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Diagnostic Performance of Anthropometric Weight and Height Markers Associated With Insulin Resistance Diagnosis

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Abstract

Background: The detection of insulin resistance (IR) is crucial to avoid long-term complications. Given that the classic methods for its measurement are challenging to implement, simpler methods are sought for its detection. The aim of the study is to determine the association and diagnostic performance of four anthropometric markers based on weight and height for IR in a sample of Peruvians.

Methods: This study is a secondary analysis of the data. The variables were body mass index (BMI), the triponderal index (TPI), the new BMI (NBMI), and the University of Navarra Clinic-Body Fat Estimator index (CUN-BAE index). IR was measured using the homeostatic model assessment of insulin resistance (HOMA-IR). The association was evaluated using the odds ratio (OR), while for diagnostic performance, the receiver operating characteristic (ROC) curve and the corresponding area under it (AUC) were applied.

Results: The prevalence of IR was 17.11%. The adjusted multivariate analysis found that the association with IR significantly increased with the increase of their levels, especially in the third tertile in BMI (adjusted odds ratio (aOR): 18.2; 95% confidence interval (CI): 8.73 - 44.6), TPI (aOR: 17.2; 95% CI: 8.34 - 40.6), NBMI (aOR: 16.5; 95% CI: 8.12 - 38.3) and CUN-BAE index (aOR: 20.8; 95% CI: 10.6 - 47.1). In addition, BMI had the highest AUC = 0.854 (0.824 - 0.884), cutoff = 27.44, sensitivity = 85.03 (78.70 - 90.07) and specificity = 73.42 (70.23 - 76.44).

Conclusions: Based on the markers that only use weight and height, BMI showed the best association and diagnostic performance for detecting IR. It is advisable to conduct prospective studies to verify these findings. If such results are corroborated, BMI could become a valuable predictor for identifying IR in different populations.

Keywords: Insulin resistance; Body mass index; Adult; Anthropometry; Body weights and measures

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Introduction

Insulin resistance (IR) refers to a state where the cells in the body are less responsive to the insulin hormone, leading to challenges in maintaining stable blood sugar levels [1]. This condition is crucial from a public health perspective because it serves as a key factor in the onset of multiple chronic and metabolic illnesses. These include metabolic syndrome, type 2 diabetes, obesity, high blood pressure, liver-related issues, and different kinds of cancer, among other conditions [2, 3].

IR underpins the onset of numerous chronic and metabolic diseases. Recent global data indicate a rising prevalence of IR, underscoring its significance as a pressing public health concern both globally and regionally [1]. As such, the early detection of IR, even among at-risk populations without overt symptoms, is paramount. While the euglycemic hyperinsulinemic clamp (a method maintaining euglycemia during insulin administration) is heralded as the gold standard for detecting IR [4], its practicality is limited by its invasiveness and cost. Conversely, the homeostatic model assessment (HOMA-IR) is more commonly deployed in the identification of IR [5]. Yet, literature highlights its limited accessibility across all populations, especially in resource-constrained settings [5].

It has been found that biochemical markers, in symptomless individuals, such as glucose, triglyceride levels, among others, are also valuable indicators to diagnose this entity [6]. Given the pressing need for practical, cost-effective, and noninvasive methods to detect IR, it is vital to assess whether simpler markers, like formulas based on weight and height, could be efficacious. Among them are the body mass index (BMI) [6], the triponderal index (TPI) [7, 8], the new body mass index (NBMI)

[9], and the University of Navarra Clinic-Body Fat Estimator index (CUN-BAE index) [10]. Due to the need to understand the behavior of these, the aim of this study is to determine the diagnostic performance of four anthropometric markers based on weight and height for IR in a sample of Peruvians.

Materials and Methods

This is an analytical and diagnostic test cross-sectional study. We utilized the secondary database from the PERU MIGRANT study, facilitated by the CRONICAS Center. The core objective of the original study was to discern differences in cardiovascular risk factors across urban, rural, and urban-rural migrant demographics. This initiative was driven by the evolving epidemiological landscape in these populations and the need for targeted public health interventions. Detailed insights into the selection criteria, variables employed, sample size, and participation rates have been articulated in prior publications [11].

The primary study included groups of subjects over 30 years of age who had no history of mental illness or pregnancy. Only those subjects who had variables of interest were considered in this study.

The response variable was IR. This was obtained with the HOMA-IR index, which was calculated using the formula = (glucose (mmol/L) × insulin (μU/mL))/22.5 [12]. The results were categorized as "insulin resistant" if HOMA-IR ≥ 2.8 [13], and "not insulin resistant" if HOMA-IR < 2.8.

The anthropometric markers that were tested were as follows:

$$\text{BMI} = \text{weight (kg)}/\text{height (m)}^2$$

$$\text{TPI} = \text{weight (kg)}/\text{height (m)}^3 \text{ [14]}$$

$$\text{NBMI} = 1.3 \times (\text{weight (kg)}/\text{height (m)}^{2.5}) \text{ [15]}$$

$$\text{CUN-BAE index} = -44.988 + (0.503 \times \text{age}) + (10.689 \times \text{sex}) + (3.172 \times \text{BMI}) - (0.026 \times \text{BMI}^2) + (0.181 \times \text{BMI} \times \text{sex}) - (0.02 \times \text{BMI} \times \text{age}) - (0.005 \times \text{BMI}^2 \times \text{sex}) + (0.00021 \times \text{BMI}^2 \times \text{age}) \text{ [16]}$$

Height was gauged with an accuracy of up to 0.1 cm using a height-measuring instrument, while weight was recorded with the individual in lightweight attire to a precision of 0.05 kg on an SECA 940 digital scale.

Additional parameters scrutinized included age brackets, gender (either male or female), demographic group (urban, rural, or transient), current tobacco use, alcohol intake, and exercise habits. Definitions for excessive drinking were categorized based on low or high alcohol consumption levels according to the amount of alcohol reported consuming. Smoker classification was split into current smokers and non-smokers. Activity levels were determined using the guidelines set by the International Physical Activity Questionnaire (IPAQ), categorizing individuals into high, medium, or low activity levels based on days of physical activity and the metabolic equivalent measured in minutes per week.

Analysis procedures and statistical methods

All data crunching was carried out via R software, version 4.0.5. Estimates were made for the frequency and mean values of sociodemographic traits and the metrics under study. The Chi-square test was employed to identify disparities among categorized variables, while the Student's *t*-test was utilized for variables on a continuous scale. Multifaceted logistic regression analysis was applied to investigate the relationships between each segmented marker and IR, as evaluated by the odds ratio (OR). A P value of 0.05 was set as the benchmark for statistical significance.

Diagnostic efficacy was gauged using the receiver operating characteristic (ROC) curve, a graphical representation showcasing the diagnostic ability of a binary classifier system, and the area underneath it (AUC). Sensitivity, specificity, positive and negative predictive values, as well as likelihood ratios, were meticulously calculated. The Youden index, a metric that balances sensitivity and specificity to derive the optimal threshold, was harnessed to ascertain the best cut-off point.

Ethical aspects

Study protocol was approved by the Institutional Review Board (IRB) at Institute for Research in Biomedical Sciences of the Ricardo Palma University. The survey information is freely accessible [11], with no personal identifiers and no contact with human subjects. Therefore, it was not considered necessary to undergo a review by an ethics committee.

Results

The prevalence of IR was 17.11%; the female sex, 52.87%, and the percentage of older adults, 14.86%. High physical activity constituted 44.52%. With respect to harmful habits, high alcohol consumption was 8.91% and cigarette consumption, 11.27% (Table 1).

The variables that found an association between IR and the covariates were sex (P < 0.001), age group (P = 0.018), group (P < 0.001), physical activity (P < 0.001), alcohol volume (P = 0.041) and all anthropometric markers (P < 0.001) (Table 2).

Finally, according to the adjusted multivariate analysis, it was found that the association with IR significantly increased with the rise of its levels, especially in the upper tertile in BMI (adjusted odds ratio (aOR): 18.2; 95% confidence interval (CI): 8.73 - 44.6), TPI (aOR: 17.2; 95% CI: 8.34 - 40.6), NBMI (aOR: 16.5; 95% CI: 8.12 - 38.3) and CUN-BAE index (aOR: 20.8; 95% CI: 10.6 - 47.1) (Table 3).

Regarding the ROC analysis, all showed an AUC greater than 0.80, except for the CUN-BAE index. The BMI had the highest AUC = 0.854 (0.824, 0.884), cutoff = 27.44, Se = 85.03 (78.70, 90.07), and Sp = 73.42 (70.23, 76.44). In women, the CUN-BAE index has the highest AUC with 0.013, both the BMI and the NBMI have AUCs slightly higher than 0.80, suggesting good diagnostic performance. In men, the CUN-BAE index showed an AUC of 0.878, while the BMI and TMI have AUCs of 0.872 and 0.849, respectively.

The rest of the indicators are found in Table 4, and the ROC curves graph is in Figure 1.

Table 1. Demographic and Anthropometric Characteristics of Participants

Characteristic	N = 976
Sex	
Female	516 (52.87%)
Male	460 (47.13%)
Age	
29 to 44 years	427 (43.75%)
45 to 59 years	404 (41.39%)
60 years to more	145 (14.86%)
Group	
Migrant	586 (60.04%)
Rural	191 (19.57%)
Urban	199 (20.39%)
Physical activity	
High	431 (44.52%)
Low	253 (26.14%)
Moderate	284 (29.34%)
Alcohol volume	
High	87 (8.91%)
Low	889 (91.09%)
Current smoker	
No	866 (88.73%)
Yes	110 (11.27%)
Insulin resistance	
No	809 (82.89%)
Yes	167 (17.11%)
Body mass index	26.5 (4.6)
Triponderal mass index	17.3 (3.2)
New body mass index	27.8 (5.0)
CUN-BAE index	26 (7)

Data were expressed as n (%) or mean (standard deviation (SD)). CUN-BAE index: the University of Navarra Clinic-Body Fat Estimator index.

Discussion

Main findings

With the purpose of determining the optimal anthropometric index of weight and height to predict IR, this study suggests that BMI was the best predictor among all other indicators analyzed. According to the available information, this is the first investigation in Peru related to this issue.

On the other hand, despite the variations observed between genders, the indices maintain significant accuracy across both groups. It is noteworthy that the BMI, TMI, and the NBMI boast AUCs above 0.80. While the CUN-BAE index generally has a lower AUC, it exhibits outstanding performance in specific gender populations. These findings lead us to conclude that all evaluated indices are valuable tools for identifying IR, especially considering they are based on simple anthropometric markers such as weight and height. Given these conclusions, the discussion will be approached globally, as differences between sexes do not seem to be decisive in this context.

Prevalence of IR

The prevalence of IR in our study for Peru is 17.11%. When compared to other countries, we find significant variations. For example, the study undertaken in Chennai, India discovered that the general occurrence of IR syndrome was approximately 11.2% [17]. A comprehensive analysis of population-level investigations exploring the epidemiology of IR among youth discovered that reported occurrence rates diverged between 3.1% and 44% across studies. This variation was partly due to different definitions used for IR [18]. Such a difference could be attributed to genetic, environmental, dietary factors, among others. While Peru's prevalence may not be the absolute highest, the continued existence of this issue demands intervention, as it remains a problematic situation worthy of attention and resolution.

Comparison with other studies

This analysis revealed that BMI would be the most effective weight and height indicator in identifying IR, while the associative level was high in the higher tertile. Although it is a widely used and suggested anthropometric measurement [19], it has also faced criticism and obstacles, and its limitation is especially relevant in distinguishing between body fat mass and lean mass [20]. Likewise, the BMI cut-off value in Pakistani subjects is 27.44 kg/m^2, while the World Health Organization (WHO) BMI cut-off values are > 30 kg/m^2 for Americans and Europeans [19] and > 25 kg/m^2 for Asians [21].

These findings coincide with other studies. Research in men of different ethnicities indicated that BMI was the best predictor of IR. Thus, Nadeem et al [22], Wang et al [23], and Hadaegh et al [24] found that BMI is the best indicator of IR in Pakistani adults (AUC = 0.690), Chinese (AUC = 0.692), and Tehranians (AUC = 0.716).

In terms of the relationship between variables, Chen et al found that BMI had a standalone and positive link with HOMA-IR [25]. In research conducted by Ferrannini et al, it was observed that both fasting insulin levels and post-oral glucose insulin secretion had a roughly linear correlation with BMI in individuals without diabetes [26]. However, research of Liu et al revealed that although BMI had an independent association with IR, this connection was not statistically significant when it came to the early and late stages of insulin secretion [27].

Other works have also evaluated these two variables in different populations. In young people, Lim et al [28] conducted a study in Korean adolescents and found that obesity indices, including BMI, had a quite high association with IR. The research of Chang-Rueda et al [29], in which they evaluated patients from 5 to 19 years old, found that IR has a moderately sig-

Table 2. Bivariate Analysis of the Characteristics Associated With Insulin Resistance

Characteristic	Insulin resistance		P value[a]
	No (n = 811)	Yes (n = 167)	
Sex			< 0.001[b]
Female	397 (76.94%)	119 (23.06%)	
Male	412 (89.57%)	48 (10.43%)	
Age			0.018[b]
29 to 44 years	357 (83.61%)	70 (16.39%)	
45 to 59 years	322 (79.70%)	82 (20.30%)	
60 years to more	130 (89.66%)	15 (10.34%)	
Group			< 0.001[b]
Migrant	482 (82.25%)	104 (17.75%)	
Rural	187 (97.91%)	4 (2.09%)	
Urban	140 (70.35%)	59 (29.65%)	
Physical activity			< 0.001[b]
High	382 (88.63%)	49 (11.37%)	
Low	198 (78.26%)	55 (21.74%)	
Moderate	222 (78.17%)	62 (21.83%)	
Alcohol volume			0.041[b]
High	79 (90.80%)	8 (9.20%)	
Low	730. (82.11%)	159 (17.89%)	
Current smoker			0.161
No	723 (83.49%)	143 (16.51%)	
Yes	86 (78.18%)	24 (21.82%)	
Body mass index	25.5 (3.8)	31.6 (4.9)	< 0.001[b]
Triponderal mass index	16.6 (2.7)	20.6 (3.5)	< 0.001[b]
New body mass index	26.7 (4.1)	33.1 (5.3)	< 0.001[b]
CUN-BAE index	24 (7)	31 (6)	< 0.001[b]

Data were expressed as n (%) or mean (standard deviation (SD)). [a]Pearson's Chi-squared test; Welch two sample *t*-test. [b]$P < 0.05$. CUN-BAE index: the University of Navarra Clinic-Body Fat Estimator index.

nificant correlation with increased BMI. Bhattacharya et al [30] found that BMI had a low AUC (AUC = 0.585) for patients with polycystic ovary syndrome, while Jamar et al [31] conducted a similar study in subjects with obesity without diabetes, where the overall discriminatory capacity was higher (AUC = 0.730).

Regarding the rest of the markers, the number of studies that have evaluated the diagnostic performance for IR is scarce. Peng et al [10] followed a group of patients for about 5 years and found that for each point that the CUN-BAE increased, so did the incidence of diabetes linearly. Neves et al [8] and Akcan et al [32] highlighted the role of TPI in the diagnosis of IR in children and young people.

Interpretation of results

IR and obesity are closely related through several interconnected pathophysiological mechanisms. Firstly, adipose tissue in obese individuals releases pro-inflammatory molecules, such as interleukin (IL)-1, IL-6, or tumor necrosis factor (TNF)-α, which interfere with insulin action in cells [33]. Additionally, the accumulation of lipids in non-adipose organs and the oxidative stress caused by excess body fat also negatively affect cell function and insulin signaling [34].

Excess weight, by altering the homeostasis of the body's intrinsic biochemicals, can impact the secretion and function of leptin and adiponectin, which ordinarily assist in modulating craving, vitality usage, and sensitivity to insulin. These mechanisms, combined with the impaired blood vessel functioning tied to obesity, contribute to IR and illuminate the relationship between the two conditions [35].

Contribution to the field

Given their ease of determination through accessible and affordable means without risk or invasiveness, anthropometric markers such as weight and height take on outsized significance for

Table 3. Simple and Adjusted Multivariate Regression Analysis of the BMI, TPI, NBMI and CUN-BAE Quartiles for IR

Characteristic	Univariable			Multivariable		
	aOR	95% CI	P value	aOR[a]	95% CI	P value
Body mass index						
Tertile 1	Reference			Reference		
Tertile 2	3.87	1.75 - 9.81	0.002[b]	2.74	1.21 - 7.04	0.022[b]
Tertile 3	31	15.3 - 74.4	< 0.001[b]	18.2	8.73 - 44.6	< 0.001[b]
Triponderal mass index						
Tertile 1	Reference			Reference		
Tertile 2	4.08	1.94 - 9.67	< 0.001[b]	3.24	1.51 - 7.79	0.004[b]
Tertile 3	25.2	12.8 - 57.0	< 0.001[b]	17.2	8.34 - 40.6	< 0.001[b]
New body mass index						
Tertile 1	Reference			Reference		
Tertile 2	3.38	1.57 - 8.09	0.003[b]	2.56	1.17 - 6.21	0.025[b]
Tertile 3	26.7	13.6 - 60.4	< 0.001[b]	16.5	8.12 - 38.3	< 0.001[b]
CUN-BAE index						
Tertile 1	Reference			Reference		
Tertile 2	6.54	3.20 - 15.2	< 0.001[b]	12.9	6.01 - 31.0	< 0.001[b]
Tertile 3	142	46.0 - 510	< 0.001[b]	20.8	10.6 - 47.1	< 0.001[b]

[a]Adjusted for: sex, age, group, current smoking status, alcohol consumption, and physical activity. [b]$P < 0.05$. aOR: adjusted odds ratio; CI: confidence interval; BMI: body mass index; TPI: triponderal index; BMI: body mass index; NBMI: new BMI; CUN-BAE index: the University of Navarra Clinic-Body Fat Estimator index.

assessment purposes owing to the simple fact that they can be so readily and inexpensively ascertained. In many settings, especially in regions with limited resources, advanced diagnostic tests for IR are neither readily accessible nor affordable. This is where the measurement of BMI and other weight- and height-based indicators showcase their true value. These metrics, being straightforward to compute, provide a preliminary tool to identify individuals at risk and take preventative actions.

Additionally, how these indicators are employed could prove determinative for wide-ranging public health initiatives. For instance, awareness and screening campaigns in communities could greatly benefit from these simple yet effective tools, enabling early interventions and potentially reducing the burden of RI-related diseases.

The escalating prevalence of IR and its role in the onset of metabolic and cardiovascular diseases underscore the urgency to intervene. This study, being one of the first in the Peruvian context, establishes a benchmark and underscores the need for national preventive and intervention strategies. In this backdrop, the significance of anthropometric markers is heightened, as they ease the early identification of at-risk populations. Coupled with community-based interventions, employing these markers can be a cost-effective strategy to counteract the complications associated with IR.

Study limitations

To begin, as this analysis looked at a single point in time, determining which event came first is impossible, raising the risk that an outcome seemed to prompt a factor when truly the opposite was true. Second, the hyperinsulinemic euglycemic clamp technique was not performed nor was the gold standard for assessing insulin sensitivity [36] considered; however, it has been proven that HOMA-IR, a substitute for IR, correlates adequately with the IR index derived from this technique [37]. Furthermore, carrying it out on enormous groups would be unworkable. Likewise, the examination solely happened in two places of the country, limiting comprehensive inferences; despite this, owing to the probabilistic nature of the sample, there exists some degree of representativeness.

Conclusions

Based on the markers that only use weight and height, BMI demonstrated to have an association and the best diagnostic performance in detecting IR. Interestingly, while other indices were evaluated, their performance was not clearly superior to that of BMI, with values being close. This suggests that there might not be a compelling need to transition away from using BMI in clinical practice for this purpose. It is advisable to carry out prospective research to verify these findings. If such results are corroborated, BMI could become a valuable predictor for identifying IR in different populations.

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Table 4. Diagnostic Values for Insulin Resistance

	Cutoffs	AUC	Se (%)	Sp (%)
General				
Body mass index	27.44	0.854 (0.824, 0.884)	85.03 (78.70, 90.07)	73.42 (70.23, 76.44)
Triponderal mass index	17.78	0.832 (0.801, 0.864)	80.84 (74.04, 86.50)	72.81 (69.60, 75.84)
New body mass index	28.97	0.847 (0.816, 0.877)	81.44 (74.70, 87.02)	75.03 (71.89, 77.97)
CUN-BAE index	31.75	0.778 (0.740, 0.816)	64.67 (56.91, 71.89)	80.34 (77.44, 83.03)
Women				
Body mass index	27.65	0.829 (0.788, 0.870)	84.87 (77.15, 90.78)	69.27 (64.47, 73.77)
Triponderal mass index	18.04	0.806 (0.762, 0.850)	86.55 (79.90, 92.11)	62.47 (57.50, 67.24)
New body mass index	30.03	0.819 (0.777, 0.861)	78.99 (70.57, 85.91)	73.80 (69.18, 78.06)
CUN-BAE index	31.98	0.813 (0.771, 0.855)	88.24 (81.05, 93.41)	63.48 (58.53, 68.22)
Men				
Body mass index	27.44	0.872 (0.824, 0.920)	83.33 (69.78, 92.52)	78.64 (74.36, 82.50)
Triponderal mass index	16.44	0.849 (0.801, 0.897)	91.67 (80.02, 97.68)	69.42 (64.72, 73.83)
New body mass index	27.76	0.864 (0.818, 0.911)	85.42 (72.24, 93.93)	75.49 (71.04, 79.56)
CUN-BAE index	20.12	0.878 (0.829, 0.927)	87.50 (74.75, 95.27)	75.97 (71.55, 80.02)

	PPV (%)	NPV (%)	LR+	LR-
General				
Body mass index	39.78 (36.07, 51,34)	95.96 (93.92, 96,54)	3.20 (2.81, 3.65)	0.20 (0.14, 0.29)
Triponderal mass index	38.03 (34.41, 48.25)	94.85 (92.57, 95.57)	2.97 (2.60, 3.40)	0.26 (0.19, 0.36)
New body mass index	40.24 (36.44, 50.72)	95.14 (92.95, 95.84)	3.26 (2.84, 3.75)	0.24 (0.18, 0.34)
CUN-BAE index	40.45 (36.32, 48.70)	91.68 (88.83, 92.95)	3.29 (2.75, 3.93)	0.44 (0.36, 0.54)
Women				
Body mass index	45.29 (39.99, 59.23)	93.86 (90.19, 95.01)	2.76 (2.33, 3.26)	0.21 (0.14, 0.33)
Triponderal mass index	40.87 (35.98, 55.64)	93.94 (90.10, 95.03)	2.31 (1.99, 2.66)	0.22 (0.14, 0.34)
New body mass index	47.47 (41.87, 59.46)	92.14 (88.20, 93.67)	3.02 (2.50, 3.64)	0.28 (0.20, 0.40)
CUN-BAE index	42.00 (37.03, 57.80)	94.74 (91.12, 95.69)	2.42 (2.09, 2.79)	0.19 (0.11, 0.30)
Men				
Body mass index	31.25 (26.37, 52.93)	97.59 (94.92, 98.11)	3.90 (3.12, 4.88)	0.21 (0.11, 0.40)
Triponderal mass index	25.88 (22.01, 57.24)	98.62 (96.30, 98.89)	3.00 (2.53, 3.55)	0.12 (0.05, 0.31)
New body mass index	28.87 (24.43, 51.75)	97.80 (95.18, 98.25)	3.48 (2.84, 4.28)	0.19 (0.10, 0.38)
CUN-BAE index	29.79 (25.23, 54.98)	98.12 (95.66, 98.51)	3.64 (2.97, 4.46)	0.16 (0.08, 0.35)

Se: sensibility; Sp: specificity; PPV: positive predictive value; NPV: negative predictive value; LR+: likelihood ratio positive; LR-: likelihood ratio negative; CUN-BAE index: the University of Navarra Clinic-Body Fat Estimator index; AUC: area under the curve.

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Conflict of Interest

The authors declare no conflict of interest.

Informed Consent

The informed consent was obtained.

Author Contributions

Victor Juan Vera-Ponce, Jhony A. De La Cruz-Vargas and Jenny Raquel Torres-Malca participated in the genesis of the idea and project design. Fiorella E. Zuzunaga-Montoya, Andrea P. Ramirez-Ortega, Cori Raquel Iturregui Paucar, and Mario J. Valladares-Garrido oversaw the data collection, interpretation,

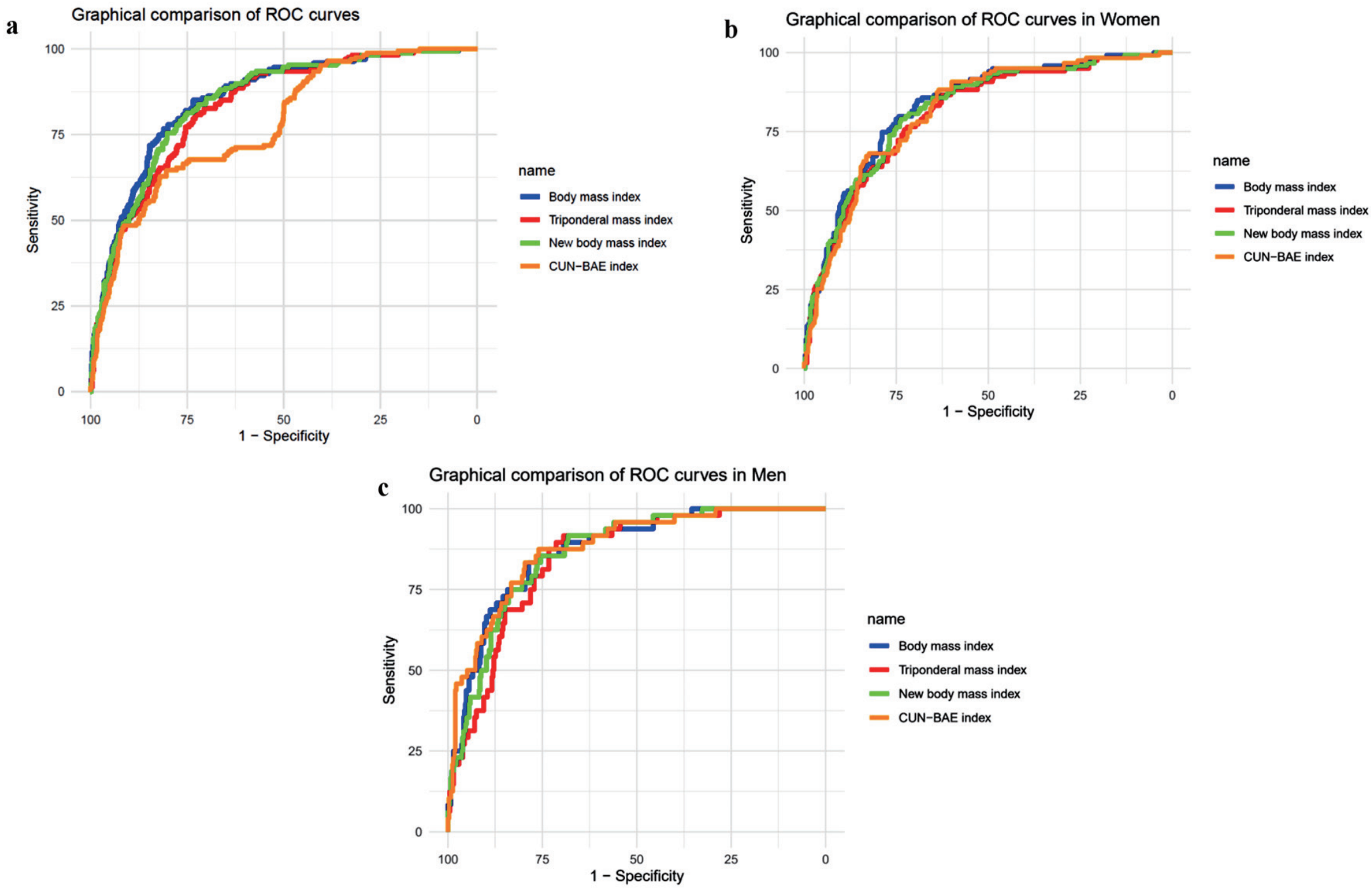

Figure 1. ROC curves graph. (a) General. (b) In women. (c) In men. ROC: receiver operating characteristic; CUN-BAE index: the University of Navarra Clinic-Body Fat Estimator index.

and analysis of results. Joan A. Loayza-Castro, Eder Jesus Orihuela Manrique and Rosa Angelica Garcia Lara contributed to the preparation of the manuscript of this research paper.

Data Availability

The data supporting the findings of this study can be accessed by the original research paper in the webpage Figshare.

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