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Neck circumference as an indicator of Obesity for Metabolic Syndrome in Mexican Healthcare workers

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ABSTRACT

Background: Neck circumference (NC) is a novel anthropometric indicator to assess adiposity in the cervical region that is rarely used in Mexico. The greatest advantage of this evaluation is the saving of time, minimal use of instruments, and no prerequisites for patients.

Objective: This study aimed to determine the effectiveness of NC as an indicator of obesity for Metabolic Syndrome (MetS) in comparison with BMI and Waist Circumference (WC), and to define NC cutoff levels based on parameters established by the International Diabetes Federation in a group of healthcare workers from a Public Health Hospital of the State of Morelos, Mexico.

Methods: This was a no-randomized, cross-sectional-observational study. Instruments: Anthropometric evaluation and biochemical parameters: lipid profile, fasting glucose, and blood pressure. Statistical analysis: Descriptive, correlational, Poisson multiple regression adjusted by age/sex, and ROC curves using SPSS.23 program.

Results: 200 healthcare workers were recruited (146 women and 54 men), age ẋ=42.87, σ=11.25 years. The prevalence of MetS was 38% (37% in women and 40.7% in men). BMI, WC, and NC were significantly correlated: BMI and WC (r=.924), BMI and NC (r=.814), and NC and WC (r=.810) (p=.01). Likewise, they were related to hyperglycemia, hypertriglyceridemia, hypertension, and decreased in HDL-cholesterol levels. The NC best cut-off points coupled with two or more components of MetS in women was ≥35.12 cm [AUC=0.765 (95% CI, 0.688-0.843)] and in men ≥41.25 cm [AUC=0.787 (95% CI, 0.688-0.906)].

Conclusion: NC proved to be a reliable indicator that can be quickly and inexpensively evaluated for the determination of obesity for the preliminary diagnosis of MetS.

KEYWORDS

Neck circumference, Cut-off points, Metabolic Syndrome, and Mexican Healthcare workers.

INTRODUCTION

The definition of Metabolic Syndrome (MetS) proposed by the International Diabetes Federation (IDF) states that obesity determined by the increase in waist circumference (WC), which depends on ethnicity or BMI ≥30 is an indispensable requirement for diagnosis, bound to the presence of two or more of the following four conditions: hyperglycemia, hypertriglyceridemia, hypertension, and/or decreased in HDL cholesterol levels[1]. For the evaluation of obesity, either health professionals need to determine the sites of the body using standard criteria to obtain precise measurements, employing certified and calibrated instruments such as a stadiometer and a scale for the determination of BMI, and a measuring tape to size the WC. In addition, the person being evaluated requires fasting, being dressed in light clothing and bare feet. However, for the evaluation of neck circumference (NC), it is just required a calibrated measuring tape placed above the thyroid cartilage and the evaluated person must be seated on an anthropometric bench with the head in the Frankfort plane, with no previous fasting requirements or need to remove shoes or clothing, except for the neck area.

The importance of studying NC is to determine the viability of its use as an indicator of obesity for MetS owing to its ease, economy of time, and low cost of measurement, both

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for the evaluator and the person being evaluated. As well, there are few studies in the scientific literature on this subject at the international level and on a much smaller scale, the Mexican population.

Internationally, some scientific investigations have determined cut-off points for NC related to MetS using IDF criteria. Such is the case of a study conducted on the Nigerian population with an understood age ≥18 years, where it was determined that the best cut-off point in women is ≥33 cm [AUC=0.688 (95% CI, .619-0.757)], and in men ≥37 cm [AUC=0.733, (95% CI, 0.597-0.869)][2]. In the Brazilian population, the cut-off point was specified at >33.3 cm [AUC=0.813, (95% CI, 0.7-0.8)] in women, and >39.5 cm [AUC=0.812, (95% CI, 0.7-0.8)] in men[3]. In a study conducted on the Thai population with age >50 years, cut-off points for NC were established at ≥33 cm [AUC=0.83 (Sensitivity 91% and Specificity 76%)] in women, and ≥38 cm [AUC=0.69 (Sensitivity 67% and Specificity 70%)] in men[4]. In Ecuadorian participants it is >32.75 cm [AUC=0.737 (Sensitivity 81.5% and Specificity 51.9%)] in women and >37.5 cm [AUC=0.753 (Sensitivity 87.5% and Specificity 50%)] in men[5]. In Mexico, the evaluation of NC is uncommon and therefore, the scientific literature is minimal.

OBJECTIVE

The aim of this study was to determine the efficiency of NC as an indicator of obesity for MetS in comparison with BMI and WC, and to define NC cutoff levels based on parameters established by the International Diabetes Federation in a group of healthcare workers from a Public Health Hospital of the State of Morelos, Mexico.

MATERIALS AND METHODS

Study design

This is a cross-sectional study.

Population and sample

The non-random sample consisted of 200 participants from a total of 800 healthcare workers who were enrolled by invitation through posters and pamphlets distributed to different sections of a Public Health Hospital of the State of Morelos, Mexico.

Inclusion Criteria: Healthcare workers actively working in the hospital: doctors, nurses, paramedics, and administrative workers. Exclusion Criteria: People being treated with steroids, antidepressants, and/or anxiolytics due to their incidence causing weight increase; women who were pregnant or lactating and/or had given birth in the last 12 months; and people with motor disability, since the taking of anthropometric measurements in this last group requires different procedures.

Ethical aspects

The protocol of the study was approved by the Bio-Ethics Committee of the hospital, registered CONBIOETHICS 17 CEI002 20190225 (PI.006.2019) following the Declaration of Helsinki[6]. The participants were informed by the researchers about the study and signed consent was obtained from all of them. Furthermore, participants were fed back with the results of their health status.

Procedure

For the evaluation of anthropometric variables, the participants were asked to fast for 12 hours and wear light clothing and bare feet.

I) Anthropometric Variables

Trained personnel certified by the International Society for the Advancement of Kinanthropometry (ISAK), evaluated and recorded anthropometric measurements.

BMI. The weight of the participants was measured on a Tanita-BC 601-F digital scale with a precision of 100 g following the recommendations of the manufacturer to obtain exact readings. They wore light clothing with bare feet and were fasted. The height of each participant was measured using a Seca 214 stadiometer, with a precision of 1 mm. BMI was calculated by dividing the weight in kilograms by the square of the height in meters[7].

WC. A Lufkin W606PM metal tape, graded in millimeters, was used to measure WC after the participants inhaled and exhaled. The tape was placed at the narrowest point between the inferior border of the tenth rib and superior border of the iliac crest. Participants stood with their arms crossed over the thorax.

NC. Lufkin W606PM metal tape, graded in millimeters, was used to measure the NC. The tape was placed directly above the thyroid cartilage. The participants were seated on an anthropometric bench with their heads in the Frankfort plane.

II) MetS diagnosis

The biomarkers of the participants were registered by hospital personnel. These included triglycerides, total cholesterol, high-density cholesterol, and serum glucose, which were examined by photometric methods using a COBAS 50 analyzer, with the requirement that participants had fasted for 12 hours. To determine arterial tension, qualified personnel at the hospital used a calibrated mercury sphygmomanometer, and measurements were taken after 10 minutes of rest. The criteria for the diagnosis of MetS and its components were based on the proposal by the IDF[1]: WC ≥90 cm in men and ≥80 cm in women, based on WC cut-off points for Mexican population[8] or having a BMI ≥30 in

persons of average height, and ≥25 in persons of shorter than average height[9]. The other criteria is having two or more of the following signs: high level of triglycerides ≥1,7 mmol/L (150 mg/dl) or to be following a specific treatment for lipid disorder; low level of HDL-cholesterol <1,03 mmol/L (40 mg/dl) in men and <1,29 mmol/L (50 mg/dl) in women, or to be following specific treatment for this disorder; hypertension defined as systolic blood pressure ≥130 mmHg or diastolic blood pressure ≥85 mmHg or be following specific treatment for hypertension previously diagnosed, and lastly, a high level of plasma glucose: fasting glucose ≥5,6 mmol/l (100 mg/dl) or type II diabetes already diagnosed.

Statistical Analysis

Descriptive analyses were performed, and a partial correlation controlled for age and sex was achieved to find the association between anthropometric indicators (BMI, WC, and NC) and biomarkers. Poisson regressions were completed for all and each of the anthropometric indicators evaluated as continuous variables, adjusted for age and sex for each component of MetS (evaluated as continuous variables and transformed into categorical variables using the cut-off points proposed by the IDF). ROC curves were generated to identify the best cut-off points for NC, BMI, and WC related to the presence of two or more components of MetS ($p \leq 0.05$) using the Statistics program SPSS-23.

RESULTS

The sample comprised 200 participants (146 women and 54 men) with an average age of 42.87 years (σ= 11.25). The prevalence of MetS found was 38.5% (Table 1). The distribution of the sample in terms of job titles was as follows: nurses (38.5%), paramedics (29%), doctors (21.5%), and administrative personnel (11%). Regarding the clinical laboratory results, there was one missing case in the evaluation of glucose, another in the evaluation of triglycerides, and in eight cases, there were no reports of HDL cholesterol levels. The absent cases were replaced with the group averages for each variable.

A partial correlation analysis was completed controlling for age and sex (Table 2) to determine the existence of a significant correlation between the anthropometric indicators and the components of MetS since age is a risk factor for both obesity and MetS. Furthermore, the cut-off points for HDL cholesterol and WC present differently in men and women. It was observed that BMI, WC, and NC showed a high correlation with each other, and at the same time were associated with fasting glucose, decrease in HDL cholesterol, and systolic blood pressure.

To identify if BMI, WC, and NC were related to the components of MetS, a Poisson regression was carried out adjusting for age and sex (Table 3). The variables that correspond to the components of MetS were transformed into dichotomous

Table 1. Descriptive Analysis. Anthropometric indicators and the components of MetS. n=200 (146 Women & 54 Men)

Anthropometric indicators & Biomarkers	$\dot{X}$	σ	Prevalence of MetS Components Increased Values (%)	
			Men	Women
BMI[a]	28.34	5.7	20.4	32.2
WC[b]	88.85	13.8	64.8	69.9
Fasting blood glucose	103.36	34.3	42.6	30.8
Triglycerides	168.46	178.5	57.4	41.4
HDL-C[e]	47.08	11.7	37.0	56.2
Hypertension			35.2	13.7
MetS[f]			40.7	37.0
NC[c]	37.21	4.1	NA[d]	NA[d]
Women	35.67	3.2	NA[d]	NA[d]
Men	41.23	3.3	NA[d]	NA[d]

[a] Body Mass Index. [b] Waist Circumference. [c] Neck Circumference. [d] No Apply. [e] High Density Cholesterol. [f] Metabolic Syndrome: WC (≥ 90 cm Men and ≥ 80 cm Women[4]) or BMI≥ 30 plus two or more of the following signs: Fasting blood glucose ≥100 mg/ml, Triglycerides ≥150 mg/ml, HDL-C <40 mg/dl (Men) and <50 mg/dl (Women), and hypertension ≥130/85 mmHg or to be following a specific treatment for any of the signs before mentioned[1].

Table 2. Partial Correlational Analysis. Anthropometric indicators and the components of MetS. n=200 (146 Women & 54 Men)

Control Variables: sex & age	BMI	WC[b]	NC[c]	Glucose	Tryglicerides	HDL-C[d]	SBP[e]	DBP[f]
BMI[a]	1.000							
WC[b]	.924**	1.000						
NC[c]	.814**	.810**	1.000					
Glucose	.294**	.326**	.254**	1.000				
Triglycerides	.118	.064	.079	.035	1.000			
HDL-C[d]	.362**	-.329**	-.283**	-.071	-.386**	1.000		
SBP[e]	.317**	.261**	.325**	.154*	.024	-.033	1.000	
DBP[f]	.145*	.126	.129	.196**	.013	.028	.584**	1.000

[a] Body Mass Index. [b] Waist Circumference. [c] Neck Circumference. [d] High Density Cholesterol. [e] Systolic blood pressure. [f] Diastolic blood pressure. * p=.05. ** p=.01.

Table 3. Poisson Multiple Regression. BMI, WC, and NC related to the components of MetS adjusting for age and sex. n=200 (146 Women y 54 Men)

	Fasting blood glucose>100 mg/dl	Tryglicerides >150 mg/dl	HDL-C<40 mg/dl (Men) <50 mg/dl (Women)	Hypertension ≥ 130/85	2 or more components of Mets
BMI					
OR (95%)	1.06	1.03	1.04	1.07	1.05
C.I.	(1.04-1.09)	(1.00-1.05)	(1.02-1.06)	(1.02-1.12)	(1.02-1.07)
p	.00	.01	.00	.00	.00
WC					
OR (95%)	1.02	1.00	1.01	1.02	1.02
C.I.	(1.02-1.03)	(.99-1.02)	(1.00-1.02)	(1.00-1.04)	(1.00-1.03)
p	.00	.14	.00	.00	.00
NC					
OR (95%)	1.10	1.06	1.05	1.10	1.09
C.I.	(1.06-1.16)	(1.01-1.10)	(1.01-1.08)	(1.02-1.20)	(1.04-1.13)
p	.00	.00	.01	.01	.00

BMI= Body Mass Index, WC= Waist Circumference, NC= Neck Circumference, OR= Odds Ratio, C.I.= Confidence Interval, p= Significance Level.

variables using, as a point of reference, the cut-off points established by the IDF[1]. The anthropometric indicators were analyzed as continuous variables.

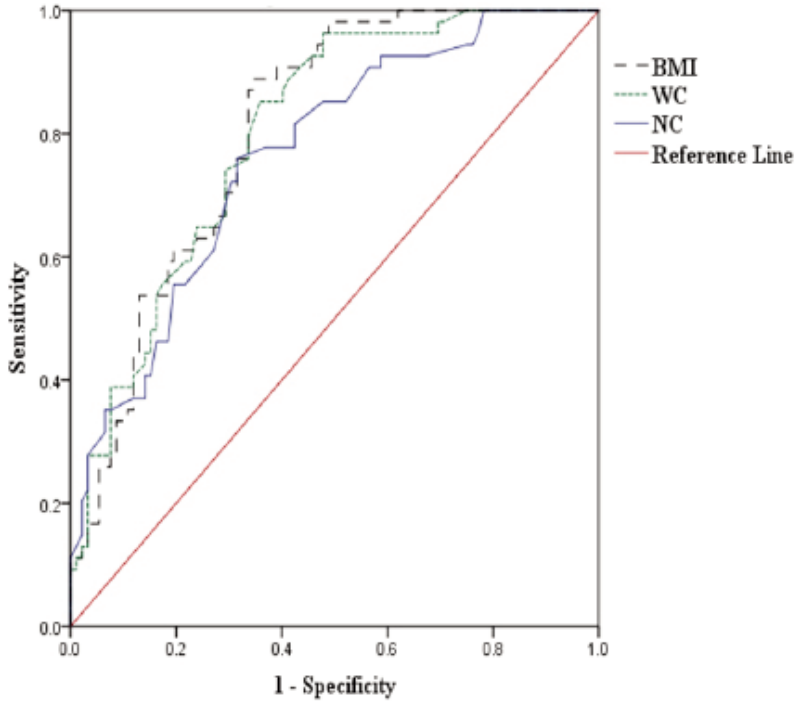
The results generated by the Poisson multiple regression for the anthropometric indicators for each component of MetS, adjusted for age and sex (Table 3), showed that the three anthropometric indicators (BMI, WC, and NC) were significantly related to the presence of two or more metabolic signs from the perspective of the global consensus definition of MetS by the IDF. Nevertheless, in the detailed analysis of each indicator for each MetS sign, it was observed in the population of the study that BMI and NC were significantly related to all the components of MetS. For WC, a significant relationship was observed for only three components.

Finally, ROC curves were generated to determine the best cut-off points for BMI, WC, and NC in the presence of two or more components of MetS. Of the participants 54 (37%) women were found to be positive for MetS and 92 (63%) were negative. Among men, 22 (40.7%) of participants were found to be positive for MetS and 32 (59.2%) were negative. A summary of the areas under the curves is presented in Table 4 and Figures 1 and 2.

Table 4. Area Under the Curve. BMI, WC, and NC for MetS

Women								
Anthropometric Indicator		AUC	Sensitivity	Specifity	Standard error	Significance Level	95% Confidence Interval	
Value	(cm)						Lower	Upper
BMI	27.48	.807	.815	.337	.035	.000	.739	.876
WC	84.12	.801	.796	.337	.036	.000	.731	.871
NC	35.12	.765	.796	.424	.040	.000	.688	.843
Men								
BMI	27.28	.844	.864	.281	.054	.000	.737	.950
WC	94.00	.852	.864	.313	.053	.000	.748	.955
NC	41.25	.787	.818	.406	.061	.000	.668	.906

MBI= Body Mass Index, WC= Waist Circumference, NC= Neck Circumference, and AUC= Area under the curve.



ROC curve analyses of Body Mass Index (BMI), Waist Circumference (WC), and Neck Circumference (NC) for women to detect metabolic syndrome according to IDF criteria. IDF = International Diabetes Federation; ROC = Receiver Operating Characteristics.

Figure 1. ROC curves for women

DISCUSSION

This study aimed to determine the effectiveness of NC as an indicator of obesity for MetS in comparison to BMI and WC, and to define NC cutoff levels based on the parameters established by IDF in a group of healthcare workers in a public health hospital in the State of Morelos, Mexico.

In the bivariate analyses controlled for age and sex, NC showed high positive correlation with BMI and WC (see Table 2), being the last two indicators recommended by the IDF for the evaluation of obesity an indispensable requirement for the diagnosis of MetS. The significant correlation found between BMI, WC, and NC is compatible with the reported findings in a study on the evaluation of NC for the identification of persons living with overweight or obesity in the Indian population[10].

Through Poisson multiple regression analysis using anthropometric indicators for each component of MetS, adjusted for age and sex (Table 3), it was observed that BMI, WC, and NC were efficient indicators for the determination of obesity for MetS due to their significant relationship with each component. Regarding NC as an indicator of obesity for

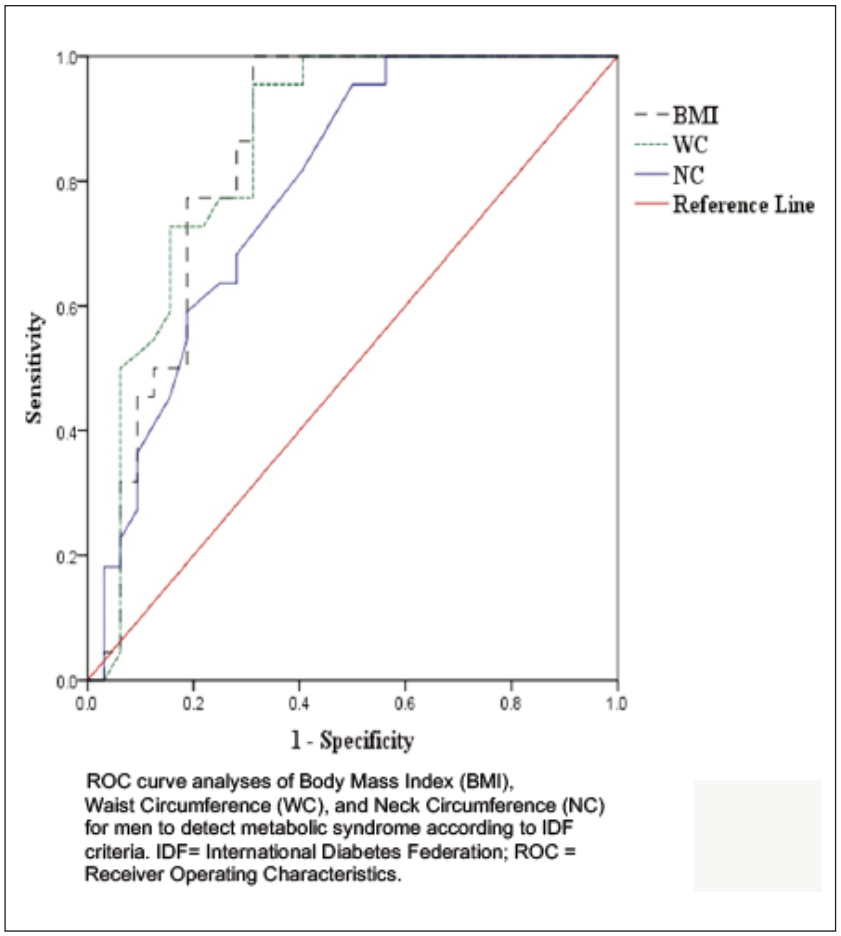


Figure 2. ROC curves for men

the diagnosis of MetS, analogous results were found in a study conducted in a population in Iran, where it was concluded that an increase in NC was associated with MetS under the diagnostic criteria of the NCEP/ATP III[11].

Waist circumference is one of the most utilized anthropometric indicators and is specifically recommended by the IDF[1] for the evaluation of central or abdominal obesity, which has shown significant relationships with all of the components of MetS in some scientific studies, as in the case of one study conducted in the Korean[12] and Mexican population[13]. However, in this study, it was found to be related to hyperglycemia, low levels of HDL cholesterol, and hypertension; nonetheless, WC was not found to be significantly related to hypertriglyceridemia (triglycerides >150mg/dl). This finding coincides with the results reported in a study on anthropometric indices as predictors of cardiovascular and metabolic risks in the Mexican adult population[14].

To date, there is little scientific information about the cut-off points for NC in the Mexican adult population aged 18 years and older, which allows the determination of both reference values for health and values related to MetS defined by IDF. A few years ago, a longitudinal study was carried out in San Juan, Puerto Rico in a sample of 1,206 Hispanics without diabetes aged between 40 and 65 years, the researchers determined a cut-off point for NC ≥35 cm in women and ≥41.3 cm in men for MetS[15], which agrees with the outcomes of the present study where the cut-off points, in unison with two or more components of MetS, were ≥35.12 cm in women [AUC=0.765 (IC 95%, 0.688-0.843)] and ≥41.25 cm in men [AUC=0.787 (IC 95%, 0.688-0.906)].

In addition to the results reported, an elevated prevalence of MetS was observed in Mexican healthcare workers (38%) which overlaps the outcomes of studies conducted with Peruvian (36%)[16,17] and Ecuadorian health workers (30%)[18]. For any population, living with signs of MetS represents a significant health problem due to the increased risk for the development of Type 2 Diabetes Mellitus, cardiovascular and chronic kidney diseases, raising the probability of premature mortality[19]. Based on this, the need arises to have reliable instruments that allow the determination of obesity for the preliminary diagnosis of MetS in an easy, quick, and accurate way.

CONCLUSIONS

Neck Circumference showed to be a dependable indicator in the evaluation of obesity as a component of MetS and as loyal as BMI and WC, which, to date, both are fundamental in the determination of obesity according to the international definition of MetS by the IDF.

The advantage of using NC in the preliminary diagnosis of MetS lies in its efficiency of evaluation because the person being evaluated is not required to follow the specific requirements that are necessary when evaluating BMI and WC: fasting, disrobing, and removing shoes.

Limitations

The results obtained in this investigation are only applicable to the sample population in this study, made up mostly of women, which is a common characteristic of hospitals in Mexico, due to the sample not being random and its size, combined with the design of the study, in this case, a cross-sectional observational study. Cohort studies with larger samples, along with a better investigation of the determination of cut-off points for NC in the Mexican population would strengthen the findings of this investigation.

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