Relation of neck circumference and relative muscle strength and cardiovascular risk factors in sedentary women

Relação da circunferência do pescoço com a força muscular relativa e os fatores de risco cardiovascular em mulheres sedentárias

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ABSTRACT

Objective: To verify the relation of neck circumference and relative muscle strength and cardiovascular risk factors in sedentary women. **Methods:** A cross-sectional study with 60 premenopausal women (33.9±9.1 years; 67.4±13.6kg; 1.57±0.6cm and 27.2±5.3kg/m^2). Based on the neck circumference, the sample was divided into two groups: Group Circumference <35cm (n=27) and Group Circumference ≥35cm (n=33) to compare relative muscle strength and cardiovascular risk factors. The correlation between variables was tested by Pearson and Spearman correlations, with a significance level established at $p<0.05$. **Results:** The findings revealed that women with neck circumference ≥35cm presented higher values of body mass, waist circumference, body adiposity index, body mass index, systolic blood pressure, blood glucose, glycated hemoglobin and volume of visceral fat when compared with the group with neck circumference <35cm. Additionally, the group with larger neck circumference presented lower values of relative strength. **Conclusion:** Neck circumference seems to be an important predictive factor of cardiovascular risk and of relative strength loss in middle-aged sedentary women.

Keywords: Neck/anatomy & physiology; Muscle strength; Anthropometry; Risk factors; Physical fitness; Sedentary lifestyle; Cardiovasular disease/etiology

RESUMO

Objetivo: O objetivo do presente estudo foi verificar a relação da circunferência do pescoço com a força muscular relativa e os fatores de risco cardiovascular em mulheres sedentárias. **Métodos:** Estudo transversal, realizado com 60 mulheres pré-menopausadas (33,9±9,1 anos; 67,4±13,6kg; 1,57±0,06cm e 27,2±5,3kg/m^2). Com base no valor da circunferência do pescoço, a amostra foi dividida em dois grupos: Grupo Circunferência <35cm (n=27) e Grupo Circunferência ≥35cm (n=33), para efeito de comparação da força muscular relativa e dos fatores de risco cardiovascular. A correlação entre as variáveis foi testada por meio da correlação de Pearson e de Spearman; o nível de significância foi estabelecido em $p<0,05$. **Resultados:** Os resultados demonstram que as mulheres com circunferência do pescoço ≥35cm apresentaram maiores valores de massa corporal, circunferência da cintura, índice de adiposidade corporal, índice de massa corporal, pressão arterial sistólica, glicemia, hemoglobina glicada e volume de gordura visceral, quando comparadas ao grupo com circunferência do pescoço <35cm. Adicionalmente, o grupo com maior circunferência do pescoço apresentou menores valores de força relativa. **Conclusão:** A circunferência do pescoço parece ser um importante fator de predição de risco cardiovascular e perda de força relativa em mulheres sedentárias de meia idade.

Descritores: Pescoço/anatomia & fisiologia; Força muscular; Antropometria; Fatores de risco; Aptidão física; Estilo de vida sedentário; Doenças cardiovasculares/etiologia

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INTRODUCTION

Excessive body fat is a risk factor for developing non-communicable chronic degenerative diseases, and it is associated to the incidence of diabetes[1], cardiovascular diseases[2,3] and early death[4,5]. However, when body fat is located in the upper part of the body, the negative repercussions - both metabolic and cardiovascular, seem to be more significant[6].

Computed tomography (CT)[7], magnetic resonance imaging (MRI)[8] and double energy X-ray absorptiometry (DEXA)[9] are considered excellent techniques to assess body fat distribution. However, access to these techniques is limited due to high costs. To measure excess body fat in the upper region of the body, simpler and affordable techniques are available. The neck (NC) and waist circumferences (WC), the waist-to-hip ratio and the waist-to-height ratio (WHR), as well as triceps skin fold thickness and abdominal diameter have been used[10].

It was recently proposed that the NC may represent a better parameter of cardiovascular risk, when compared to fat stored in the visceral region[11], possibly because visceral fat is not the major source of free fatty acids circulating levels[12]. Furthermore, it was demonstrated that the upper part of the body (neck) is responsible for greater release of systemic free fatty acids from the visceral region, mainly in obese individuals [13]. Yang et al.[14] found an association between NC and central obesity, overweight and metabolic syndrome in 3182 Chinese type 2 diabetic individuals.

In this context, physical exercises, such as aerobic and strength training, are included in the recommendations for prevention and prophylaxis of non-communicable chronic degenerative diseases in adults[15]. Some studies demonstrated a possible association of muscle strength and reduction in cardiovascular risk factors[16], type 2 diabetes[17], obesity[18] and hypertension[19,20]. However, as far as we know, no study assessed the association between NC and cardiovascular risk factors and relative muscle strength in sedentary Brazilian women.

OBJECTIVE

To compare and associate cardiovascular risk factors and relative muscle strength in Brazilian sedentary women, with different NC values. The hypothesis of the present study was that women with higher NC values had more cardiovascular risk factors and less relative muscle strength, as compared to those with lower NC values.

METHODS

Model of the study and sample

This was a cross-sectional convenience study, carried out from 2010 to 2011, in women living in Vila Telebrasília, in Brasília (Federal District). After signing the informed consent form, 60 women voluntarily participated in the investigation. Based on the NC value proposed by Yang et al.[14], and to make the comparison between relative muscle strength and cardiovascular risk factors, the sample was divided into two groups: Circumference <35cm (n=27) and Group ≥35cm (n=33). The inclusion criteria were age ≥18 years and non- menopausal status; signing the consent form; submitted to all laboratory and anthropometric tests. The exclusion criteria were having systematically exercised during the six months before the study; presence of cardiorespiratory diseases; physical limitations that would affect health conditions and performance during the tests; neck deformity, goiter and hypertrophy of parotid glands.

The study was approved by the Committee of Human Being Research Ethics, of the *Universidade Católica de Brasília* (UCB), by means of Resolution 196/96 of the National Health Council (project 376/2010).

Anthropometry

The body mass measurement was taken with the individual wearing light clothes and bare feet, using digital scales (W110H, Welmy, São Paulo, Brazil) with capacity of 150kg, and 100-gram divisions. Height was measured by a wall stadiometer (Sanny, São Paulo, Brazil), with capacity of 2200mm and 1-mm divisions. Waist circumference was measured with the participant standing up, with minimal clothing as possible, midway between the last floating rib and the iliac crest. The body adiposity index (BAI) was calculated by the formula:

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

The BAI can be used to reflect the percentage of body fat in adult males and females, of diverse ethnicities and with no numerical corrections. It also has strong association (R=0.85) with body fat values derived from DEXA[21].

The NC was measured using a measuring tape (Sanny, Brazil). The participants were asked to stand erect, with their head positioned in the Frankfort horizontal plane. The upper edge of the measuring tape was placed just below the laryngeal prominence and applied perpendicularly to the long axis of the neck[22].

Visceral fat assessment

The visceral fat volume (VFV) was estimated based on the predictive equation proposed by Petribú et al.[23], which uses the WHR and fasting glucose (FG) as independent variables, as follows:

$$VFV = -130.941 + (198.673 \times WHR) + (1.185 \times FG)$$

This equation, based on a multiple regression analysis and using ultrasonography (USG) as reference, is able to predict the VFV in approximately 45% of the individuals with an estimated standard error of ±15.19cm^2.

Blood pressure

Systolic (SBP) and diastolic (DBP) blood pressure were measured by the oscillometric method, adopting the methodology proposed by the 5th Brazilian Arterial Hypertension Guideline, of 2010[24]. An oscillometric device (Microlife 3AC1-1, Widnau, Switzerland) was employed, validated by the European Society of Hypertension, with cuff appropriate to the size of the arm, the individual sitting, after resting for 10 minutes, and the right arm supported at the heart level. The cuff was placed roughly 3cm above the antecubital fossa, centralizing the rubber bag on the humeral artery.

Biochemical tests

Triglyceride, high-density lipoprotein (HDL-C), glucose, glycated hemoglobin and insulin levels were determined by the following methods: cholesterol esterase and cholesterol oxidase; homogeneous HDL cholesterol; hexoquinase; high-performance liquid chromatography (HPLC) and electrochemiluminescence, respectively. With the insulin and glucose results, the homeostasis model assessment - insulin resistance (HOMA-IR)[25] was calculated, using the formula: HOMA-IR = fasting glucose (mmol/L) x fasting insulin (μU/mL)/22.5.

Handgrip strength

Handgrip strength was measured by a mechanic hand dynamometer (TKK *Grip Strength Dynamometer* 0-100kg, Takei, Japan), according to the Heyward protocol[26]. The voluntary subjects stood up with both arms extended and the forearm in neutral rotation. For all participants, the dynamometer grip was individually adjusted, according to the size of the hands, so that the stem closer to the body of the dynamometer was positioned over the second phalanges of the following fingers: index, middle and annular. The recovery time between measurements was approximately one minute. The test was performed in three attempts in each dominant hand and non-dominant hands. The best score among three attempts was used as the measure for each hand.

Statistical analysis

The significance level for all variables studied was $p \leq 0.05$. Initially a descriptive analysis of the variables was carried out with central trend and dispersion measurements. Next, the Smirnov-Kolmogorov and Levene test were conducted to assess data normalcy. Based on NC values, the sample was divided into <35cm and ≥35cm circumference to compare relative muscle strength, anthropometric data, blood pressure and biochemical tests by unmatched Student *t*-test and Wilcoxon test for non-parametric data. In addition, the correlation between NC and cardiovascular risk factors was evaluated, as well as the relative strength by means of Pearson and Spearman correlation for triglycerides, insulin and HOMA-IR). The data were analyzed by the Statistical Package for the Social Sciences (SPSS), version 13.0.

RESULTS

Table 1 presents the anthropometric, biochemical and blood pressure characteristics of the groups with

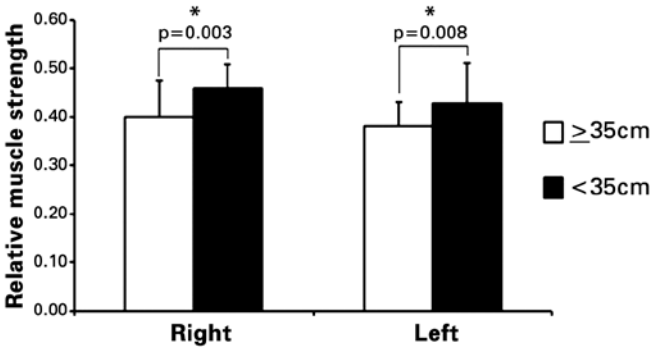
Table 1. Sample characteristics per neck circumference values

Characteristics	Neck circumference (cm)		p-value
	<35 (n=27)	≥35 (n=33)	
Age (years)	32.7±8.4	34.7±8.5	0.45
Body mass (kg)	59.5±7.4*	75.9±12.1	0.001
Height (cm)	1.57±0.1	1.59±0.1	0.28
BMI (kg/m^2)	24.3±3.4*	30.1±4.1	0.001
WC (cm)	76.8±8.5*	90.1±8.6	0.001
NC (cm)	31.8± 1.5*	35.4±1.3	0.001
HC (cm)	98.6±8.0*	107.4±8.6	0.001
BAI (%)	24.3±3.8*	27.0±3.8	0.007
VFV (cm^2)	64.5±14.3*	87.0±23.2	0.001
SBP (mm Hg)	112.7±8.7*	125.4±16.9	0.005
DBP (mm Hg)	75.8±5.9	82.4±10.6	0.02
Glucose (mg/dL)	83.4±7.4	92.5±17.3	0.03
HbA1c (%)	5.18±0.4	5.25±0.5	0.52
Insulin (μUI/mL)	6.3	8.8	0.67
HOMA-IR	1.42	1.82	0.43
Triglycerides (mg/dL)	100	94	0.59
HDL (mg/dL)	52.9±11.1	52.1±13.4	0.84

BMI: body mass index; WC: waist circumference; NC: neck circumference; HC: hip circumference; BAI: body fat index; VFV: visceral fat volume; SBP: systolic blood pressure; DBP: diastolic blood pressure; HbA1c: glycated hemoglobin; HDL: high-density lipoprotein. *p≤0.05.

different NC values. There was no difference between the groups regarding age, height, DBP, insulin, HOMA-IR and HDL-C. However, women with lower NC values (<35cm) presented lower body mass, body mass index (BMI), waist circumference, BAI, visceral fat volume, SBP, glucose and glycated hemoglobin values when compared to women with greater NC (≥35cm). Relative muscle strength was significantly lower ($p<0.01$) in women with higher NC values (Figure 1).

The correlation among the variables of the study is summarized on table 2. Correlations of NC with body mass, BMI, waist circumference, BAI, visceral fat volume, SBP ($p<0.01$), DBP ($p<0.05$) and inverse association with relative muscle strength ($p<0.01$) were observed. Nevertheless, no correlations among NC and biochemical variables were found.



* Significant difference between the groups.

Figure 1. Relative muscle strength of the groups with different neck circumference values

Table 2. Correlation coefficient of neck circumference and cardiovascular risk factors and relative muscle strength

Characteristics	Correlation coefficient	
	r	p-value
Body mass (kg)	0.76*	<0.01
BMI (kg/m^2)	0.72*	<0.01
WC (cm)	0.75*	<0.01
BAI (%)	0.62*	<0.01
VFV (cm^2)	0.51*	<0.01
SBP (mmHg)	0.45*	<0.01
DBP (mmHg)	0.36*	0.05
Glucose (mg/dL)	0.16	0.35
HbA1c (%)	0.23	0.15
Insulin (μUI/mL)	0.18	0.25
Triglycerides (mg/dL)	0.19	0.22
HDL (mg/dL)	-0.18	0.27
Relative muscle strength	-0.44*	<0.01

BMI: body mass index; WC: waist circumference; BAI: body adiposity index; VFV: visceral fat volume; SBP: systolic blood pressure; DBP: diastolic blood pressure; HbA1c: glycated hemoglobin; HDL: high-density lipoprotein. *p≤0.05.

DISCUSSION

The objective of the present study was to compare and associate relative muscle strength values and cardiovascular risk factors in Brazilian sedentary women with different NC measurements. Confirming our initial hypothesis, women with greater NC presented more cardiovascular risk factors and less relative muscle strength as compared to women with lower NC values. Furthermore, NC was associated to cardiovascular risk factors and relative muscle strength.

Yang et al.[14] investigated the association of NC and central obesity, overweight and metabolic syndrome in 3182 Chinese type 2 diabetic individuals. The results showed a positive correlation of NC with BMI, waist circumference and metabolic syndrome in men and women. Ben-Noun and Laor[10] analyzed the relation between NC and changes in cardiovascular risk factors. The authors demonstrated that increased NC is correlated to higher BMI, waist circumference, total cholesterol, LDL and glucose levels in males and females. Similarly, in the present study, women with NC ≥35cm had greater body mass, BMI, waist circumference, BAI, SBP, glucose and glycated hemoglobin levels.

Although the studies mentioned above examined the association between NC and cardiovascular risk factors, none of them related NC to relative muscle strength in Brazilian sedentary women. In this study, women with higher NC values presented lower relative muscle strength. Hence, non-drug treatments, such as strength training (ST), have been used in patients with cardiovascular risk factors. Several systematic reviews and meta-analyses highlighted effectiveness of ST in improving lipid profile[27], SBP and DBP[28], obesity[29,30] and glucose metabolism[17,29]. Therefore, ST can be considered an essential component in a physical activity program, designed to prevent and treat cardiovascular risk factors.

Some methodological limitations of the present study are worth mentioning. First, it is a cross-sectional study, with a reduced number of participants, which hinders establishing a cause-effect relation between NC and cardiovascular risk factors and relative muscle strength. However, NC is an important predictive factor of increased cardiovascular risk. Second, muscle

strength was assessed only by the handgrip strength. This tool was used as a parameter to assess general strength of the individuals, but unpublished data of our group demonstrated a moderate correlation of handgrip muscle strength with 1RM tests in leg press and bench press. In addition, this methodology is easy to apply and does not require using large sophisticated equipment or trained staff; hence its ecological validation must be taken into account.

CONCLUSION

The present study demonstrated that women with higher NC values presented greater cardiovascular risk factors and less relative muscle strength. Thus, it seems to be clinically relevant to use NC as a measure of excessive fat in the upper region of the body, due to its ease of application, little exposure of the individual assessed, and as a prevention factor for cardiovascular risk and for loss of relative muscle strength. It must be emphasized that this tool is cheap and can be applied to large populations to assess possible diseases and loss of functional capacity. Moreover, physical activity programs with ST should be performed for prevention and treatment of increased neck circumference and consequently, for less cardiovascular risk.

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