

Correlation between anthropometric measurements, arterial hypertension and fasting glucose, in a rural population of Paraguay

Correlación entre medidas antropométricas, hipertensión arterial y glucosa en ayunas, en una población rural de Paraguay

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Abstract: *Background:* Overweight and obesity are important risk factors of hypertension and type 2 diabetes. Furthermore, they impose significant burden on national health-care system. *Objective:* To evaluate the correlation between body mass index (BMI) and waist circumference (WC) with blood pressure and fasting glucose in residents from the Norma Luisa fraction of the municipality of Minga Guazú, Paraguay in 2013. *Methods:* An cross-sectional study including 280 participants between 18 and 64 years-old, from the Norma Luisa community of the municipality of Minga Guazú, Paraguay between September 2012 and May 2013. *Results:* In the four categories of BMI and WC, the differences between median values for systolic and diastolic arterial pressure and fasting glucose were statistically significant ($p < 0.01$). There was a statistically significant correlation between both BMI and WC indicators with systolic blood pressure, diastolic and fasting glucose. Furthermore, there was a significant correlation between the BMI and the WC. *Conclusions:* The results obtained showed that BMI and the WC are predictors of hypertension and increased fasting glucose. These estimators may help to establish predictions of morbidity and mortality, both for clinical purposes and in the design of community intervention programmes to change lifestyle habits in the local population.

Keywords: risk factors, hypertension, diabetes mellitus, obesity, body mass index, waist circumference.



Resumen: *Antecedentes:* el sobrepeso y la obesidad son importantes factores de riesgo de hipertensión y diabetes tipo 2. Además, imponen una carga significativa sobre el sistema nacional de salud. *Objetivo:* evaluar la correlación entre el índice de masa corporal (IMC) y la circunferencia de la cintura (CC) con la glucemia de glucosa en ayunas por presión arterial en residentes de la fracción Norma Luisa del municipio de Minga Guazú, Paraguay en 2013. *Métodos:* Estudio transversal que incluyó a 280 participantes entre 18 y 64 años, de la comunidad Norma Luisa del municipio de Minga Guazú, Paraguay, entre septiembre de 2012 y mayo de 2013. *Resultados:* en las cuatro categorías de IMC y WC, las diferencias entre los valores medios para la presión arterial sistólica y diastólica y la glucosa en ayunas fueron estadísticamente significativas ($p < 0.01$). Hubo una correlación estadísticamente significativa entre los indicadores de IMC y WC con la presión arterial sistólica, diastólica y glucosa en ayunas. Además, hubo una correlación significativa entre el IMC y el WC. *Conclusiones:* Los resultados obtenidos mostraron que el IMC y el WC son predictores de hipertensión y aumento de la glucosa en ayunas. Estos estimadores pueden ayudar a establecer predicciones de morbilidad y mortalidad, tanto con fines clínicos como en el diseño de programas de intervención comunitaria para cambiar los hábitos de estilo de vida en la población local.

Palabras clave: factores de riesgo, hipertensión, diabetes mellitus, obesidad, índice de masa corporal, circunferencia de la cintura.

1. INTRODUCTION

Obesity involves genetic, environmental and lifestyle aspects that lead to a cardio-metabolic disorder. The World Health Organisation (WHO) defines obesity as a chronic disease characterised by an increase in body fat of multifactorial aetiology and associated with greater health risk, according to its magnitude and topographic location. Another feature of obesity is a positive energy balance, which occurs when the ingestion of calories exceeds energy expenditure, causing an increase in body fat deposits and therefore weight gain^(1, 2).

Overweight and obesity are one of the main challenges for the primary health-care system and public health. Only a few countries, such as Finland, have been able to achieve regression of the obesity epidemic^(3, 4). In Paraguay, in 2010, 54% of the overweight and obese population also had hypertension. The prevalence of hypertension in the overall population was 39%. Furthermore, it was 1.5 to 3% higher among those with diabetes⁽⁵⁾.

Diagnostic techniques for imaging of adiposity are the most efficient methods to diagnose obesity. However, these techniques present limitations for

epidemiological studies due to the high cost and logistic difficulties in their application⁽⁶⁾. Therefore, widely used methods to evaluate the percentage of body fat and abdominal obesity include body mass index (BMI)⁽⁷⁾ and waist circumference (WC)^(8,9). WC is a biometric measure that is used to determine centripetal obesity by measuring the accumulation of abdominal fat⁽¹⁰⁻¹²⁾.

Epidemiological studies have described an increase in the incidence of certain chronic non-communicable diseases with the increase in BMI, especially type 2 diabetes and cardiovascular disease (CVD)⁽¹¹⁾. However, from a clinical point of view, certain paradoxes exist. It is known, for example, that some patients may present a metabolic profile of normal risk, despite showing an excess of body fat, whereas others, with a moderate excess of weight, already present some metabolic complications^(10,13,14). Vague et al.⁽¹⁴⁾ observed already in 1947 that people with abdominal obesity developed cardiometabolic pathologies more frequently, compared with those who had peripheral obesity^(10, 15, 16). Similarly, Crepaldi et al were one of the first to report the simultaneous presence of central obesity, hyperinsulinaemia, hypertriglyceridemia and hypertension⁽¹⁷⁾.

The joint determination of WC and BMI better predicts the risk of cardiometabolic diseases when compared with BMI alone^(18, 19, 20). However, it has been shown that increased hip circumference decreases the risk for metabolic health. While WC is positively associated with an increased health risk, the hip and thigh circumference are inversely associated with this risk^(21, 22). This implies a protective effect linked to large hip circumference or thigh circumference (or both), which could be due to greater lean mass in the non-abdominal regions⁽²³⁾.

Thus, the objective of the present study was to evaluate the correlation between BMI and WC with hypertension and fasting glucose in residents of a rural population in Paraguay between 2012-2013.

2. MATERIALS AND METHODS

2.1. Study design and Population

This cross-sectional study was conducted in Norma Luisa Fraction, a rural population close to the city of Minga Guazú, Alto Paraná Department in Paraguay. Minga Guazú is a city in the east of Paraguay with a total population of around 60.719⁽⁵⁾.

The study population consisted of 280 participants between September 2012 and May 2013. The inclusion criteria were aged 18 to 64 years-old who lived in the Norma Luisa Fraction and were not institutionalised. People who did

not have full enjoyment of their faculties or who suffered from an illness that prevented them from responding to the questionnaire were excluded from the study.

2.2. Instruments

Determination of the energy balance

Weight measurement was performed using a balance (Toledo® model 2096PP/2 10399512 series) with a maximum capacity of 200 kg and a precision of 0.05 kg, chosen for its accuracy and ease of use. The participants were measured without shoes wearing light clothing. Each respondent was asked to stand on the scale, with feet 15 cm apart from each other, facing forward. The information was recorded in kilograms with two decimals.

Height was determined using the balance's stadiometer, which had a measurement range of 150 to 201 cm (with 0.5 cm of precision). The measurement was made with the participant without shoes,

EBMI was calculated according by dividing the weight in kg of each person by the square of their height in metres (kg/m²) [24]. The BMI categorisation used was that proposed by the WHO⁽²⁾:

- BMI < 18.5 = Underweight
- BMI 18.5 - 24.9 = Normal weight
- BMI 25.0 - 29.9 = Overweight
- BMI 30.0 - 34.9 = Obesity (class 1)
- BMI 35.0 - 39.9 = Obesity (class 2)
- BMI > 40.0 = Obesity (class 3)

According to the criteria of the International Diabetes Federation (IDF) of 2005, later revised in 2009, abdominal obesity was defined as a WC ≥ 80 cm in women and ≥ 94 cm in men⁽²⁵⁾.

Biochemical measurement

Blood glucose were measured after fasting. The samples were processed on the same day they were obtained in the laboratory of the Medical Research Centre (Centro de Investigaciones Médicas) of the School of Health Sciences of the National University of the East (Universidad Nacional del Este), an institution certified by the Department of Health Surveillance of the Ministry of Public Health and Social Welfare (Ministerio de Salud Pública y Bienestar Social – MSPyBS).

The cut-off points applied for glycaemia were those recommended by the National Cholesterol Education Programme (NCEP) and the Adult Treatment Panel III (ATPIII)⁽²⁶⁾.

Measurement of blood pressure

Trained evaluators measured arterial pressure in the left arm of each subject after resting for 5 minutes with the back supported and the arm held at heart level. Two measurements were taken, separated by a recommended time interval of 3 minutes, with OMRON 781 electronic tensiometers. In the case of diabetic patients or patients taking antihypertensive medications, the occurrence of postural changes was verified, with readings taken immediately and 2 minutes after the patient stood up. The classification of blood pressure levels used was that proposed by the seventh Joint National Committee on Prevention, Detection, Evaluation, and Treatment of High Blood Pressure.

Variables of interest

Table 1. Variables of interest.

<i>Dimensions</i>	<i>Variables</i>	<i>Indicators</i>	<i>Measurement units</i>
Overweight and obesity (<i>independent</i>)	Body fat	Body Mass Index (BMI)	kg/cm ²
	Abdominal fat	Waist Circumference (WC)	cm
Cardiometabolic diseases (<i>dependent</i>)	Hypertension	Arterial pressure (AP)	mm/Hg
	Glycaemia	Glycaemia	mg/dl

Statistical analysis

The loading, editing and analysis of data were conducted using Excel® electronic spreadsheets. Descriptive analyses (indicators of relative frequencies and summary measures), correlation analyses (Pearson coefficient and Spearman's Rho) and comparisons between groups (Kruskal-Wallis) were conducted, assuming a confidence level of 99%.

Ethical considerations

This study followed the standards of good clinical practice of the Declaration of Helsinki and was developed in accordance with current Paraguayan regulations: Resolution No. 146 of March 8, 2012, Ministry of Public Health and Social Welfare (Ministerio de Salud Pública y Bienestar Social – MSPyBS)⁽²⁷⁾, which classifies this type of study in the category of risk-free research as described in the informed consent signed by each participant.

Radice-Oviedo CA, Piris-Auada MA, Paniagua-Cristaldo DR, Jiménez-Rolón HJ, Jiménez-Britez G. Correlation between anthropometric measurements, arterial hypertension and fasting glucose, in a rural population of Paraguay.

3. RESULTS

The recruitment period was from January to June 2012, and the data were collected from September 2012 to May 2013. Of the total number of invited persons (n = 345) between 18 to 64 years of age of the Norma Luisa Fraction of the San Roque González de Santacruz neighbourhood, in the city of Minga Guazú, the response rate was 81% (n = 280), of whom 28% (n = 77) were males and 72% (n = 203) were females.

The highest frequency of participants according to age and sex was 18.9%, which was recorded in the age range of 42 to 47 years.

Statistically significant differences were observed in the systolic and diastolic blood pressure and glycaemia values in the four categories of BMI and WC.

The most significant difference in arterial pressure was that between the medians of normal BMI and those in the overweight and obesity groups.

With respect to fasting glucose, a significant difference was observed between the groups with normal BMI and those with obesity (Table 2).

Table 2. Arterial pressure and glycaemia according to BMI.

	<i>BMI Nutritional Status (n = 280)</i>				<i>P</i>
	<i>Undernourishe</i>	<i>Normal</i>	<i>Overweight</i>	<i>Obesity</i>	
	<i>d</i>	<i>Median</i>	<i>Median</i>	<i>Median</i>	
Diastolic Arterial Pressure	67.00	74.50	84.00	89.00	< 0.01*
Systolic Arterial Pressure	95.00	112.00	130.50	132.00	< 0.01*
Fasting glucose	73	78	80	83	< 0.01*

Significant differences were observed in the medians of the systolic and diastolic arterial pressure and glycaemia values according to the different categories of WC (Table 3).

Table 3. Arterial pressure and glycaemia according to WC.

	<i>Waist circumference (n = 280)</i>			<i>P</i>
	<i>Low</i>	<i>Moderate</i>	<i>High</i>	
	<i>Median</i>	<i>Median</i>	<i>Median</i>	
Diastolic Arterial Pressure	75.00	86.00	88.00	< 0.01*
Systolic Arterial Pressure	113.00	127.00	132.00	< 0.01*
Glycaemia	78	81	83	< 0.0

The most significant difference between the medians of arterial pressure was between the categories of low WC and those of moderate WC and high WC.

Regarding glycaemia, a significant difference was observed between the medians of the group with low WC and that of the group with high WC.

There was a strong correlation between both biometric indicators (BMI and WC), with a confidence level of 0.99. On the other hand, the correlations that occurred between the biometric indicators, according to each cardio-metabolic variable (blood pressure and fasting glucose) were also statistically significant, with the correlation between the biometric indicators and arterial pressure being greater than the correlation with glycaemia (Table 4).

Table 4. Correlation between arterial pressure and glycaemia with BMI and WC biometric indicators.

			<i>Correlation coefficient</i>	<i>p</i>
Pearson correlation	WC	BMI	0.848**	< 0.01
Spearman's Rho	BMI	Diastolic Arterial Pressure	0.397**	< 0.01
		Systolic Arterial Pressure	0.397**	< 0.01
		Glycaemia	0.214**	< 0.01
	WC	Diastolic Arterial Pressure	0.420**	< 0.01
		Systolic Arterial Pressure	0.429**	< 0.01
		Glycaemia	0.306**	< 0.01

**The correlation was considered significant at the 0.01 level (2-tailed).

4. DISCUSSION

Our study found that there was a significant correlation between BMI and WC with higher arterial pressure and glycaemia levels in the population studied. Furthermore, there was a significant correlation between the BMI and WC indices in this population.

Our study had a high response rate, since 81% of the people from the community who were invited responded. Women had a greater participation rate, which was possibly due to the patriarchal culture where the woman is the one who represents the families in most gatherings [28-34]. According to age, the modal class was between 42 and 47 years. Similar results with respect to the sex with greater participation can be seen in the studies of Brännström et al.⁽²⁸⁾, Calandrelli et al.⁽³¹⁾, Ng et al.⁽³⁵⁾, Moura et al.⁽³⁰⁾. A similar result in terms of age and sex ranges can be seen in the study of Choo et al.^(28-31, 35, 36).

The BMI and WC indicators are commonly used as indicators of health status, as stated by several epidemiological and clinical studies^(37, 38) whose results coincide with those obtained in this study conducted in Norma Luisa, which shows a strong positive correlation between both parameters.

The results obtained in this study on the correlation between systolic and diastolic blood pressure and fasting glucose with the BMI and WC indicators were significant. These findings are similar to those reported in the study by Yon⁽³⁷⁾ in Cambodia and the review performed by Rosales⁽²⁰⁾, especially for predicting the risk of cardiovascular diseases, hypertension, type 2 diabetes and dyslipidaemia. The study by Ford et al.⁽³⁹⁾ supports the use of the WC to predict trends in health risk, such as the review performed by Rosales⁽²⁰⁾, who cited the study of Lean in 1995, on the validation of the WC as one of the most accepted indicators in health promotion programmes worldwide. Likewise, the meta-analysis of Vazquez et al.⁽⁴⁰⁾ mentions that clinically, central obesity generates diabetogenic substances and is measured by the WC, so it is more informative than the BMI. This leads us to conclude that WC alone can be used to indicate metabolic risk factors, so that men and women with BMIs that do not exceed the range considered normal but who have a WC greater than the ranges considered normal are exposed to significant health risks^(20, 40). This is the time when primary prevention actions should be initiated in these people to reduce the development of cardio-metabolic diseases⁽²⁵⁾.

The importance of this study lies in its ability to categorise the study population into groups with healthy and unhealthy lifestyles, especially in middle- and low-income countries⁽²⁾ through the use of accessible low-cost

indicators, with great predictive power from the epidemiological point of view.

5. CONCLUSIONS

The results obtained showed that BMI and the WC are predictors of hypertension and high glycaemia. The use of these estimators will help to establish predictions of morbidity and mortality, both for clinical purposes and in the design of community intervention programmes for changes of behaviour.

ETHICS APPROVAL AND CONSENT TO PARTICIPATE

The study was approved by the Institutional Review Board at National University of the East, Paraguay.

HUMAN AND ANIMAL RIGHTS

No animals/humans were used for studies that are the basis of this review.

CONSENT FOR PUBLICATION

A consent form was signed by all of the participants enrolled in the study.

CONFLICT OF INTEREST

The authors declare no conflict of interest, financial or otherwise.

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