Neck circumference and success in the weight-reducing treatment of patients with obesity: a real-life study

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Abstract

Introduction: Evaluation of the patient with obesity is a challenge due to the technical difficulties to carry out measurements.

Objective: To assess the association between neck circumference (NC) and waist circumference (WC) with cardio-metabolic risk markers, as well as treatment success in patients with morbid obesity. **Method:** Four-hundred and seventy patients of 39.3 ± 11.4 years of age and with a body mass index (BMI) of 44.1 ± 8.4 were studied; 73.5% were females. Baseline and final BMI, WC, NC, hip circumference and cardio-metabolic markers were assessed. Success was defined as weight loss $\geq 5\%$.

Results: Significant correlations were found between WC and NC, and between these and cardio-metabolic risk markers, as well as between changes in WC and NC and treatment success. NC predicted success in logistic regression models.

Conclusions: The association of WC and NC with cardio-metabolic risk indicators and the association of NC with treatment success in patients with morbid obesity was documented. Given the simplicity for obtaining it, NC might replace WC in the assessment and follow-up of patients with class III obesity.

KEY WORDS: Neck circumference. Waist circumference. Body mass index. Obesity. Adults.

Perímetro de cuello y éxito del tratamiento de pacientes con obesidad: estudio de vida real

Resumen

Introducción: La evaluación del paciente con obesidad es un reto debido a las dificultades técnicas para efectuar las mediciones. **Objetivo:** Evaluar la asociación entre el perímetro de cuello (PCu) y el de cintura (PC) con marcadores de riesgo cardiometabólico y el éxito del tratamiento de pacientes con obesidad mórbida. **Método:** Se estudiaron 470 pacientes de 39.3 ± 11.4 años e índice de masa corporal de 44.1 ± 8.4 ; 73.5 % era del sexo femenino. Se evaluó índice de masa corporal, PC, PCu, perímetro de cadera y marcadores cardiometabólicos basales y finales. Se definió como éxito a una pérdida ponderal $\geq 5\%$. **Resultados:** Se encontraron correlaciones significativas entre PC y PCu y entre estos y marcadores de riesgo cardiometabólico, así como entre los cambios en PC y PCu y el éxito en el tratamiento. El PCu predijo el éxito en modelos de regresión logística. **Conclusiones:** Se documentó la asociación entre PC y PCu con indicadores de riesgo cardiometabólico y la asociación del PCu con éxito en el tratamiento en pacientes con obesidad mórbida. Dada la sencillez de su obtención, el PCu podría sustituir al PC en la evaluación y seguimiento de pacientes con obesidad clase III.

PALABRAS CLAVE: Perímetro de cuello. Perímetro de cintura. Índice de masa corporal. Obesidad. Adultos.

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Introduction

Obesity is a public health problem at globally.¹ In Mexico, the prevalence of overweight and obesity has shown an upward trend since 1988, and in 2016 it reached a combined prevalence (overweight + obesity) of 72.5 % in adults.²

Obesity is a disease that is characterized by an abnormal increase in adiposity. Even when the body mass index (BMI) measures mass rather than adiposity, it has been used to define and assess obesity for epidemiological and clinical purposes. The measurement of fat, particularly visceral fat, requires methods that are not readily accessible in clinical practice,³ although there are alternatives such as measuring the waist (WC), hip and, more recently, neck circumference (NC).⁴ BMI combined with central adiposity indicators such as WC has been proposed, since it is predictive of cardiometabolic risk.⁵ However, although WC is a low-cost practical measure and its association with metabolic risk markers is high, there are technical problems in people with obesity and its convenience in individuals with BMI ≥ 35 has been questioned due to its low accuracy and reproducibility, to the difficulty to identify bone referents^{6,7} and to the fact that the measurement can vary due to postprandial distension, breathing and clothing.^{8,9}

Like WC, NC is an indicator of upper body adiposity and central obesity,¹⁰ although its use is less widespread and there is a lack of unified risk criteria. It is a low-cost measurement that is quick and easy to perform by trained personnel, it is more reproducible than WC and has been proposed as an alternative to assess patients with overweight or obesity because it has less technical difficulties, it is more stable and it is not subject to postprandial distention.⁹

The relationship of NC with the diagnosis, evaluation and follow-up of patients with overweight or obesity,⁹ obstructive sleep apnea-hypopnea syndrome,¹¹⁻¹³ insulin resistance,¹⁴ hypertension¹⁵ or cardiovascular risk has been explored;¹⁶ in addition, it is associated with metabolic syndrome.^{6,17} To the best of our knowledge, there are only few studies^{18,19} that have explored the relationship between WC and NC in patients with morbid obesity, as well as with success in obesity treatment programs.

At the Obesity and Eating Disorders Clinic of the National Institute of Medical Sciences and Nutrition Salvador Zubirán, the Program for the Care of the Patient with Obesity has been implemented. It offers

comprehensive treatment, with medical, nutritional and psychological care, through a 20-week psychoeducational program with monthly visits. It includes a standardized nutritional plan, medical treatment of comorbidities and psychological support to promote treatment adherence. More than 70 % of patients participating in the program has morbid obesity (BMI ≥ 40 or ≥ 35 in the presence of comorbidities).

In order to explore the usefulness of NC in patients with obesity, particularly morbid obesity, the purpose of the present study was to assess the association between WC and NC in patients participating in this program and their association with cardiometabolic risk markers, as well as with treatment success.

Method

Real-life study,²⁰ consisting of a retrospective analysis of a cohort of 470 patients who were newly admitted to the Program for the Care of the Patient with Obesity between April 2004 and July 2010, concluded the program and had complete data on baseline and final anthropometric variables. Patients aged between 18 and 59 years, with BMI ≥ 30 and at least complete elementary education were included.

Weight, height, WC, hip circumference and NC were assessed. The measurements were made by standardized nutritionists using methods accepted by international consensus.²¹ Weight was obtained with a TANITA bioelectrical impedance scale with 250-kg weight capacity, with the patient wearing light clothes and no shoes; height was measured with a wall stadiometer with flexometer. Circumferences were measured with a fiberglass measuring tape (SECA 201). WC was measured at the midpoint between the lower border of the rib cage and the iliac ridges at the level of the axillary midline at the height of the umbilical scar, and hip circumference, at the widest point of the gluteal perimeter. NC was measured just below the laryngeal prominence, with the head on the Frankfort plane.^{15,21} BMI (kg/m^2) and waist/hip index were calculated. Blood pressure was measured using a wall aneroid sphygmomanometer with an appropriate size cuff.²² Fasting glucose and lipid profile (total cholesterol, LDL cholesterol, HDL cholesterol and triglycerides) were determined at the Central Laboratory of the National Institute of Medical Sciences and Nutrition Salvador Zubirán. Metabolic syndrome was defined as the presence of three or more components of Alberti's harmonized criteria.²³ Treatment was considered successful with a weight reduction $\geq 5\%$.⁶

Table 1. Baseline and final clinical and metabolic characteristics, by gender

	Males (n = 123)					Females (n = 347)				
	Baseline		Final		p*	Baseline		Final		p*
	Mean ± SD		Mean ± SD			Mean ± SD		Mean ± SD		
Age (years)	38.6 ± 11.9					39.2 ± 11.3				
Height (m)	1.71 ± 0.07					1.58 ± 0.07				
Weight (kg)	133.8 ± 30.0		126.2 ± 28.8		0.000	109.2 ± 21.9		104.1 ± 21.3		0.000
BMI	45.4 ± 8.9		42.8 ± 9.0		0.000	43.7 ± 8.2		41.7 ± 8.0		0.000
Waist circumference (cm)	136.5 ± 18.1		129.9 ± 18.5		0.000	118.4 ± 16.9		113.9 ± 16.2		0.000
Hip circumference (cm)	134.5 ± 18.3		129.9 ± 18.2		0.000	135.7 ± 15.8		132.0 ± 16.2		0.000
Waist/hip index	1.02 ± 0.07		1.00 ± .07		0.004	0.87 ± 0.08		0.86 ± 0.07		0.000
Neck circumference (cm)	46.1 ± 3.4		44.7 ± 4.1		0.000	39.6 ± 3.5		38.4 ± 3.7		0.000
Systolic blood pressure (mm Hg)	133.5 ± 14.9		126.9 ± 13.5		0.000	129.1 ± 15.2		125.6 ± 14.1		0.000
Diastolic blood pressure (mm Hg)	87.1 ± 10.8		83.2 ± 10.2		0.001	84.0 ± 11.0		81.4 ± 9.3		0.000
Glucose (mg/dL)	101.2 ± 20.1		99.1 ± 36.5		0.497	103.3 ± 26.1		97.1 ± 21.6		0.000
Total cholesterol (mg/dL)	184.4 ± 34.2		173.1 ± 38.4		0.036	190.3 ± 38.5		184.9 ± 37.3		0.006
Triglycerides (mg/dL)	182.2 ± 78.0		159.2 ± 70.2		0.022	170.1 ± 89.4		158.2 ± 76.3		0.001
LDL-cholesterol (mg/dL)	112.6 ± 28.7		95.4 ± 37.4		0.035	118.5 ± 32.2		108.2 ± 40.8		0.001
HDL-cholesterol (mg/dL)	33.6 ± 6.7		33.6 ± 8.2		0.301	38.8 ± 9.0		39.2 ± 9.1		0.752
Metabolic syndrome components [#]	3.59 ± 1.04		3.05 ± 1.05		0.001	3.43 ± 1.03		3.05 ± 0.67		0.000
	n	%	n	%	p [§]	n	%	n	%	p [§]
Altered glucose	50	40.7	26	21.1	0.000	148	42.7	65	18.7	0.000
Altered triglycerides	68	55.5	44	35.8	0.001	168	48.4	100	28.8	0.000
Altered HDL-cholesterol	97	78.9	62	50.4	0.000	296	85.3	203	58.5	0.000
Altered blood pressure	95	77.2	64	52.0	0.000	211	60.8	160	46.1	0.041
Metabolic syndrome [#]	65	81.3	58	72.5	0.005	171	81.0	145	68.7	0.000

*Paired t-test. [§]Chi-square test. [#]Males n = 80; females n = 211 with baseline and final assessment for all components of the metabolic syndrome.

The study was approved by the Institute's own Ethics in Research and Research Committees. All participants granted written informed consent upon entering the Program for the Care of the Patient with Obesity.

Central tendency and dispersion measures were determined (mean, standard deviation) for continuous variables, and frequencies and percentages for categorical variables. A simple correlation analysis (Pearson's r) was carried out between anthropometric and cardiometabolic risk variables and Spearman correlation analysis between success and changes in WC and NC. To assess mean differences (baseline and final), a paired t-test was used, assuming equality or non-equality of variances according to Levene's test

(F) or chi-square test results for categorical variables. Logistic regression models were generated for treatment success, and odds ratios and their 95 % confidence intervals were estimated. All analyses were made divided by gender and statistical significance was considered with a p-value < 0.05. The SPSS program version 22.0 for Windows was used.

Results

Four-hundred and seventy patients with obesity were studied (BMI ranging from 30.2 to 77.7); 73.5 % were females. Age was 39.3 ± 11.4 years and baseline weight and BMI were 115.7 ± 26.6 kg and 44.1 ± 8.4,

respectively; 63.6 % of patients had a BMI ≥ 40 (with no differences between genders), which indicated class III obesity according to the World Health Organization criteria.²⁴ In both genders, WC indicated abdominal obesity²³ and NC showed values higher than those reported in different studies.⁸ Metabolic parameters had values consistent with the metabolic syndrome components and only total cholesterol showed mean values within normal. At baseline, all patients had altered WC and 78.9 % of males and 85.3 % of females had hypoalphalipoproteinemia (Table 1).

Significant differences were found in WC, hip circumference and NC ($p < 0.001$) when patients were divided by BMI < 35 and ≥ 35 groups. Females with BMI ≥ 35 had higher values for systolic blood pressure, diastolic blood pressure, glucose, and lower for LDL-cholesterol and HDL-cholesterol ($p < 0.01$ for systolic blood pressure and diastolic blood pressure and $p < 0.05$ in all other cases) than those with BMI < 35 . No differences in cardiometabolic risk parameters were found in men by BMI group.

A significant improvement was documented in anthropometric, clinical and metabolic indicators at the end of the program in both genders, except for glucose in females and HDL-cholesterol in males and females (Table 1).

When the variables were contrasted by BMI group, significantly higher values in weight, BMI, WC, hip circumference, NC, systolic blood pressure, diastolic blood pressure, glucose, LDL-cholesterol and HDL-cholesterol were found in females with BMI ≥ 35 , while only differences in anthropometric variables were found in males.

There was a significant decrease in the prevalence of altered markers, except for WC. The evolution of metabolic syndrome and its components was studied in 80 males and 211 females with complete data for these markers. At baseline, 81.3 % of males and 81 % of females had metabolic syndrome. At the end of the program, a reduction in the number of metabolic syndrome components was documented ($p = 0.001$ in males and $p = 0.000$ in females) and their frequency was reduced ($p = 0.005$ in males and $p = 0.000$ in females) (Table 1). The frequency of metabolic syndrome in females with BMI ≥ 35 was higher than in those with BMI < 35 (82.4 % versus 60.0 %, $p = 0.000$); this did not occur in males (84.1 % versus 63.6 %, $p = 0.202$).

A positive and significant correlation was found between WC and NC in males and females (0.353 and 0.558, respectively; $p < 0.01$). In males, reverse correlations of BMI, WC y NC with cholesterol and

Table 2. Pearson's correlation between anthropometric variables and cardiometabolic indicators at baseline, by gender

	Risk variables	BMI	Waist	Neck
Males	Glucose	-0.099	-0.073	-0.084
	Triglycerides	-0.075	-0.087	-0.049
	Cholesterol	-0.248**	-0.239**	-0.216*
	HDL-cholesterol	-0.167	-0.148	-0.126
	LDL-cholesterol	-0.233*	-0.215*	-0.228*
	Systolic blood pressure	0.232**	0.235**	0.144
	Diastolic blood pressure	0.213*	0.188*	0.166
Females	Glucose	0.142**	0.149**	0.105
	Triglycerides	0.069	0.005	0.138*
	Cholesterol	-0.026	0.036	0.088
	HDL-cholesterol	-0.109*	-0.130*	-0.126*
	LDL-cholesterol	-0.030	0.018	0.056
	Systolic blood pressure	0.214**	0.140*	0.162**
	Diastolic blood pressure	0.199**	0.153**	0.121*

Baseline values were used.

* $p < 0.05$; ** $p < 0.01$.

LDL-cholesterol, and positive correlations of BMI and WC with systolic blood pressure and diastolic blood pressure were documented. In females, significant correlations of BMI, WC and NC with systolic and diastolic blood pressure and HDL-cholesterol were found, as well as of BMI and WC with glucose and of NC with triglycerides. The direction of the correlations was as expected except for cholesterol and LDL-cholesterol in males (Table 2).

Median weight loss in males was 7.6 kg (-28.8 to + 9.2 kg), and 4.4 kg (-28.8 to + 7.2 kg) in females; 56.1 % of males and 42.1 % of females had weight loss ≥ 5 %, with significant differences between genders ($p = 0.007$).

Significant correlations were found between WC and NC changes and weight loss percentage or treatment success, except for NC changes and weight loss percentage in females with BMI < 35 . Correlations were higher in males. WC showed higher correlations than NC. High correlations of WC with weight loss percentage and success stand out in males and females with BMI < 35 (Table 3).

NC was included in all regression models, except for model 4, while WC was not included in any. Model 3 had higher r^2 and explained 21.7 % of variance of the dependent variable (success) with three variables: age, neck circumference and fasting glucose (Table 4).

Table 3. Correlation between changes in waist and neck circumference and outcome variables (% of weight loss or success)

	Outcome variable	BMI	Waist changes	Neck changes
Males	Weight loss % [#]	All	0.472**	0.329**
		BMI < 35	0.823**	0.718*
		BMI ≥ 35	0.456**	0.316**
	Success [§]	All	0.461**	0.384**
Women	Weight loss % [#]	All	0.475**	0.201**
		BMI < 35	0.630**	0.258
		BMI ≥ 35	0.454**	0.191**
	Success [§]	All	0.361**	0.251**

[#]Pearson's correlation. [§]Spearman's correlation (neck and waist as dichotomous variables and percentile 66 as cutoff point by gender). *p < 0.05. **p < 0.001.

Table 4. Forward stepwise logistic regression models for treatment success (≥ 5% of weight loss)

Model	Variables in the model	OR	95% confidence interval		p	r ²
			Lower	Upper		
1	Neck	1.076	1.030	1.124	0.004	0.035
	Hip	0.988	0.976	0.999	0.039	
2	Age	1.022	1.003	1.040	0.020	0.036
	Neck	1.053	1.008	1.100	0.021	
3	Age	1.051	1.013	1.092	0.009	0.217
	Neck	1.150	1.012	1.305	0.032	
	Glucose	1.032	1.003	1.062	0.002	
4	Diastolic blood pressure	1.022	1.000	1.044	0.049	0.049

Independent variables (all corresponding to baseline values):

Model 1: gender, age, body mass index, waist, hip, neck.

Model 2: model 1 and systolic blood pressure, diastolic blood pressure, glucose, triglycerides, total cholesterol, HDL-cholesterol, LDL-cholesterol.

Model 3: model 2 (except for gender) in males.

Model 4: model 2 (except for gender) in females.

Discussion

The present study assessed the association of NC and WC with cardiometabolic risk markers and treatment success in patients undergoing an obesity treatment program in a tertiary care institution in a real-life setting. There was a predominance of class III obesity, and 45.7 % of the patients succeeded by reaching a weight loss ≥ 5% with an improvement in cardio-metabolic risk indicators.

Due to the nature of the patients, the NC values were higher than the reported cutoff points.⁸ As in other studies, a significant correlation of WC with NC was identified in males and females, although with lower values (0.353 in males and 0.558 in females);

however, the frequency of class III obesity was high and the BMI values higher than those previously reported,^{15,19} even in the meta-analysis by Kroll et al.⁸

Although the correlations of WC and NC with metabolic risk markers were not high, they were significant (Table 2); however, throughout the treatment, higher correlations of WC or NC changes with outcome variables such as weight loss percentage or treatment success were documented (Table 3), as well as a relative superiority of WC over NC in all cases, even against expectations in patients with BMI ≥ 35, where the WC measurement is often inaccurate and poorly reproducible.^{6,7} NC predicted treatment success in logistic regression models, albeit with low odds ratios and explanatory power.

The results suggest that NC is an indicator of central adiposity given that, as in other studies^{5,15-17} it was associated with cardiovascular risk indicators (total cholesterol, LDL-cholesterol, triglycerides and blood pressure). NC has been documented to show a high correlation ($r = 0.4196$, $p < 0.001$), even higher than BMI, with 10-year risk of coronary heart disease.⁹

Our study has limitations: being a real-life study, some data were missing, particularly in biochemical variables, possibly due to scarcity of patient resources or minimal request for tests when resources are limited. However, controlled clinical trials do not reflect usual clinical practice, and generating real life evidence for this purpose is required.²⁵ The prevalence of metabolic syndrome might be underestimated in this study, since there was a lack of information on patients with risk variables at normal values who received or started treatment during the program. The change in WC should be taken with caution in patients with BMI ≥ 35 . Nevertheless, the study contributes information to existing literature by including a large proportion of patients with class III obesity, with unusually high BMI values (40 to 77), rarely described, which allowed studying NC in a wide range of BMI values and its possible usefulness beyond classical anthropometric measurements.²⁶

Although in the present study NC was not superior to WC, successful correlations with the treatment and metabolic changes were similar and suggest that NC could be a time-saving tool in the office that is less invasive than WC.

In conclusion, the present study documented the association of WC and NC with cardiometabolic risk indicators and the association of NC with treatment success in patients with morbid obesity and could be an alternative to WC in the evaluation, diagnosis and follow-up of these patients. Being an indicator of central adiposity and being associated with common comorbidities, NC might complement BMI.

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