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RESEARCH

PERFORMANCE OF ANTHROPOMETRIC INDICES AS SCREENING INSTRUMENTS FOR SELF-REPORTED DIABETES IN THE BRAZILIAN POPULATION: A CROSS-SECTIONAL STUDY

DESEMPENHO DE ÍNDICES ANTROPOMÉTRICOS COMO INSTRUMENTOS DE RASTREIO PARA DIABETES AUTORREFERIDO NA POPULAÇÃO BRASILEIRA: ESTUDO TRANSVERSAL

DESEMPEÑO DE ÍNDICES ANTROPOMÉTRICOS COMO INSTRUMENTOS DE CRIBADO PARA LA DIABETES AUTOINFORMADA EN LA POBLACIÓN BRASILEÑA: ESTUDIO TRANSVERSAL

Maria Luiza Moreira-Souza[1]
Luís Antônio Batista Tonaco[2]
Fabiana Lucena Rocha[3]
Gustavo Velasquez-Melendez[2]
Mariana Santos Felisbino-Mendes[2]

[1]Universidade Federal de Minas Gerais - UFMG, Escola de Enfermagem – EE, Programa de Pós-Graduação em Enfermagem. Belo Horizonte, MG - Brazil.

[2]Universidade Federal de Minas Gerais – UFMG, Escola de Enfermagem – EE, Departamento de Enfermagem Materno Infantil e Saúde Pública. Belo Horizonte, MG - Brazil.

[3]Universidade Federal de Campina Grande – UFCG, Escola Técnica de Saúde de Cajazeiras - ETSC. Cajazeiras, PB - Brazil.

Corresponding author: : Mariana Santos Felisbino-Mendes
E-mail: marianafelisbino@yahoo.com.br

Authors' Contributions:

Conceptualization: *Maria L. Moreira-Souza, Luis A. B. Tonaco, Fabiana L. Rocha, Gustavo Velasquez-Melendez, Mariana S. Felisbino-Mendes;* **Data Collection:** *Maria L. Moreira-Souza, Luis A. B. Tonaco, Fabiana L. Rocha, Gustavo Velasquez-Melendez, Mariana S. Felisbino-Mendes;* ***Funding Acquisition:*** *Mariana S. Felisbino-Mendes;* ***Investigation:*** *Maria L. Moreira-Souza, Luis A. B. Tonaco, Fabiana L. Rocha, Gustavo Velasquez-Melendez, Mariana S. Felisbino-Mendes;* ***Methodology:*** *Maria L. Moreira-Souza, Luis A. B. Tonaco, Fabiana L. Rocha, Gustavo Velasquez-Melendez, Mariana S. Felisbino-Mendes; Project* ***Management:*** *Maria L. Moreira-Souza, Luis A. B. Tonaco, Fabiana L. Rocha, Gustavo Velasquez-Melendez, Mariana S. Felisbino-Mendes;* ***Resources Management:*** *Mariana S. Felisbino-Mendes;* ***Software****: Maria L. Moreira-Souza, Luis A. B. Tonaco, Fabiana L. Rocha, Gustavo Velasquez-Melendez, Mariana S. Felisbino-Mendes;* ***Statistical Analysis:*** *Maria L. Moreira-Souza, Luis A. B. Tonaco, Fabiana L. Rocha, Gustavo Velasquez-Melendez, Mariana S. Felisbino-Mendes;* ***Supervision:*** *Maria L. Moreira-Souza, Luis A. B. Tonaco, Fabiana L. Rocha, Gustavo Velasquez-Melendez, Mariana S. Felisbino-Mendes; Validation: Maria L. Moreira-Souza, Luis A. B. Tonaco, Fabiana L. Rocha, Gustavo Velasquez-Melendez, Mariana S. Felisbino-Mendes;* ***Visualization:*** *Maria L. Moreira-Souza, Luis A. B. Tonaco, Fabiana L. Rocha, Gustavo Velasquez-Melendez, Mariana S. Felisbino-Mendes;* ***Writing - Original Draft Preparation:*** *Maria L. Moreira-Souza, Luis A. B. Tonaco, Fabiana L. Rocha, Gustavo Velasquez-Melendez, Mariana S. Felisbino-Mendes;* ***Writing - Review & Editing:*** *Maria L. Moreira-Souza, Luis A. B. Tonaco, Fabiana L. Rocha, Gustavo Velasquez-Melendez, Mariana S. Felisbino-Mendes.*

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Tânia Couto Machado Chianca

ABSTRACT

Objective: to evaluate the diagnostic capacity of the anthropometric indices for self-reported diabetes screening in the Brazilian population. **Methods:** a cross-sectional study conducted with Brazilians ≥18 years old participating in the National Health Survey who had their anthropometric measures assessed. Individuals who reported a previous diagnosis of the disease or use of insulin/oral hypoglycemic agents were considered diabetic. The anthropometric indices evaluated were the following: Waist Circumference (WC), BMI, Waist-to-Height Ratio (WHR) and Body Shape Index (ABSI). Diagnostic performance according to gender and age was evaluated by means of the Receiver Operator Characteristic (ROC) curve. **Results:** the cut-off points of each measure presented little variation with age, with BMI in the male gender varying from 26.71 to 29.84; WC from 91.97 to 98.40; WHR from 0.55 to 0.60; and ABSI from 0.23 to 0.14. In turn, in the female gender, BMI ranged from 26.31 to 27.65, WC from 90 to 93.59, WHR from 0.58 to 0.60, and ABSI from 0.12 to 0.13. WHR performed better in both genders and at all ages, except in men over 60 years old. **Conclusion:** the anthropometric indices with the best performance in the diagnosis of self-reported diabetes were WC and WHR.

Keywords: *Diabetes Mellitus*; Anthropometry; Diagnostic Screening Programs; Self Report; Cross-Sectional Studies.

RESUMO

Objetivo: *avaliar a capacidade diagnóstica dos índices antropométricos para o rastreamento do diabetes autorreferido na população brasileira.* ***Métodos:*** *estudo transversal realizado com brasileiros ≥18 anos participantes da Pesquisa Nacional de Saúde que tiveram suas medidas antropométricas aferidas. Foram considerados diabéticos indivíduos que referiram diagnóstico prévio da doença ou uso de insulina/hipoglicemiantes orais. Os índices antropométricos avaliados foram: Circunferência da Cintura (CC), IMC, Relação Cintura Estatura (RCE) e Body Shape Index (ABSI). O desempenho diagnóstico segundo sexo e idade foi avaliado pela curva ROC (Receiver Operator Characteristic).* ***Resultados:*** *os pontos de corte de cada medida apresentaram pouca variação com a idade, sendo que o IMC no sexo masculino variou de 26,71 a 29,84; a CC 4de 91,97 a 98,40; o RCE de 0,55 a 0,60 e o ABSI de 0,23 a 0,14. Já no sexo feminino, o IMC variou de 26,31 a 27,65; a CC de 90 a 93,59; o RCE de 0,58 a 0,60 e o ABSI de 0,12 a 0,13. O RCE apresentou melhor desempenho em ambos os sexos e em todas as idades, exceto em homens acima de 60 anos.* ***Conclusão:*** *os índices antropométricos com melhor desempenho no diagnóstico de diabetes autorreferida foram a CC e RCE.*

Palavras-chave: *Diabetes Mellitus; Antropometria; Programas de Triagem Diagnóstica; Autorrelato; Estudos Transversais*

RESUMEN

Objetivo*: evaluar la capacidad diagnóstica de los índices antropométricos para el cribado de la diabetes autoinformada en la población brasileña.* ***Métodos****: estudio transversal realizado con brasileños ≥18 años participantes de la Encuesta Nacional de Salud a los que se les tomaron las medidas antropométricas, siendo considerados diabéticos aquellos individuos que reportaron diagnóstico previo de la enfermedad o uso de insulina/hipoglucemiantes orales. Los índices antropométricos evaluados fueron los siguientes: Circunferencia de la Cintura (CC), IMC, Relación Cintura–Estatura (RCE) y Body Shape Index (ABSI). El desempeño diagnóstico según sexo y edad fue evaluado por la curva ROC (Receiver Operator Characteristic).* ***Resultados****: los puntos de corte de cada medida mostraron poca variación con la edad, siendo que el IMC en el sexo masculino varió de 26,71 a 29,84; la CC de 91,97 a 98,40; la RCE de 0,55 a 0,60; y el ABSI de 0,23 a 0,14. En el sexo femenino, el IMC varió de 26,31 a 27,65; la CC de 90 a 93,59; la RCE de 0,58 a 0,60; y el ABSI de 0,12 a 0,13. La RCE presentó mejor desempeño en ambos sexos y en todas las edades, excepto en hombres mayores de 60 años.* ***Conclusión****: los índices antropométricos con mejor desempeño diagnóstico para la diabetes autoinformada fueron la CC y la RCE.*

Palabras clave: *Diabetes Mellitus; Antropometría; Programas de Detección Diagnóstica; Autoinforme; Estudios Transversales.*

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INTRODUCTION

Diabetes Mellitus (DM) is a major cause of potentially life years lost Disability Adjusted Life Years (DALYs)[1]. In 2019, the disease accounted for 2.8% of all DALYs in the world and for 2.7% of the total deaths[2]. It is estimated that in 2021, 10.5% of the world population between 20 and 79 years old had diabetes, which corresponds to 537 million people, with approximately 240 million (44.69%) not diagnosed[3]. Populations in underdeveloped and developing countries deserve greater attention, as 90% of the undiagnosed cases are found in these regions[3]. In Brazil, between 2014 and 2015, 8.4% DM prevalence was estimated using the criterion of glycated hemoglobin values or use of hypoglycemic agents[4]. Regarding self-reported DM, there was a 24% increase in its gross prevalence over 5 years. In 2013, it was 6.2% and it reached 7.7% in 2019[5].

Late diagnosis of diabetes is associated with micro- and macro-vascular damage[6,7]. The main complications of the disease are neuropathy, retinopathy, blindness, diabetic foot, amputation and nephropathy[6,7]. In addition to that, diabetes increases the risk of acute myocardial infarction and stroke[7]. Due to its magnitude and social/economic impact, the disease is target of several public policies aimed at controlling, diagnosing and preventing it[8]. An example of this is the 2021 Plan of Strategic Actions to Combat Chronic Diseases and Noncommunicable Health Problems in Brazil, which seeks to articulate and group assistance programs with the objective of reducing the DM global burden indicators[9]. In addition to that, this plan addresses the need to expand coverage in Primary Health Care, offering services for detecting, monitoring and controlling Type 2 Diabetes Mellitus in asymptomatic adults[9]. These actions show the urgency of detecting diabetic patients early in time to avoid the complications caused by the disease.

Increased adipose tissue above the normal limit is directly related to insulin resistance, which can cause widespread metabolic deteriorations. Individuals with metabolic syndrome have worse anthropometric profiles and generally have a Body Mass Index (BMI) ≥30 kg/m2, while those without DM are overweight on average, with BMI values between 25 kg/m and 30 kg/m2[10]. In this context, it is proposed that anthropometric indices indicating excess adiposity can act as proxy measures capable of quickly identifying these at-risk or sick individuals. Based on this context, actions aimed at reducing such measures have been implemented in Brazil, such as the Health at School Program and the Health Academy, which ease access to health in other spaces, in addition to promoting food education. In addition to that, the inclusion of professional nutritionists and physical educators in basic health units through expanded teams helps monitor weight control and raise popular awareness on the topic[11]. Studies from various nations analyze the use of anthropometric measures in Diabetes Mellitus screening. A number of studies have shown that the indices which assess central adiposity, such as Waist-to-Height Ratio (WHR) and Waist Circumference (WC), are more strongly associated with insulin resistance[10,12]. In an Australian study, the Body Shape Index (ABSI) was the anthropometric index most strongly associated with all-cause mortality in people with Type 2 Diabetes[13]. In a study of diagnostic testing of anthropometric measures in diabetes screening, a Brazilian study showed that WHR and WC are the measures with the highest sensitivity to screen people at risk or already affected by diabetes, although ABSI and BMI also show reasonable predictive capacity[14].

Self-reported diagnosis of diseases has been widely used in representative national surveys. Although not an accurate form of diagnosis, evaluation in large populations has the advantage of low-cost monitoring, especially for outcomes that require laboratory diagnoses, such as *Diabetes Mellitus*[14]. Given underdiagnosis of cases and future projections related to DM, it is relevant to seek new forms of disease screening to maximize diagnosis and treatment. The objective of this study was to evaluate the diagnostic capacity of anthropometric indices as a screening tool for self-reported diabetes in the Brazilian population.

METHODS

Study design and population

This is a descriptive study conducted using data from the National Health Survey (*Pesquisa Nacional de Saúde, PNS*), a population-based survey carried out in 2013 by the Brazilian Institute of Geography and Statistics (*Instituto Brasileiro de Geografia e Estatística*, IBGE) in partnership with the Ministry of Health. The PNS data are available for open access at https://www.ibge.gov.br/estatisticas/sociais/saude/9160-pesquisa-nacional-de-saude.html?=&t=downloads.

The PNS sample plan is conglomerated sampling in three stages, with stratification of the primary sampling units. The primary unit of this sample consisted of the census tracts or set of tracts. The second stage consisted of households and, finally, the third stage included residents over 18 years old. All selections were by simple random sampling[15].

The PNS used a questionnaire comprised by three parts: referring to the household, to the household residents and to the selected individual. In our study, the following modules were used: chronic diseases and anthropometry. The eligibility criteria for this study were as follows: having participated in the PNS; having had their anthropometric measures assessed; and being at least 18 years old. In this study, the individuals that reported a previous medical diagnosis of the disease or use of at least one oral hypoglycemic agent or insulin were considered diabetic.

Anthropometric indices

To collect the anthropometric data, all collection agents, supervisors and coordinators were trained in order to standardize the measuring method. To measure weight, a portable electronic scale with a capacity of 150 kilograms and gradation of 100 grams was used. The weight of each participant was recorded in kilograms, considering the first decimal place displayed on the scale. Height was measured using portable stadiometers and the values were recorded in centimeters, considering the first decimal place. To obtain the WC value, the midpoint between the tenth rib and the iliac crest was marked at the mid-axillary line, and the measurement was performed using a tape measure with 0.1 cm precision. The value was recorded in centimeters[15]. BMI was calculated as the weight in kilograms divided by the squared height in meters. To calculate WHR, waist circumference was divided by height, both in centimeters[15]. Finally, ABSI was calculated using the formula below:

$$\text{IFC} = \frac{\text{CC}}{\text{IMC}^{2/3} \text{ X altura}^{1/2}}$$

Data analysis

Diagnostic performance was evaluated with the aid of the MedCalc Statistical Software statistical program, version 16.4.3. Receiver Operator Characteristic (ROC) curves were constructed for each anthropometric index, which allowed estimating the cut-off points with better diagnostic performance and greater area under the curve. The parameters calculated for the diagnostic evaluation of anthropometric indices for DM detection were as follows: sensitivity, specificity, Positive Predictive Value (PPV), Negative Predictive Value (NPV) and Youden Index. All anthropometric indices were estimated by gender and age group (individuals under 40 years old, between 40 and 60 years old and over 60 years old).

Ethical aspects

This study used secondary data of public and free access. The National Heath Survey was approved by the National Commission of Ethics in Research. All National Heath Survey participants were duly informed about the research and consented to participate. Therefore, as this study was conducted with secondary data, it was not necessary to request a new consent from the participants.

RESULTS

In the group of men under 40 years old, WHR had the largest area under the ROC curve, in addition to being the index with the highest sensitivity(40,63). In this age group, the best cut-off point was 0.57. The negative predictive values were greater than 99% for all measures, and the positive predictive values were below 3.5%. WHR remained the best performance index in the group of men aged from 40 to 59 years old, with the highest sensitivity(72,53) and the second highest positive predictive value(10.2). In this group, the best cut-off point for WHR was 0.55; in turn, ABSI presented a lower negative predictive value(94,22) and lower specificity(46,56). The negative predictive values in this age group remained above 94%. In the male population aged at least 60 years old, WC had the largest area under the ROC curve, and the best cut-off point for the index was 98.4 cm. In addition to that, WC obtained the highest positive predictive value (17.6%) and the lowest negative predictive value (87.97%) when compared to the other age groups (Table 1).

In the women's group, WHR was also the index with the largest area under the ROC curve. For those under 40, the best cut-off point was 0.58. WHR presented higher specificity(74.16), whereas WC obtained higher sensitivity(63.33). In this age group, ABSI was not significant ($p>0.05$). The negative predictive values remained above 98% for all indices, while the highest positive predictive value was recorded in WHR (3.39%) . For the women aged between 40 and 59 years old, the WHR cut-off point was 0.6, and the highest sensitivity and specificity were found in the WC and WHR indices, respectively. In this group, there was a higher positive predictive value in relation to women under 40 years old and a lower negative

Table 1 – Diagnostic performance indicators of the anthropometric indices to screen DM in the Brazilian male population.

	BMI	WC	WHR	ABSI
Age: 18–39 years old				
Sensitivity	36,46	28,12	40,63	19,79
Specificity	84,35	91,97	81,03	89,59
Best cut-off point	29,84	106,90	0,57	0,14
AUC (95% CI)	0,587 (0,577–0,597)	0,600 (0,590–0,610)	0,630 (0,621–0,640)	0,532 (0,522–0,542)
p-value	0,0098	0,0026	<0,0001	0,2831
Youden Index	0,2081	0,2009	0,2166	0,09383
PPV (%)	2,2991	3,4164	2,1176	1,8841
NPV (%)	99,2448	99,2167	99,2653	99,1038
Age: 40-59 years old				
Sensitivity	51,17	69,3	72,53	62,66
Specificity	66,65	51,53	51,21	46,56
Best cut-off point	28,22	95,09	0,55	0,13
AUC (95% CI)	0,611 (0,600–0,622)	0,642 (0,631–0,652)	0,667 (0,647–0,668)	0,555 (0,544–0,566)
p-value	<0,0001	<0,0001	<0,0001	<0,0001
Youden Index	0,1782	0,2083	0,2375	0,09219
PPV (%)	10,4956	9,8507	10,2022	8,2242
NPV (%)	94,2885	95,6307	95,0069	93,5252
Age: ≥60 years old				
Sensitivity	54,14	59,55	52,23	63,06
Specificity	61,86	58,79	63,95	47,87
Best cut-off point	26,71	98,40	0,60	0,14
AUC (95% CI)	0,591 (0,575–0,605)	0,611 (0,596–0,626)	0,595 (0,580–0,610)	0,561 (0,546–0,576)
p-value	<0,0001	<0,0001	<0,0001	<0,0001
Youden Index	0,16	0,1834	0,1618	0,1093
PPV (%)	20,0949	20,3826	20,4251	17,6486
NPV (%)	88,3908	89,1349	88,3128	87,9730

Note: BMI = Body Mass Index. WC = Waist Circumference. WHR = Waist-to-Height Ratio. ABSI = Body Shape Index. AUC = Receiver Operating Characteristic curve. 95% CI = 95% Confidence Interval. PPV = Positive Predictive Value. NPV = Negative Predictive Value. Source: National Health Survey (2013).

Table 2 – Diagnostic performance indicators of the anthropometric indices to screen DM in the Brazilian female population.

	IMC	CC	RCE	ABSI
Age: 18–39 years old				
Sensitivity	60	63,33	57,62	49,52
Specificity	67,9	69,78	74,16	59,93
Best cut-off point	27,34	90	0,58	0,12
AUC (95% CI)	0,664 (0,656–0,672)	0,685 (0,677–0,692)	0,699 (0,691–0,706)	0,535 (0,526–0,543)
p-value	<0,0001	<0,0001	<0,0001	0,0813
Youden Index	0,279	0,3311	0,3178	0,09453
PPV (%)	2,8587	3,194	3,3917	1,9086
NPV (%)	99,081	99,1794	99,1083	98,6912

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	IMC	CC	RCE	ABSI
Age: 40-59 years old				
Sensitivity	62,25	74,02	62,59	62,12
Specificity	55,46	50,59	63,33	48,68
Best cut-off point	27,65	90,69	0,60	0,12
AUC (95% CI)	0,611 (0,602–0,620	0,656 (0,647–0,665)	0,665 (0,655–0,674)	0,570 (0,560–0,579)
p-value	<0,0001	<0,0001	<0,0001	<0,0001
Youden Index	0,177	0,2461	0,2591	0,1081
PPV (%)	11,0577	11,7607	13,1836	9,7222
NPV (%)	94,2885	95,6307	95,0069	93,5252
Age: ≥60 years old				
Sensitivity	63,96	64,98	68,53	53,15
Specificity	47,62	51,04	48,2	55,75
Best cut-off point	26,31	93,59	0,60	0,13
AUC (95% CI)	0,575 (0,563–0,587)	0,608 (0,596–0,620)	0,611 (0,599–0,623)	0,552 (0,540–0,564))
p-value	<0,0001	<0,0001	<0,0001	<0,0001
Youden Index	0,1157	0,1603	0,1673	0,08907
PPV (%)	23,1634	24,6798	24,6204	22,8715
NPV (%)	84,2569	85,5144	86,1185	82,8178

Note: BMI = Body Mass Index. WC = Waist Circumference. WHR = Waist-to-Height Ratio. ABSI = Body Shape Index. AUC = Receiver Operating Characteristic curve. 95% CI = 95% Confidence Interval. PPV = Positive Predictive Value. NPV = Negative Predictive Value.
Source: National Health Survey (2013).

predictive value in all indices. Finally, the women aged at least 60 years old, as well as the men belonging to the same age group, presented the highest positive predictive values and the lowest negative predictive values in relation to other ages. The best cut-off point for WHR was 0.60, and this index was more sensitive than the others (Table 2).

In the men, WHR presents the largest areas under the curve for those aged up to 59 years old. However, in older adults, WC displays the highest AUC, and ABSI presents the closest values to 0.5 (Figure 1).

In turn, in the group of women, WHR has the largest area under the curve in all ages, whereas ABSI is the closest index to the 0.5 axis (Figure 2).

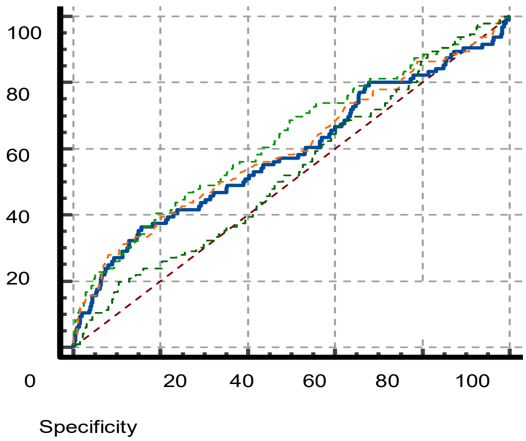
DISCUSSION

In this study, the sensitivity values corresponding to the anthropometric indices evaluated were relatively low at all ages, with AUC values close to 0.6. WHR and WC were the best-performing indices for self-reported diabetes screening in the case of adults and aged people, respectively. In a study conducted with 8,663 African adults, these same indices obtained the highest AUC values, remaining around 0.6[16]. Other studies with similar results reinforce the applicability of these indices for diabetes screening, and a meta-analysis showed that WHR is more strongly associated with diabetes when compared to BMI or WC[17]. A recent study carried out with a South Asian population showed that higher BMI values in adulthood were associated with higher chances of diabetes in old age (OR: 1.05 [1.01–1.9]), in addition to other chronic diseases[18]. In this sense, the applicability of using this index and the importance of keeping its values low are reinforced.

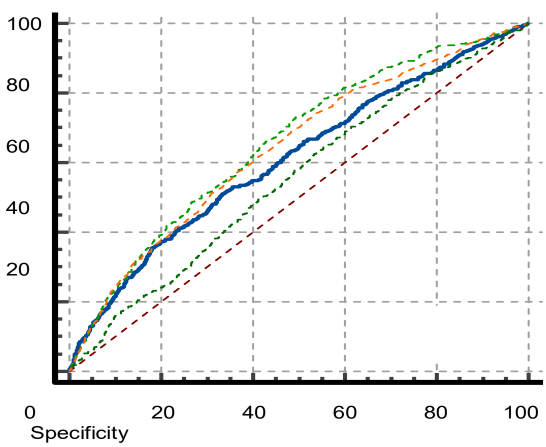
The relationship between abdominal adiposity and diabetes has been previously described in the scientific literature[11,12], which might explain the best sensitivity values obtained by the WHR and WC indices. However, due to the divergent anatomical sites that can be used to assess WC, this measure should be used with caution and in a standardized manner in the clinical practice[19]. A literature review carried out with studies published between 1990 and 2010 evidenced divergences in measuring techniques and cut-off points, which makes it difficult to compare these results[20]. On the other hand, WHR stands out for not having variant cut-off points related to gender or ethnicity, as is the case with BMI and WC[21],

Figure 1 – Performance of the anthropometric indices in the male population according to age group

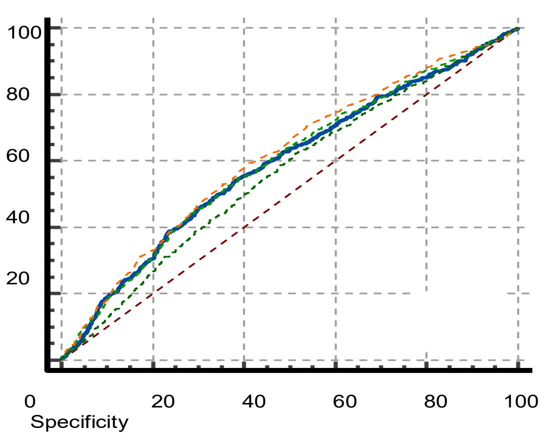
Performance of the anthropometric indices in the male population aged from 18 to 39 years old.



Performance of the anthropometric indices in the male population aged from 40 to 59 years old.



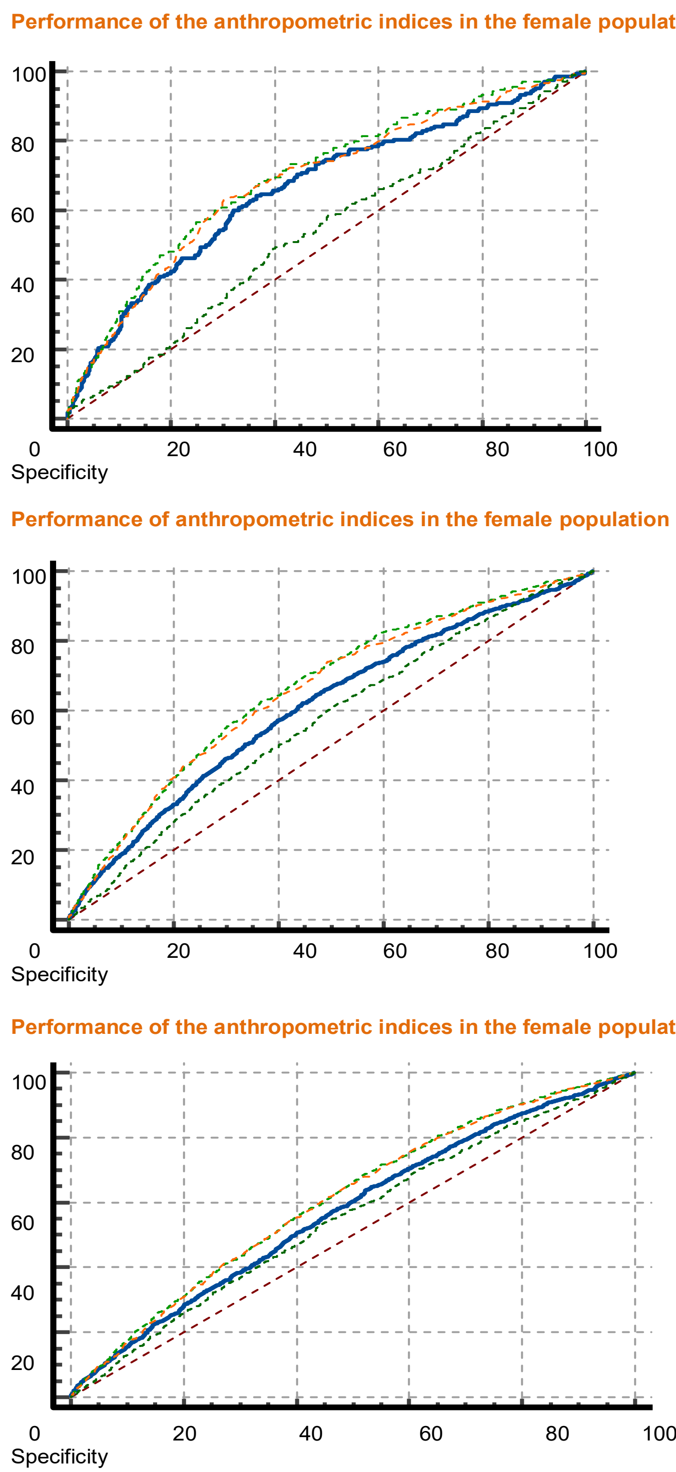
Performance of the anthropometric indices in the male population aged at least 60 years old



Legend: BMI - - WHR - - WC - - ABSI

Note: BMI = Body Mass Index. WC = Waist Circumference. WHR = Waist-to-Height Ratio. ABSI = Body Shape Index.

Figure 2 – Performance of the anthropometric indices in the female population according to age group



Legend: BMI WHR WC ABSI

Note: BMI = Body Mass Index. WC = Waist Circumference. WHR = Waist-to-Height Ratio. ABSI = Body Shape Index.

thus being more replicable for different populations. The WHO proposes WC cut-off points of 102 cm in men and 88 cm in women[22] for high metabolic risk. In this study, the cut-off points of this index for DM were 106 cm and 90 cm, respectively. A Chinese study evaluated 11 anthropometric indices to predict metabolic syndromes and described that, among them, only ABSI had poor predictive capacity[23]. In this same study, it was observed that WHR values above 0.53 would be effective to screen the risk of metabolic syndrome[23]. In addition to that, Correa et al. (2017) suggested WHR values greater than 0.60 as an indication of increased health risk in older adults[24]. In this sense, the literature findings corroborate those of this article since, in the Brazilian population. ABSI was also the index with the lowest AUC in all ages and genders. As a differential, the Chinese study found AUC values greater than 0.8, which was not possible to identify in our study. This difference can be correlated with the population of choice for the study, considering that the Chinese study only works with the middle-aged and elderly population (from 45 to 98 years old), which is the population most prone to developing CNCDs and increased adipose tissue.

BMI is used to assess a person's total body mass and diagnose obesity, but this index does not consider the accumulation of abdominal adipose tissue, which is more strongly related to the occurrence of metabolic syndrome[11,12]. Thus, corroborating findings from other studies, BMI was the index with the lowest performance for diabetes screening[17,18], explained by some limitations, such as not evaluating the percentage and distribution of fat and muscle mass.

When analyzing the differences by gender, a higher sensitivity value was observed in the group of women. However, the AUC remained similar for both genders, thus showing that these anthropometric indices can be used for the population without gender distinctions. Thus, this anthropometric index can be easily applied in the clinical practice. In Brazil, a study that evaluated anthropometric measures and the DM laboratory diagnosis attested that WHR and WC have better predictive capacity for diabetes[25]. In the study by Tonaco[14], the AUC values are around 0.7 and there is similarity in the cut-off points of his study with this one, as the WC cut-off point for men was 97.3 and 98.4 for those over 40 years old; WHR for men under the age of 40 was 0.58 and 0.59 for those over 40; finally, for women under 40 years old, this value was 0.57 and 0.59 for those over 40[14]. These values are close to those found in this study, showing that both when using the gold standard for DM diagnosis and when resorting to self-report, the anthropometric indices are effective for DM screening in the Brazilian population. A recent survey of Brazilian adults showed that nearly 32% of the people with diabetes were unaware of the diagnosis[25]. In addition to that, other studies indicate that there is a relationship between sociodemographic factors, social inequalities and diabetes[4]. Using anthropometric measures is advantageous, as it is a non-invasive, simple and low-cost screening assessment[21]. Thus, their use can be easily incorporated into the clinical practice as a diabetes screening strategy, not requiring the presence of any specialized health professional to perform the measurements. These findings confirm the potential of using anthropometric indices to identify individuals at risk of developing diabetes.

Among the limitations of this study we can mention its cross-sectional design, which does not allow establishing a time relationship between the opportunity to measure the index and the self-reported diagnosis of diabetes, in addition to the possibility of underestimation in the self-reported characterization. An external validity aspect is observed in this study, given its sample nature and representativeness of the Brazilian population, when compared to similar studies with more restricted and less representative populations in the country.

The results of this study and others[10, 17, 24] show that simple anthropometric measures are effective for screening diabetes in general. Among these measures, those that assess abdominal/central fat deposition, such as WHR and WC, performed better in screening people with diabetes or at risk of developing it, in all age groups. Although the women had higher sensitivity for the WHR and WC measures, the AUCs (areas under the curve) remained similar regardless of gender. It is important to highlight the diagnostic capacity of low-cost and easy-to-apply measures for self-reported diabetes screening. Although the AUC estimates were close to 0.6, the anthropometric assessment for diabetes screening is an alternative for preventing and controlling the disease.

CONCLUSION

The anthropometric measures that performed better in the diagnosis of self-reported diabetes were WC and WHR, as they obtained higher AUC values. The results of this research are representative at the national level, although the self-reported diagnosis of the disease is a limitation. The anthropometric assessment for Diabetes Mellitus screening is an important tool for early detection, control and prevention, although the AUC estimates were close to 0.6.

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