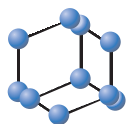
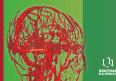


RESEARCH ARTICLE

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Association Between Adiposity Indices and Blood Pressure is Stronger in Sarcopenic Obese Women

Current
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Reviews

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Abstract: Background: Anthropometric indices are useful to identify excess weight and poor health outcomes. Previous research showed that some indices are correlated to blood pressure (BP) among adults. Yet, these associations are poorly characterized in women with sarcopenic obesity (SO). SO is characterized as the combination of sarcopenia and obesity and has been examined as an emerging cause of disorders and frailty.

Objective: The study aims to examine the association between anthropometric indices and BP in community-dwelling women with and without SO.

Method: 118 women (46.3 ± 15.6 years; 1.56 ± .07m; 66.9 ± 12.5kg) underwent BP and anthropometric assessments. Body weight, height, as well as waist (WC) and hip circumference were measured. Body mass index (BMI), body adiposity index (BAI), waist-to-hip (WHR) and waist-to-height (WHtR) ratio were calculated. SO was identified based on median values of percent body fat and muscle mass. Partial correlation was used to assess the association between adiposity indices and BP adopting age, presence of hypertension and use of antihypertensive medication as controlling variables. The significance level was set at $P \leq .05$.

Results: systolic BP was significantly higher in subjects with SO (126.4 ± 14.1 vs 121.0 ± 11.6mmHg, $P = .01$). Correlations between anthropometric indices and systolic BP were generally higher in women with SO, reaching statistical significance for WC ($r = .39, P < .05$) and WHtR ($r = .30, P < .05$) when age was the controlling variable.

Conclusion: The association of adiposity indices and BP is stronger in subjects with SO when compared to those without SO.

Keywords: Blood pressure, sarcopenia, obesity, hypertension, adiposity indices, sarcopenic obesity.

1. INTRODUCTION

Anthropometric indices such as body mass index (BMI), waist circumference (WC), waist-to-hip ratio (WHR) and waist-to-height ratio (WHtR), are notably useful to identify excess weight and poor health-related outcomes in clinical settings and large populations [1]. In the past few years, a new index was proposed in the literature. The body adiposity index (BAI) is based on height and hip circumference and proved to be valid for estimating body fat [2]. Previous and

recent research showed that these indices of adiposity are correlated to cardiovascular risk factors, such as high blood pressure (BP) and the incidence of hypertension among adults [3-6].

Chronic high BP is highly prevalent in developed and in low to middle-income countries [7, 8]. Also, hypertension is a common condition that may lead to myocardial infarction, stroke, renal failure and death if not detected early and treated appropriately [9]. So, it is considered a major public health issue. The association of adiposity indices with BP may be related to body composition alterations that result in a reduction in fat-free mass (FFM) and increase in fat mass (FM). Such changes are well documented in sedentary people and as a consequence of the ageing process [10].

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Recently, the combination of reduced FFM (*i.e.* sarcopenia) and increased FM (*i.e.* obesity) has been named as sarcopenic obesity (SO). This condition has been examined as an emerging cause of disorders and frailty [10, 11]. Furthermore, it has been argued that SO is the worst condition than sarcopenia or obesity alone [12]. In this sense, there is evidence that SO is associated with functional limitations and increased mortality [12, 13]. Thus, it is not a surprise that, similar to hypertension, SO has important healthcare costs implications [14]. Of note, it has been argued that since women have less muscle mass compared to men, they may be at higher risk for sarcopenia [15] and, therefore, for SO-related consequences. Moreover, after menopause, women undergo significant adverse changes in body composition, that besides the loss of FFM and increases in FM, is characterized by a redistribution of fat from the periphery to the central region of the body [16].

Despite the cited arguments, little evidence is available regarding the relationship of adiposity indices and BP in women with SO. Hence, the purpose of the present investigation was to examine the association between several anthropometric indices and BP in community-dwelling women from the Federal District, Brazil.

2. MATERIALS AND METHOD

2.1. Study Design

This is a cross-sectional study. Adult and elderly women were invited to undergo anthropometric evaluations in several locations of an urban community of the Federal District, Brazil. Participants were invited as they walked through the evaluation sites that had previously been set up by the researchers in distinct locations of the community. They answered a questionnaire addressing medical history, hypertension diagnosis, tobacco use, alcohol consumption and physical activity habits. Body mass and height, as well as waist and hip circumferences, were measured to analyze adiposity indices. Also, BP was measured twice, after a 10 minutes seated rest. Adiposity indices were correlated to BP values. This study complies with the Helsinki Declaration and the procedures were approved by the Institutional Review Board.

2.2. Sample

A hundred and twenty-three women volunteered to participate. Inclusion criteria for the present analysis were age between 20 and 85 years and people who had been living in the community for at least one year. Thus, this study reports data from the one hundred eighteen women (46.3 ± 15.6 years; $1.56 \pm .07$ m; 66.9 ± 12.5 kg) who completed BP and anthropometric measures and fulfill inclusion criteria. All participants gave written consent before undergoing evaluations.

2.3. Blood Pressure and Hypertension

It is known that office measurements of BP do not reflect diurnal variation and nocturnal BP levels [17]. Hence, the prevalence of hypertension was determined by analyzing participant's answers in the medical history questionnaire. All subjects were oriented to answer the questionnaire based on clinical examination performed prior to the present inves-

tigation. Therefore, it was assumed that all subjects that reported hypertension did so based on the previous diagnosis made by a physician through accurate method, such as 24 h ambulatory BP monitoring.

Blood pressure of each volunteer was measured twice by trained technicians after a 10 minutes seated rest. Measurements were taken by auscultation using a mercury sphygmomanometer. Systolic BP and diastolic BP were defined as the points of the appearance and disappearance of Korotkoff sounds, respectively. Mean of the two measurements was calculated and recorded as the BP value. These values were used only for correlation with the adiposity indices.

2.4. Adiposity Indices

Waist circumference was assessed at the level of umbilicus and hip circumference was determined at the level of the maximum extension of the buttocks posteriorly in a horizontal plane. Thus, Waist-to-hip and Waist-to-height ratios were calculated as waist divided by hip and height (in centimeters), respectively. BMI was calculated as weight divided by height squared (kg/m^2) and BAI was calculated according to the following equation [2]:

$$\text{BAI} = [(\text{hip circumference}) / ((\text{height})^{1.5}) - 18].$$

2.5. Body Composition and Sarcopenic Obesity Identification

Total body mass, FM and FFM percentages were measured using a tetrapolar bioelectrical impedance device (OMRON HBF-510, OMRON Healthcare Inc. Lake Forest, IL). Body weight was measured to the nearest 0.1 kg with volunteers dressed in light clothes. Height was measured to the nearest 0.1cm using a portable stadiometer (Sanny®, São Bernardo do Campo, SP, Brazil). Obesity was defined as values greater than the median FM percentage [18]. In the present sample, median %FM was 39.3. So, participants with a %FM higher than 39.3 were classified as obese. Subjects were classified as sarcopenic if their percent FFM was below the median of the study sample. This cut-off point was 24.7%. So, analogous to the classification of obesity, participants with a %FFM lower than 24.7 were classified as sarcopenic. Based on the combination of sarcopenia and obesity cut-off points, participants were further classified into sarcopenic obese and non-sarcopenic obese. All subjects who presented both sarcopenia and obesity were classified as sarcopenic obese.

2.6. Statistical Analysis

Descriptive data are expressed as mean and standard deviation. The normal distribution of data was examined using the Kolmogorov-Smirnov test. Only height, WC and WHR presented parametric distribution. Thus, comparisons between women with and without SO were carried out by Mann Whitney-U test and independent samples T-test, when appropriate. Chi-square test was used to compare SO and hypertension. Odds ratio and confidence intervals (CI: 95%) considering SO as a risk factor for hypertension were also calculated. Spearman correlation test was used to analyze the association between continuous variables. Moreover, partial correlation between adiposity indices and BP was performed

adopting age, presence of hypertension and use of antihypertensive medication as controlling variables. The significance level was set at $P \leq .05$, and all analyses were conducted using the Statistical Package for Social Sciences (IBM SPSS 20.0, Armonk, New York, USA).

3. RESULTS

The overall prevalence of SO and hypertension in the present sample was 43.2% and 33.9%, respectively. Prevalence of hypertension was significantly higher among subjects with SO (49.0%) when compared to those without SO (22.4%) ($X^2 = 9.17$; $P = .002$). Most of the participants reporting hypertension also reported antihypertensive medication use ($n = 22$ out of 25 in the SO group and $n = 13$ out of 15 in the non-SO group). Antihypertensive medication use was significantly higher among participants with SO ($X^2 =$

6.76; $P = .009$). Moreover, the odds ratio and confidence intervals regarding SO classification showed that women with SO present a significantly increased risk for the presence of hypertension (Odds Ratio 3.33, CI: 1.51-7.38).

Table 1 presents continuous variables regarding the comparison between groups according to SO classification. Of note, %FM, BMI, CC, WHR, BAI and WHtR were significantly higher in women with SO. As it could be expected, %FFM was higher in participants without SO. Also, systolic BP value was significantly higher in subjects with SO.

Spearman correlation coefficients regarding total sample ($n = 118$) showed that age correlated with WC ($r_s = .26$), BAI ($r_s = .21$), WHR ($r_s = .45$), WHtR ($r_s = .37$), systolic BP ($r_s = .26$), and %FFM ($r_s = -.23$), all $P < .05$. Thus, partial correlation adopting age as the controlling variable was tested and the results of this analysis are presented in Table 2. Interest-

Table 1. Comparison between groups according to SO classification (Mean ± SD).

	SO	Non-SO	P
n	51	67	
Age (years)	49.0 ± 16.8	44.2 ± 14.4	.08
Height (m)	1.55 ± .07	1.56 ± .06	.45
Body weight (kg)	73.4 ± 13.1	62.0 ± 9.4	.00
BMI (kg/m ²)	30.3 ± 3.6	25.4 ± 3.6	.00
WC (cm)	93.8 ± 8.8	83.0 ± 9.6	.00
Waist-to-hip ratio	.87 ± .07	.84 ± .08	.03
Waist-to-height ratio	.60 ± .05	.53 ± .07	.00
BAI (%)	37.6 ± 3.8	32.4 ± 4.3	.00
Fat mass %	45.8 ± 3.0	35.4 ± 4.5	.00
Fat free mass %	22.7 ± 1.1	27.3 ± 2.7	.00
Systolic BP (mmHg)	126.4 ± 14.1	121.0 ± 11.6	.01
Diastolic BP (mmHg)	80.7 ± 10.5	81.3 ± 8.5	.86

BMI: body mass index; BAI: body adiposity index; WC: waist circumference; BP: blood pressure.

Table 2. Correlation coefficients between adiposity indices and BP. Partial correlation adopting age as the controlling variable.

Indices	SO n = 51		non-SO n = 67	
	SBP	DBP	SBP	DBP
BMI	.25	.04	.02	.09
WC	.39*	.06	.02	.11
WHR	.25	.02	.06	.14
WHtR	.30*	-.05	.02	.08
BAI	.02	-.14	-.04	-.03

* $P < .05$. SBP: systolic blood pressure. DBP: diastolic blood pressure. BMI: body mass index. WC: waist circumference. WHR: waist-to-hip ratio. WHtR: waist-to-height ratio. BAI: body adiposity index.

Table 3. Correlation coefficients between adiposity indices and BP. Partial correlation adopting presence of hypertension as the controlling variable.

Indices	SO <i>n</i> = 51		non-SO <i>n</i> = 67	
	SBP	DBP	SBP	DBP
BMI	.18	.03	.01	.05
WC	.32*	.04	-.001	.03
WHR	.23	.008	.07	.009
WHtR	.26	-.07	.03	-.004
BAI	.03	-.14	-.006	-.04

**P* < .05. SBP: systolic blood pressure. DBP: diastolic blood pressure. BMI: body mass index. WC: waist circumference. WHR: waist-to-hip ratio. WHtR: waist-to-height ratio. BAI: body adiposity index.

Table 4. Correlation coefficients between adiposity indices and BP. Partial correlation adopting use of antihypertensive medication as the controlling variable.

Indices	SO <i>n</i> = 51		non-SO <i>n</i> = 67	
	SBP	DBP	SBP	DBP
BMI	.15	.03	-.01	.06
WC	.30*	.05	-.02	.06
WHR	.21	.02	-.009	.04
WHtR	.24	-.06	-.04	.02
BAI	.02	-.14	-.05	-.05

**P* < .05. SBP: systolic blood pressure. DBP: diastolic blood pressure. BMI: body mass index. WC: waist circumference. WHR: waist-to-hip ratio. WHtR: waist-to-height ratio. BAI: body adiposity index.

ingly, correlations between anthropometric indices and systolic BP were generally higher in women with SO, reaching statistical significance for WC and WHtR.

As the prevalence of hypertension and the use of antihypertensive medication were higher in the SO subsample, partial correlation was also tested adopting the presence of hypertension and the use of medication as the controlling variable, and the results are presented in Tables 3 and 4, respectively. Noteworthy, the results of this analysis are very similar and show that correlations between anthropometric indices and systolic BP are generally higher in women with SO, reaching statistical significance for WC.

In addition, BMI (*r* = .90), WC (*r* = .71), WHtR (*r* = .62) and BAI (*r* = .63) presented a high and significant correlation with %FM in subjects with SO (all *P* < .05). These coefficients were lower, but still significant (*P* < .05) in subjects without SO (BMI: *r* = .60, WC: *r* = .54, WHtR *r* = .51, BAI: *r* = .38, and WHR: *r* = .40).

4. DISCUSSION

The present investigation aimed to examine the association between several anthropometric indices and BP in com-

community-dwelling women from Brazil. The main finding was that the relationship between indices of adiposity and BP is stronger within women with SO. Moreover, the prevalence of hypertension is significantly higher within women presenting SO.

Sarcopenic obesity is characterized by important reductions in FFM combined with the pathological accumulation of FM [10]. In this sense, the present report shows that all adiposity indices (BMI, WC, WHR, WHtR, BAI), as well as %FM measured by electrical bio impedance, were significantly elevated compared to the non-SO group (Table 1). Conversely, %FFM was found to be significantly lower in sarcopenic obese participants (Table 1). These results were expected and are probably related to the vicious cycle of SO that involves activation of inflammatory pathways mediated by adipose tissue. This inflammation causes an imbalance in protein synthesis that may lead to loss of muscle mass [19, 20]. In other words, low-grade inflammation caused by body fat accumulation can result in the onset of protein degradation and in a decrease in FFM.

Interestingly, sarcopenic obese subjects of the present work also showed a significantly higher systolic BP when compared to non-SO individuals (Table 1). Although the

difference was around 5 mmHg, it is important to mention that small decreases in blood pressure can protect the cardiovascular system. Previous data in the literature showed that reductions in systolic BP of only 2 to 5 mmHg may decrease the risk of infarction in 6 to 14% and the risk of coronary heart disease in 4 to 9% [21]. Of note, mean systolic and diastolic BP values found in this study were not within elevated BP values (Table 1) as most of the participants reporting hypertension also reported that the condition was controlled by use of medication. Nevertheless, participants with SO presented a higher prevalence of hypertension (49.0% vs 22.4%), which corroborate the higher values of systolic BP and the higher use of antihypertensive medication found in sarcopenic obese subjects. In addition, a significant odds ratio was observed showing that women with SO present a significantly increased risk for the presence of hypertension (Odds Ratio 3.33, CI: 1.51-7.38). This result is probably related to the pathophysiological mechanisms of hypertension related to obesity such as increased sympathetic nervous activity, renal sodium retention, impaired endothelial function and up-regulation of adipokines (*i.e.* leptin) [22].

The association of anthropometric indices with risk factors of cardiovascular diseases is well known in the literature [4]. Of note, WC and its corrections to height and hip circumference (*i.e.* WHtR and WHR, respectively) were found to better predict the incidence of hypertension in a sample of 592 Brazilian men and women compared to BMI [5, 6]. In line with this, a previous research analyzing a large sample of Chinese men and women ($n = 2895$; 25-74 years old) observed that WHtR was the best index in predicting elevated systolic and diastolic BP in women when compared to BMI, WC and WHR (WHtR likelihood ratios in that study were 3.05 and 3.38 for systolic and diastolic BP, respectively) [23]. A recent study reported a very similar result in a cohort of more than eight thousand adults in India and Pakistan [3]. Although the present study did not analyze the incidence of hypertension, we found that WC and WHtR presented the highest correlation coefficients with systolic BP within women with SO. When the correlation was adjusted for age, both indices reached statistical significance. This result is in line with the above-mentioned studies and are probably related to the increased risk of abdominal fat accumulation (*i.e.* fat mass in the central region of the body). In this regard, it is argued that the link between obesity with cardiometabolic risk and low-grade inflammation is stronger when central obesity measurements are considered [24]. Indeed, the present report reinforces this explanation, once WHR and BAI, which are more representative of subcutaneous fat, presented lower and non-significant correlation with systolic BP than WC and WHtR (Tables 2-4).

Interestingly, the results of this study regarding BAI and WHR do not corroborate other investigations. For instance, a recent study identified BAI to be a useful index to predict hypertension in adult obese women from India ($n = 131$; odds ratio = 3.28, CI: 1.95-5.51, $P = .001$) [25]. Furthermore, WHR significantly correlated to C-reactive protein (CRP) in a sample of Brazilian elderly women ($n = 130$; aged between 60 and 80 years) [26]. It is known that CRP is a biomarker of cardiovascular disease associated with vascular stiffness and hypertension [27]. In the present investigation, nor BAI,

neither WHR correlated to BP regardless of SO classification. Yet, BAI significantly correlated to %FM and corroborate previous findings reporting that this index may be a useful estimator of body adiposity in women with and without SO [2, 26]. Noteworthy, correlation of BMI and WC with %FM were even stronger, highlighting these indices as good adiposity indicators regardless of SO classification.

An important finding of the present investigation was that the correlation between anthropometric indices and BP was not significant within the sixty-seven non-SO participants. Two possible reasons are related to this result. Firstly, mean BP values within this group were significantly lower compared to SO subset and were not considered to be elevated (Table 1). Allied with this, the prevalence of hypertensive individuals in this group was also lower compared to women classified as SO. Thus, it becomes more difficult to observe significant correlations. Secondly, these subjects presented significantly less body fat and more muscle mass, even though they would be classified as overweighted based on BMI. Altogether, these characteristics show that SO worsened body composition and BP profile of the subjects.

This study has some limitations. Firstly, the identification of SO was not performed using previously proposed methodology based on DEXA-derived fat mass and appendicular fat-free mass [28]. Also, strength or functional tests that help to identify sarcopenia were not performed. However, this study was conducted within a local community, and estimates of body fat and muscle mass were derived from a portable and reliable device previously tested in Brazilian women [29]. Also, bioelectrical impedance analysis has been considered a potential acceptable method in terms of accuracy and applicability in the context of sarcopenic obesity [30]. Additionally, cut-off points for obesity classification based on median values of the sample were previously used elsewhere [18]. Still, future research should be done using gold standard methods to diagnose sarcopenic obesity. Secondly, even though we found a prevalence of SO higher than other investigations [20, 28], the relatively small number of subjects enrolled makes it difficult to discuss prevalence. Still, only women participated in the study, removing the potential influence of gender in the results. Moreover, as age may influence body composition and BP, partial correlations adjusted for age allowed a more accurate interpretation of the results. Thirdly, blood samples from the participants were not obtained. Blood glucose levels, adipokines, some myokines and/or the components of the renin-angiotensin system could have shed some mechanistic light on the results. Finally, there may be a selection bias in the present study, and the cross-sectional design does not allow for long-term cause and effect analysis of SO on BP.

CONCLUSION

Results of the present work suggest that SO worsens not only body composition, but also BP profile. Also, the association of adiposity indices and blood pressure is stronger in sarcopenic obese women. This is particularly true to indices related to central obesity such as waist circumference and waist-to-height ratio.

ETHICS APPROVAL AND CONSENT TO PARTICIPATE

The study procedures were approved by the Ethics Committee of the Medical Faculty of the University of Brasilia, Brazil. Approval number 908.058/2014.

HUMAN AND ANIMAL RIGHTS

No animals were used in the study all reported human were experimented in accordance with the ethical standards of the committee responsible for human experimentation (institutional and national), and with the Helsinki Declaration of 1975, as revised in 2008 (<http://www.wma.net/en/20activities/10ethics/10helsinki/>).

CONSENT FOR PUBLICATION

All participants gave informed consent for the study.

AVAILABILITY OF DATA AND MATERIALS

Not applicable.

FUNDING

None.

CONFLICT OF INTEREST

The authors declare no conflict of interest, financial or otherwise.

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