Predictive Power of a Body Shape Index (ABSI) for Diabetes Mellitus and Arterial Hypertension in Peru: Demographic and Health Survey Analysis - 2020

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Abstract:

Introduction: Given the relationship between obesity and type 2 diabetes mellitus (T2DM) and hypertension, an indicator of body fat, A Body Shape Index (ABSI), has been considered to have apparent predictive power for these diseases.

Objective: To determine the predictive power of the ABSI for DMT2 and hypertension in Peru through the analysis of the Demographic and Health Survey-2020 (ENDES-by its acronym in Spanish-2020).

Methods: Cross-sectional analytical study of the ENDES-2020. The variables evaluated were ABSI, body mass index, high abdominal waist, waist-to-height ratio, body roundness index (BRI) and conicity index (COI). Areas under the curves (AUC) together with their 95% confidence interval (95%CI) were used to present each index.

Results: A total of 19 984 subjects were studied. Regarding hypertension, the highest AUC was presented by the COI: AUC=0.707 (95%CI 0.694-0.719). While the ABSI obtained the penultimate place: AUC=0.702 (95% CI 0.689-0.715). In case of DM2, the highest ABC was presented by BRI: AUC=0.716 (95%CI 0.689-0.743); while ABSI obtained the second place: AUC=0.687 (95%CI 0.658-0.717).

Conclusions: The results demonstrate that ABSI is not a good predictor for hypertension and DMT2 in the Peruvian population. If these findings are confirmed by other studies, its use would not be recommended for these diseases, and other anthropometric indicators that could perform better should be further explored.

Keywords: Diabetes mellitus, hypertension, abdominal circumference, body weight, body height (Source: MeSH NLM).

1. INTRODUCTION

Hypertension and Diabetes Mellitus type 2 (DMT2) are global health problems with an incidence that is increasing rapidly throughout the world [1]. Consequently, arterial hypertension remains the leading cause of death globally with 10.4 million deaths per year [2]. While 1 in 11 people in the world has DMT2 [3], both illnesses have had great impact on worldwide public health systems.

On the same way, the prevalence of arterial hypertension is estimated at 21.7% [4] and DMT2 about 7% [5] among Peruvian people, which are still a matter of concern, added to this some studies indicate that obesity is closely related to hypertension and DMT2 [6]. Against this, assessment and control through anthropometric measurements have been useful as information to approach risk indicators in public health, mainly because they do not require technological sophistication.

Recently, Krakauer NY and Krakauer JC developed a new obesity index called the Body Shape Index (ABSI), based on abdominal waist, weight, and body mass index [7], which represents an interesting indicator for measuring related illnesses. Although some studies have found that ABSI is a good predictor of hypertension and DMT2 [8-11], some research has questioned its ability to [12-16]. So then, it is important to know its behavior in Peru for the aforementioned diseases.

The present study aims to determine the predictive power of the ABSI for DMT2 and hypertension among Peruvian population registered in the demographic and health survey-2020 (ENDES-2020).

2. METHODS

2.1. Study Design

We carried out a cross-sectional study from a secondary data analysis of the Demographic and Family Health Survey of Peru 2020. This was a database that worked with data obtained from a survey

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with multistage sampling by clusters and representative of the country's population [17]. In addition, it collected data related to health indicators and responses to three questionnaires (household, individual, and health).

2.2. Population and Sample

The ENDES-2020 included a sample of 32,197 men and women aged 15 years or older from 25 Peruvian regions. In the present study, we included only those individuals that registered complete anthropometric measurements. The final sample analyzed was 19,984 people.

2.3. Variable Definition

2.3.1. Response Variable

People were considered to have hypertension if: 1) their average systolic blood pressure (two readings) was ≥140 mmHg or diastolic blood pressure was ≥90 mmHg using a digital blood pressure monitor; or 2) through self-report, through the question if *has a doctor ever diagnosed high blood pressure?* (yes vs no)

DMT2 was measured by self-report, using the question has a doctor ever diagnosed type 2 diabetes mellitus or high blood sugar levels? (yes vs no)

2.3.2. Exposure Variables

Waist Circumference (WC)

Body Mass Index (BMI) = Weight (Kg) / Height^2 (meters)

A Body Shape Index (ABSI) = $\frac{WC}{BMI^{2}/^{3}x\ Height^{1/2}}$

Body Roundness Index (BRI) = 364,2 - 365,5 x $\sqrt{1-\frac{\left(\frac{WC}{2\pi}\right)^{2}}{(0.5x\ Weight)^{2}}}$

Conicity Index (COI) = $\frac{WC}{0.109\sqrt{\frac{Weight(kg)}{Height(m)}}}$

Waist-to-height ratio (WHtR) = WC/Height

2.3.3. Other Variables

The following covariates were considered: sex (male vs female), age (categorized as 18 to 29, 30 to 60, 61 years or older), area (rural vs urban), education (none, primary, secondary, higher) and rate of wealth (very poor, poor, medium, rich, very rich).

2.4. Procedure and Statistical Analysis

Data were analyzed using STATA version 17 software. Descriptive statistics mean ± standard deviation (SD), previous normality-test assessed, absolute frequencies, and percentages were used to summarize demographic and metabolic characteristics. Sample weights and adjustment were used for the sample design (clustered and stratified)

We analyzed the area under the curve (AUC) with 95% confidence interval (95%CI) to estimate the discriminatory power of each variable. In addition, we established the optimal cut-off point to predict hypertension and DMT2 using the Youden index. For each evaluated index, we presented the values of sensitivity (sens), specificity (sp), positive and negative predictive value, and positive and negative likelihood ratio

In addition, logistic regression analysis was performed considering the sample weights. Each index was divided into tertiles and crude OR (cOR) and adjusted OR (aOR) were obtained for the potential confounding variables: sex, categorized age, area, wealth and level of education.

2.6. Ethical Aspects

Because this study is a free-access secondary database and the data provided is anonymous, harm to the people in the study is minimal.

3. RESULTS

The Table **1** presents the characteristics of the entire sample. The relative frequency was presented in a weighted manner. 53.04 % were women. The most frequent age group was 30 to 60 years. The prevalence of hypertension was 22.15%, while DMT2 was 4.27%. The mean and SD of the ABSI was 0.08 ± 0.01.

Table **2** shows the diagnostic accuracy. Regarding hypertension, the highest AUC was presented by COI: AUC=0.707 (95% CI 0.694-0.719), COP=1.29; sens = 69.9% (95% CI 67.8-71.9) and sp=59.9% (95% CI 58.8-61.0). While the ABSI obtained the penultimate place: AUC=0.702 (95% CI 0.689-0.715), COP=0.082; sensitivity=65.5% (95% CI 63.3-67.6); sp=65.4% (95% CI 64.3-66.5). In the case of T2DM, the highest AUC was presented by the BRI: AUC=0.716 (95% CI 0.689-0.743), COP=4.74; sens = 64.1% (95% CI 58.5-69.4) and sp=61.9% (95% CI 60.9-62.9). While the ABSI obtained second place: AUC=0.687 (95% CI 0.658-

0.717), COP=0.082; sens=64.1% (95% CI 4 8.5-69.4); sp=55.2% (95% CI 54.1-56.2). In Figure **1a** and **1b** we show the ROC curves of each indicator evaluated, both for hypertension and for DMT2, respectively.

Table 1: Characteristics of the Sample Taken from the ENDES-2020

Characteristics	n (% weighted)
Sex	
Masculine	9385 (46.96)
Feminine	10599 (53.04)
Categorized age	
18 to 29 years old	5664 (30.40)
30 to 60 years old	10957 (52.30)
61 years old or more	3363 (17.30)
Area	
Rural	4420 (15.34)
Urban	10357 (84.66)
Education	
None	221 (1.04)
Primary	2931 (14.60)
Secundary	6461 (44.61)
Superior	4740 (39.75)
Wealth	
Very poor	3783 (13.54)
Poor	3794 (19.42)
Medium	3071 (22.32)
Rich	2331 (21.93)
Very rich	1798 (22.79)
Systolic blood pressure (mmHg)*	123.23 ± 18.19
Diastolic blood pressure (mmHg)*	73.10 ± 10.45
BMI(Kg/m^2)*	27.52 ± 4.93
WC (cm)*	92.67 ± 12.06
WHtR*	0.59 ± 0.08
ABSI*	0.08 ± 0.01
BRI*	5.28 ± 1.86
COI*	1.29 ± 0.80
Arterial Hypertension	
Yes	3722 (22.15)
DMT2	
Yes	720 (427)

*Mean and standard deviation.

For the multivariable regression analysis, in the case of hypertension, as the tertile increased, a statistically significant association was found with each anthropometric indicator, except with the ABSI Table **3**.

In the case of DMT2, no statistically significant association was found between each anthropometric indicator, except for the third tertile of the ABSI (aOR: 1.69; 95% CI 1.02 - 2.80) and the COI (aOR: 1.70; 1.01 - 2.85) Table **4**.

4. DISCUSSION

4.1. Main Findings

In this study, the predictive capacity of ABSI for DMT2 and hypertension was estimated, in comparison with other indices, in addition to estimating the optimal cut-off points for these. It was found that the ABSI is not the best indicator for these diseases. In addition, in the association analysis, the ABSI did not show an association with hypertension, while for DMT2 it was only present with the third tertile. To the best of our knowledge, this is the first study that estimates said power using a database with information representative of Peru.

4.2. Comparison with other Studies

In relation to hypertension, ABSI has been shown to be indirectly useful for cardiovascular mortality [8,13], endothelial dysfunction [18] and metabolic syndrome in the Peruvian population [19]. Which shows that it could have an effect on cardiovascular health, although not specifically on hypertension.

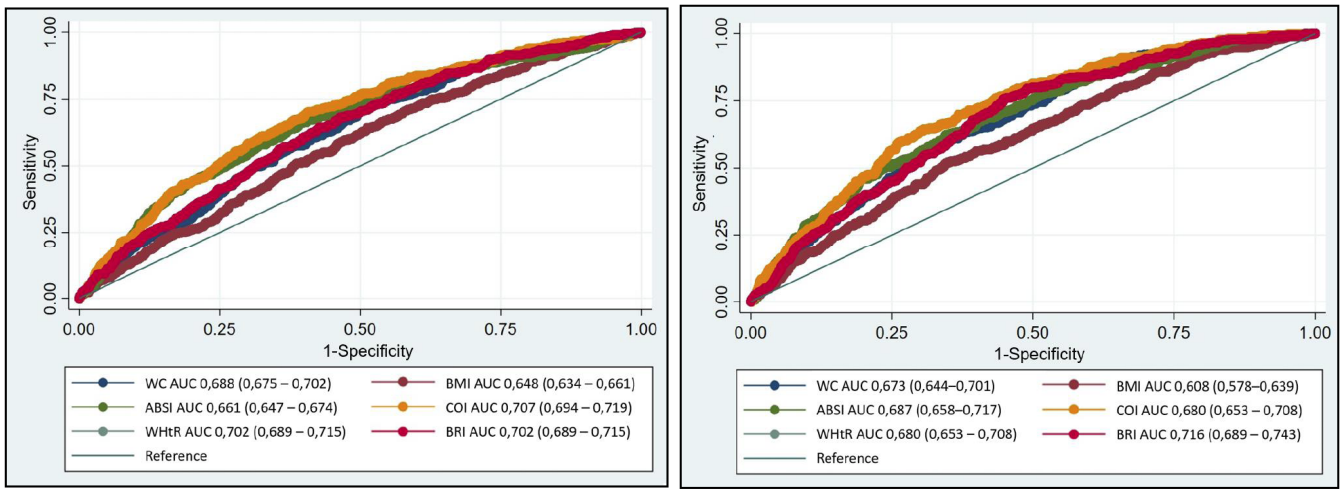
Multiple studies corroborate these findings. Cheung [20], who carried out a study in Indonesia, found that the ABSI is the least associated with the incidence of hypertension, unlike the WC and the BMI. The same with the work of Choi *et al.* [21], where WC and WHtR showed a superior predictive capacity compared to COI and ABSI, to determine the incidence of hypertension in a prospective study based on the community. Yang *et al.* [22], who identified a total of 1,787 incident cases of hypertension (27.59%), did not find a significant association or a good predictive capacity on the part of the ABSI. Another study showed that ABSI had the weakest association with hypertension, while BRI was the best [23]. The latter has also been seen in a systematic review, where BRI was better than ABSI.

For ABSI and DMT2, these findings are like others worldwide. The work of Chang *et al.* [12] summarizes that the ABSI showed the weakest predictive capacity, while the BRI showed the best. He *et al.* [15] in a

Table 2: Diagnostic Values of Obesity Indices for Hypertension and DMT2

	COP	YI	AUC (CI 95%)	Sens (%) (IC 95%)	Sp (%) (IC 95%)	PPV (%) (IC 95%)	NPV (%) (IC 95%)	LR+ (%) (IC 95%)	LR-(%) (IC 95%)
Hypertension									
WC (cm)	95.45	0.285	0.688 (0.675 - 0.702)	59.5 (57.3 - 61.7)	68.7 (67.6 - 69.7)	32.8 (31.2 - 34.4)	86.8 (86.0 - 87.7)	1.90 (1.81 - 2.00)	0.59 (056 - 0.62)
BMI (Kg/m^2)	27.03	0.224	0.648 (0.634 - 0.661)	60,0 (57.7 - 62.2)	62.3 (61.2 - 63.4)	29.0 (27.6 - 30.5)	85.8 (84.9 - 86.7)	1.59 (1.52 - 1.67)	0.64 (0.61 - 0.68)
ABSI	0.082	0.234	0.661 (0.647 - 0.674)	56.7 (54.5 - 59.0)	65.6 (64.6 - 66.7)	29.8 (28.3 - 31.3)	85.5 (84.6 - 86.4)	1.65 (1.57 - 1.74)	0.66 (0.62 - 0.70)
BRI	4.92	0.309	0.702 (0.689 - 0.715)	65.5 (63.3 - 67.6)	65.4 (64.3 - 66.5)	32.7 (31.3 - 34.3)	88.1 (87.2 - 88.9)	1.89 (1.81 - 1.98)	0.53 (0.49 - 0.56)
COI	1.29	0,.307	0.707 (0.694 - 0.719)	69.9 (67.8 - 71.9)	59.9 (58.8 - 61.0)	30.9 (29.6 - 32.3)	88.6 (87.6 - 89.4)	174 (1.67 - 1.81)	0.50 (0.47 - 0.54)
WHtR	0.58	0312	0702 (0.689 - 0.715)	63.1 (60.8 - 65.2)	67.1 (66.0 - 68.2)	33.0 (31.5 - 34.6)	87.6 (86.7 - 88.4)	1.92 (1.83 - 2.01)	0.55 (0.52 - 0.58)
DMT2									
WC (cm)	88.85	0.255	0.673 (0.644-0.701)	84.8 (80.3-88.6)	40.7 (39.7-41.8)	4.6 (4.1-5.2)	98.7 (98.3-99.1)	1.43 (1.36 - 1.50)	0.37 (0.29 - 0.49)
BMI (Kg/m^2)	27.82	0.173	0.608 (0.578-0.639)	52.1 (46.4-57.8)	65.1 (64.1-66.1)	4.8 (4.1-5.6)	97.6 (97.1-97.9)	1.49 (134 - 1.67)	0.74 (0.65 - 0.83)
ABSI	0.082	0.279	0.687 (0.658-0.717)	64.1 (58.5-69.4)	61.9 (60.9-62.9)	5.4 (4.7-6.2)	98.1 (97.7-98.4)	1.68 (1.54 - 1.84)	0.58 (0.50 - 0.67)
BRI	4.74	0.310	0.716 (0.689 - 0.743)	75.7 (70.6-80.4)	55.2 (54.1-56.2)	5.4 (4.8-6.2)	98.5 (98.2-98.8)	1.69 (1.58 - 1.81)	0,44 (0,36 - 0,54)
COI	1.32	0.339	0.680 (0.653 - 0.708)	62.5 (56.8-67.9)	70.4 (69.5-71.4)	6.7 (5.8-7.7)	98.2 (97.9-98.5)	2.11 (1.93 - 2.31)	0.53 (0.46 - 0.62)
WHtR	0.57	0.310	0.680 (0653 - 0.708)	73.1 (67.8-78.0)	56.1 (55.1-57.1)	5.4 (4.7-6.1)	98.4 (98.0-98.7)	1.67 (1.55 - 1.79)	0.48 (0.40 - 0.58)

COP: cut-off point, Sens: sensitivity, Sp: specificity, PPV: positive predictive value, NPV: negative predictive value, LR+: positive likelihood ratio, LR-: negative likelihood ratio, 95% CI: 95% confidence interval %, YI: Younden Index.



a **b**

Figure 1: a ROC curve for hypertension. **b** ROC curve for DMT2.

Table 3: Crude and Adjusted Logistic Regression Analysis for the Association between Arterial Hypertension and each Anthropometric Indicator

Characteristics		Arterial hypertension					
		cOR	CI 95%	p	aOR*	CI 95%	P*
WC (cm)	**Q1**	**Ref**			**Ref**		
	Q2	2,40	2,01 - 2,86	<0,001	1,53	1,21 - 1,94	<0,001
	Q3	4,82	4,06 - 5,71	<0,001	3,59	2,83 - 4,56	<0,001
BMI (Kg/m^2)	**Q1**	**Ref**			**Ref**		
	Q2	1,66	1,41 - 1,95	<0,001	1,36	1,07 - 1,71	<0,001
	Q3	3,29	2,83 - 3,83	<0,001	3,05	2,41 - 3,85	<0,001
ABSI	**Q1**	**Ref**			**Ref**		
	Q2	1,78	1,50 - 2,12	<0,001	1,09	0,88 - 1,37	0,408
	Q3	3,20	2,73 - 3,74	<0,001	1,16	0,93 - 1,44	0,170
BRI	**Q1**	**Ref**			**Ref**		
	Q2	2,40	2,01 - 2,86	<0,001	1,61	1,26 - 2,05	<0,001
	Q3	4,82	4,06 - 5,71	<0,001	3,09	2,43 - 3,92	<0,001
COI	**Q1**	**Ref**			**Ref**		
	Q2	2,54	2,13 - 3,04	<0,001	0,41	0,23 - 0,59	<0,001
	Q3	5,51	4,65 - 6,54	<0,001	0,70	0,52 - 0,88	<0,001
WHtR	**Q1**	**Ref**			**Ref**		
	Q2	2,40	2,01 - 2,86	<0,001	1,61	1,26 - 2,05	<0,001
	Q3	4,82	4,06 - 5,71	<0,001	3,09	2,43 - 3,92	<0,001

*Adjusted by sex, categorized age, area, wealth and level of education.
cOR: crude odds ratio. aPR: adjusted odds ratio.
95% confidence intervals (95% CI).

Table 4: Crude and Adjusted Logistic Regression Analysis for the Association between DMT2 and each Anthropometric Indicator

Characteristics		Diabetes mellitus type 2					
		cOR	IC 95%	p	aOR*	IC 95%	p
WC (cm)	**Q1**	**Ref**			**Ref**		
	Q2	2,04	1,39 - 3,00	<0,001	1,09	0,69 - 1,74	0,688
	Q3	3,87	2,70 - 5,55	<0,001	1,42	0,91 - 2,20	0,117
BMI (Kg/m^2)	**Q1**	**Ref**			**Ref**		
	Q2	1,41	1,03 - 1,93	0,034	0,92	0,60 - 1,41	0,721
	Q3	2,24	1,64 - 3,06	<0,001	1,23	0,83 - 1,82	0,284
ABSI	**Q1**	**Ref**			**Ref**		
	Q2	2,10	1,42 - 3,11	<0,001	1,47	0,92 - 2,35	0,103
	Q3	4,57	3,22 - 6,47	<0,001	1,69	1,02 - 2,80	0,040
BRI	**Q1**	**Ref**			**Ref**		
	Q2	2,33	1,60 - 3,41	<0,001	0,99	0,63 - 1,55	0,984
	Q3	4,28	2,96 - 6,19	<0,001	1,51	0,95 - 2,38	0,075
COI	**Q1**	**Ref**			**Ref**		
	Q2	2,04	1,34 - 3,11	0,001	1,12	0,68 - 1,84	0,651
	Q3	5,51	3,77 - 8,05	<0,001	1,70	1,01 - 2,85	0,042
WHtR	**Q1**	**Ref**			**Ref**		
	Q2	3,34	1,60 - 3,41	<0,001	1,00	0,64 - 1,56	0,984
	Q3	4,28	2,96 - 6,20	<0,001	1,51	0,95 - 2,38	0,075

*Adjusted by sex, categorized age, area, wealth and level of education.
cOR: crude odds ratio. aPR: adjusted odds ratio.
95% confidence intervals (95% CI).
Source: self-made.

prospective study conducted in China, found that ABSI was not superior to BMI and WC in predicting T2DM. Similarly, Fujita *et al.* [16], in a retrospective cohort study, concluded that, compared to BMI or WC, ABSI was not a better predictor of T2DM, hypertension and dyslipidemia in Japanese adults.

Nascimento-Souza *et al.* [24], who conducted a study in Brazilian older adults, concluded that given the low predictability of the ABSI, BMI, WC and the waist-hip ratio probably continue to be useful indices in public health, at least in relation to with hypertension and DMT2. However, the studies by Gómez-Peralta *et al.* [9] and the cohort by Tate *et al.* [11] found that ABSI does have the ability to identify patients with T2DM.

4.3. Interpretation of Results

The reasons behind the weak predictive power of the ABSI, compared to the other indices, are still unclear. One reason would be because the ABSI was initially developed to predict the risk of mortality in a follow-up study [7], and we applied it to predict DMT2 and hypertension. Another argument would be that the ABSI formula was developed in the United States, where body characteristics differ in our population, so it would be necessary to modify said calculation for the Peruvian people.

4.4. Implication in Public Health

Both DMT2 and hypertension are chronic diseases that lead to several metabolic diseases, this condition has been growing rapidly throughout the world. Therefore, for Peru as for Latin American countries, to delay or prevent the acute onset of these conditions, early detection is necessary in health facilities, especially in primary care. For this, it is necessary to have accurate, accessible, and easy-to-measure methods. This study gives us a first overview of the markers that could be quite reliable for this purpose, and which ones seem to indicate that they are not.

4.5. Study Limitations

This study has some limitations. The predictive power of the ABSI has been carried out in a cross-sectional study, so it does not allow the establishment of a temporal relationship between variables, requiring subsequent longitudinal studies. Another aspect to highlight is the use of self-reported information for the case of DMT2, which may have introduced an information bias in the study; however, studies have shown its usefulness [25,26].

5. CONCLUSIONS

The results show that ABSI is not a good predictor of hypertension and T2DM in the Peruvian population. If these findings are confirmed with other studies, their use would not be recommended for these diseases, and other anthropometric indicators that could have better performance should continue to be explored.

COMPETING INTEREST

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AUTHORSHIP CONTRIBUTIONS

The authors participated in the genesis of the idea, project design, data collection and interpretation, analysis of results, and preparation of the manuscript of this research work.

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