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Original Article

Can neck-thigh ratio (ntr) be an anthropometric index to diagnose metabolic syndrome?

A relação pescoço-coxa (RPCx) pode servir como índice antropométrico para diagnosticar a síndrome metabólica?

¿La Relación Cuello-Muslo (RCMx) puede servir como índice antropométrico para diagnosticar el Síndrome Metabólico?

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Descritores
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Descriptores
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Abstract
Objective: Investigate the Neck-to-Thigh Ratio (NTR) as an anthropometric index for the diagnosis of Metabolic Syndrome in Brazilian university students.
Methods: A cross-sectional study with 691 adults (> 18 years) of both sexes. Anthropometric parameters were investigated: abdominal circumference, neck circumference, thigh circumference, body mass index, and NTR. In addition, laboratory data were collected, such as: triglycerides, glycaemia and HDL cholesterol.
Results: The abdominal circumference (83.59 ± 10.68 cm), neck (37.29 ± 2.36 cm), thigh (52.37 ± 5.71 cm) and the neck-thigh ratio (0.72 ± 0.07 cm) was higher among men (p <0.001). In the analysis of the components of the syndrome, the NTR showed a statistically significant positive linear correlation with all.
Conclusion: This research showed that NTR is not a criterion capable of diagnosing MS, but indicates changes in the components that form the syndrome.

Resumo
Objetivo: Investigar a Relação Pescoço-Coxa (RPCx) como índice antropométrico para diagnosticar a Síndrome Metabólica em estudantes universitários brasileiros.
Métodos: Estudo transversal com 691 adultos (> 18 anos) de ambos os sexos. Foram investigados os seguintes parâmetros antropométricos: circunferência abdominal, circunferência de pescoço, circunferência de coxa, índice de massa corporal e RPCx. Além disso, foram coletados dados laboratoriais, tais como: triglicérides, glicemia e colesterol HDL.
Resultados: Foram encontrados valores de circumferência abdominal (83,59 ± 10,68 cm), de pescoço (37,29 ± 2,36 cm), coxa (52,37 ± 5,71 cm) e relação de pescoço-coxa (0,72 ± 0,07 cm) superiores entre os homens (p <0,001). Ao analisar os componentes da síndrome, a RPCx mostrou uma correlação linear positiva estatisticamente significante com todos.
Conclusão: Nesta pesquisa foi demonstrado que a RPCx não serve como critério diagnóstico da SM, mas indica alterações nos componentes constituintes da síndrome.

Resumen
Objetivo: Investigar la Relación Cuello-Muslo (RCMx) como índice antropométrico para diagnosticar el Síndrome Metabólico en estudiantes universitarios brasileños.
Métodos: Estudio transversal con 691 adultos (>18 años) de ambos sexos. Se investigaron los siguientes parámetros antropométricos: circunferencia abdominal, circunferencia de cuello, circunferencia de muslo, índice de masa corporal y RCMx. Además, se recogieron datos de laboratorio, tales como triglicéridos, glicemia y colesterol HDL.
Resultados: Se encontraron valores de circunferencia abdominal (83,59 ± 10,68 cm), de cuello (37,29 ± 2,36 cm), muslo (52,37 ± 5,71 cm) y relación de cuello-muslo (0, 72 ± 0,07 cm) superiores entre los hombres (p <0,001). Al analizar los componentes del síndrome, la RCMx mostró una correlación lineal positiva estadísticamente significativa para todos los casos.
Conclusión: En esta investigación se ha demostrado que la RCMx no sirve como criterio diagnóstico del SM, pero indica alteraciones en los componentes constituyentes del síndrome.

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Introduction

Over the years, the distribution of adiposity has been the focus of research because it is an important predictor of cardiovascular and metabolic disorders. The accumulation of fat located in the central, peripheral, visceral or subcutaneous region is strongly associated with the risk of developing chronic diseases, such as diabetes, hypertension, dyslipidaemias and coronary diseases, among others closely related to the progression of a group of dysfunctions that determine the Metabolic Syndrome (MS) - a complex disorder represented by a set of cardiovascular and metabolic risk factors related to fat accumulation and insulin resistance.(1-3)

Although university life offers positive educational resources and opportunities that lead to healthy habits, the behaviors presented by university students have been mostly negative and associated with weight gain, higher alcohol consumption, sedentary lifestyle and non-nutritive diets, ideal for the accumulation of obesity and cardiovascular risks for chronic diseases. (4) The question is: what kind of interventions are needed for this population?

In this direction, it is indisputable that obesity prevails as one of the determining conditions for the appearance of MS, and, therefore, researchers have shown an interest in anthropometric markers and indexes that measure the concentration of fat in body regions different from the usual ones.(1,5,6) We highlight the accumulation of subcutaneous fat of the upper and lower trunk, measured by neck circumference (NC) and thigh circumference (TC), respectively. Studies have shown that, individually, the estimates drawn by NC and TC are capable of indicating risks for the development of chronic diseases, being better than other known anthropometric measures, such as body mass index (BMI).(7-12)

Similarly, research has also emphasized the use of obesity indicators, such as waist-hip ratio and waist-to-height ratio (WHR), in determining cardiovascular and metabolic adverse conditions.(13-16) However, even with significant results regarding the predictive capacity of the NC and TC estimates, there are no data demonstrating the neck-thigh ratio (NTR) as an anthropometric index to measure the role of chronic diseases that condition MS.

It should also be noted that studies from different countries have shown different outcomes regarding the superiority of one or other obesity index, as well as cut-off points for estimating obesity diagnoses or even MS, and dysfunctions associated with it.(11,12,16-18) Thus, the evidence indicates that variations in age, clinical, ethnic and racial condition of different populations are characteristics that influence the determination of markers and anthropometric indexes and cut-off points to diagnose MS, and need to be extensively investigated, the aim of facilitating clinical practice in the different health settings.(14,19)

So far, researchers are unaware of Brazilian or international studies investigating the consensus of a better anthropometric index for obesity, nor is there an appropriate cut-off point for prediction or diagnostic component of MS. From this, taking into consideration the anatomical regions of the neck and thigh, they have little variability throughout the day, and that NC and TC measurement are low cost and easy to estimate in the screening of individuals with accumulation of adiposity, yet there is a gap in knowledge of indexes for MS, is that the present study proposes to investigate the NTR as an anthropometric index for the diagnosis of MS.

Methods

A cross-sectional study involving adult population-based patients (≥ 18 year old) of both sexes. This study is part of a project, in which data were extracted, titled "Prevalence of Metabolic Syndrome and its components in a population of university students from Fortaleza, Ceará, Brazil", developed by researchers linked to the Federal University of Ceará, between March 2010 and June 2011, in the city of Fortaleza, Ceará, Brazil.

The target population was composed of 17,228 university students enrolled in 2011 in 24 undergraduate courses, divided into six major areas of knowledge (humanities, maths, agrarian, health, sciences and technology), in different university campuses located in the city of Fortaleza, Ceará, Brazil. To select the participants, at least two undergraduate courses were chosen in each area of knowledge, and in each course, students from different academic semesters were selected. Based on this population, a simple random sample without replacement was calculated from a formula for infinite populations.

The sample was calculated according to a percentage of 50% (P = 50%, Q = 50%), significance level (α = 0.05) and sample error of 8% (absolute error = 4%) were adopted. The applied formula was for infinite populations ($n = t^2 5\% \times P \times Q / e^2$).

A 10% fee was added due to the loss of information in questionnaires by means of erroneous or incomplete answers, resulting in the need for investigation of 606 people. However, the final sample consisted of 691 people. The sample consisted of conglomerates, each department (area of knowledge) represented a unit of sample analysis in this research. After stratification and calculation of the representative percentage of each area of knowledge in the composition of the total sample, the following values were obtained: Humanities (21.5%), Maths (17.5%), Agrarian (14.5%), Health (14%), Sciences (17%) and Technology (15.5%).

The sample was stratified and the proportions were calculated by area. The criterion of selection of the participants was by probabilistic sampling by means of simple draw, by means of number of enrollment, giving to the students the same chance of participation in the study.

Those elected to participate in the study should be enrolled in undergraduate courses in the face-to-face modality, reside in the city of Fortaleza, participate in all stages of data collection and have a telephone and e-mail for contact. Subjects with a condition that interfered with the measurement of anthropometric data, blood pressure and blood collection, who were pregnant or those who did not comply with the 12-hour fast, required to collect blood samples were excluded from the survey.

It should be noted that the information about the research was posted on the murals, placed on the university's website and sent to students' e-mails to facilitate the participation of students who were not in the classroom at the time of the first recruitment. Data collection took place in two moments. First, in the classroom, the students answered a questionnaire about sociodemographic data. Then the students were referred to the blood pressure measurement and to the measurement of anthropometric data: weight, height, waist circumference, neck circumference and thigh circumference. In the second stage, a room was prepared to receive the participants of the research, as well as to receive the laboratory of clinical analyses, which was contracted with their respective employees and materials. It is noteworthy that, previously, university students were instructed by telephone and e-mail about the need for 12-hour fasting, and for abstinence from alcohol, tobacco and physical activity. The collection was performed by three trained nurses.

In this study, we investigated the Metabolic Syndrome, diagnosed through the International Diabetes Federation (IDF) criteria: abdominal circumference ≥90 cm for men and ≥80 cm for women, added with at least two components: triglycerides ≥ 150mg/dL; high-density lipoprotein (HDL-cholesterol) <40mg/dL (men) or <50mg/dL (women); blood pressure ≥ 130/85mmHg or use of antihypertensive and fasting glycaemia ≥100mg/dL or diagnosis of type 2 diabetes.

All subjects underwent a detailed anthropometric examination while wearing light clothing and maintained without shoes. Body weight was assessed using a digital portable scale (Tec-Silver Techline®), with a capacity of 150 kg and a precision of 0.1 kg. The height was measured with a precision of 0.1 cm closer, and in order to ensure height accuracy, the participants were instructed to stand erect and still, with their hands flat on their thighs and their head adjusted to the plane of Frankfurt. The body mass index (BMI) was calculated by the ratio of weight (kg) to height (m), squared. Students with values between 25.0 and 29.9 kg/m² were considered overweight, and those with values of ≥ 30 kg/m² were obese.

Abdominal circumference was measured using an inelastic tape, with an accuracy of 0.5 cm at the midpoint between the last rib and the upper border of the iliac crest at the end of the expiratory movement. Values ≥ 90 cm and ≥ 80 cm were considered high in men and women, respectively.[20] In order to measure the circumference of the neck, an inelastic metric tape with a precision of 0.1 cm was placed just below the superior border of the prominence of the larynx, being applied perpendicularly along the axis of the neck and measured at the midpoint. For the male audience, the measurement was performed just below the Adam's apple, and may indicate a measurement bias. The cut-off values were> 39 cm for men and> 35 cm for women.[7] The following values were considered as the cutoff point for determining individuals with MS: men with neck circumference ≥ 39 cm and women ≥ 35 cm. For the thigh circumference, the inelastic tape, with a precision of 0.1 cm, was positioned horizontally at the midpoint of the thigh between the inguinal fold and the proximal edge of the patella, while maintaining a slight knee flexion. The left thigh was measured in individuals whose right hand was dominant and on the right side of the body in those in which the left hand was dominant.

The neck-to-thigh ratio (NTR) is a result of the ratio between the neck circumference (cm), measured at the midpoint of the neck, and the median thigh perimeter (cm), which have been used as subcutaneous adipose tissue of the upper and lower body regions, respectively. Following the tricompartmental body composition model (subcutaneous and visceral adipose tissue and lean mass), after adjustment for lean mass and for visceral adipose tissue.[13,21-23]

The diagnosis of MS was better identified when correlated with NTR, but it is not clear. The studies suggest associations of anthropometric measures combined to determine the CVR and changes in blood pressure, BMI and others related to insulin resistance or to the diagnosis of MS.[13,21-23]

The application of the adopted anthropometric measures follow studies that relate these measures with insulin resistance, cardiovascular diseases or complications which have relation with the metabolic syndrome. Until the moment, no other study involving colleges students was carried out using the these anthropometric measurements.

Blood pressure measurements were performed with Tycos aneroid sphygmomanometers and Welch Allyn® (United States) cuffs, with rubber widths corresponding to 40% of the circumference of the arm and the length involving at least 80%. Binaural stethoscopes (Littmann® Master Cardiology, United States) were also used for auscultatory technique. Initially, for the adequate choice of arm, the measurements were obtained in both upper limbs and, in case of difference; the one that presented the highest blood pressure level was used for the subsequent measurements. Then, three measurements were taken with a minimum interval of one minute between each and the mean of the last two measurements was considered as the blood pressure of the individual investigated. In order not to be considered hypertensive individuals should have the pressure values ≤ 130/85mmHg.[24]

After the anthropometric data collection, the blood samples were collected. The biochemical samples were collected by trained professionals, in rooms reserved for this purpose, at the chosen university, through the use of a vacuum collection system BD Vacuteiner®, by means of venipuncture. Study subjects underwent 12-hour food fasting for biochemical determinations of fasting, triglyceride and HDL-cholesterol venous blood glucose. Blood was collected in two 2 ml test tubes, one without anticoagulant (for triglyceride and HDL-cholesterol dosages), and another with anticoagulant sodium fluoride (to determine fasting venous glucose). Serum was separated by centrifugation at 3000 rpm for 15 min. Plasma glucose was measured using the hexokinase glucose-6-phosphate dehydrogenase method. The triglyceride and HDL-cholesterol levels were determined enzymatically using an autoanalyzer (Type C8000, Roche Ltd, Germany).

Secondary data analysis was used. Data were typed by different professionals in an Excel spreadsheet, compared and then exported to Statistical Package for Social Sciences version 20 (SPSS Inc., Chicago, IL, USA) for treatment and generation of results. The data treatment consisted of validation of the internal consistency of the information entered and calculation of the indicators defined for the study.

Statistical measures of central tendency were calculated, based on a 95% confidence interval of the quantitative variables. To verify the differences between the proportions of the characteristics analyzed, the Chi-square tests, Pearson's test and the Fisher's exact test were used.

The continuous variables of the study were evaluated for normality by means of the Shapiro-Wilk test, checking non-normality (p<0.001). Association tests were performed between variables. To analyze the relationship between the anthropometric variables, the Spearman linear correlation test was adopted.

Pearson's correlation was verified between neck-thigh, thigh circumference, abdominal circumference, triglycerides, systolic and diastolic pressure and glucose. Some relationships were bi-caudal correlated, which demonstrates the association with MS in general. The ROC curve was constructed from the variable neck-thigh ratio and determination of the metabolic syndrome.

The confidence level used was 95% with confidence interval defined by $\bar{x} \pm Za / 2 * \sigma / \sqrt{(n)}$, where Za / 2 = the confidence coefficient, where a = confidence level, σ = standard deviation, n = sample size.

The study was approved by the Committee of Ethics in Research with Human Beings of the Health Sciences Centre of the Federal University of Ceará, under the protocol number 208/2010. The inclusion of the participants in this study was made through the signing of a free and informed consent form, containing guidelines on the research.

Results

Of the 691 students (aged between 18 and 58 years, SD±4,52), 62.2% were women, 53.3% of those aged 20-24 years (21.5 ± 1.57), 52.4% mixed race, 69.1% enrolled between the first and the fifth semester and 39.5% with monthly family income of US$ 1,705 (SD=200). Physical inactivity was present in 70.5%, with the female being more sedentary (p <0.001). Regarding alcohol use, only 6.7% were dependent on this drug. Most university students did not declare themselves to be smokers (90.6%).

As for anthropometric data, men were higher than women, and overweight was significantly more present in this gender (p<0.001). The values measured by the BMI calculation revealed that 26.6% of the sample was overweight, 21.3% were overweight (25.0-29.9kg/m²), and 5.3% were obese (≥30kg/m²). The waist circumference (83.59 ± 10.68 cm), the neck (37.1±2.36 cm), the thigh (52.00±5.60 cm) and the neck-thigh ratio (0.72 ± 0.07 cm) was higher among males (p<0.001). The fasting glucose values were between 73.5-112 mg/dL in this sample.

Only 4.05% (n=28) of the sample was identified with MS according to IDF criteria. In the comparison between the means of university students with and without MS with PRC, the low amplitude made it impossible to consider this anthropometric index as a predictor for MS (Table 1).

Table 1. Association of metabolic syndrome with thigh circumference, neck circumference and neck-thigh ratio in university students, according to sex

Sex		Without MS		With MS		
		Mean	SD	Mean	SD	p-value
Female	NTR	0.61	0.05	0.58	0.04	<0.001
	TC	52.0	5.1	57.9	6.0	
	NC	31.7	1.8	33.3	1.6	
Male	NTR	0.72	0.07	0.69	0.04	<0.001
	TC	52.0	5.6	58.0	4.0	
	NC	37.1	2.3	40.1	1.7	
Total	NTR	0.65	0.08	0.65	0.07	<0.001
	TC	52.0	5.3	58.0	4.8	
	NC	33.7	3.3	37.4	3.8	

†MS – Metabolic Syndrome; TC – Thigh Circumference; NC – Neck Circumference; NTR – Neck-Thigh Ratio.

The difference in means for the variable neck-thigh relationship was performed. This relationship showed a statistically significant difference presenting lower variability in the group with metabolic syndrome.

In the analysis of the components of MS, NTR showed a statistically significant positive linear correlation with all, and more thigh circumference (p<.000) and neck circumference (p<.000) (Table 2). In addition, important analysis variables such as NTR presented a significant relationship between

Table 2. Correlation between neck-thigh ratio, thigh circumference, neck circumference, and metabolic syndrome components in college students

Variables	Statistic†	Variables								
		NTR	TC	AC	NC	TG	HDL	DBP	SBP	FG
NTR	r	1	-0.573**	0.065	0.536**	0.098*	-0.342**	0.292**	0.376**	0.014
	p	-	0.000	0.088	0.000	0.010	0.000	0.000	0.000	0.713
TC	r	-0.573**	1	0.643**	0.370**	0.051	-0.001	0.096*	0.101**	0.054
	p	0.000	-	0.000	0.000	0.180	0.976	0.012	0.008	0.158
AC	r	0.065	0.643**	1	0.730**	0.141**	-0.200**	0.289**	0.338**	0.025
	p	0.088	0.000	-	0.000	0.000	0.000	0.000	0.000	0.506
NC	r	0.536**	0.370**	0.730**	1	0.183**	-0.398**	0.422**	0.528**	0.065
	p	0.000	0.000	0.000	-	0.000	0.000	0.000	0.000	0.089
TG	r	0.098*	0.051	0.141**	0.183**	1	-0.252**	0.137**	0.146**	0.074
	p	0.010	0.180	0.000	0.000	-	0.000	0.000	0.000	0.052
HDL	r	-0.342**	-0.001	-0.200**	-0.398**	-0.252**	1	-0.191**	-0.273**	-0.063
	p	0.000	0.976	0.000	0.000	0.000	-	0.000	0.000	0.098
DBP	r	0.292**	0.096*	0.289**	0.422**	0.137**	-0.191**	1	0.697**	0.070
	p	0.000	0.012	0.000	0.000	0.000	0.000	-	0.000	0.068
SBP	r	0.376**	0.101**	0.338**	0.528**	0.146**	-0.273**	0.697**	1	0.045
	p	0.000	0.008	0.000	0.000	0.000	0.000	0.000	-	0.239
FG	r	0.014	0.054	0.025	0.065	0.074	-0.063	0.070	0.045	1
	p	0.713	0.158	0.506	0.089	0.052	0.098	0.068	0.239	-

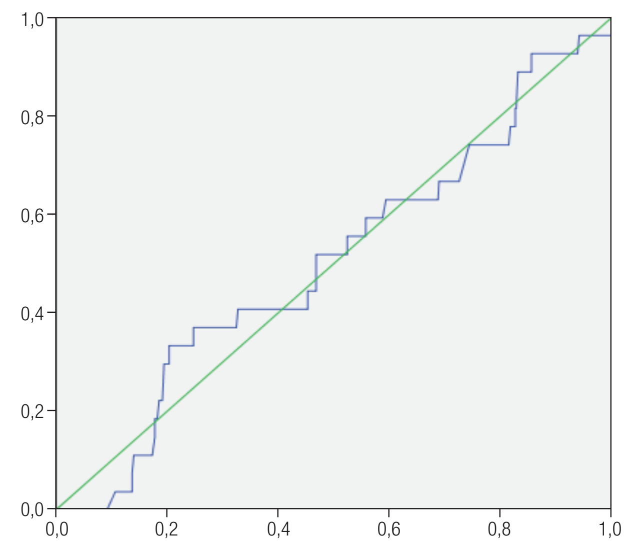
† Pearson test (r); *p<0.05 e **p<0.001. NTR – Neck-Thigh Ratio; TC – Thigh circumference; AC – Abdominal circumference; TG – Triglycerides; DBP – Diastolic blood pressure; SBP – Systolic blood pressure; FG – Fasting glucose

determinants of MS such as triglycerides and blood pressure.

The figure 1 shows the evaluation of NTR as an index to identify MS, the area under the ROC curve did not present statistical significance (p = 0.943 / AUC = 0.504), indicating that this relationship is not a good discriminatory test in this population.

It is not possible to determine cutoff point due to the homogeneity of the data, this was demonstrated by the curve (area under the curve), nor the determination of a regression model that explains the outcome in relation to the predictor variables due to the homogeneity of the data evaluated, and only the description, association and correlation of the findings that showed significance with the isolated components of MS.

Also, based on the findings of this study, there may be a bias in this ratio proposition (neck-thigh) since there was practically a tie in the values.



AUC* (IC 95%): 0.504 (0.393-0.615) / p=0.943
*Area under the curve

Figure 1. ROC curve of NTR in the identification of MS of university students

Discussion

The objective of this study was to investigate NTR as an indicator for MS diagnosis. Traditionally, AC and BMI have been used to predict the risk of cardiovascular and metabolic dysfunctions associated with adiposity accumulation as in MS. However, studies have suggested the introduction of new indicators to compose the list of anthropometric criteria related to the diagnosis of the syndrome, such as the circumference of the neck and circumference of the thigh. In addition, the correlation of anthropometric markers has also been the focus of investigations that point out cardio metabolic risks. [1, 7, 15, 21, 25-26]

This study showed that NTR is not the most appropriate measure to estimate MS in a population of Brazilian university students. However, NC and TC have been shown to be useful in predicting metabolic and cardiovascular dysfunctions related to the progression of diseases such as diabetes, atherosclerotic disease, systemic arterial hypertension, or others involving the accumulation of visceral and subcutaneous adiposity, influencing the development of components for MS.[27-30]

In the analysis of the correlation between NTR and MS componentes, it was observed that the establishment of this anthropometric index has a positive impact with almost all, being an excellent indicator of risk through these biomarkers. Changes in biomarkers that signal MS, indicated by the NTR, are directly linked to the genesis of overweight/obesity, which in turn are the main determinants of dyslipidaemia, diabetes and hypertension. It is emphasized that the greater the number of components that an individual presents, the higher the pathogenicity linked to cardiovascular events. Thus, making use of NTR is important in helping to identify more quickly and economically the components that indicate SM, compared to more advanced technologies, such as computed tomography that demands a high cost and trained professionals.

Studies that investigated MS by means of analysis of the level of fat accumulation in the neck region indicate a strong association between changes in lipid and glycaemic variables. Indian researchers investigating MS using anthropometric indices have shown that NC has been a good predictor of MS and cardiovascular risk factors, impacting triglycerides, HDL cholesterol, and diseases such as diabetes and hypertension.[10, 31-32] In South Korea, a study revealed that NC measurement is a proxy for evaluation of epicardial adiposity and abdominal circumference, indicating glycaemic changes.[33] In relation to Brazil,[7] neck measurement has shown to be an effective and innovative alternative in the determination of fat distribution, as well as, it has been associated with MS and insulin resistance. In addition, estimation of subcutaneous fat through NC has also indicated the development of cardio metabolic risk profiles in different age, gender and ethnic groups.[34]

On the other hand, TC has been identified as a protective factor for adverse cardiovascular events. The presence of elevation of the thigh perimeter, composed of muscle mass instead of fat, has estimated better lipid levels and lower metabolic dysfunctions that lead to MS, and are important for tracing preventive measures against injuries.[29, 35-36]

None of the individual components of the syndrome can predict the diagnosis of the metabolic syndrome in isolation. However, the NTR is directly related to all components and is a positive indicator for MS.

Some of the limitations to be considered are related to bias as to the extent of the neck, that while some studies consider the measurement of the neck below the laryngeal prominence, others just use measured at the midpoint, regardless of sex. As for TC measurement, this study used the values obtained from the midline of the thigh. However, other investigations have considered making use of the upper or lower portion of the thigh. It is added, in this context, that it is impossible to establish a cut-off point for NTR. It is also worth noting that the criterion used to identify MS influenced the prevalence. The studied population was composed of predominantly young people, marked by a great miscegenation between indigenous, white and black, of different ethnicities and low occurrence of chronic pathologies, preventing the data being generalized.

The present study also has some limitations in the statistical analysis derived from the sample composition (direct average differences, for example). This impaired an adjusted analysis between dependent and independent variables. The sensitivity and specificity calculations, ROC curve predictor instruments, can not be calculated due to the homogeneity between real positive and negative real cases.

Thus, it is recommended that further investigations be carried out in order to clarify the use of the NTR as an anthropometric index to be included in the criteria previously established by the competent organizations to assist the identification of MS. In addition, considering that MS itself still raises doubts about the diagnosis, it is important to consider other populations with different specificities so that the NTR can serve as a subsidy for other health professionals to use this marker in clinical practice.

Anthropometric measures are important to be used in the screening of chronic diseases or in the accumulation of chronic dysfunctions, such as metabolic syndrome. At the frontline of health care, nurses can use these tools to determine earlier interventions, especially at the first level of health care.

Conclusion

In conclusion, it was found that NTR is related to all the components of SM, individually, and is related to cardio metabolic risk factors, but it cannot be considered an direct anthropometric marker capable of screen the MS. The college students need preventive measures to avoid developing health problems such as the metabolic syndrome and can be investigated for simple and low-cost measures, such as accurate anthropometry. More investments and research should be directed at reducing the risk of chronic diseases or the accumulation of chronic diseases in a population so young and changeable.

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Collaborations

Araújo MFM and Freitas RWJF conceived the project and carried out the experiments and analyzed data. Lira Neto JCG, Lisboa KWSC, Gomes EB e Damasceno MMC were involved in writing the manuscript. Damasceno MMC, Bispo GMB e Rodrigues EMD were involved with the critical review. Damasceno MMC was involved in writing the paper and had final approval of the submitted and published versions.

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