de corte de índice cintura-cadera para sobrepeso y obesidad en población peruana

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Abstract

Introduction: Waist-to-hip ratio (WHR) is an anthropometric indicator of obesity that, contrary to BMI, reflects visceral fat. The WHO recommends establishing specific cut-off points for excess weight by country and/or population group. At present, there are no cut-off points for the Peruvian population.
Objective: To establish WHR cut-off points to identify overweight and obesity in the Peruvian population.
Materials and methods: Cross-sectional analytical study conducted using data from a nationally representative sample of the adult Peruvian population (8 984 men and 11 200 women). An area under the receiver operating characteristic curve (AUC-ROC) analysis was performed to establish the WHR cut-off points for overweight and obesity in men and women according to the presence of overweight and obesity measured using BMI. The strength of the association between WHR cut-off points and BMI cut-off points was assessed using Cramér's V correlation and calculating the Odds Ratio. Furthermore, the chi-square automatic interaction detection (CHAID) method was employed to determine the WHR values most strongly associated with nutritional status according to BMI in men and women.
Results: The AUC-ROC analysis showed that, according to the BMI cut-off points for overweight and obesity, the appropriate WHR cut-off points for overweight and obesity were 0.52 (AUC-ROC: 0.862; p<0.001) and 0.57 (0.934; p<0.001) for men and 0.54 (AUC-ROC: 0.876; p<0.001) and 0.59 (AUC-ROC: 0.933; p<0.001) for women. The association between WHR cut-off points and BMI cut-off points was stronger for obesity in both men (OR=70.46) and women (OR=61.98). Sensitivity for overweight was 87% in men and 91% in women, while these values for obesity were 97% and 96%. Based on the CHAID decision tree, the WHR values most strongly associated with overweight and obesity were 0.580-0.601 and >0.631 in men and 0.579-0.599 and >0.689 in women. Finally, the correlation between BMI and WHR was high in both men and women (Rho=0.843 and 0.861).
Conclusions: WHR showed a high correlation with BMI and is a useful tool for identifying excess weight in Peruvian adults. The proposed cut-off points showed good diagnostic performance, with high sensitivity and acceptable specificity.

Resumen

Introducción. El índice cintura-cadera (ICC) es un indicador antropométrico de obesidad que, a diferencia del IMC, refleja la grasa visceral. La OMS recomienda establecer puntos de corte para exceso de peso específicos para países y/o grupos poblaciones. En la actualidad no hay puntos de corte para población peruana.
Objetivo. Establecer los puntos de corte de ICC para identificar sobrepeso y obesidad en población peruana.
Materiales y métodos. Estudio analítico transversal realizado con datos de una muestra representativa a nivel nacional de población adulta peruana (8 984 hombres y 11 200 mujeres). Se realizó un análisis de área bajo la curva de característica operativa del receptor (AUC-ROC) para establecer los puntos de corte de ICC para sobrepeso y obesidad en hombres y mujeres según la presencia de sobrepeso y obesidad determinada por el IMC. El grado de intensidad de la asociación entre los puntos de corte de ICC y los puntos de corte de IMC se evaluó mediante el coeficiente V de Cramer y el cálculo de Odds Ratio. Además, se usó el método de detección automática de interacciones de chi-cuadrado (CHAID) para determinar los valores de ICC con mayor asociación al estado nutricional según IMC en hombres y mujeres.
Resultados. El análisis de la AUC-ROC mostró que, según los puntos de corte del IMC para sobrepeso y obesidad, los puntos de corte de ICC apropiados para sobrepeso y obesidad fueron 0.52 (AUC-ROC: 0.862; p<0.001) y 0.57 (0.934; p<0.001) para hombres y 0.54 (AUC-ROC: 0.876; p<0.001) y 0.59 (AUC-ROC: 0.933; p<0.001) para mujeres. La asociación entre los puntos de corte del ICC y los del IMC fue más fuerte para la obesidad tanto en hombres (OR=70.46) como en mujeres (OR=61.98). La sensibilidad para sobrepeso fue 87% en hombres y 91% en mujeres, mientras que para obesidad fue 97% y 96%. Según el árbol de decisiones CHAID, los valores de ICC que se asociaron con mayor intensidad a sobrepeso y obesidad fueron 0.580-0.601 y >0.631 en hombres y 0.579-0.599 y >0.689 en mujeres. Finalmente, la correlación entre IMC e ICC fue alta tanto en hombres como mujeres (Rho=0.843 y 0.861).
Conclusiones. El ICC mostró alta correlación con el IMC y se presenta como una herramienta útil para identificar el exceso de peso en adultos peruanos. Los puntos de corte propuestos mostraron un buen rendimiento diagnóstico, con una alta sensibilidad y una especificidad aceptable.

Introduction

Overweight and obesity are defined as an excessive accumulation of fat that can be harmful to health.[1,2] Obesity is a multifactorial disease[1,2] caused by genetic variants, psychosocial factors, and obesogenic environments,[2] but it has been established that modifiable factors such as a sedentary lifestyle, a high-calorie diet, sleep disorders, among others, are the main factors involved in its development.[3] Some complications associated with obesity include diabetes, cancer (mainly endometrial, breast, and colon cancer), cerebrovascular disease, coronary heart disease, gastrointestinal complications, respiratory diseases, musculoskeletal disorders, and others.[4]

Obesity is a public health problem with a global prevalence that has shown a twofold increase among adults and a fourfold increase among adolescents since 1990, reaching pandemic proportions. In this regard, according to the World Health Organization (WHO), in 2022 approximately 2.5 billion adults were overweight and 890 million of them were living with obesity.[2] In Peru, a press release from the Ministry of Health published in 2024 reported that around 15 million people suffered from obesity, which accounts for 62% of the Peruvian population over the age of 15.[5]

Various anthropometric indicators have been used to diagnose overweight and obesity, such as body fat percentage, waist-to-height ratio, waist-to-hip ratio (WHR), tri-ponderal mass index, and body mass index (BMI).[6] The latter is the most widely used due to its simplicity and rapidity of measurement, as it only requires a scale, a height rod, and minimal training to be calculated; however, it has some disadvantages compared to other anthropometric parameters because it does not measure body fat distribution (e.g., it does not recognize the most harmful abdominal fat).

BMI is a limited measure of body fat, making it more prone to misclassifying muscular individuals or those with large bone structures, and it does not provide information on the origin or heterogeneity of obesity. Therefore, its use is more useful for epidemiologic purposes than for individual assessment.[7] On the other hand, WHR is an indicator of visceral fat that is calculated by dividing waist circumference by hip circumference.[6,8] It can be measured more precisely than skinfolds and provides an index of both subcutaneous and intra-abdominal adipose tissue.[9]

While the WHO defined WHR cut-off points for abdominal obesity in 1999 (≥0.90 in men and ≥0.85 in women), in its most recent report on the subject (2008) it indicated that the optimal cut-off points for overweight and obesity, as well as measures of abdominal obesity, vary among population groups and ethnicities. Therefore, there are no cut-off points that are applicable worldwide,[9] a finding that has been confirmed by several studies,[10] and instead, it pointed to the need to establish cut-off points for a specific country, region, or population.

In this regard, after conducting a literature search, we found that no studies reported WHR cut-off points for overweight and obesity specific to the Peruvian population. Consequently, the objective of this research was to establish the WHR cut-off points for identifying overweight and obesity in Peruvian population.

Materials and methods

Study design

Cross-sectional analytical study.

Data

The open-access database used in the study conducted by Pajuelo-Ramírez *et al.*[11] was employed, as it includes data from 20 489 individuals aged ≥20 years (9 142 men and 11 347 women) who participated in the *Encuesta Nacional de Hogares 2013 - ENAHO* (2013 National Household Survey) in Peru. This dataset does not contain records of pregnant women or records with unreliable data.[11] Purposive sampling was used to select records with information on the following variables: WHR, waist circumference, weight, height, and BMI. The database is available on Figshare.[12]

Anthropometric measurements were taken by anthropometric personnel trained by the Centro Nacional de Alimentación y Nutrición (National Center for Food and Nutrition) in accordance with international standards. Waist circumference was measured with the individual in a standing position, placing a tape measure at the midpoint between the last rib and the upper edge of the iliac crest. Hip circumference was measured with the person in a standing position, placing a tape measure around the widest part of the gluteal muscles. Weight and height were measured using a scale and a height gauge, respectively.

Statistical analysis

Data are described using means, standard deviations, and minimums and maximums, as they showed a normal distribution (Kolmogorov-Smirnov test).

To establish the WHR cut-off points for overweight and obesity in Peruvian men and women, an area under the receiver operating characteristic curve (AUC-ROC) analysis was performed according to the presence of overweight and obesity measured by BMI (normal weight: 18-24. 99, overweight: 25-29.99, and obesity: ≥30).[2] As reported in the literature, AUC-ROC values between 0.7 and 0.8 are considered acceptable, values between 0.8 and 0.9 are considered good, and values ≥0.9 are considered excellent.[13] The Spearman's rank correlation coefficient was used to evaluate, stratified by sex, the correlation between BMI and WHR. In other words, BMI and WHR values were analyzed separately in men and women, obtaining two correlation coefficients, one for each group. It should be noted that no mean values or cut-off points were used for this assessment, but rather the individual values of each participant.

Subsequently, the strength of the association between these cut-off points and BMI cut-off points was assessed using Cramér's V coefficient and calculating Odds Ratios with their corresponding 95% confidence intervals (95%CI). The level of agreement between the classifications obtained with the different cut-off points was assessed using the Cohen's Kappa coefficient. Moreover, sensitivity, specificity, positive and negative predictive values, and positive and negative likelihood ratios were calculated.

Finally, the chi-square automatic interaction detection method (CHAID) was used to determine the WHR values most closely associated with nutritional status according to BMI (normal weight, overweight, and obese) in men and women, which is a supervised machine learning method used to predict scenarios and draw conclusions involving logistic regression and decision trees. This predictive model generates decision trees by applying chi-square tests to the variables (represented as nodes), allowing them to be classified and segmented, either as qualitative or quantitative, based on their level of association with the dependent variable. Segmentation is performed using categories with lower and higher probability of occurrence regarding the event of interest, as per the

CHAID algorithm criteria, which divides groups based on statistically significant differences.[14] This study considered three events of interest: normal weight, overweight, and obesity as measured by BMI. Data were processed and analyzed using the SPSS Statistics 25™ program.

Ethical considerations

Although the analyzed data are open access, this research followed the ethical principles for conducting biomedical studies involving human subjects established in the Declaration of Helsinki.[15] In addition, the records are numerically coded, ensuring the anonymity of the individuals surveyed.

Results

Of the 20 489 records available in the open-access database registered by Quispe,[12] 305 were excluded because they lacked data on the variables of interest, resulting in a sample of 20 184 adults (8 984 men and 11 200 women) (Figure 1).

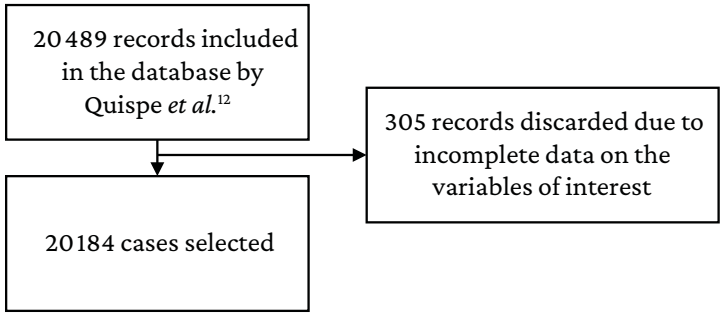

Figure 1. Sample selection flowchart.

The mean WHR was 0.58 (±0.07) and 0.55 (±0.06) in women and men, respectively. The mean BMI was 27.04 (±4.75) and 25.97 (±3.84). The anthropometric characteristics studied in the sample are presented in Table 1.

Table 1. Anthropometric characteristics of the study population by sex.

Anthropometric characteristics	Women				Men			
	Minimum	Maximum	Mean	SD	Minimum	Maximum	Mean	SD
Weight (kg)	26.01	136.10	60.81	11.84	34.74	141.12	68.20	12.21
Height (m)	1.21	1.93	1.50	0.06	1.32	1.94	1.62	0.06
WC (cm)	47.60	144.40	87.92	11.56	58.8	145	89.38	10.35
WHR	0.32	0.96	0.58	0.07	0.35	0.85	0.55	0.06
BMI (kg/m²)	14.66	56	27.04	4.75	13.55	53.32	25.97	3.841

WC: waist circumference; WHR: waist-to-hip ratio; BMI: body mass index; SD: standard deviation.

The AUC-ROC analysis showed that, according to the BMI cut-off points for overweight and obesity, the appropriate WHR cut-off points for overweight and obesity in Peruvian men were 0.52 (AUC-ROC: 0.862, 95%CI: 0.854-0.970; p<0.001) and 0.57 (0.934, 95%CI: 0.928-0.941; p<0.001), and 0.54 (AUC-ROC: 0.876, 95%CI: 0.869-0.883; p<0.001) and 0.59 (AUC-ROC: 0.933, 95%CI: 0.929-0.938; p<0.001) in women (Figure 2).

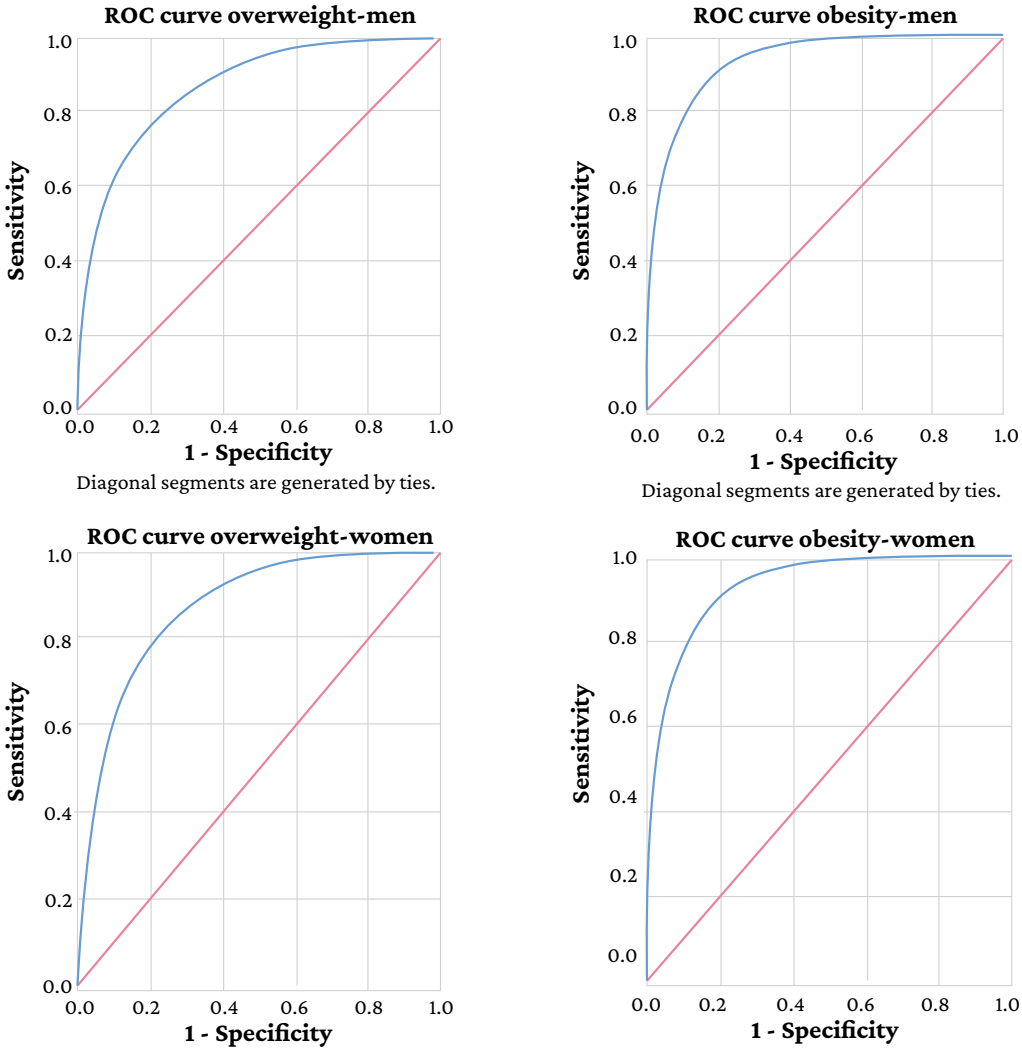

Figure 2. Area under the receiver operating characteristic curve to determine waist-to-hip ratio cut-off points for overweight and obesity in Peruvian men and women based on the presence of overweight and obesity measured using body mass index.

The correlation between BMI and WHR was high in both men (Rho=0.843) and women (Rho=0.861). Furthermore, the association between WHR and BMI cut-off points was stronger for obesity in men (OR=70.46, 95%CI: 56.14-104.48) and women (OR=61.98, 95%CI: 50.38-76.27) (Table 2).

The sensitivity and specificity of the WHR cut-off points for overweight were 87% and 65% in men and 91% and 69% in women, respectively, while they were 97% and 73% in men and 96% and 70% in women for obesity. The remaining diagnostic performance measures are shown in Table 2.

Table 2. Association between WHR cut-off points and BMI cut-off points for overweight and obesity and diagnostic performance measures of BMI cut-off points by sex in Peruvian adults.

	Men (Rho=0.843)		Women (Rho=0.861)	
	Overweight	**Obesity**	**Overweight**	**Obesity**
Cut-off point	**0.52**	**0.57**	**0.54**	**0.59**
OR (95%CI)	12.827 (11.42-14.40)	70.46 (56.14-104.48)	22.46 (19.76-25.49)	61.98 (50.38-76.27)
V	0.536	0.510	0.618	0.570
K	0.532	0.454	0.606	0.501
S	87%	97%	91%	96%
SP	65%	73%	69%	70%
VPP	71%	38%	77%	52%
VPN	84%	99%	87%	98%
LR+	2.51%	3.62	2.90	3.24%
LR-	0.2	0.05	0.13	0.05%

WHR: waist-to-hip ratio; BMI: body mass index; Rho: Spearman's correlation coefficient; OR: Odds Ratio; V: Cramér's V coefficient; K: Cohen's Kappa coefficient; S: sensitivity; SP: specificity; PPV: positive predictive value; NPV: negative predictive value; LR+: positive likelihood ratio; LR-: negative likelihood ratio.

In men, the CHAID decision tree had a depth of 1, with a total of 11 nodes, of which 10 were terminal nodes. The WHR values most strongly associated with normal weight, overweight, and obesity were ≤0.474, 0.580-0.601, and >0.631, respectively (Figure 3).

In women, the CHAID decision tree had a depth of 1, with 11 nodes in total, of which 10 were terminal nodes. The WHR values most strongly associated with normal weight, overweight, and obesity were ≤0.487, 0.579-0.599, and >0.689, respectively (Figure 4).

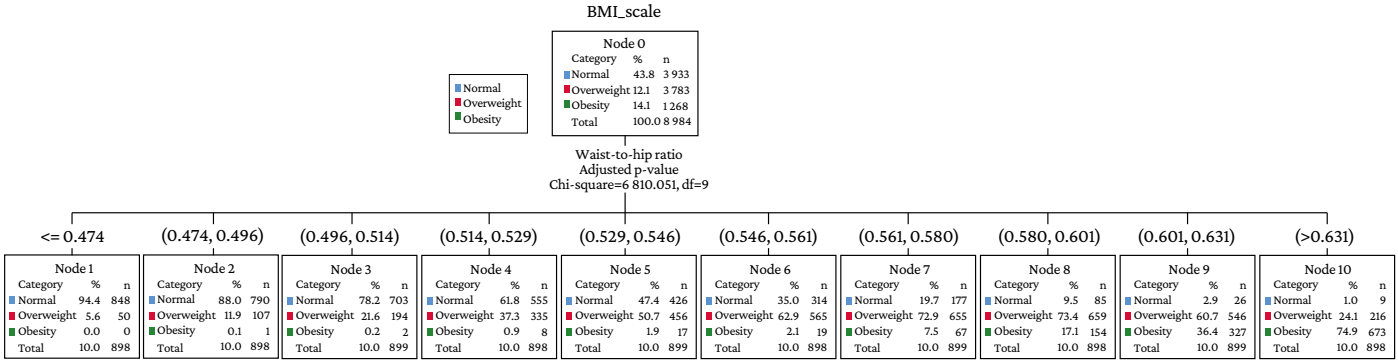

Figure 3. Association between WHR values and presence of normal weight, overweight, and obesity based on BMI in men (CHAID). WHR: waist-to-hip ratio; BMI: body mass index.

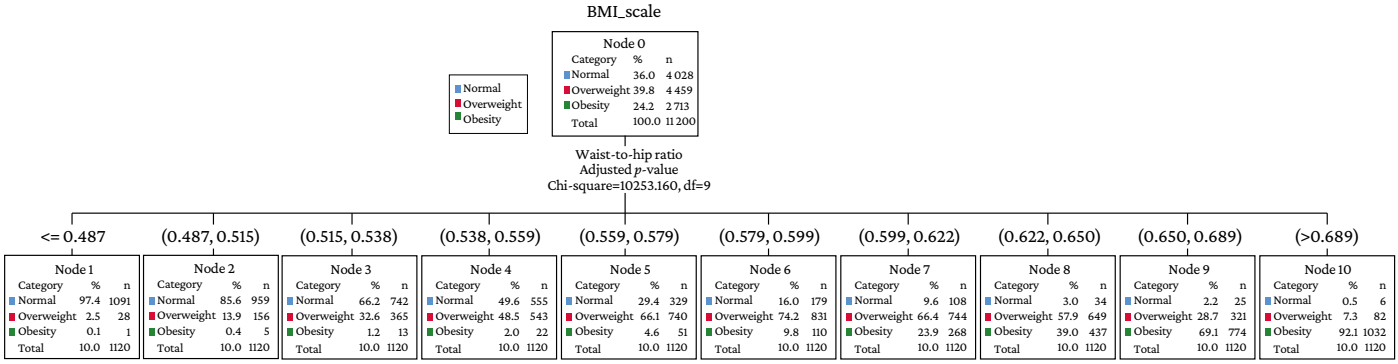

Figure 4. Association between WHR values and presence of normal weight, overweight, and obesity based on BMI in women (CHAID). WHR: waist-to-hip ratio; BMI: body mass index.

Discussion

The objective of this study was to establish WHR cut-off points for detecting overweight and obesity in Peruvian adults. A noteworthy finding is that a very high correlation was observed between WHR and BMI in both men (Rho=0.843) and women (Rho=0.861), indicating that both measures are closely related and could be used complementarily in the assessment of excess weight.

However, beyond this high correlation, WHR offers significant clinical advantages over BMI. While BMI quantifies excess weight without distinguishing between lean mass and fat mass, or their distribution in the body, WHR provides a better approximation of central body fat distribution. This allows for a more accurate assessment of abdominal fat accumulation, an important marker of metabolic and cardiovascular risk, as it is associated with insulin resistance, dyslipidemia, high blood pressure, hyperglycemia, and cardiovascular disease.[16,17]

The proposed cut-off points for identifying overweight and obesity in the Peruvian population were 0.52 and 0.57 in men and 0.54 and 0.59 in women. These values showed robust diagnostic performance, with high sensitivity (87%-97% in men, 91%-96% in women) and acceptable specificity (65%-73% in men, 69%-70% in women). In addition, high negative predictive values and low negative likelihood ratios were observed, supporting the usefulness of WHR as an effective tool for ruling out excess weight in clinical and epidemiological settings.

When comparing the cut-off points obtained in this study with those proposed in research conducted in other countries such as Iran, China, Indonesia, and Oman, significant discrepancies are noted. For example, the proposed WHR cut-off points for obesity in men and women are 0.88 and 0.83 in southeastern Iran,[18,19] 0.86 and 0.77 in Indonesia,[20] 0.91 and 0.91 in Oman,[21] and 0.88 and 0.82 in Ethiopia,[22] while the WHR cut-off points for overweight or obesity proposed for men and women are 0.87 and 0.78 in northeastern Iran,[23] 0.88 and 0.86 in northeastern China,[24] and 0.85 and 0.76 in Taiwan.[25] These differences are likely related to ethnic, genetic, cultural, and environmental variations among populations, including differences in average height, body proportions, fat mass composition, lifestyle, and dietary patterns.

Such findings strengthen the World Health Organization (WHO)[9] recommendation to establish specific cut-off points for each country, region, or ethnic group, as the use of foreign thresholds may lead to misclassification and underestimation of risk in local contexts. In this regard, the present study responds to this need in Peru by proposing cut-off points based on a nationally representative sample, contributing solid and contextualized evidence for nutritional surveillance and the prevention of chronic diseases in the country.

Given that these values differ from those reported in other populations, the findings support the need to establish specific cut-off points for each country or region, taking into account local anthropometric characteristics.[9] Using WHR, as it provides a better approximation to body fat distribution, can complement or even improve the identification of metabolic risk over BMI because, as mentioned above, it reflects abdominal fat accumulation more accurately, which is closely associated with insulin resistance, dyslipidemia, hypertension, and other components of metabolic syndrome.[16,17,26,27]

It is clear that the WHR cut-off points for obesity proposed in this study for the Peruvian population (0.57 in women and 0.59 in men) are considerably lower than those reported in other populations, including the values initially suggested by the WHO in 1999 (0.85 for women and 0.90 for men).[9] However, this discrepancy could be related to

a smaller body surface area, as it has been reported that Peruvians are among the shortest people in the world.[28,29]

In this regard, it has been suggested that height could affect body dimensions and fat distribution, modifying the relationship between anthropometric measurements and cardiometabolic risk indicators. For example, Rangel-Baltazar *et al.,*[30] in a study of 3 550 Mexican adults (≥20 years old), found that height modifies the cut-off point of the WHR for predicting cardiovascular risk, which is higher in shorter people than in people with normal height (men: 0.58 vs. 0.56; women: 0.63 vs. 0.58). In the case of obesity, as observed in this study with the Peruvian population, the relationship would be direct, and a shorter stature would result in a lower WHR cut-off point. This hypothesis is relevant considering that, as evidenced above, these cut-off points have been calculated in only a few countries, all of which have populations with much taller average heights; therefore, similar studies are needed in other countries with shorter populations to confirm this hypothesis.

From this perspective, the use of specific cut-off points for the Peruvian population could improve the early detection of people at risk of cardiometabolic diseases, allowing for more timely interventions in primary care. For example, a health center in the Peruvian highlands could incorporate these adapted cut-off points into its routine screening to optimize nutritional risk classification. Likewise, in local epidemiological studies, the use of national cut-off points instead of international values could prevent a bias in the estimation of obesity prevalence and its associated factors, which is especially relevant given that untreated abdominal obesity can lead to complications such as type 2 diabetes, high blood pressure, dyslipidemia, and cardiovascular disease.[31]

One of the strengths of this study is the use of an extensive database that is representative of the Peruvian adult population, as well as the use of robust statistical methods, including ROC curves, correlation coefficients, and CHAID classification trees, which allowed us to validate the proposed cut-off points using a multidimensional approach.

Limitations include the fact that the relationship between height, body proportions, and fat distribution can influence WHR estimates, although further anthropometric and physiological evidence is still needed to establish more precise adjustments. Furthermore, although BMI was used as a diagnostic reference despite its limitations as an indirect measure of adiposity, this decision was methodologically necessary since direct methods for measuring body fat are not feasible in large-scale studies.

Conclusions

WHR showed a strong correlation with BMI and is a useful tool for identifying excess weight in Peruvian adults. The proposed cut-off points for overweight and obesity (0.52 and 0.57 in men and 0.54 and 0.59 in women) had a good diagnostic performance, with high sensitivity and acceptable specificity, providing reference values adapted to the Peruvian anthropometric profile that can be used for early interventions.

Given that WHR measurement is accessible and easily integrated into primary care, it is proposed to use it as a complementary tool in nutritional and metabolic risk assessment in the Peruvian population.

Finally, as part of the validation and regulatory consensus process, it is suggested that these findings be presented to the competent authorities in the country for the official inclusion of these cut-off points in nutritional assessment and metabolic risk protocols.

Conflicts of interest

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