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Relationship between waist circumference and sagittal abdominal diameter measured at different anatomical sites and inflammatory biomarkers in apparently health men

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Abstract

Introduction: **Visceral fat accumulation is associated with several changes, such as, increased production of inflammatory biomarkers, especially, C-reactive protein (CRP) and fibrinogen. Anthropometric measurements for central adiposity evaluation, such as, waist circumference (WC) and sagittal abdominal diameter (SAD) have been highlighted. However, there is no consensus on the best anatomical site for measurement.**

Objective: **To evaluate the reliability of different measurements of WC and SAD and verify their capacity to discriminate changes in inflammatory biomarkers.**

Method: 130 men (20-59 years) were assessed, having measurements of weight, height, WC and SAD. It was considered as the cutoff point for high-sensitivity CRP (hs-CRP) values ≥ 0.12 mg/dL and for fibrinogen the 50th percentile of the evaluated sample.

Results: **All measurements presented an intraclass correlation coefficient between 0.998 and 0.999. WC measured at the umbilical level (AUC=0.693±0.049) and the smallest circumference between the thorax and the hips (AUC=0.607±0.050) had greater ability to discriminate changes in concentrations of hs-CRP and fibrinogen, respectively. SAD (umbilical level) showed the better ability to detect changes in concentrations of hs-CRP (AUC=0.698± 0.049) and fibrinogen (AUC=0.625±0.049), according to the ROC analysis (p<0.05).**

Conclusion: **WC (smallest circumference between the thorax and the hips) and SAD (umbilical level) are the anatomic sites of measurement for use in predicting the inflammatory risk in apparently health men.**

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Key words: *Waist circumference. Sagittal abdominal diameter. Abdominal obesity. C-reactive protein. Fibrinogen.*

RELACIÓN ENTRE LA CIRCUNFERENCIA DE LA CINTURA Y EL DIÁMETRO ABDOMINAL SAGITAL MEDIDO EN DIFERENTES SITIOS ANATÓMICOS Y BIOMARCADORES DEL ESTADO INFLAMATORIO EN HOMBRES ADULTOS SANOS

Resumen

Introducción: **La acumulación de grasa visceral se asocia con varios cambios, tales como, aumento de la producción de los biomarcadores inflamatorios, en especial, la proteína C-reactiva (PCR) y fibrinógeno. Las medidas antropométricas para la evaluación de la adiposidad central, como la circunferencia de la cintura (CC) y el diámetro abdominal sagital (DAS) se han destacado. Sin embargo, no hay consenso sobre el mejor sitio anatómico para la medición.**

Objetivos: **Evaluar la fiabilidad de diferentes mediciones de CC y DAS y verificar su capacidad para discriminar los cambios en biomarcadores inflamatorios.**

Métodos: Se evaluaron 130 hombres (20-59 años). Se midió peso, estatura, circunferencia de la cintura (CC) y diámetro abdominal sagital (DAS). Se consideró como punto de corte para los valores de PCR ultrasensible (PCR-us) ≥ 0,12 mg/dL y para el fibrinógeno se utilizó el percentil 50 de la muestra evaluada.

Resultados: **Todas las mediciones presentaron un coeficiente de correlación intraclase entre 0.998 y 0.999. CC medida a nivel umbilical (AUC=0,693±0,049) y la circunferencia más pequeña entre el tórax y las caderas (AUC=0,607±0,050) tuvieron una mayor capacidad para discriminar los cambios en las concentraciones de PCR-us y fibrinógeno, respectivamente. DAS (nivel umbilical) mostró la mejor capacidad para detectar cambios en las concentraciones de PCR-us (AUC=0,698±0,049) y fibrinógeno (AUC=0,625±0,049), de acuerdo con el análisis ROC (p<0,05).**

Conclusiones: **CC (circunferencia más pequeña entre el tórax y las caderas) y DAS (nivel umbilical) son los sitios anatómicos de elección para su uso en la predicción del riesgo inflamatorio en hombres adultos sanos.**

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Palabras clave: *Circunferencia de la cintura. Diámetro abdominal sagital. Obesidad abdominal. Proteína C-reactiva. Fibrinógeno.*

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Abbreviations

AUC: Areas under the ROC curves.
BMI: Body mass index.
CC: Circunferencia de la cintura.
CI: Confidence interval.
CRP: C-reactive protein.
DAS: Diámetro abdominal sagital.
hs-CRP: High-sensitivity C-reactive protein.
ICC: Intraclass correlation coefficient.
PCR: Proteína C-reactiva.
PCR-us: Proteína C-reactiva ultrasensible.
ROC: Receiver Operating Characteristic.
SAD: Sagittal abdominal diameter.
WC: Waist circumference.
WHO: World Health Organization.

Introduction

The association between obesity, cardiovascular disease and diabetes was observed in several studies, however without setting causality[1]. Hak et al.[2] suggest that an increase in the acute inflammatory response would be the common factor of these diseases. Other studies have demonstrated an association between higher concentrations of inflammatory biomarkers, in particular C-reactive protein (CRP), and obesity, a subclinical inflammatory condition, as well as the presence of obesity-related comorbidities, such as, diabetes and hypertension, the risk of developing heart failure, myocardial infarction and stroke[3-6].

The subclinical inflammation is characterized by increased concentrations of inflammatory biomarkers, ranging from leukocytes to acute phase reactants, such as, CRP and fibrinogen, in which increased concentrations are associated with higher cardiometabolic risk[6].

Evidence has shown that central adiposity is more strongly correlated to cardiovascular disease than the presence of general adiposity, highlighting the fact that abdominal adiposity is also associated with subclinical inflammation. Anthropometric measurements have been widely used for evaluation of visceral adipose tissue, highlighting the waist circumference (WC) and the sagittal abdominal diameter (SAD)[7, 8].

Petersson et al.[9] found that SAD was the only significant predictor of CRP concentrations after adjustment for body mass index (BMI) and WC. The WC, compared to other traditional anthropometric measurements, have shown to be better than the BMI and the waist to hip ratio to identify visceral adiposity, which is more strongly associated with metabolic disorders[10]. Nakamura et al.[11] found that WC showed the strongest correlation with CRP between variables related to the metabolic syndrome.

In a review article, Wang et al.[12] identified fourteen different descriptions of anatomical sites for measurements of WC. However, there is no universally standard site to measure the WC or the SAD[12,13]. Therefore, the present study aimed to compare different anatomical sites of measurements of WC and SAD and verify its ability to discriminate higher concentrations of high-sensitivity CRP (hs-CRP) and fibrinogen in apparently health men.

Methods

Participants and data collection

A cross sectional study was conducted on apparently healthy adult men from Brazil using a convenience sampling method. Data were collected in the Nutrition Sector of the Universidade Federal de Viçosa, Brazil. The volunteers were recruited through posters, leaflets, web sites and e-mail. In the recruitment message, the age range (20-59 years old) and the gender (men) were mentioned. Exclusion criteria of the participants included in this study were: BMI ≤ 18.5 kg/m^2 or ≥ 35 kg/m^2, self-reported hypertension or treatment with antihypertensive medication, type 1 or type 2 diabetes, osteoarthritis, treatment with drugs that could interfere with the expression of inflammatory biomarkers (i.e.: hormonal and nonhormonal anti-inflammatory, statins, steroids, cyclosporine, anticonvulsants and diuretics), current smokers, bacterial infections at the time of collection, subjects with plasma concentrations of hs-CRP above 1.0 mg/dL suggesting the presence of inflammation and/or infection[14,15].

The general design of research was explained before the study began and all participants provided written informed consent. The protocol has been approved by the Ethics Committee of the Universidade Federal de Viçosa (ref no. 006/2008), in accordance with the principles of the Helsinki Declaration[14,15].

Anthropometric measurements

The anthropometric assessment was conducted by a single trained examiner. The WC and the SAD were evaluated in triplicate, using the two closest values to calculate the respective averages. The weight and the height were measured according to the techniques recommended by the World Health Organization (WHO)[16]. The BMI was calculated as the weight (kg) divided by the square of the height (m) and classified according to criteria established by the WHO[17].

The WC was measured with flexible and inelastic tape at the end of a normal expiration and taking care not to compress the tissues[16]. The WC was measured at four different anatomical sites: umbilical level; midpoint between the lowest rib and the iliac crest; smallest circumference between the thorax and the hips; and highest point of the iliac crest.

The SAD was measured with a portable abdominal caliper (Holtain Kahn Abdominal Caliper®). The measurement was performed with the participants lying on a flat and firm table, in the supine position with bent knees. The subject was asked to inhale and exhale gently, and the arm of the caliper was brought down to touch the abdominal without compression[18]. The SAD was measured at four different anatomical sites: umbilical level; largest point of abdominal diameter; smallest circumference between the thorax and the hips; and midpoint between the iliac crest.

Biochemical analysis

The blood samples were collected after a 12 hours overnight fasting. The determination of complete blood count was performed by flow cytometry, in order to detect the presence of bacterial infections at the time of collection. Serum concentrations of uric acid, HDL-cholesterol and triglycerides were determined by enzymatic colorimetric method. Fasting glucose was analyzed by the glucose oxidase method. The hs-CRP was determined by nephelometry. Participants with hs-CRP concentrations above the 3rd quintile of the population distribution (≥0.12 mg/dL) were considered at higher relative risk of cardiovascular events[19]. Fibrinogen was estimated by the Clauss method. It was considered as the cutoff point for analysis of fibrinogen value to the 50th percentile in the study sample.

Statistical analysis

Variables with normal distribution were analyzed with a Student's t-test, analysis of variance (ANOVA) with Tukey's post hoc test and Pearson's correlation coefficient. Non-parametric variables were analyzed with the Mann-Whitney test, Kruskal-Wallis test with Dunn`s post hoc test and Spearman's correlation coefficient. The areas under the Receiver Operating Characteristic (ROC) curves (AUC) were calculated for each anthropometric measurement and risk condition. It was adopted a confidence interval (CI) of 95%. The statistical analyses and ROC curves were performed by using SPSS for WINDOWS (version 15.0, SPSS Inc, Chicago, IL) and MedCalc (version 9.3). $P < 0.05$ was considered as statistically significant.

Results

Were evaluated 152 adult men, of which 130 filled out the inclusion criteria. Overweight men (BMI ≥ 25 kg/m²) showed higher triglycerides, fasting glucose and uric acid concentrations and lower HDL-cholesterol concentrations. There was no difference between men with normal weight and those with overweight in relation to concentrations of the inflammatory biomarkers hs-CRP and fibrinogen (data not shown).

The comparison between the measurements of the WC and the SAD evaluated at four different anatomical sites according to the nutritional status are presented in table I. In the group with BMI < 25 kg/m² the WC measured at the smallest circumference between the thorax and the hips was lower compared to other sites of measurements. On the other hand, in the group

Table I
Comparison of different measurements of waist circumference and sagittal abdominal diameter according to the nutritional status

Anthropometric measurements	*Total (n=130)*	*BMI < 25 kg/m² (n=71)*	*BMI ≥ 25 kg/m² (n=59)*
Waist circumference (cm)			
Umbilical level	89.1 (70.2-115.4) ^{a†}	83.99±5.63^{a‡}	96.12±7.31^{a*}
Midpoint between the lowest rib and the iliac crest	88.45 (69.2-115.8)^{ab}	83.45±5.58^{a}	95.77±7.41^{a}
Smallest circumference between the thorax and the hips	85.7 (67.5-110.3)^{b}	80.91±5.29^{b}	92.44±6.51^{b}
Highest point of the iliac crest	89.05 (73.1-112.7)^{a}	84.95±4.88^{a}	95.3±6.78^{ab}
Sagittal abdominal diameter			
Umbilical level	19.3 (14.9-26.8)^{a}	18.31±1.58^{a}	21.63±2.13^{a}
Largest point of abdominal diameter	19.5 (15.2-27.6)^{a}	18.53±1.61^{a}	21.85±2.28^{a}
Smallest circumference between the thorax and the hips	19.8 (15.2-27.8)^{a}	18.63±1.58^{a}	21.87±2.12^{a}
Midpoint between the iliac crest	19.3 (15.0-26.5)^{a}	18.26±1.57^{a}	21.53±2.11^{a}

ANOVA with Tukey's post hoc test for variables presented as mean ± standard deviation; Kruskal-Wallis test with Dunn`s post hoc test for variables presented as median (range). Comparisons within the same column for the four anatomical sites of measurements of waist circumference and sagittal abdominal diameter. Same letters indicate no significant difference and different letters indicate statically significant differences.
* $p < 0.05$.
† $p < 0.01$.
‡ $p < 0.001$.
BMI: Body Mass Index.

with BMI ≥ 25 kg/m^2 the WC measured at the smallest circumference between the thorax and the hips was lower than those measured at the umbilical level and the midpoint between the lowest rib and the iliac crest, whereas the WC measured at the highest point of the iliac crest did not differ from others. In the total sample, the WC measured at the smallest circumference between the thorax and the hips was lower than those measured at the umbilical level and the highest point of the iliac crest, while the WC measured at the midpoint between the lowest rib and the iliac crest did not differ from others. For the SAD no significant difference was found between the different anatomical sites of measurements for both the total sample and stratified according to the nutritional status.

The evaluation of the reliability of the measures of WC and SAD allowed to identify intraclass correlation coefficient (ICC) very high for both measures in the four anatomical sites of measurements, showing high reliability of the same (table II).

The WC measured at the smallest circumference between the thorax and the hips showed better correlation with both hs-CRP and fibrinogen concentrations when compared to other anatomical sites of measurements. It is noteworthy that no significant correlations were found between the WC measured at the midpoint between the lowest rib and the iliac crest and the highest point of the iliac crest and the hs-CRP concentrations. There was no statistically significant correlation between the fibrinogen concentrations and the WC measured at the highest point of the iliac crest. For SAD the best correlation for both hs-CRP and fibrinogen was at the smallest circumference between the thorax and the hips (table III).

The ROC analysis showed that the WC measured at the umbilical level, followed by the WC measured at the smallest circumference between the thorax and the hips showed the highest absolute value for AUC, highlighting these two anatomical sites as the best predictors of changes in the concentrations of hs-CRP. In relation to the fibrinogen, the only AUC statistically significant was for the WC measured at the smallest circumference between the thorax and the hips. This result indicates that the measurements of the WC at the umbilical level, the midpoint between the lowest rib and the iliac crest and the highest point of the iliac crest were not predictors of risk for changes in the fibrinogen concentrations. The SAD measured at the umbilical level showed greater predictive ability to detect changes in both concentrations of hs-CRP and fibrinogen (table IV).

Discussion

Several studies differ on the anatomical site for measurement of WC and SAD or even not report where they were measured. Since the various measures of WC and SAD differ, it is essential that the anatomical site of measurement be identified. The present study indicated that the measurement of WC at the smallest circumference between the thorax and the hips differed from other anatomical sites evaluated, regardless of the nutritional status. This result indicates that the anatomical sites of measurement of the WC, commonly used, are not similar, therefore comparison of results from different studies must be carefully evaluated. Comparisons between studies are valid only if the same anatomical site of measurement is used in both studies. According to this, Wang et al.[12] verified that the WC measured at the smallest circumference between the thorax and the hips was significantly lower than the WC measured at three other anatomical sites of measurement in the men evaluated. Adding,

Table II
Reliability of waist circumference and sagittal abdominal diameter measured three times in four anatomical sites

Anthropometric measurements	*ICC*	*CI (95%)*
Waist circumference		
Umbilical level	0.999‡	0.999-0.999
Midpoint between the lowest rib and the iliac crest	0.999‡	0.999-1.000
Smallest circumference between the thorax and the hips	0.999‡	0.999-1.000
Highest point of the iliac crest	0.999‡	0.999-1.000
Sagittal abdominal diameter		
Umbilical level	0.998‡	0.998-0.999
Largest point of abdominal diameter	0.998‡	0.998-0.999
Smallest circumference between the thorax and the hips	0.999‡	0.998-0.999
Midpoint between the iliac crest	0.999‡	0.999-0.999

‡ $p < 0.001$.
ICC: Intraclass Correlation Coefficient, CI: Confidence Interval.

Table III
Correlations between different measurements of waist circumference and sagittal abdominal diameter and the inflammatory biomarkers high-sensitivity C-reactive protein and fibrinogen

Anthropometric measurements	*hs-CRP*	*Fibrinogen*
Waist circumference		
Umbilical level	0.183*	0.199*
Midpoint between the lowest rib and the iliac crest	0.169	0.185*
Smallest circumference between the thorax and the hips	0.186*	0.205*
Highest point of the iliac crest	0.158	0.159
Sagittal abdominal diameter		
Umbilical level	0.232†	0.216*
Largest point of abdominal diameter	0.225*	0.210*
Smallest circumference between the thorax and the hips	0.235†	0.223*
Midpoint between the iliac crest	0.218*	0.201*

Pearson's correlation coefficient for variables with normal distribution; Spearman's correlation coefficient for non-parametric variables.
* $p < 0.05$.
† $p < 0.01$.
hs-CRP: high-sensitivity C-reactive protein.

Table IV
Areas under the ROC curves for different measurements of waist circumference and sagittal abdominal diameter according to high-sensitivity C-reactive protein and fibrinogen concentrations

Anthropometric measurements	*hs-CRP AUC±SE (CI 95%)*	*Fibrinogen AUC±SE (CI 95%)*
Waist circumference		
Umbilical level	0.693±0.049 (0.597-0.790)‡	0.594±0.050 (0.496-0.692)
Midpoint between the lowest rib and the iliac crest	0.685±0.049 (0.588-0.782)‡	0.587±0.050 (0.488-0.685)
Smallest circumference between the thorax and the hips	0.690±0.049 (0.593-0.787)‡	0.607±0.050 (0.510-0.704)*
Highest point of the iliac crest	0.686±0.050 (0.589-0.784)‡	0.572±0.050 (0.474-0.671)
Sagittal abdominal diameter		
Umbilical level	0.698±0.049 (0.602-0.794)‡	0.625±0.049 (0.529-0.720)*
Largest point of abdominal diameter	0.689±0.050 (0.590-0.787)‡	0.624±0.049 (0.529-0.720)*
Smallest circumference between the thorax and the hips	0.693±0.049 (0.596-0.790)‡	0.620±0.049 (0.524-0.716)*
Midpoint between the iliac crest	0.692±0.049 (0.596-0.788)‡	0.612±0.049 (0.515-0.709)*

* $p < 0.05$.
‡ $p < 0.001$.
hs-CRP: high-sensitivity C-reactive protein, AUC: Areas under the ROC curves, SE: Standard Error, CI: Confidence Interval.

Willis et al.[13] showed that the measurement of the WC at the smallest circumference between the thorax and the hips was significantly lower than the WC measured at the umbilical level.

In the group with BMI ≥ 25 kg/m², the WC measured at the highest point of the iliac crest was similar to other anatomical sites, in the present study. This suggests a greater difficulty in defining the location of the smallest circumference in subjects with overweight. In the total sample, it was found that the WC measured at the midpoint between the lowest rib and the iliac crest was similar to other anatomical sites. The results showed different behaviors depending on the nutritional status.

On the other hand, in the present study, for the SAD no statistically significant differences were found between the four anatomical sites evaluated, regardless of nutritional status. Nevertheless, Vasques et al.[20], assessing the same four anatomical sites of the present study, verified that the SAD measured at the largest point of abdominal diameter differed from others. However, according to our results, the choice of the best anatomical site for measuring the SAD could be based on facility of measurement. For example, the SAD measured at the midpoint between the iliac crest, requires touching the bone structures and greater skill on the part of the examiner. Moreover, in severely obese subjects, the location of these bone structures may be impaired depending on the accumulation of adipose tissue[20]. Therefore, it is suggested to measure the DAS at the easier anatomical site of measurement, for example, at the umbilical level, once the umbilicus is easily visible, regardless of the nutritional status.

The reliability of measurements of the WC and the SAD, assessed by the ICC, proved to be very high in the four anatomical sites. Study that evaluated four different anatomical sites of measurement of the WC found elevated ICC for both sexes; in men the ICC ranged from 0.996 to 0.998[12]. Willis et al.[13] identified ICC of 0.990 for both the WC measured at the smallest circumference between the thorax and the hips and the WC measured at the umbilical level. Sampaio[21] verified very high reliability (r=0.991) for the SAD measured at the midpoint between the iliac crest; whereas Zamboni et al.[22] identified high ICC (0.999) for the SAD measured at the largest point of abdominal diameter.

The WC measured at the smallest circumference between the thorax and the hips showed the best correlation with the inflammatory biomarkers hs-CRP and fibrinogen. Willis et al.[13] found that, in men, the WC measured at the smallest circumference showed higher correlation coefficients than the WC measured at the umbilical level for insulin sensitivity, fasting insulin and visceral adipose tissue; however there was no significant difference. In this same study, the WC measured at the smallest circumference was related to the metabolic syndrome, whereas the WC measured at the umbilical level did not show the same behavior. The WC measured at the smallest circumference between the thorax and the hips is probably the most frequently recommended anatomical sites. However, for some subjects, there is no single smallest point between the lowest rib and the iliac crest because of either a large amount of abdominal fat or extreme thinness[12].

Pannacciulli et al.[23], in a study with a sample of 201 women aged 18-60 years, found a correlation of 0.337 ($p<0.0001$) between the WC measured at the smallest circumference and the CRP concentrations. The correlation was higher than that observed in the present study. This difference can be attributed to the larger sample (n=201) compared to our sample (n=130), which may have contributed to increase the statistical power of correlation and also to the fact that in the present study were included only males. However, the responsible factors for variation in CRP concentrations between the sexes remain unclear, and differences in study design, such as, inclusion of women who use hormone replacement therapy, may further contribute to these discrepancies[24]. Araújo et al.[25] identified higher CRP concentrations in Brazilian women (0.09 mg/dL) than in Brazilian men (0.07 mg/dL), whereas the value observed for men was similar to the median of the present study (0.08 mg/dL) (data not shown).

In a prospective case-control study with participants of the European Prospective Investigation into Cancer and Nutrition (EPIC) were observed significant correlations between the WC and the CRP (r=0.250, $p<0.01$) and the fibrinogen (r=0.130, $p<0.01$); however it was not mentioned the anatomical site of measurement of the WC[26].

It is noteworthy that, in the present study, no statistically significant correlations were found between the hs-CRP and the WC measured at the midpoint between the lowest rib and the iliac crest, and the highest point of the iliac crest. Even as, no significant correlation was observed between the fibrinogen and the WC measured at the highest point of the iliac crest. These results demonstrated different behaviors depending on the anatomical site of measurement of WC compared to cardiometabolic risk factors. The WHO[16] recommends that the WC be measured at the midpoint between the lowest rib and the iliac crest and the guidelines of the National Institutes of Health[27] advise that the measurement of the WC occurs immediately above the iliac crests. Despite national and international organizations recommend these two anatomical sites of measurement of WC, in the present study, there was no correlation between these two anatomical sites and cardiometabolic risk. However, Snodgrass et al.[24], evaluating 56 indigenous men (18-58 years), verified a statistically significant correlation between the hs-CRP concentrations and the WC measured immediately above the iliac crests (r=0.270, $p<0.05$).

Girerd et al.[28] determined that middle-aged men (< 65 years) with a "inflammatory waist" defined as a WC (midpoint between the lowest rib and the iliac crest) > 102 cm and CRP ≥ 0.15 mg/dL are at higher risk for postoperative atrial fibrillation.

For SAD, positive correlations between the four anatomical sites and the hs-CRP and the fibrinogen were found and the best correlations were observed between the DAS measured at the smallest circumference between the thorax and the hips and both inflammatory biomarkers. Petersson et al.[9], evaluating a sample of 157 women, identified that the SAD showed stronger association with CRP concentrations compared to BMI, WC and waist to hip ratio.

The ROC analysis identified the higher AUC for the WC measured at the umbilical level and the hs-CRP concentrations, followed by the WC measured at the smallest circumference between the thorax and the hips. Whereas for fibrinogen, the only AUC with statistically significant value was for the WC measured at the smallest circumference between the thorax and the hips; therefore, our results suggested this anatomical site as a measurement of the WC. Studies showed that the WC measured at the smallest circumference is a strong predictor of the total adipose tissue and visceral adipose tissue measured by computed tomography[29,30]. Turcato et al.[31], in a study with 83 men (67-78 years), verified that the WC measured at the smallest circumference was one of the anthropometric parameters of body fat distribution that was more associated with cardiovascular risk factors in older age.

For the SAD, in the ROC analysis, the SAD measured at the umbilical level showed the higher AUC for both inflammatory biomarkers hs-CRP and fibrinogen. It is noteworthy that, in relation to the hs-CRP concentrations, the AUC of the WC and the SAD measured at the four anatomical sites were similar; whereas in relation to the fibrinogen, of the two measures, the SAD measured at the four anatomical sites showed greatest predictive ability compared to the four anatomical sites of measurement of the WC. On the other hand, Paula et al.[32] verified that the WC measured at the umbilical level (AUC=0.694±0.079) and the SAD measured at the midpoint between the iliac crests (AUC=0.747±0.076) showed the largest AUC ($p<0.05$) with respect to the identification of cardiometabolic risk factors associated with the metabolic syndrome in elderly women.

Conclusion

The results of the present study indicated that the four anatomical sites of measurements of the WC differ according to the nutritional status; whereas the DAS was similar for all anatomical sites evaluated, regardless of the nutritional status, indicating greater flexibility in choosing the anatomical site to measure the DAS. Our results suggested that the WC measured at the smallest circumference between the thorax and the hips and the SAD measured at the umbilical level are the anatomic sites of measurement for use in predicting the inflammatory risk in apparently health men.

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