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ARTIGO ORIGINAL

Waist and abdomen perimetry: evaluation of the optimal point in patients with risk factor for cardiovascular disease and in apparently healthy individuals

Perimetria da cintura e abdomen: avaliação do ponto ótimo em pacientes com fator de risco para doenças cardiovasculares e em indivíduos aparentemente saudáveis

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Abstract

Introduction: One of the criteria for stratification of cardiometabolic risk (CMR) is waist circumference (WC). However, some guidelines have used abdominal circumference (ABC). *Objective:* To evaluate and compare the validity of WC and ABC in the determination of CMR in apparently healthy adult individuals or with risk factors for cardiovascular diseases in both sexes. *Methods:* one hundred ninety three men and two hundred and twenty women (18-74 years). WC and ABC were measured and submitted to the normality test (Kolmogorov-Smirnov test) and to the homogeneity test (Levene test). The Wilcoxon test was applied, and the results presented in median and interquartile intervals were applied. Formulas were developed and the Spearman's Correlations were applied. The Bland-Altman's concordance Test and the percentage difference calculation of the groups were performed. The level of significance adopted was ($p<0.05$) and the analyses performed with the Sigma Plot Software for Windows version 11.0, copyright© 2008 System Software, Inc. *Results:* The groups showed significant difference for man ($p=0.032$) with values for WC 86.5(80-97) cm and ABC 89.5(83-101) cm. And for women showed significant difference for ($p=0.001$) with values for WC 79(72-88) cm and ABC 86(79.5-97) cm. Percentage differences were 9.8 for men and 46.8 for women, and the correlations of ($r=0.98$) and ($r=0.96$), respectively. The differences between the comparison of

the measurements that presented divergence in the CMR classification were (p=0.001)/both sexes. The formulas were developed in the Sigma Plot Software - WC = 0.75 + 0.98 X (ABC) for men and women - WC = 2.52 + 0.89 X (ABC). *Conclusion:* In both sexes, anthropometric measurements showed significant differences and if ABC was adopted, almost half of the female sample would be mistakenly included in the CMR classification.
Keywords: metabolic syndrome; obesity; physical exercise; lifestyle; primary health care.

Resumo

Introdução: Um dos critérios para estratificação do risco cardiometabólico (RMC) é a circunferência da cintura (CC). No entanto, algumas diretrizes usaram a circunferência abdominal (ABC). *Objetivo:* Avaliar e comparar a validade da CC e do ABC na determinação da RMC em indivíduos adultos aparentemente saudáveis ou com fatores de risco para doenças cardiovasculares em ambos os sexos. *Métodos:* cento e noventa e três homens e duzentas e vinte mulheres (18 a 74 anos). Foi aplicado o teste de Wilcoxon e aplicados os resultados apresentados em mediana e intervalos interquartis. Foram desenvolvidas fórmulas e aplicadas as Correlações de Spearman. Foi realizado o teste de concordância de Bland-Altman e o cálculo da diferença percentual dos grupos. O nível de significância adotado foi (p<0,05) e as análises foram realizadas no software Sigma Plot para Windows versão 11.0, copyright© 2008 System Software, Inc. *Resultados:* Os grupos apresentaram diferença significativa para o homem (p=0,032) com valores para WC 86,5(80-97) cm e ABC 89,5(83-101) cm. E para as mulheres apresentou diferença significativa para (p=0,001) com valores de CC 79(72-88) cm e ABC 86(79,5-97) cm. As diferenças percentuais foram de 9,8 para os homens e 46,8 para as mulheres, e as correlações de (r=0,98) e (r=0,96), respectivamente. As diferenças entre a comparação das medidas que apresentaram divergência na classificação da RMC foram (p=0,001)/ambos os sexos. As fórmulas foram desenvolvidas no Software Sigma Plot - WC=0,75+0,98X (ABC) para homens e mulheres - WC=2,52+0,89X(ABC). *Conclusão:* Em ambos os sexos, as medidas antropométricas apresentaram diferenças significativas e se o ABC fosse adotado, quase metade da amostra feminina seria incluída erroneamente na classificação da RMC.
Palavras-chave: síndrome metabólica; obesidade; exercício físico; estilo de vida; atenção primária em saúde.

Introduction

Adipose tissue is considered an endocrine organ and is responsible for the synthesis of numerous pro and anti-inflammatory cytokines [1]. Pro-inflammatory cytokines, according to studies [2,5], might be related to several comorbidities, such as obesity, insulin resistance (IR), cardiovascular diseases associated with numerous metabolic dysfunctions, and in cases of plurimetabolic disease.

Internationally, one of the clinical criteria for the determination of the CMR has been WC [6,9]. However, Brazilian guidelines have recommended ABC as a parameter for determining MS and

not WC [10,11]. In a previous study [12], in agreement with International Society Advancement Kinanthropometry ISAK [13] and other studies [14,15] have shown that WC represents distinct anatomical points and should be observed with caution. The major issue with this dichotomy in the evaluations refers to the risk of a mistaken evaluation of the CMR when considering ABC in the light of cutoff values determined specifically for WC.

Thus, to avoid conflicts at the time of the physical evaluation, especially if the interest is determining one of the parameters adopted for the diagnosis of MS, there is a need to confront these two anatomical references in order to verify whether these two variables could be applied with the same objective. In this sense, this study aimed to evaluate and compare the validity of WC and ABC to determine CMR in apparently healthy adult individuals or with risk factors for cardiovascular and metabolic diseases. In addition, as a secondary objective, to propose a correction formula, to adjust the difference between the different anatomical points, if the ABC is adopted by the evaluator as a criterion for determining the CMR.

Methods

Participants

The present study is cross-sectional and selected men and women, over 18 years of age, who presented an apparently healthy profile or any CMR factor. The apparently healthy individuals were students at a university in the city of Rio de Janeiro and individuals with risk factors for cardiometabolic diseases were selected through a nutrition outpatient clinic also located in the city of Rio de Janeiro.

The exclusion criteria adopted were as follows: i) individuals who had undergone some surgical intervention that prevented the anthropometric measurement process; ii) individuals who presented body mass index (BMI) lower than 18.5 kg/m^2; iii) individuals who did not make themselves available to participate in the research. It is noteworthy that apparently healthy individuals who were also part of the research were considered recreationally active.

In addition, the study was approved by the Ethics Committee of the Clementino Fraga Filho University Hospital in accordance with resolution number 466/12 of research with human beings (CAAE: 47813415.8.0000.5257). All participants read and signed the informed consent form (TCLE) before being included in the study and obtained the information.

Anthropometric profile and physical exercise pattern

The data of the different anatomical points WC and ABC, as well as the data for the determination of the sample characteristics suchet as height, body mass, and BMI=kg/m^2 were measured and calculated according to the criteria recommended by ISAK [13]. The WC was measured, evaluated, and classified through the midpoint between the iliac crest and the last rib, as well as the ABC on top of the umbilical scar [12]. In order to determine the correct measurement, the evaluator instructed the evaluator to perform an inspiration followed by a complete expiration. At the end of expiration, it is worth mentioning that both anthropometric measurements were performed three times and the result obtained came from the mean of these anthropometric variables.

The classification of the CMR in the individuals of the present study met the recommended criteria [8,16], where WC is classified according to gender and divided into three categories; i) men and women who

present, respectively, < 94 cm and < 80 cm measurements are categorized with low risk of development for cardiometabolic diseases, ii) men with ≥ 94 cm measurement and women with ≥ 80 cm measurement would be included in the category of moderate risk of development; iii) reference values ≥ 102 cm in men and ≥ 88 cm in women the classification is high risk for the development of cardiometabolic diseases.

It is noteworthy that the measurements were performed three times and the result obtained came from the mean of these anthropometric variables. Finally, body mass and height measurements were obtained using, respectively, a Digital G. tech BALGL 10 scale with LCD display and a Cescorf pocket stadiometer. The resolutions of anthropometric measurements were 0.1 kg for body mass and 0.1 cm for height.

For the determination of the physical exercise profile, no questionnaire was applied. However, all individuals who participated in the study were queried whether they practiced physical exercise or some sports modality, and what the weekly frequency was. All participants practiced physical exercise or sports, with a weekly frequency of at least three times a week lasting at least 60 minutes.

Statistical analysis

The statistical variables were submitted to the Kolmogorov-Smirnov Test and homogeneity test (Levene Test) and presented parametric behavior. Thus, the Wilcoxon Test was applied for intra-group comparison and the results were presented in median and interquartile intervals. Spearman's Correlations were then applied to evaluate the correlation between the two anatomical points and were classified as – (0-0.19 – fairly weak correlation; 0.20-0.39 - weak correlation; 0.40-0.69 - moderate correlation; 0.70-0.89 - strong correlation; 0.90-1 very strong correlation) [17].

In addition, two correction formulas were developed for men and women, to facilitate for the evaluator to have the possibility of measuring the anatomical point by ABC and correcting it for WC. Formulas developed - WC = 0.75 + 0.98 X (ABC) for men and - WC = 2.52 + 0.89 X (ABC) for women.

The Bland-Altman's Concordance Test was also performed to verify the different measurements, both visually and qualitatively. The percentage between anthropometric differences in WC and ABC in both groups and the calculation of the percentage delta between the different anatomical points were calculated using the formula – Δ% = (Total Number of Individuals - Total Number of Individuals with Incorrect Classification) / Total Number of Individuals X 100.

Finally, the variables of WC and ABC were compared, for both sexes the anthropometric measurements that presented classification for the wrong CMR. The data were also submitted to the Kolmogorov-Smirnov Test and the Levene Test. Both sexes presented non-parametric behavior. Thus, the Wilcoxon Test was applied for the comparations and the results were presented in median and interquartile range. The level of significance adopted was $p<0.05$ and the analyses were performed with the software Sigma Plot for Windows 11.0 Version, copyright© 2008 System Software, Inc.

Results

Table 1 shows the main demographic and anthropometric characteristics, and the percentage of medications used in the sample analyzed.

Table 1 - *Main demographic, anthropometric, and medication characteristics used in the sample*

	Total	Male	Female
n	413	193	220
Age (years)	30 (24-37)	29 (24-36)	31 (25-39)
Body mass (kg)	73.3 (63.5-85.2)	82.2 (72.0 93.4)	67.0 (60.3-76.1)
Height (m) **BMI (kg/m^2)**	1.67 (1.60-1.75) 26.0 (23.0-29.7)	1.75 (1.71-1.81) 26.4 (24.0-29.6)	1.61 (1.58-1.65) 25.4 (22.7-30.0)
MEDICATION			
BET - n (%)	5 (1.7%)	5 (2.6%)	0 (0.0%)
ACEI - n (%)	7 (1.7%)	6 (3.1%)	1 (0.5%)
CHM - n (%)	6 (1.5%)	0 (0.0%)	6 (2.7%)
IR - n (%)	5 (1.7%)	3 (1.6%)	2 (1.0%)
CM - n (%)	18 (4.8%)	3 (1.6%)	15 (6.8%)
Other - n (%)	11 (2.7%)	6 (3.1%)	5 (2.3%)
PROFILE			
Apparently Healthy - n (%)	278 (67.3%)	130 (72.5%)	148 (67.3%)
Obese - n (%)	81 (19.1%)	39 (20.7%)	42 (19.1%)
Hypertension - n (%)	14 (8.2%)	11 (6.3%)	3 (0.9%)
Altered Lipid Profile - n (%)	6 (1.5%)	0 (0.0%)	6 (2.7%)
Diabetes *Mellitus* - n (%)	5 (1.2%)	3 (1.6%)	2 (0.9%)
WC			
Low Risk - n (%)	321 (59.0%)	130 (65.28%)	191 (53.65%)
Moderate Risk - n (%)	50 (17.9%)	28 (16.05%)	22 (19.55%)
High Risk - n (%)	42 (23.0%)	35 (18.65%)	7 (26.81%)
ABC			
Low Risk - n (%)	265 (41.89%)	119 (60.62%)	146 (25.45%)
Moderate Risk - n (%)	63 (23.25%)	27 (15.02%)	36 (30.45%)
High Risk - n (%)	85 (34.87%)	47 (24.35%)	38 (44.10%)

Data expressed in median and interquartile intervals (non-parametric variables). *BMI - Body Mass Index. BET - Beta-blocker. ACEI - Angiotensin-converting Enzyme Inhibitor. CHM – Cholesterol Medication. IR - Insulin Resistance. CM - Combined Medications. *ABC - Abdominal Circumference. *WC - Waist Circumference.

Figure 1 shows the significant difference between the two anthropometric variables measured, WC and ABC, in females, (p = 0.001). In addition, another relevant data is that 46.8%, i.e., almost half of the female sample, would be included in an incorrect risk classification for the determination and/or association of cardiometabolic diseases when the two anatomical points were compared. The same occurred with the masculine sex, also showing a significant difference between the two anthropometric variables (p = 0.032).

Thus, concerning the correct anatomical point, it makes no sense to measure the ABC, since WC would be the recommended measure for the determination of the CMR. However, as determining one of the five criteria for the diagnosis of MS, when we extrapolate to clinical practice it did not seem to be as relevant as observed in women. Because the error found in the CMR classification was less than 10%, unlike women who were inadequately classified in almost half of the population evaluated. However, whatever the error might be, when we think about the risk stratification and/or inclusion of these individuals in scientific studies, any error should be rectified. Thus, it seems appropriate to measure WC instead of ABC in both sexes.

The percentage differences between the WC and ABC measurements of both sexes, as well as the delta percentage, which aimed to verify the percentage of error in which the different anatomical points could present. It is clear, when calculating the percentage delta, that the measurements performed in males present a relatively low percentage of disagreement. However, according to the arguments mentioned above, it is essential to establish a specific and correct point following a methodological and anatomical logic and, mainly, to meet what is recommended by the guidelines [8,13,16], for the determination of MS.

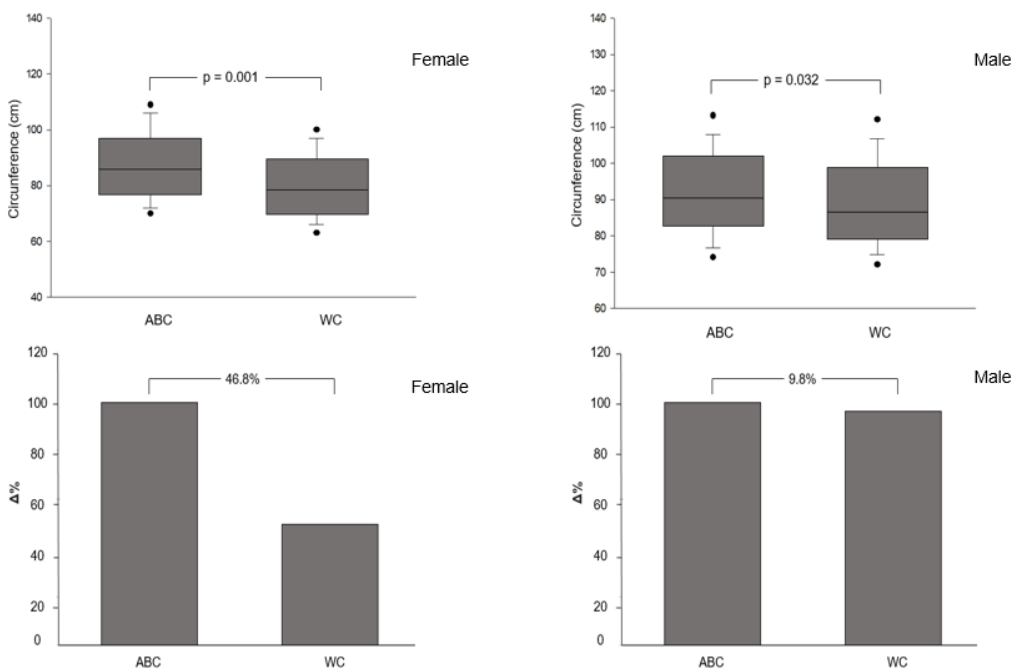

Figure 1 - *Data expressed in median and interquartile interval in the Wilcoxon test for the anthropometric variables abdominal circumference (ABC) and waist circumference (WC) for both sexes. Data from the percentage delta of the anthropometric variables abdominal circumference (ABC) and waist circumference (WC) in both sexes. The calculation performed from the formula Δ% = (Total Number of Individuals - Total Number of Individuals with Incorrect Classification) / Total Number of Individuals X 100*

In Figure 2, Spearman's Correlations between the different anatomical points are presented, as well as the results of Bland Altman's concordance analyses in both sexes. It is noteworthy that the correlation presented was very strong for the two groups evaluated. This demonstrates that both WC and ABC measurements presented directly proportional results, i.e., the relationship between the two variables through a common factor. In addition, for both sexes, correction formulas were created and available to adjust the difference between the different anatomical points, if the ABC is adopted by the evaluator as a criterion for determining the CMR, instead of WC.

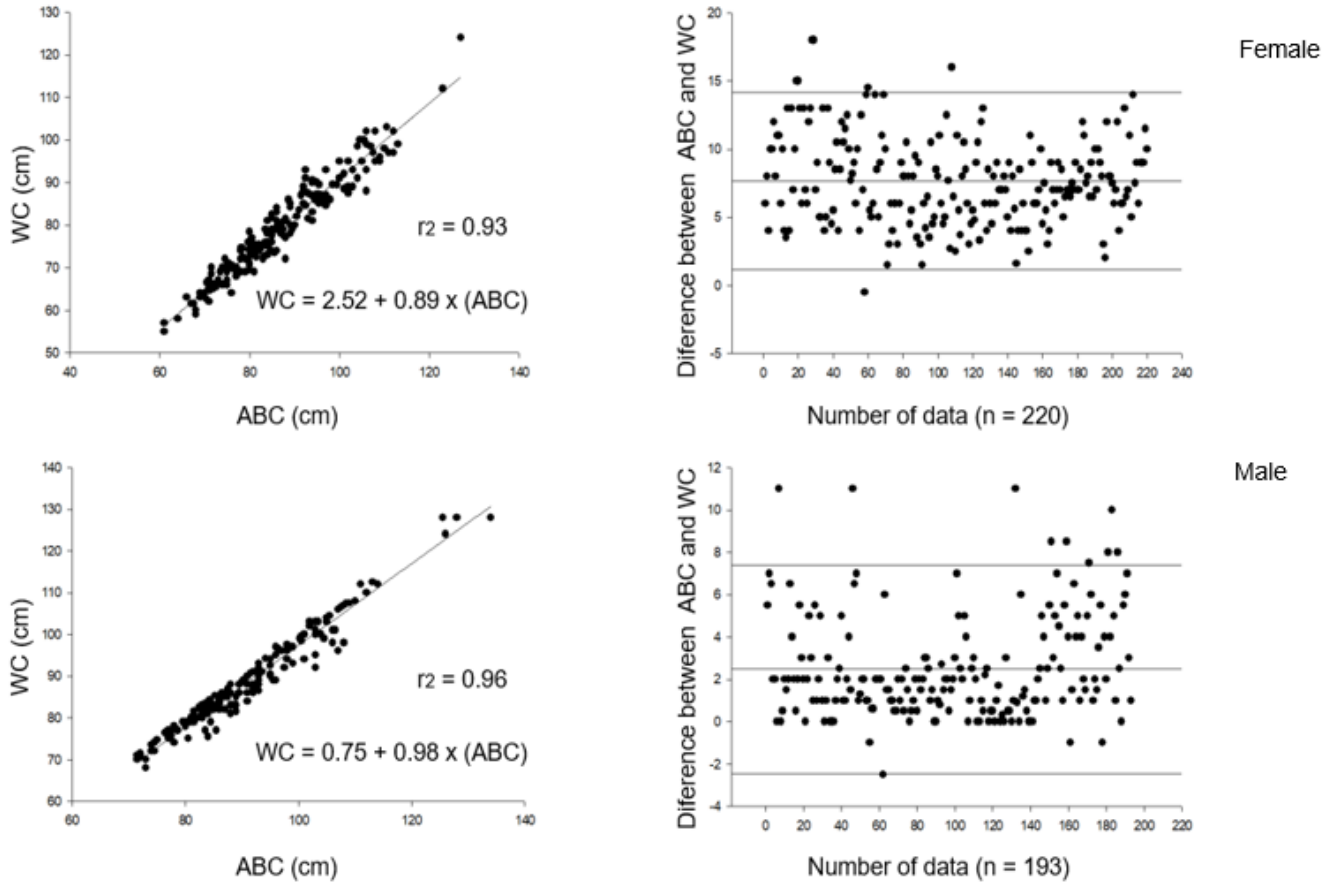

Figure 2 - *Spearman's Correlation and Bland-Altman's Concordance Test for anthropometric variables of waist circumference (WC) and abdominal circumference (ABC) for both sexes*

Finally, figure 3 shows the significant difference between the two anthropometric variables, WC and ABC for both sexes, when the circumference measurements that disagreed with the CMR classification criterion were compared. The results suggest that the classification of the CMR should not be performed by the ABC measurement, but by the WC.

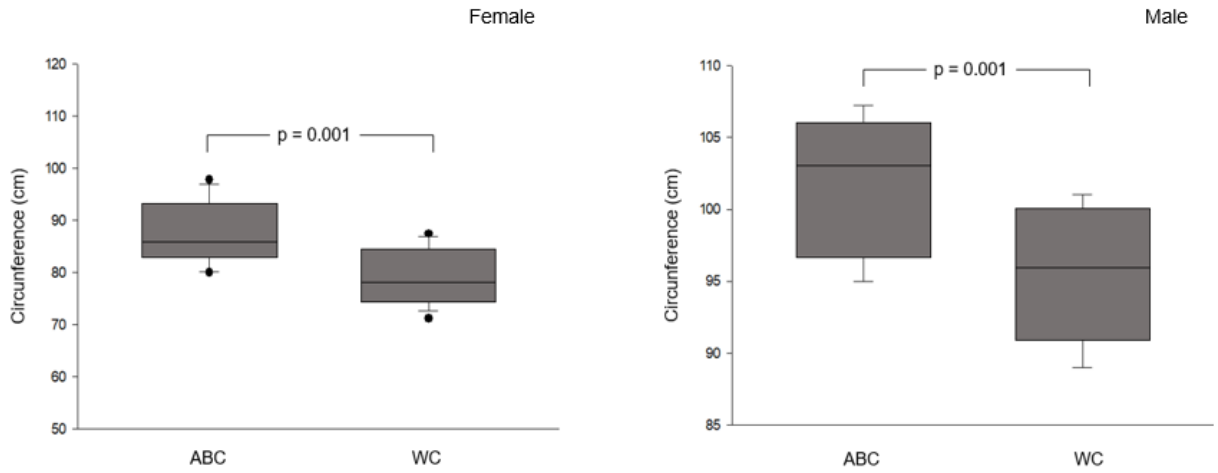

Figure 3 - *Data expressed in the median and interquartile interval in the Wilcoxon test for the anthropometric variables Abdominal Circumference (ABC) and Waist Circumference (WC) of volunteers of both sexes who presented disagreement in the classification of cardiometabolic risk*

Discussion

The results suggest the importance of rethinking what would be the ideal cutoff point for stratification of the CMR. This evaluation determined by the measurement of central adiposity is a fundamental variable for stratification and is one of the criteria for the determination and clinical diagnosis of MS [18].

It is important to highlight that there is a conflict between the criterion of determination carried out by Brazilian guidelines [10,11] in relation to other studies published in international journals [19-21]. Thus, it would be essential to align what would be the best anatomical point, in order to measure, evaluate, analyze, and determine the risk of diseases associated with metabolism and the cardiovascular system, in individuals with MS.

In this context, the main finding of the present study was the difference between the two anatomical points WC and ABC, and verified that the classification and stratification of the CMR was mistaken in almost half of the sample in females and also in a smaller portion in males. In addition, very strong correlations were found between the WC and ABC measurements, however, in Bland Altman's Concordance analysis, it was clear that the measurements are distinct and should not be used for the same purpose. Furthermore, in both sexes who presented disagreement in the Classification of the CMR, differences were also presented between the different anatomical points when the two measurements were compared.

Correction formulas were elaborated for both sexes to adjust the difference between the different anatomical points, if ABC is adopted by the evaluator as a criterion for determining the CMR, instead of WC. Thus, regardless of whether the evaluators who work with physical, nutritional, or clinical evaluation, choose to determine the CMR by ABC, they would considerably reduce classification errors, due to the lack of accuracy and methodological accuracy to the detriment of the different nomenclatures used [10,11,22-24].

Another important point that deserves to be emphasized is that, in addition to WC and ABC being distinct anatomical points and the percentage of error being considerably higher for females, the pelvic structure of women is different than that of men. This was made clear in previous research published by Merrill et al[25]. In this study, 1801 individuals of both sexes were evaluated and compared through a multivariate regression analysis. In this robust analysis, it was evident that factors such as gender, race and age could directly influence changes in pelvic structural form, directly impacting its anatomy.

The difference in circumference between WC and ABC could be explained by the morphological difference of the pelvis bone between men and women, as well as, in the respective anatomical point, which was clear in a previous study that reported the difference between the different anatomical points and the particularities between both sexes [12]. It is also worth mentioning that if ABC were adopted as a criterion for determining central obesity, mistakes were being made regarding the classification of the CMR. We know that WC is one of the five criteria for determining and for clinical diagnosis of MS [26]. Thus, if ABC were considered instead of WC, we would possibly be overestimating the classification of the CMR in a very significant way, especially in the group constituted by the female sex. Another point that deserves attention is that the classification of the CMR was also very compromised, especially for females in almost 50%.

In a study published by Oliveira et al [27], three measurements for WC were compared in men, of which three different anatomical points were determined as follows: (i) narrower point of the abdominal region, i.e., close to 1 cm from the last rib; (ii) midpoint between the last rib and the edge of the iliac crest; (iii) umbilical line, i.e., on top of the navel. This cross-sectional study aimed to evaluate in 300 middle-aged men from the southeast region, which of these anatomical points mentioned above could reflect higher CMR.

The results presented according to the researchers of the study suggest that the measurement performed on top of the umbilical scar was the best predictor of overweight, obesity, and visceral fat measured by densitometry by emission of double-energy X-rays DEXA. In addition, the measurement performed on top of the umbilical scar showed better correlations for individuals diagnosed with MS, insulin resistance, and risk factors for cardiometabolic diseases, suggesting that ABC would be the best point to determine the CMR. However, in the present study, more than 400 people were evaluated, 220 of them female, and the results presented suggest that adopting the ABC in women would be a mistake, which, according to the present discovery, one would reach almost 50% concerning the classification of the CMR.

Moreover, since the anatomy of the female pelvis is different [25], and since there is an important prevalence for the distribution of gynoid fat in this population, which would be associated with lower CMR [28], the results found in males in a previous study [27] could present different results if female individuals were evaluated. It is also worth mentioning the study published by WANG et al [29], which evaluated different anatomical points as follows: (1) immediately below the last rib; (2) at the lowest point of circumference; (3) at the midpoint between the last rib and the iliac crest; and (4) immediately above the iliac crest. After comparing the various anthropometric measurements, a significant difference was found only in women, according to the following order: measurement 2 <1 <3 <4. In this context, and similarly, in the present study, discrepancies were found in the different anatomical points measured in female individuals when both were confronted. In addition, innovative percentage

data were also presented that demonstrated that the classification of the CMR would be mistaken in the qualitative classification criterion in almost 50% of the female sample if the ABC was adopted.

Central fat, which is one of the criteria adopted in the determination of MS, has been strongly studied in previous studies [30,31], as well as in more recent studies [32,33]. In this context, it is suggested the importance of standardization of the measurement position, especially for female individuals. If this does not occur, original studies would be important that could enable a new cut-off point for ABC, particularly since WC is already available and is widely used by international studies [34,38].

In this sense, if ABC is used to determine the CMR instead of WC, in addition to overestimating quantitative results mainly for females, the screening of scientific studies could be compromised at the time of their selection, if the ABC measurement was performed. Thus, the formula developed in the present study seems to be very useful and practical to reduce the impact of the wrong classifications, especially in females, as well as to reduce errors in stratification and selection criteria. In addition, it is necessary to agree on the standardization of the measurement, as well as in the use and correction of the appropriate nomenclature.

Moreover, it is important to emphasize the positive aspects as well as the limitations of the present study. The positive points that deserve to be mentioned are: All evaluations were performed by only one evaluator who has the experience and a lot of practice in the method and physical evaluation. In addition, the criterion for determining the anatomical point followed the standards of ISAK [13]. However, there are also limitations such as there were no participants with other pathologies or body profiles different from those presented in the study. It was not possible to evaluate the fat present in the central region with DEXA and possible associations with WC and ABC measurements concerning cardiometabolic risk. It was not possible to analyze more robustly the structural differences of the pelvis in both sexes and also in variables such as age.

Conclusion

In conclusion, the data presented allowed us to emphasize that anthropometric measurements of WC and ABC in women have a difference not only in the anatomic point but also in their circumference. Another point that deserves to be mentioned was the high percentage of female individuals who could be misclassified and compromise analyses if ABC were used as a parameter. Moreover, the creation of the correction formula seemed to be quite important for reducing the possible errors of the evaluators if they choose to use the ABC. Further research is necessary to verify whether the same behavior obtained in the results presented in the present context will occur in different populations with different comorbidities.

Conflict of interest

The authors report no conflicts of interest

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Author's contributions

Conception and design of the study, data analysis, interpretation; Statistical analysis and manuscript writing: Chaves TO, Mauricio CÁ, Reis MS; Critical review of the manuscript for important intellectual content: Chaves TO, Mauricio CÁ, Reis MS

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