Neck circumference can differentiate obese from non-obese individuals

Raquel Eduardo Lucas[I], Ana Laura Ferreira Fonseca[I], Roberto Oliveira Dantas[I]

[I] Universidade de São Paulo, Faculdade de Medicina de Ribeirão Preto, Department of Medicine, Ribeirão Preto, SP, Brazil.

BACKGROUND: Obesity is an important problem of public health with increasing prevalence in the population. The diagnosis is made based on body mass index (BMI) levels; the objective of this study was to determine whether the measurement of the neck circumference may be an option to differentiate non-obese from obese individuals.
METHOD: Neck circumference was measured using a graduated tape over the thyroid cartilage, in 50 non-obese individuals (66% women) and 97 obese individuals (65% women), diagnosed by BMI.
RESULTS: Neck circumference was higher for obese than for non-obese individuals and higher in men than in women. The values of neck circumferences greater than 42 cm for men and 36 cm for women were associated with obesity, with high sensitivity (98%) and specificity (96%). There is a positive association between neck circumference with weight and BMI in women. Age has a negative correlation with BMI in obese individuals. Obese women have less height than non-obese.
CONCLUSION: Neck circumference can differentiate obese from non-obese individuals, with high sensitivity and specificity. It is higher in obese than in non-obese individuals, higher in men than in women, and is associated with the grade of obesity.

KEYWORDS: Obesity, Neck circumference, Body Mass Index.

◾ INTRODUCTION

Obesity is an important problem of public health with increasing prevalence in the population.[1,2,3] It is associated with comorbidities, such as type 2 diabetes, chronic kidney disease, depression, stroke, coronary artery disease and other diseases, which have a significant economic impact.[2,4]

The diagnosis of obesity is made based on body mass index (BMI) levels, which represents the weight in kilograms divided by the square of the body height in meters (kg/m^2). The World Health Organization classified non-obese individuals as those with BMI from 18.5 to 25.0 kg/m^2, overweight with BMI between 25.0 and 30.0 kg/m^2 and obese for individuals with BMI over 30 kg/m^2, class I with BMI from 30 to 35 kg/m^2, class II with BMI from 35 to 40 kg/m^2 and obese class III (severe obesity) with BMI over 40 kg/m^2.

The measurement of neck circumference has been described as a good method to differentiate obese from non-obese individuals,[5,6,7] but this measurement may suffer the influence of cultural variables of each country. Neck circumference is a marker of upper body subcutaneous adipose tissue distribution and a reliable index for obesity.[5] A clear difference between non-obese and obese individuals can be established.[6] Neck circumference is associated with cardiovascular risk factors, metabolic syndrome, and fatty liver disease.[8-10] The measurement is influenced by gender and BMI; it may also be influenced by height and age. There is a positive correlation between neck circumference and weight, BMI, waist circumference, hip circumference and with the waist/hip ration in Turkish adults.[7]

This study evaluated the neck circumference in men and women, obese and non-obese, the correlation of

weight and BMI with neck circumference, the correlation between BMI and age and the difference in height between obese and non-obese individuals in the Brazilian population. Our hypothesis was that neck circumference is related with BMI, gender and weight of the individuals, and that neck circumference may differentiate severe obese from non-obese subjects.

■ MATERIAL AND METHODS

Neck circumference was measured in 50 non-obese and in 97 obese volunteers. Non-obese volunteers included 17 (34%) men and 33 (66%) women, aged 30 to 42 years; in 40 (80%) BMI from ranged 18.0 kg/m^2 to 25 kg/m^2 and in 10 (20%) it ranged from 25 kg/m^2 to 30 kg/m^2. The obese group included 34 (35%) men and 63 (65%) women, aged 18 to 63 years, eight (8%) with BMI from 35 kg/m^2 to 40 kg/m^2 and 89 (92%) with BMI over 40 kg/m^2. The included volunteers did not have digestive, cardiac or respiratory diseases, no previous surgical treatment for obesity and were not taking drugs for weight loss. The study was conducted at the University Hospital of the Medical School of Ribeirão Preto, University of São Paulo, and the protocol of the investigation was approved by the Human Research Committee of the University Hospital of Ribeirão Preto, case number HCRP 15919/2014. Written informed consent was obtained from each participant and the anonymity of each volunteer was preserved.

Neck circumference was measured with the individuals seated on a chair, the head in a neutral position, looking straight ahead. A graduated tape was used that was passed around the neck, over the thyroid cartilage. Measurements were taken after the researchers had received training in the measurement of neck circumference. The results were compared between obese and non-obese individuals, and the influence of gender, weight and BMI on neck circumference was evaluated.

Statistical analysis was done using the unpaired t-test, the analysis of covariance (ANCOVA) test, adjusted weight, and the correlation coefficient of Spearman (rho). Differences were considered significant when $p \leq 0.05$.

■ RESULTS

There was no difference in age and height between non-obese and obese individuals (Table 1), even though non-obese women were taller than the obese women ($p = 0.02$). Neck circumference was larger in men vs. women and in obese vs. non-obese (Table 2).

The limits of neck circumference, which can differentiate obese from non-obese individuals, were 42 cm for men and 36 cm for women (Figure 1). These values determined a sensitivity of 98% and a specificity of 96% of the neck circumference measurement in the diagnosis of obesity.

In women there was a positive correlation in neck

Table 1 - Characteristics of the subjects

	Non-Obese ($n = 50$)		Obese (n = 97)	
	Mean ± SD	Limits	Mean ± SD	Limits
Age (years)	38.6 ± 10.6	30 - 42	41.8 ± 11.6	18 - 63
Height (m)	1.67 ± 0.09	1.50 - 1.91	1.64 ± 0.09	1.43 - 1.90
Weigth (kg)	64.8 ± 10.1	40 - 92	141.6 ± 32.4	90.8 - 242.6
BMI (kg/m^2)	23.2 ± 2.6	18.2 - 29.4	52.2 ± 10.3	31.4 - 86.2

SD - standard deviation

Table 2 - Neck circumference (cm) of obese and non-obese men and women

	Non-Obese ($n = 50$)		Obese ($n = 97$)		All ($n = 147$)	
	Mean ± SD	Limits	Mean ± SD	Limits	Mean ± SD	Limits
Men	37.9 ± 2.6	33.5 - 42.0	49.1 ± 4.3	41.5 - 61.0	45.4 ± 5.2	33.5 - 61.0
Women	32.3 ± 1.6	28.5 - 36.5	42.6 ± 3.9	35.5 - 54.5	39.1 ± 4.3	28.5 - 54.5
All	34.2 ± 3.3	28.5 - 42.0	44.9 ± 5.1	35.5 - 61.0	41.3 ± 6.0	28.5 - 61.0

$p < 0.01$ men vs women and non-obese vs obese, SD - standard deviation
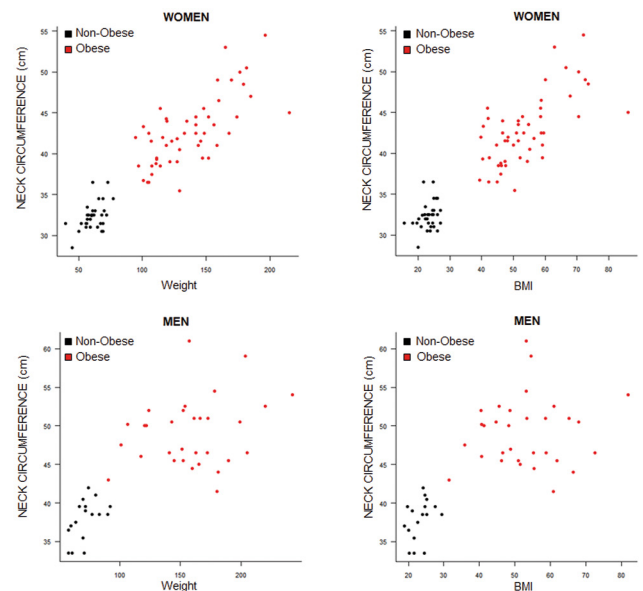
Figure 1. Correlation between neck circumference with weight (kg) and body mass index (BMI - kg/m^2) in men and women. $p = 0.01$ for correlation neck circumference and weight in men and women, and for BMI in women.

circumference and weight for obese and non-obese individuals and with BMI for obese (Table 3). In men there was a positive correlation between weight and neck circumference in obese individuals.

The correlations between neck circumference, weight and BMI were stronger in women than in men (Figure 1). In obese individuals, age exhibited a negative correlation with BMI (Table 4).

Table 3 - Correlation coefficient of Spearman (rho) between neck circumference with weight and body mass index (BMI)

	WEIGHT		BMI	
	rho	p	rho	p
Men				
Non Obese	0.57	0.02	0.42	0.09
Obese	0.20	0.25	0.06	0.75
All	0.74	0.01	0.30	0.09
Women				
Non Obese	0.45	0.01	0.30	0.09
Obese	0.63	0.01	0.57	0.01
All	0.87	0.01	0.85	0.01

Table 4 - Correlation coefficient of Spearman (rho) between age and body mass index (BMI)

	MEN			WOMEN		
	NON OBESE	OBESE	ALL	NON OBESE	OBESE	ALL
rho	0.30	- 0.38	0.08	0.09	- 0.43	- 0.14
p	0.25	0.02	0.57	0.60	0.01	0.18

■ DISCUSSION

The measurement of neck circumference is an easy and simple way to evaluate obesity. Taking the present results into consideration, it is possible to say that a neck circumference greater than 42 cm in men and greater than 36 cm in women is an indication of obesity. A previous study in non-diabetic individuals described that a neck circumference greater than 37 cm is an indication of obesity.[11] For metabolic syndrome, the best cut-off point is 39 cm for men and 33 cm for women.[6] The limit for obesity in adolescents was found to be 38 cm for men and 33 cm for women.[11] The results of these different studies were similar to that which was found in our study. The observed differences may be a consequence of the method of measurement and of the population characteristics of each country. Normal values should be defined for each country or region and with an established method of measurement. Under these conditions, neck circumference is able to separate non-obese from obese individuals, at least class III obesity. The sensitivity for the neck circumference measurement in adults in the diagnosis of obesity was previously found to be 98% in men and 100% in women, and the specificity as 89% in men and 98% in women[6], similar with the results we found of 98% sensitivity and 96% specificity in all groups.

In women, but not in men, we found a good correlation between weight and BMI with neck circumference. The lack of correlation in men might be a consequence of the smaller number of men included in the study ($n = 51$) compared with the number of women ($n = 96$). The measurement of neck circumference in men is different than the measurement in women, which may be a consequence of anatomic differences and not only caused by obesity.

Obese women had less height than non-obese. It is possible that in women the shorter height causes a predisposition to obesity, a situation that is not clear or may even be absent in men. It is also interesting to note that the aging process is associated with a lower BMI in obese individuals, which may be a consequence of the clinical treatment for obesity these patients receive, which may have some effect later in time, even knowing that most of them still have severe obesity. The decrease of weight with age was not seen in non-obese individuals. It was described in a recent study that high general adiposity is more frequent in men than in women and in older age groups.[12] Different populations may have different genetic, social, geographic characteristics, as well as different levels of food availability, physical activities and other influences relevant to the development of obesity. It is not easy to arrive at conclusions that are the same for all populations. However, the neck circumference measurement is a good indicator of obesity for all of them.

There is an important racial/ethnic influence in the prevalence of overweight and obesity.[1] Some countries have a significant variation in their racial/ethnic distributions which can influence the distribution of the prevalence of obesity. The diagnosis of the condition is of great importance to establish prevention and treatment; in this context, the neck circumference measurement should be of value.

This investigation has some limitations. The number of men included should be higher and the neck circumference measurement could have been performed by more than one investigator. However, we have presented clear results which demonstrate the value of the measurement to define obese individuals.

Neck circumference is an important predictor of some complications of obesity, such as sleep apnea,[13,14] high blood pressure in children and adolescents,[15] difficulties in mask ventilation,[16] cardio-metabolic syndrome,[17] erectile dysfunction,[18] metabolic syndrome,[8,9] cardiovascular risk factors,[8] and fatty liver disease.[10] These associations demonstrate the importance of the neck measurement, which translates the grade of obesity of the individual and the possibility of complications.

■ SUMMARY

Neck circumference is higher in obese than in non-obese individuals, higher in men than in women, and is associated with the grade of obesity. The neck circumference measurement has a high sensitivity and specificity in the definition of obesity.

■ AUTHOR CONTRIBUTION

Raquel E Lucas: participated in the planning, in the measurement, and in making the decision to submit

this manuscript to MedicalExpress. Ana Laura F Fonseca: participated in the planning, in the measurement, and in making the decision to submit this manuscript to MedicalExpress. Roberto O Dantas: participated in the planning, in the write and in making the decision to submit this manuscript to MedicalExpress.

■ CONFLICT OF INTEREST

CIRCUNFERÊNCIA DO PESCOÇO PODE DIFEREN-CIAR PESSOAS OBESAS DE NÃO OBESAS

OBJETIVO: A obesidade é um importante problema de saúde pública, com crescente prevalência na população. O diagnostico é fundamentado no índice de massa corporal (IMC). No entanto, a circunferência do pescoço pode ser uma alternativa para diferenciar obesos de não obesos.

MÉTODO: Circunferência do pescoço foi medida sobre a cartilagem cricóide, usando uma fita graduada, em 50 indivíduos não obesos (66% mulheres) e 97 indivíduos obesos (65% mulheres) diagnosticados pelo IMC.

RESULTADOS: A circunferência do pescoço foi maior em obesos comparados aos não obesos, e maior nos homens quando comparados às mulheres. Medidas acima de 42 cm para homens e 36 cm para mulheres foram associados à obesidade, com alta sensibilidade (98%) e especificidade (96%). Nas mulheres houve associação positiva entre os valores da circunferência do pescoço com o peso e o IMC. Nas pessoas obesas houve correlação negativa entre idade e IMC. A altura das mulheres obesas foi menor do que a das mulheres não obesas.

CONCLUSÕES: A medida da circunferência do pescoço pode diferenciar pessoas obesas de não obesas, com alta sensibilidade e especificidade. Ela é maior em obesos que não obesos, maior em homens do que em mulheres, e é associada com o grau de obesidade.

PALAVRAS-CHAVE: Obesidade, Circunferência do Pescoço, Índice de Massa Corporal

■ REFERENCES

1. Wang Y, Beydoun MA. The obesity epidemic in the United States - gender, age, socioeconomic, racial/ethnic, and geographic characteristics: a systematic review and meta-regression analysis. Epidemiol Rev. 2007;29(1):6-28. DOI: http://dx.doi.org/10.1093/epirev/mxm007

2. Ortiz VE, Kwo J. Obesity: physiologic changes and implications for preoperative management. BMC Anesthesiol. 2015;15:97. DOI: http://dx.doi.org/10.1186/s12871-015-0079-8

3. Ng M, Fleming T, Robison M, Thomson B, Graetz N, Margono C, et al. Global, regional and national prevalence of overweight and obesity in children and adults during 1980-2013: a systematic analysis for the Global Burden of Disease Study 2013. Lancet. 2014;384:766-81. DOI: http://dx.doi.org/10.1016/S0140-6736(14)60460-8

4. de Gonzales AB, Hartge P, Cerhan JR, Flint AJ, Hannan L, MacInnis RJ, et al. Body mass index and mortality among 1.46 million white adults. N Engl J Med. 2010;363(23):2211-9. doi: http://dx.doi.org/10.1056/NEJMoa1000367.

5. Aswathappa J, Garg S, Kutty K, Shankar V. Neck circumference as an anthropometric measure of obesity in diabetics. N Am J Med Sci. 2013;5(1):28-31. doi: http://dx.doi.org/10.4103/1947-2714.106188.

6. Ben-Noun L, Sohar E, Laor A. Neck circumference as a simple screening measure for identifying overweight and obese patients. Obes Res. 2001;9(8):470-7. DOI: http://dx.doi.org/10.1038/oby.2001.61

7. Saka M, Türker P, Ercan A, Kiziltan G, Bas M. Is neck circumference measurement an indicator for abdominal obesity? A pilot study on Turkish adults. Afr Health Sci. 2014; 14(3):570-5. doi: http://dx.doi.org/10.4314/ahs.v14i3.11.

8. Limpawattana P, Manjavong M, Sopapong R. Can neck circumference predict metabolic syndrome? An experience from a university community. Endocr Pract. 2016;22(1):8-15. doi: http://dx.doi.org/10.4158/EP15902.OR.

9. Aoi S, Miyake T, Harada T, Ishizaki F, Ikeda H, Nitta Y, et al. Neck circumference has possibility as a predictor of metabolic syndrome in postmenopausal women. Hiroshima J Med Sci 2014;63: 27-32.

10. Huang BX, Ihy MF, Wu T, Zhou JY, Liu Y, Chen XL, et al. Neck circumference, along with other anthropometric indices, has an independent and additional contribution in predicting fatty liver disease. PLoS One 2015; 10: e0118071. doi: http://dx.doi.org/10.1371/journal.pone.0118071.

11. Ferretti RL, Cintra IP, Passos MAZ, Ferrari GLM, Fisberg M. Elevated neck circumference and associated factors in adolescents. BMC Public Health. 2015;15:208-17. DOI: http://dx.doi.org/10.1186/s12889-015-1517-8.

12. Kowalkowska J, Poinhos R, Franchini B, Afonso C, Correia F, Pinhão S, et al. General and abdominal adiposity in a representative sample of Portuguese adults: dependency of measures and socio-demographic factors' influence. Br J Nutr. 2016;115(1):185-92. doi: http://dx.doi.org/10.1017/S0007114515004055.

13. Wysocki J, Charuta A, Kowalcze K, Ptaszynska-Sarosiek I. Anthropometric and physiologic assessment in sleep apnea patients regarding body fat distribution. Folia Morphol. 2015;ahead of print. DOI: http://dx.doi.org/10.5603/FM.a2015.0127

14. Duarte RLM, Magalhães da Silveira FJ. Factors preditive of obstructive sleep apnea in patients undergoing pré-opertive evaluation for bariatric surgery and referred to a sleep laboratory for polysomnography. J Bras Pneumol. 2015;41(5):440-8. http://dx.doi.org/10.1590/S1806-37132015000000027

15. Kuciene R, Duskiene V, Medzioniene J. Association of neck circumference and high blood pressure in children and adolescents: a case control study. BMC Pediatr 2015;15:127-36. DOI: http://dx.doi.org/10.1186/s12887-015-0444-2

16. Leoni A, Arlati S, Ghisi D, Verwej M, Lugani D, Ghisi P, et al. Difficult mask ventilation in obese patients: analysis of predictive factors. Minerva Anestesiol 2014;80(2):149-57.

17. Zhou J, Ge H, Zhu M, Wang LJ, Chen L, Tan YZ, et al. Neck circumference as an independent predictive contributor to cardio-metabolic syndrome. Cardiovasc Diabetol 2013;12:76-82. doi: http://dx.doi.org/10.1186/1475-2840-12-76.

18. Akin Y, Gulmez H, Bozkurt A, Nuhoglu B, Usta MF. Usage of neck circumference as novel indicator of erectile dysfunction: a pilot study in Turkish population. Andrologia 2014;46(9):963-70. doi: http://dx.doi.org/10.1111/and.12181.