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**Original Article**

# CAN ANTHROPOMETRIC MEASURES DISCRIMINATE BIOCHEMICAL FACTORS IN PHYSICALLY ACTIVE WOMEN OVER THE AGE OF 50 YEARS?

## MEDIDAS ANTROPOMÉTRICAS DISCRIMINAM FATORES BIOQUIMICOS EM MULHERES ACIMA DE 50 ANOS PRATICANTES DE ATIVIDADE FÍSICA?

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**RESUMO**
No Brasil, são encontrados maiores índices de sobrepeso e obesidade na faixa etária de 55 a 64 anos. Nesse sentido, tais distúrbios da composição corporal podem associar-se às alterações metabólicas, tornando-se relevante investigar quais as medidas antropométricas podem discriminar níveis de alterações bioquímicas. O objetivo deste estudo foi analisar por meio da sensibilidade e especificidade se variáveis antropométricas são discriminadoras de alterações bioquímicas de colesterol, triglicerídeos e glicemia em mulheres acima de 50 anos praticantes de atividade física. Participaram 139 mulheres com 50 anos ou mais de idade praticantes de atividade física regular. As variáveis antropométricas analisadas foram: Índice de Massa Corporal (IMC); Perímetro de Cintura (PC); Razão cintura-quadril (RCQ); razão cintura estatura (RCE); Índice de conicidade (IC) e percentual de Gordura (%G). As variáveis bioquímicas analisadas foram: Glicemia (GL); Triglicerídeos (TG) e colesterol total (CT). Foi utilizada a estatística descritiva e a curva ROC. Como resultado, IMC, PC, RCQ, RCE e %G discriminaram GL aumentada. A RCQ discriminou TG aumentada e nenhuma variável antropométrica discriminou CT aumentada. Conclui-se que o risco aumentado de alterações bioquímicas, glicemia e triglicerídeos, podem ser discriminadas por algumas variáveis antropométricas em mulheres acima de 50 anos praticantes de atividade física.
**Palavras-chave**: Antropometria. Atividade Motora. Composição Corporal.

**ABSTRACT**
In Brazil, higher rates of overweight and obesity are observed in the age group of 55-64 years. These body composition disorders may be associated with metabolic changes and it is therefore important to investigate which anthropometric measures can discriminate levels of biochemical changes. The aim of this study was to analyze by means of sensitivity and specificity if anthropometric variables can discriminate biochemical changes in cholesterol, triglycerides and glucose in physically active women over the age of 50 years. A total of 139 women aged 50 years and older who take part in regular physical activity participated in the study. The following anthropometric variables were analyzed: body mass index (BMI), waist circumference (WC), waist-to-hip ratio (WHR), waist-to-height ratio (WHtR), conicity index, and body fat percentage (BF%). The biochemical variables analyzed were blood glucose, triglycerides, and total cholesterol (TC). Descriptive statistics and ROC curves were used. The results showed that BMI, WC, WHR, WHtR and BF% were able to discriminate increased blood glucose. The WHR discriminated elevated triglycerides, while none of the anthropometric variable was able to discriminate increased TC. In conclusion, some anthropometric variables can be used to identify an increased risk of biochemical changes, such as elevated blood glucose and triglycerides, in physically active women over the age of 50 years.
**Keywords:** Anthropometry. Body composition. Motor Activity.

## Introduction

Over the age of 50 years, women show a greater predisposition to metabolic changes than men[1]. This increased predisposition can be attributed to the arrival of the postmenopausal period, which is responsible for different physiological alterations in the female body[2]. Consequently, postmenopausal women are at a higher risk of having metabolic disorders[3].

In addition to postmenopause, the development of metabolic changes is related to some risk factors such as ethnic background, gender, and age[4], as well as socioeconomic status, smoking, physical activity level, inadequate diet, and body composition disorders[1]. Elevated serum levels of biochemical parameters such as triglycerides, total cholesterol, and fasting glucose are also risk factors for metabolic disorders and cardiovascular diseases[5-7].

Within this context, body composition disorders such as overweight and obesity, in addition to being associated with metabolic changes[8], are also considered a problem of pandemic proportion because of the high prevalences found[9]. In Brazil, the highest rates of overweight and obesity are observed in the age group of 55 to 64 years[10]. Studies designed to identify risk factors for the development of metabolic changes are important to raise the awareness of the population to improve their health condition[11,12]. In this respect, anthropometric measurements such as body mass index (BMI), conicity index (CI), waist circumference (WC), waist-to-hip ratio (WHR), waist-to-height ratio (WHtR) and body fat percentage (BF%)[13-15] may be useful to discriminate biochemical alterations because of their practicality and low operational cost[16,17].

Based on this assumption, it is necessary to investigate which anthropometric measures are most indicated to discriminate biochemical changes since the pattern of body fat distribution has been shown to be a determinant factor for defining an individual's metabolic profile[18]. In this respect, only anthropometric measures will permit referral for further evaluation and monitoring so that the most appropriate treatments and interventions can be implemented. Furthermore, exercise in women over the age of 50 years has been shown to be effective in reducing anthropometric variables and biochemical alterations[2,19], but specific studies involving this population are necessary.

Therefore, the objective of the present study was to analyze by means of sensitivity and specificity if anthropometric variables can discriminate biochemical changes in cholesterol, triglycerides, and glucose in physically active women over the age of 50 years.

## Methods

*Study Design*

This was a cross-sectional, observational study with analysis of quantitative data.

*Participants*

Approximately 200 individuals taking part in physical activities of the Programa Mafra em Forma conducted by the Municipal Health Department through the Gyms for Senior Citizens (ATI in the Portuguese acronym) project participated in the study. The objective of the ATI is to provide stretching, muscle strengthening, and aerobic exercises[21]. The ATI are offered at two squares of the town and consist of 10 physical activity devices: stretching place, rowing machine, walker machine, shoulder rotator, rider, ski machine, leg press, extensor, flexor, and development). The subjects are invited at the Basic Health Units. People older than 50 years can participate. The activities are supervised and monitored by Physical Education professionals and students and are performed in circuit training comprising stretching and warm-up, main part (strength exercises), and relaxation.

Nonprobability purposive sampling was used for this study. The following inclusion criteria were adopted: age of 50 years or older, female gender, participation in the ATI project for at least 6 months, and a class attendance of at least 75%. Thus, 139 women aged 50 years and over who took part in regular physical activity participated in the study.

*Instruments and Data Collection*

*Anthropometric Variables*

The following instruments, respectively, were used for the determination of body weight, height and waist and hip circumferences: Welmy® scale; WCS® wall-mounted stadiometer on a flat surface; Cescorf® anthropometric measurement tape. The anthropometric measurements were obtained according to the protocol of the International Society for the Advancement of Kinanthropometry (ISAK)[22].

The BMI was obtained by dividing the body weight (kg) by the square of the height (m). For the determination of WHR, WC (cm) was divided by hip circumference (cm). The WHtR was calculated by dividing WC (cm) by height (cm). The following equation was used to determine the CI: WC (cm)/0.019 x square root of body weight (kg)/height (m). BF% was measured using the protocol for body density as described by Tran and Weltman[23,34] and the equation of Brozek et al.[25].

Table 1 shows the reference values used to classify the anthropometric and metabolic variables as "risk condition".

**Table 1**. Reference values of the anthropometric and metabolic variables used to define a health risk in women.

| Variable | Cutoff | Reference |
|---|---|---|
| WC | ≥ 80 | WHO[26] |
| WHtR | ≥ 0.53 | Lin[27] |
| WHR | ≥ 0.82 | Bray and Gray[28] |
| CI | ≥ 1.22 | Pitanga[29] |
| BMI | ≥ 30 | WHO [30] |
| BF% | ≥ 31 | Pollock and Wilmore[31] |

WC = waist circumference (cm); WHtR = waist-to-height ratio; WHR = waist-to-hip ratio; CI = conicity index; BMI = body mass index (kg/m²); BF% = body fat percentage;. The assessment criteria were grouped for the definition of health risk: waist circumference ("moderate risk" and "high risk"); BMI ("obesity I", "obesity II", and "morbid obesity").
Source: The authors.

The anthropometric evaluations occurred in the second week of March, 2012, and were conducted by previously trained (12 hours of training) Physical Education students. After the anthropometric measurements, the participants had an interval of 2 weeks for collection of the biochemical variables.

*Biochemical Variables*

The biochemical variables analyzed in this study were fasting glucose, triglycerides, and total cholesterol. The blood collections and biochemical analyses were performed by a clinical analysis laboratory in the town of Mafra, SC. For the analysis of serum fasting glucose, triglycerides and total cholesterol, approximately 5 ml venous blood samples were collected from the participants for the separation of serum. The analyses were carried out by a colorimetric enzymatic method using specific kits (Biotécnica®, Belo Horizonte, MG, Brazil). The reactions were read in a BTLyzer 100 spectrophotometer (Biotécnica®, Belo Horizonte, MG, Brazil) at a wavelength of 500 nm and the results are expressed as milligram per deciliter blood (mg/dL).

The following cutoffs were used for the biochemical variables: glucose, ≥ 100 mg/dl below and above the recommended); triglycerides, > 200 ("high" and "very high"); total cholesterol, > 239 ("borderline" and "high")[32].

*Ethical Aspects*

The study was approved the Ethics Committee on Research Involving Humans of Universidade do Contestado (UnC) (Protocol 192/10). All participants received information about the objective of the study and signed the free informed consent form.

*Data Analysis*

Descriptive statistics (frequency, mean, and standard deviation) was used for analysis of the data. Receiver operating characteristic (ROC) curves were utilized to verify the sensitivity and specificity for each cutoff between the biochemical and anthropometric variables. Still, it was identified the total area under the curve and statistical significance. The better sensitivity and specificity values corresponded to the cutoffs between the biochemical and anthropometric variables. A 95% confidence interval was used for all analyses.

## Results

A total of 139 women with a mean age of 62.2 (SD=7.3) years participated in the study. Table 2 shows the descriptive statistics for the anthropometric (BMI, WC, CI, WHR, WHtR, and BF%) and biochemical variables (triglycerides, total cholesterol, and blood glucose) and the frequency of a risk condition.

**Table 2.** Descriptive statistics for the anthropometric and biochemical variables.

| Variable | Mean (SD) | Participants with increased risk (%) |
|---|---|---|
| Body weight (kg) | 72.8 (12.1) | - |
| Height (cm) | 157.9 (6.3) | - |
| WC (cm) | 94.3 (10.8) | 91.4 |
| HC (cm) | 103.7 (8.8) | - |
| WHtR | 59.8 (7.0) | 82.0 |
| WHR | 0.90 (0.06) | 90.2 |
| CI | 1.2 (0.08) | 80.6 |
| BMI (kg/m²) | 29.1 (4.4) | 42.4 |
| BF% | 38.9 (5.1) | 89.1 |
| Triglycerides (mg/dL) | 161.8 (119.0) | 17.3 |
| Total cholesterol (mg/dL) | 228.9 (45.3) | 41.7 |
| Glucose (mg/dL) | 110.9 (32.2) | 55.4 |

WC = waist circumference; HC = hip circumference; WHtR = waist-to-height ratio; WHR = waist-to-hip ratio; CI = conicity index; BMI = body mass index; BF% = body fat percentage; SD = standard deviation.
Source: The authors.

Analysis of the frequency of the anthropometric variables showed an increased risk among 91.4% of the subjects for WC, 90.2% for WHR, and 89.1% for BF%. Regarding the biochemical variables, 55.4% of the participants exhibited an unacceptable blood glucose level.

Table 3 shows the ROC curve values, sensitivity and specificity of the biochemical parameters (glucose, total cholesterol, and triglycerides) in relation to the anthropometric variables (BMI, BF%, WHtR, WHR, and WC), and the differences between curves.

**Table 3.** ROC curve values, cutoffs, sensitivity and specificity, statistical differences between curves, and confidence intervals of the biochemical and anthropometric variables.

| | | ROC curve[§] | 95% CI | Cutoff | Sensitivity (%) | Specificity (%) | p-value |
|---|---|---|---|---|---|---|---|
| Glucose | BMI | 0.661 | 0.576-0.739 | 30 | 54.5 | 74.2 | 0.0004* |
| | BF% | 0.616 | 0.530-0.697 | 41.1 | 64.9 | 54.8 | 0.014* |
| | WHtR | 0.627 | 0.541-0.708 | 57.2 | 75.3 | 50 | 0.006* |
| | CI | 0.56[a] | 0.480-0.650 | 1.34 | 24.7 | 88.7 | 0.173 |
| | WHR | 0.608 | 0.521-0.689 | 0.95 | 36.4 | 82.3 | 0.024* |
| | WC | 0.65[a] | 0.569-0.733 | 92.5 | 63.6 | 61.3 | <0.001* |
| Total cholesterol | BMI | 0.592 | 0.505-0.674 | 31 | 38.6 | 78.9 | 0.07 |
| | BF% | 0.556 | 0.470-0.640 | 36.7 | 81.2 | 31.6 | 0.29 |
| | WHtR | 0.571 | 0.485-0.655 | 61.6 | 42.6 | 76.3 | 0.18 |
| | CI | 0.539 | 0.452-0.623 | 1.27 | 50.5 | 60.5 | 0.47 |
| | WHR | 0.519 | 0.433-0.605 | 0.98 | 13.9 | 94.7 | 0.72 |
| | WC | 0.584 | 0.497-0.667 | 92.5 | 57.4 | 60.5 | 0.11 |
| Triglycerides | BMI | 0.573 | 0.486-0.656 | 34.1 | 24 | 93.3 | 0.15 |
| | BF% | 0.541 | 0.455-0.626 | 35.3 | 94 | 18 | 0.42 |
| | WHtR | 0.571 | 0.484-0.654 | 59.2 | 64 | 53.9 | 0.16 |
| | CI | 0.553 | 0.467-0.638 | 1.29 | 44 | 69.7 | 0.29 |
| | WHR | 0.611 | 0.525-0.693 | 0.87 | 88 | 38.2 | 0.02* |
| | WC | 0.569 | 0.482-0.652 | 94.5 | 52 | 64 | 0.18 |

* = p<0.05. BMI = body mass index (kg/m²); BF% = body fat percentage; WHtR = waist-to-height ratio; CI = conicity index; WHR = waist-to-hip ratio; WC = waist circumference. [§]Variables followed by the same superscript letter present significant differences between areas under the ROC curve.
Source: The authors.

The largest areas under the ROC curve for glucose were obtained for BMI (0.661) and WC (0.654). The best cutoffs of these variables in the present study were 30 kg/m² and 92.5 cm, respectively. In this respect, BMI discriminated 54.5% of women with acceptable blood glucose and 74.2% with unacceptable blood glucose and WC discriminated 63.6% of women with acceptable blood glucose and 61.3% with unacceptable blood glucose. Comparison between ROC curves showed no statistically significant difference, except for CI and WC in relation to blood glucose.

With respect to total cholesterol, none of the anthropometric variables was able to discriminate elevated levels of this biochemical variable. In the case of triglycerides, the WHR was able to discriminate altered levels, identifying 88% of women with acceptable triglyceride levels and 38.2% with unacceptable levels. However, there was no significant difference between WHR and the other variables analyzed. Figure 1 illustrates the area under the ROC curve between the biochemical and anthropometric variables for which a significant difference was obtained.

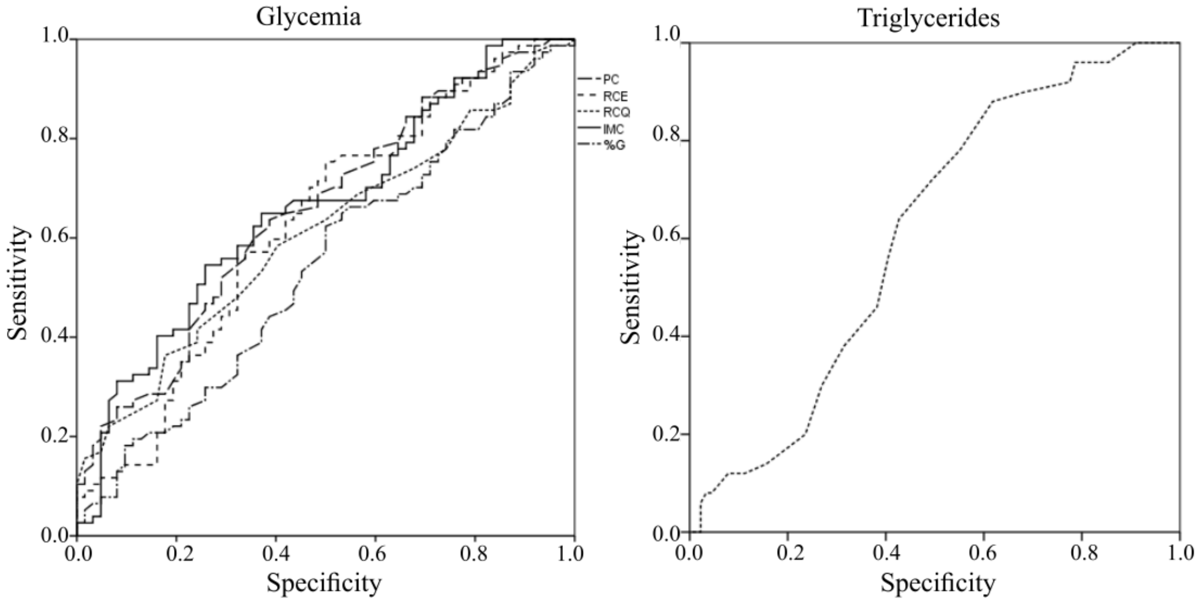


**Figure 1.** The area under the ROC curve between the biochemical and anthropometric variables for which a significant difference was obtained.
Source: The authors.

## Discussion

The objective of this study was to analyze by means of sensitivity and specificity if anthropometric variables can discriminate biochemical changes in cholesterol, triglycerides and blood glucose in physically active women over the age of 50 years. The anthropometric variables WC, WHtR, WHR, BMI and BF% were able to discriminate increased blood glucose levels, while WHR was also able to discriminate elevated triglyceride levels. However, none of the anthropometric variables was able to discriminate elevated levels of total cholesterol.

Regarding the anthropometric variables, although the participants performed physical activity, a high percentage of the women were considered at risk situation by the cutoffs proposed in the literature, especially when BF%, WHR and WC were analyzed. This fact may have been a limitation of the study considering the homogeneity of the group.

Similarly, other studies investigating samples of women of the same age group also found a considerable number of subjects at an increased risk based on WHR[33,34] and WC[35]. However, based on BF%, less than 40% of the sample studied were considered to be "at risk"[11].

These results can be explained by the fact that obesity in women is related to the postmenopausal period which, in turn, causes physiological alterations such as an increase in adipose tissue and a reduction in lean mass and bone mass. These alterations are caused by hormonal changes and can change the lipid profile[2].

With respect to the biochemical variables, our results showed a higher prevalence of women with elevated total cholesterol and blood glucose levels when compared to the prevalence of elevated triglycerides. At the same proportion, another study demonstrated a higher prevalence of elevated total cholesterol (67.8%) compared to triglycerides (45.8%)[35].

Divergences in the results of the present study and those of other studies were found. One study reported an association of total cholesterol with abdominal circumference and fat percentage, but not with BMI[36]. In another study, cholesterol was associated with body fat, but not with abdominal circumference or BMI[37]. A study involving 102 older women ranging in age from 60 to 84 years found a significant association for total cholesterol only in the group older than 70 years, in which this parameter was associated with BMI, WHR and abdominal circumference[38]. It should be noted that abdominal circumference (measured 5 cm above the umbilical scar) was not used in the present study, but WC was measured as the smallest circumference between the 10$^{th}$ rib and iliac crest according to the procedure proposed by Stewart[22].

In the present study, WHR was able to discriminate elevated triglycerides. A study involving subjects aged 15 to 64 years also found WHR to be the anthropometric variable that explained most of the variation in triglycerides[39]. Another study investigating associations between anthropometric variables and lipid profile in adult women concluded that the strongest relationship occurred between triglycerides and WHR[14]. In a study involving older adults from Saudi Arabia[40], triglycerides were associated with WHR, BMI and abdominal circumference. A relationship of WHR and WC with triglycerides has also been reported in another study, but only in subjects older than 70 years[38].

These findings agree with the results of the present study in which only WHR was able to discriminate elevated triglycerides. However, according to the literature[12], caution is needed when this variable is used in older adults. According to that study, WHR is an inaccurate measure of internal fat and is influenced by hormonal changes[12]. In addition, WHR does not detect a proportional increase in the waist and hip, with the individual gaining weight while its initial and final WHR are the same. Thus, although WHR significantly discriminated elevated triglyceride levels, the results obtained for the population studied should be viewed with caution considering that the women of the present study were older than 50 years.

With respect to blood glucose levels, except for CI, the anthropometric variables were able to discriminate increased glucose levels. Divergent results regarding this association have been reported in the literature. A study evaluating the relationship of blood glucose with BF%, abdominal circumference and BMI found an association with abdominal circumference and BMI, but not with BF%[37]. In another study[36], the only variable associated with blood glucose was abdominal circumference. Based on this finding, the authors highlighted the determinant role of blood glucose in the accumulation of fat in the central region of the body. A cross-sectional study[38] corroborated this finding by showing a significant association of fasting glucose with BMI, WHR and abdominal circumference in older adults aged 60 to 69 years. However, another study[14] found no association between blood glucose and anthropometric variables. However, the present findings demonstrate that anthropometric variables can be indicators of increased blood glucose.

Corroborating our findings, according to the guidelines of the Brazilian Diabetes Society[41], obesity, and central obesity is a predictive factor of insulin resistance and BMI and WC are correlated with blood glucose levels. According to the literature[42], anthropometric and biochemical measures are important for evaluating nutritional status and the evolution of diabetic subjects since they help monitor possible changes and identify the most appropriate dietary treatment

One limitation of the present study was the fact that only total cholesterol was measured, which may be a limited prognostic value in women who frequently exhibit elevated levels of high-density lipoprotein-cholesterol (HDL-C) and in subjects with diabetes or metabolic syndrome who often progress to low HDL-C levels[32].

## Conclusion

Anthropometric variables can discriminate some biochemical changes in physically active women over the age of 50 years. The anthropometric variables studied (WC, WHtR, WHR, BMI, and BF%) were able to discriminate increased blood glucose, while only WHR was able to discriminate elevated triglycerides in women. In addition, none of the anthropometric variables was able to discriminate increased levels of total cholesterol and a significant difference between curves was only observed for WC and CI in relation to blood glucose.

Taken together, the results suggest that the easy application of anthropometric measures makes them a low-cost alternative to verify increased blood glucose levels. However, further studies are needed to confirm the capacity of anthropometric evaluations to discriminate increased biochemical parameters. In addition, studies using total cholesterol fractions (HDL and LDL) and involving samples of women and men of other age groups should be conducted.

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