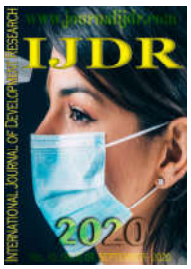
ISSN: 2230-9926

Available online at http://www.journalijdr.com

IJDR

International Journal of Development Research
Vol. 10, Issue, 09, pp. 40382-40386, September, 2020
https://doi.org/10.37118/ijdr.19864.09.2020



RESEARCH ARTICLE OPEN ACCESS

NECK CIRCUMFERENCE IS ASSOCIATED WITH METABOLIC SYNDROME IN HYPERTENSIVE WOMEN

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ARTICLE INFO

Article History:
Received 27th June 2020
Received in revised form
19th July 2020
Accepted 10th August 2020
Published online 30th September 2020

Key Words:
Metabolic Syndrome, Anthropometry, Hypertension, Neck fat Mass.

Corresponding author:
Lilia Maia de Morais Sales

ABSTRACT

Introduction: Neck circumference (NC) has been used as an anthropometric measure to estimate cardiometabolic risk. **Objective:** To verify whether NC is able to assist in the diagnosis of metabolic syndrome (MetS). **Methods**: The sample consisted of 60 patients of both gender. mean age 62.6±11.7 years. Shapiro-Wilk. non-paired t test. Mann-Whitney ($p<0.05$). Pearson and Spearman correlations were used for statistical analysis. **Results:** The NC values were. for men (37.1±3 cm) and women (33.1±2.49 cm) and waist circumference (WC) in men (95.3±0.69 cm) and women (91.3±9.61 cm). The mean NC was higher in women with MetS (32±2.8 cm vs 33.8±2.5 cm; $p= 0.02$). There was a positive correlation between NC and WC ($r= 0.46$; $p= 0.001$ for women) and ($r= 0.67$; $p= 0.04$ for men) and with body mass index (0.73 $p= 0.02$ for women) and ($r= 0.40$; $p= 0.01$ for men). In women. The NC showed a higher area under the ROC curve (0.688; confidence interval 0.526 - 0.850; $p= 0.03$). **Conclusion:** NC is an anthropometric marker useful in the ratification of the MetS and can be used as an additional tool for screening this pathology in similar populations.

Citation: ***Erika C R L Carneiro, Luana M A Azoubel, Raimunda S C Dias, Dyego J A Brito, Giselle A S Silva et al. 2020.*** "Neck circumference is associated with metabolic syndrome in hypertensive women*", International Journal of Development Research*, 10, (09), 40382-40386.

INTRODUCTION

The body fat distribution is a strong predictor of metabolic dysfunction and cardiovascular risk. and waist circumference is the most used anthropometric measure in this diagnosis. However. in recent years. neck circumference has received prominence. initially used in research on obstructive sleep apnea. and later verified the association with metabolic syndrome and visceral fat accumulation in the upper body (Fantin *et al*. 2017; Lee *et al*. 2017; Poirier *et al*. 2016; Stabe *et al*. 2013). A fat distribution in the upper body. especially with increased visceral adipose tissue. is considered to be predictive of cardiometabolic conditions. The association between neck fat and metabolic syndrome and its components. can be attributed to an excessive release of free fatty acids in the plasma of subcutaneous fat. in the upper body (Preis *et al*. 2010). High levels of free fatty acids in plasma have been associated with markers of oxidative stress and insulin resistance. which consequently impact blood glucose (Santos; Jensen. 2008). In 2014. a study verified. through of cervical computed tomography. a positive association with MetS. neck circumference and accumulation of cervical fat. mainly in women. postulating the importance of this measure to detect fat accumulation with an atherogenic profile.In this same study. there was a positive association with triglycerides. and a negative one with High Density Lipoprotein Cholesterol (HDL-C). similar to the results found in the study by Vallianou and collaborators (Vallianou. 2013; Torriani *et al*. 2014). In another survey conducted with the Chinese population. it was found that neck circumference obtained similar statistical

power to waist circumference to identify cardiometabolic syndrome. verified by visceral adiposity in nuclear magnetic resonance (Luo *et al*. 2017). Although studies have shown associations between neck circumference and components of the metabolic syndrome.further studies are needed in specific populations. such as hypertensive individuals. since NC is rarely assessed in clinical practice. Therefore. this research aimed to verify the correlation of neck circumference with the metabolic syndrome in a relatively elderly population. and to demonstrate its importance as an anthropometric measure capable of assisting in the detection of this pathology.

METHODS

This is a cross-sectional study. performed in *Centro de Prevenção de DoençasRenais.*annex of *Hospital Universitário da Universidade Federal do Maranhão* (HUUFMA). held from January to July 2017. The study is part of a larger project. entitled "Inflammation and cardiovascular risk in chronic non-dialysis renal patients. São Luís-MA". which was submitted to the Ethics Committee of the *Hospital Universitário do Maranhão* (opinion n. 2.015 .866). in compliance with the requirements demanded by the Resolution n. 466/12 of the National Health Council and its complementaries for research involving human beings.

This study included 60 individuals aged 18 years or over. who had clinical follow-up carried out by the Academic League of Arterial Hypertension. and who had complete data in the medical record. Pregnant women. people with autoimmune and infectious diseases. cancer and acquired immunodeficiency syndrome were not included. Social. demographic. economic characteristics. clinical data. lifestyle. blood pressure. comorbidities and medication consumption were collected.Blood pressure (BP) was measured using a digital sphygmomanometer (Omron®) and with an appropriate cuff. on the subject's right arm in a sitting and resting position. The measurements were performed in triplicates. with an interval of ten minutes between each one. considering the average value of the three measurements. For the classification of BP. the values proposed by the *VII DiretrizBrasileira de Hipertensão*. were adopted (SBC. 2016). Anthropometric variables were collected by properly trained professionals and included: weight. height. waist (WC) and neck (NC) circumferences. The nutritional indicators used were: waist circumference (WC). neck circumference (NC) and body mass index (BMI). BMI was obtained by the ratio between body weight and height in metres squared. and was classified according to the reference standards defined by the World Health Organization for adults and Lipchitz for the elderly.

Neck circumference was measured with a non-elastic anthropometric tape in the middle of the neck. between the middle cervical spine and cricothyroid cartilage line. in men. in the presence of prominence. the measurement was performed immediately below it. The cutoff points for the anthropometric indicators used for women and men were WC: ≥ 88 cm and ≥102 cm (NCEP. 2002) and NC: ≥ 34 and ≥ 37. respectively (Ben-Noun; Laor. 2006). The biochemical parameters (fasting blood glucose and lipidogram) were collected using results of tests performed within a period of up to 3 months prior to the research. Blood tests were performed at the *Laboratório de AnálisesClínicas of HUUFMA* and are part of the service routine.The presence of metabolic syndrome was defined according to the criteria of the National Cholesterol Education Program's Adult Treatment Panel III (NCEP-ATP III) (Alberti *et al*. 2009). which requires the presence of three or more of the following clinical conditions: WC > 102 cm in men and > 88 cm in women; Systolic BP > 130 mmHg and/or Diastolic BP > 85 mmHg or pharmacological treatment for arterial hypertension; Triglyceride levels > 150 mg/dL or pharmacological treatment for hypertriglyceridemia; HDL-C levels < 40 mg/dL in men and < 50 mg/dL in women or pharmacological treatment; Fasting blood glucose > 100 mg/dL or pharmacological treatment for hyperglycemia.To ensure the validity of data entry. they were entered twice. by different people. and compared.

The descriptive analysis of the variables was performed. and the results of the quantitative variables were presented as mean and standard deviation. whereas the qualitative variables. by frequencies and percentages.The Shapiro Wilk test was used to assess the normality of quantitative variables.Variables with normal distribution were compared using the Student's t test and those with non-normal distribution using the Mann-Whitney test. Pearson's or Spearman's correlation coefficients assessed the correlation between MetS and anthropometric indicators. ROC analysis was used to assess the diagnostic accuracy of anthropometric variables for MetS. The level of significance adopted was 5% ($p < 0.05$). The data were analyzed using the GraphPad statistical program (Version 21; IBM Corporation. Chicago. IL).

RESULTS

The sample studied. composed of 60 patients. had a mean age of 62.6 ± 11.7 years and a predominance of women (83.6%). The mean time of hypertension was 15.8 ± 8.8 years. Clinical investigation showed 25.4% of diabetics and 58.1% with metabolic syndrome (Table 1).

Table 1. Clinical and laboratory parameters of hypertensive patients

Variables	Mean ± SE
Age	62.6±11.7
Diagnosis time ofH	15.8±8.8
SBP	130.9±19.6
DBP	77.2±10.8
WC male	95.2±10.9
WC female	90.1±9.8
NC male	37.8±31.1
NC female	32.7±2.7
BMI	27.4±4.3
eGFR	82.2±17.1
Cholesterol total	185.3±35.8
HDL-C	53.2±14.3
LDL-C	100.5±35.1
Triglycerides	120.3±50.8
Fasting glucose nondiabetic	94.2±9.7
Fasting glucose diabetics	134.7±44.8
Albuminuria	22.5±41.3
Potassium	4.2±0.4
Uricacid	4.9±1.3

HDL-C:high density lipoprotein cholesterol.LDL-C:Low density lipoprotein cholesterol; WC: waist circumference; NC: neck circumference; SBP: systolic blood pressure; DBP: diastolic blood pressure; BMI: body mass index; eGFR: estimated glomerular filtration rate; H: hypertension.

Nutritional status revealed by means of BMI that most participants were overweight. regardless of gender. The mean BMI values were 25.2 ± 3.56 and 27.3 ± 4.7 for men and women. respectively.

The average NC for men was 37.1 ± 3 cm and for women 33.1 ± 2.49 cm. Patients with MetS had higher means of NC. and the results were statistically significant in females (p = 0.02) (Table 2).

Table 2. Neck circumference in men and women with and without MetS

Neckcircumference (cm)			
Gender	WithoutMetS	withMetS	*p-valor*
Female	32±2.8	33.8±2.5	0.02
Male	35.6±1.1	38.3±3.8	0.21

MetS; metabolicsyndrome

When assessing the correlation between NC and anthropometric indicators related to obesity. there were statistically significant positive correlations with WC and BMI. regardless of gender.After correlation analysis. it was also found that NC correlates positively with WC in women (r = 0.46 p = 0.001) and men (r = 0.67 p = 0.04) (Figure 1). and with female BMI (0.73 p = 0.02) and male (r = 0.40 p = 0.01) (Figure 2).

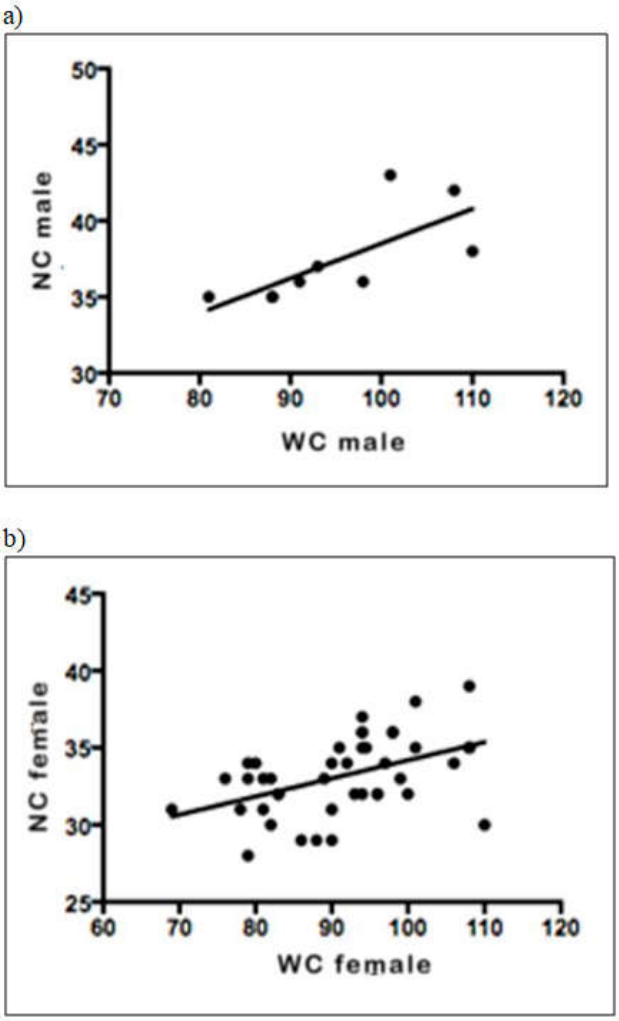

Figure 1. Correlation of neck circumference (NC) and waist circumference (WC) in hypertensive women and men

The analysis of the ROC curve. which examined the AUC of NC in the prediction of MetS. showed a significant difference (p <0.05). with a higher area for women (AUC: 0.688; 95% CI: 0.526-0.850; p = 0. 03) (Figure 3).

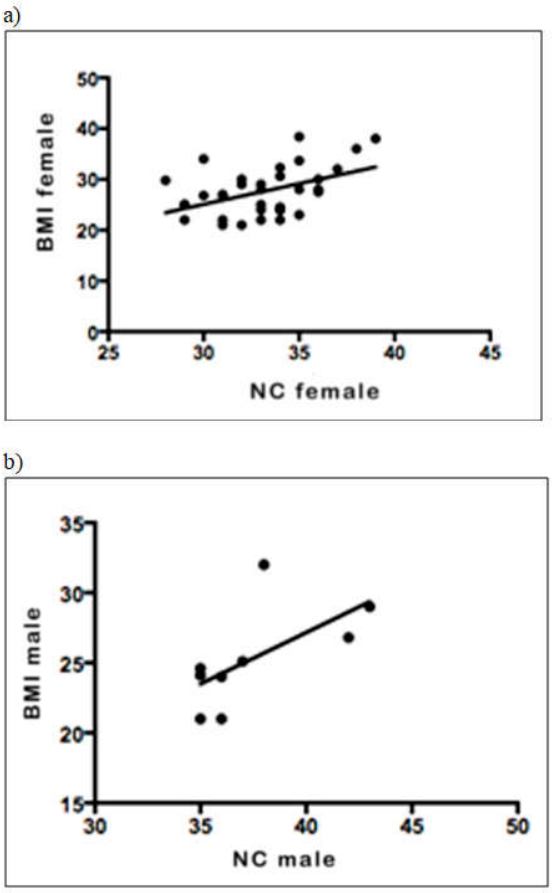

Figure 2. Correlation of neck circumference and body mass index in hypertensive women and men

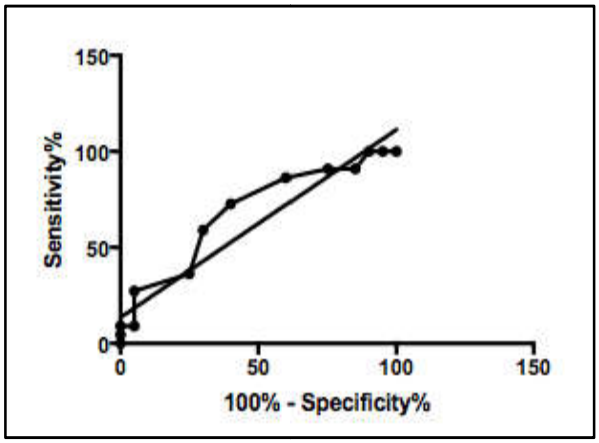

Figure 3. ROC curve analysis. neck circumference and metabolic syndrome

DISCUSSION

The results of the study showed that hypertensive patients with MetS had higher means of NC. and this difference was significant in females (p = 0.02). Likewise. the ROC analysis showed a higher AUC for NC. in women. In a cross-sectional study of population data among adults in Thailand. it was shown that NC is strongly associated with MetS. which was significantly higher in patients with MetS than in patients without MetS (35.8 ± 2.4 cm and 32. 4 ± 3.0 cm. respectively). Moreover. the AUC for NC of 38 cm in men was 0.69. while the AUC for NC of 33 cm in women was 0.83 (Laohabut *et al*. 2020). Other studies have also shown an association between NC and the components from MetS. Zhou *et al*. 2013. showed

that NC correlated positively with SBP and DBP. fasting glucose. triglycerides. total cholesterol and LDL-C and negatively with HDL-C (Zhou *et al*. 2013). In the study by Joshipura *et al*. 2016. the percentage of individuals with pre-diabetes. hypertension and MetS were higher in the group with increased NC (Joshipura *et al*. 2016). It is estimated that approximately 20-25% of the world's adult population is diagnosed with MetS.

In Brazil. this prevalence is slightly higher than the world average. varying between 28.9 and 29.6% (De Carvalho *et al*. 2013). The prevalence found in the study population (58.1%) was significantly higher than the national and world rates. which can be partially explained by being a referral clinic in a university center and by attending patients with a higher average age. Corroborating the findings of this research. a study conducted in China with 4227 individuals identified a higher prevalence of MetS in the elderly (Cui *et al*. 2018).MetS is a set of cardiometabolic risk factors that have been related to type 2 diabetes mellitus (DM2). CKD. cardiovascular disease (CVD). stroke. and all-cause mortality in the general population. These risk factors include hyperglycemia. increased blood pressure. dyslipidemia and central fat accumulation (Go *et al*. 2014; Gurka *et al*. 2014; Thomas *et al*. 2011; Al-Qaoudi *et al*. 2011). Individuals with MetS have a doubled risk of developing cardiovascular disease in five to ten years. and a five-fold increase in the risk of developing DM2. when compared to healthy individuals (Alberti *et al*. 2009).The mean NC values were higher for men (37.1 ± 3 cm) when compared to women (33.1 ± 2.49 cm). Similar results were observed in the study conducted by Zhou *et al*. 2013 with 4201 participants (Zhou *et al*. 2013). In this study. the NC showed a significant correlation with BMI and WC. similar to a study carried out with a population sample of 1912. of Turkish adult men and women. with an average age of 55.1 ± 12 years (Onat *et al*. 2009). In a study conducted by Stabe *et al*.. With young adults. Brazilians. a significant correlation between NC. BMI and WC was also demonstrated (Stabe *et al*. 2013). In the study conducted by Frizon and Boscaini. 2013. with 155 adults in a primary health care in the city of Nova Prata - RS. participants with increased NC had a higher amount of hypertension. diabetes. dyslipidemia. obesity and changes in BMI. WC and waist-to-hip ratio (Frizon; Boscaini. 2013).

It is well established in the literature that obesity is associated with metabolic disorders and cardiovascular risk factors (Nikolopoulou; Kadoqlou. 2012). Although BMI and WC are anthropometric indices widely used to assess obesity and predict cardiometabolic risks. some studies have suggested that NC is an anthropometric measure that is easy to measure and shows advantages over WC and BMI measurements. since WC is influenced by respiratory movements and types of clothing. whereas BMI does not provide information on fat distribution (Gharipour *et al*. 2013; Odat; Ahmad; Haddad. 2012). Overweight and obesity may be associated with fat deposition in the neck. resulting in higher NC (Stabe *et al*. 2013). NC is a simple anthropometric measure that is correlated with WC and BMI. and has been associated with components of the metabolic syndrome in several populations. including pediatric (Ozkaya; Tunçkale. 2016; Saka *et al*. 2014; Coutinho *et al*. 2014; Pereira *et al*. 2014). The association between neck fat and MetS and its components. can be attributed to the excess release of free fatty acids in the upper body plasma (Fantin *et al*. 2013). Elevated levels of free fatty acids in plasma. on the other hand. have been associated with markers of oxidative stress and insulin resistance (Santos; Jensen. 2008). Preis *et al*. 2010. suggest that neck fat has a similar effect to visceral fat. which is more strongly related to cardiometabolic risks compared to subcutaneous fat.Visceral adipose tissue has shown a stronger association with most metabolic risk factors. and is associated with higher levels of blood pressure. insulin resistance and dyslipidemia (Pi Sunyer. 2002). In the present study. there was no correlation between NC and isolated laboratory variables. only when associated with the diagnosis of MetS. perhaps due to the sum of clinical conditions specific to MetS (WC. high triglycerides. insulin resistance and low HDL-C) having greater clinical importance. Limitations of this study are the number of patients. including the low number of men. and the laboratory impossibility of analyzing HOMA-IR due to the non-availability of insulin dosage in our service. Perhaps the increase in NC in men does not reflect an increase in cervical fat. due to the greater muscle mass of this population.Therefore. it is concluded that NC is an important anthropometric measure in clinical practice to help predict the risk of metabolic syndrome. especially in women.

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