Prevalence of central obesity according to different definitions in normal weight adults of two cross-sectional studies in Panama

Roger Montenegro Mendoza,[a,*] Ilais Moreno Velásquez,[a] Flavia Fontes,[b] and Hedley Quintana [a]

[a]Gorgas Memorial Institute for Health Studies, Ave. Justo Arosemena Street 35 and 36, Panama City 0816-02593, Panama
[b]Nutrition Department, Medicine Faculty, University of Panama, Panama City, Panama

The Lancet Regional Health - Americas 2022;10: 100215
Published online 1 March 2022
https://doi.org/10.1016/j.lana.2022.100215

Summary

Background Central Obesity (CO) might arise among individuals with normal body mass index (BMI). We aim to estimate the prevalence of Normal Weight CO (NWCO), using different definitions, and to compare its association with cardiometabolic risk factors in the adult population of Panama.

Methods Data from two population-based studies conducted in Panama in 2010 and 2019 were used. Using standard definitions, normal weight was defined as a BMI between 18·5 and 24·9 while CO was defined as a Waist-to-Height Ratio (WHtR) ≥ 0·5 in both sexes or a Waist Circumference (WC) ≥ 90, ≥94, or ≥102 cm for men, and 80 or 88 cm for women. Unconditional logistic regression models were used to estimate the association between each CO definition and dyslipidemia, high blood pressure (HBP), diabetes, and clusters of cardiovascular risk factors.

Findings Recent CO prevalence ranged between 3·9% (WC ≥ 102 cm for men and WC ≥ 88 cm for women) and 43·9% (WHtR ≥ 0·5) among individuals classify as normal weigh according to the BMI. Different cardiovascular risk factors were present in this normal weight population but among men the threshold of WC ≥ 102 cm screened less than 1·0%.

Interpretation NWCO was associated with cardiovascular risk factors, particularly with elevated concentration of triglycerides. CO evaluation at the primary health care level may be a useful technique to identify normal weight people with metabolically obese characteristics.

Funding Gorgas Memorial Institute for Health studies via Ministry of Economy and Finance of Panama and Inter-American Development Bank.

Keywords: Normal weight central obesity; Waist to height ratio; Waist circumference; Panama

Introduction

Body Mass Index (BMI) is extensively used to evaluate general adiposity. Several studies have shown that individuals with normal BMI have lower mortality risk, as compared to those with obesity.[1–3] Further, obesity is associated with several comorbidities such as cardiovascular disease (CVD), hypertension, gallbladder disease, sleep apnea, cancer, and metabolic disorders.[4] Consequently, the BMI categories are often applied at different levels of the health-care system as a screening tool for detecting persons at high risk of developing non-communicable diseases (NCD). Nevertheless, BMI does not adequately reflect body fat distribution or discriminate between lean mass and body fat, especially among persons with a BMI <30.[5]

Due to this BMI limitation, another condition called, Normal Weight Central Obesity (NWCO) is used to refer to the co-occurrence of having both, a normal BMI and excessive visceral fat.[6–8] NWCO has been significantly associated with higher risk of cardio-metabolic diseases and all-cause mortality, compared to persons with other types of body fat depot distribution or even classified as overweight or obese by BMI only.[8–12]

Waist circumference (WC) and Waist-to-hip ratio (WHR) are the most common and simple anthropometric measurements to assess Central Obesity (CO).[4] However, their cutoff points differ depending on different definitions given by the World Health Organization

*Corresponding author.
E-mail address: rmontenegro@gorgas.gob.pa (R. Montenegro Mendoza).

Research in context

Evidence before this study

Current evidence about central obesity (CO) among normal-weight people, using the terms: "Normal-weight central obesity" "Waist-to-height ratio" "Waist circumference" "Central obesity", "Latin American region" and considering papers published in English and Spanish without applying a year filter in both PubMed and Google scholar, indicates an association with higher prevalence of cardiometabolic dysregulation, metabolic syndrome, and cardiovascular (CVD) risk factors.

At the primary health care level, central fat evaluated by waist circumference is not a very well standardized method and it has several cut-off points, as proposed in the literature defining CO. Using Waist to Height Ratio (WHtR) seems to be a more reliable and standardized screening technique to detect persons with Normal Weight Central Obesity (NWCO).

Added value of this study

Findings presented in this article showed how population prevalence of NWCO changes depending on the cut-off point and technique used. We evaluate the association with different CVD risk factors and different techniques for assessing CO in two different cross-sectional studies performed in the Panamanian population.

Implications of all the available evidence

Our findings support the existing evidence that the co-occurrence of normal weight with central obesity may confer a higher frequency of CVD risk factors. The WHtR was a CO assessment technique associated to CVD risk factors. WHtR, different from other CO measurements, has a unique cutoff point for both sexes and different ethnicities across populations. Our results suggest that this technique could be considered as a CO assessment at the primary health care office, as well as, and for the public health campaigns.

(WHO), the International Diabetes Federation (IDF), and the Adult Treatment Panel III guidelines (ATP III).

The cutoff point definitions also vary according to sex.[13,14] For example, in men, there are three cutoff definitions for CO (≥90 or ≥94 or ≥102 cm), and in women, two cutoff definitions are widely utilized (≥80 or ≥88 cm). The use of different thresholds engenders a wide range of CO prevalence among different population-based studies, hampering comparisons among these populations.

Another CO anthropometric measurement is Waist-to-Height Ratio (WHtR) for which a cutoff point of ≥ 0·5 has proved to be a simple and effective non-invasive screening tool for cardiovascular risk factors and mortality because its threshold remains constant regardless of sex and ethnicity.[15–20] Having a single cutoff point that is suitable for both sexes and different ethnic groups may facilitate the CO assessment in the primary health care services, comparisons between population-based studies and, might simplify public health campaigns.

Results derived from three national population-based in Panama studies have shown an increase in the prevalence of obesity since 1982 with factors such as sex, living in urban areas, Afro-Panamanian ethnicity, and poverty being associated with obesity.[21] However, to our knowledge very little is known about NWCO in Panama.

Thus, this study aims to estimate the prevalence of NWCO in the adult population as well as to compare the association between cardiometabolic risk factors and different definitions of CO, proposed in the literature, using data from two population-based studies conducted in Panama. We also aim to evaluate the co-occurrence of NWCO with sociodemographic and lifestyle variables.

Methods

Settings

Panama has an estimated population of 4·2 million inhabitants as of 2019 and is divided into 13 first level administrative divisions, with nine such administrative division called Provinces and three Indigenous territories (*Supplementary Fig.* 1).

Data was obtained from the cross-sectional Prevalencia de Factores de Riesgo de Enfermedad Cardiovascular (PREFREC; *Survey on Risk Factors Associated with Cardiovascular Disease* – in English) study, which analyzed the risk factors associated with CVD in Panama and the Encuesta Nacional de Salud de Panamá-for National Health Survey for Panama (ENSPA). PREFREC was carried out in 2010-2011, and ENSPA in 2019.

Briefly, the PREFREC study included 3,590 participants, aged 18 years or older living in urban, rural and a small number of indigenous areas from the provinces of Panama and Colon which makes it representative only for these two provinces where 60·4% of all adult Panamanians lived when the survey was conducted. Households were selected using a probabilistic and randomized approach with multivariate stratification stage. As a first stage, census segments (according to the national census for the 2000) were used as selection strata, and samples were calculated separately for urban, rural, and indigenous areas. In the second stage, primary sampling units (consisting of 8-30 homes) were randomly selected and were stratified according to the Administrative Political Code of the Republic and then by population size. The third stage stratified these units according to the education level of the study population. A detailed description of the study has been reported elsewhere.[22–24]

ENSPA is a population-based study that analyzed health determinants, environmental, nutritional,

anthropometric factors as well as access and use of health services in the study population. Eligible subjects were all individuals with at least 6 months of residency in their household. The sampling was designed to ensure the representativeness of the population divided into two groups, 0-14 years old and 15 years old and older with a complex sampling design (a randomized tri-phased stratified by conglomerates). Geographic distribution of eligible residents was identified through the last national census (2010). The sample design applied for the ENSPA allowed the results to be representative of the whole country population including urban, rural, and indigenous areas, as well as its second-level administrative division (district) and its third level administrative division (corregimiento) in Panama and San Miguelito districts. However, this representation does not apply for results derived from biomarkers data, since our biomarker data represented the whole country. Based on census estimates, a total of 20,118 households were randomly computed to achieve representativeness of national, provincial, indigenous, rural, and urban areas. Per household, two individuals (≥15 and < 15 years old) were randomly selected. More details are presented on the Spanish language website.[25] For this study we only include participants ≥ 18 years old.

Fasting blood samples and urine were obtained from study participants in both studies.

Anthropometric measurements

NWCO was defined as having a BMI ranged from 18·5-24·9 and CO defined by a WC ≥ 90 cm (men) / ≥80 cm (women), according to the IDF guidelines[4,13] or a WC ≥ 94 cm (men)/ ≥ 80 cm (women), according to the WHO[4] or a WC ≥ 102 cm (men) / ≥ 88 cm (women), according to the ATP III guidelines[14] or a WHtR ≥ 0·5 for both sexes.[26]

For the PREFREC study, anthropometric measurements were carried out in primary health care facilities using stationary SECA measuring instruments (Hamburg, Germany).[22] For the ENSPA study, all measurements were done in the household of the participants using a portable digital scale SECA model 874dr for the weight and, a stadiometer SECA model 213 I equipped with level (Hamburg, Germany) was used for the height. In the present study, we excluded persons without complete anthropometric data (i.e., weight, height, and WC), blood pressure measurements or without blood tests.

For both studies weight was measured with a precision of 0·1 kg, while height and WC were measured to the nearest millimeter. Two repeated measurements were done by two trained health personnel with an absolute maximal difference accepted between measurement of 0·5 kilograms for the weight, 0·5 centimeters for the height and 1·0 cm for the WC. When the difference of the two first measurements was greater than the maximal error accepted, a third measurement was performed and the average of the two closest was recorded and used for the analysis. Participants were evaluated without shoes, and with light clothes. BMI was computed as the weight in kilograms divided by the height in squared meters. Participants were classified according to the WHO BMI categories used to assess the risk of developing diseases: underweight (BMI below 18 m/Kg^2), normal weight (between 18·5 and 24·9 m/Kg^2), overweight (between 25·0 and 29·9 m/Kg^2), and obesity (30 m/Kg^2 or more).[4] For the present study, we included only the population classified as normal weight.

For the WC, two protocols of measurement were performed. For the PREFREC study, participants were asked to uncover their abdominal area and the WC was measured at umbilicus level. For ENSPA study, participants were asked to uncover their abdominal area or wore light clothes and the measuring tape was place at the midpoint between the lowest rib and the top of the iliac crest.[27,28] For both studies participants were requested to inhale deeply followed by exhaling normally before the measuring tape was placed in the reading position. For both studies, the WC was measured using a retractable SECA measuring tape model 201 (Hamburg, Germany). For women, CO was defined using the following cutoff points: WC ≥ 80 cm (WHO/IDF); WC ≥ 88 cm (ATP III). For men CO was defined with the following cutoff points: WC ≥ 90 cm (IDF), WC ≥ 94 cm (WHO), WC ≥ 102 cm (ATP III). Finally, both men and women with a WHtR ≥ 0·5 were also classified with CO.[20]

Blood pressure measurements

Systolic blood pressure (SBP) and diastolic blood pressure (DBP) measurements (mmHg) were taken three times in a sitting position after 5 min of rest and recorded with three minutes' interval between each other (ENSPA) and with five minutes' interval between each other (PREFREC). Measurements were performed by the same trained personnel responsible for the anthropometry. For the PREFREC study, the BP measurements were taken usually with the right arm whereas in the ENSPA, measurements were taken with the left arm.[28] In both studies, the participants' SBP and DBP were defined as the average of the two last measurements.

Blood Pressure (BP) was measured using digitals and calibrated automatic sphygmomanometers. For the PREFREC study, the sphygmomanometers used were the model 6013 made by Americas Diagnostic Corporation. For the ENSPA study, OMROM device model HEM-7120 with an adjustable cuff for different arms sizes was utilized. Hypertension was defined as self-reported medical diagnosis or SBP ≥ 140 mmHg and/

or DBP ≥90 mmHg and/or the current use of antihypertensive medications.

Diabetes

Participants were classified as having diabetes according to a self-report medical diagnosis or fasting blood glucose levels (FBG) ≥ 126 mg/dL or a level of hemoglobin A1c (HbA1C) ≥ 6·5%, and/or current diabetes medication treatment. Prediabetes was defined as FBG ≥ 100 mg/dL and <126 mg/dL or HbA1C ≥5·7% and <6·5%.[29] For assessing glucose levels, colorimetric enzymatic method was used in automated chemistry equipment Beckman CX7[24] and Coulter DXC800/600 for PREFREC and ENSPA, respectively. For the HbA1c, a High-Performance Liquid Chromatography (HPLC) technique was performed using the D-10 System.

High concentration of blood lipids

Blood test analysis was conducted through colorimetric enzymatic methods to estimate Triglycerides (TG), total cholesterol (TC), High Density Lipoproteins- Cholesterol (HDL-C), and Low-Density Lipoproteins-Cholesterol (LDL-C) using for PREFREC study the automated chemistry equipment Beckman CX7[24] and for ENSPA study the automated chemistry equipment Coulter DXC800/600. High concentration of blood lipids included TC ≥ 200 mg/dL or having a current anti-cholesterol medication, TG ≥ 150 mg/dL, LDL-C ≥ 130 mg/dL and low concentrations of HDL-C < 50 mg/dL for women and < 40 mg/dL for men.[13,14]

CVD risk factors clusters

For clustering the CVD risk factors, we considered the presences of High Blood Pressure (HBP), diabetes, high LDL-C, TG, and low HDL-C. TC was not included due to high correlation with LDL-C (Spearman correlation =0·87, p value < 0.001). People were identified with the presence of none, one, two and at least three CVD risk factors.

Physical activity

In the PREFREC study physical activity was evaluated with a group of questions addressed to quantify the daily time in minutes used to perform different physical activities. According to the weekly average, people were classified as having sedentary behavior (< 60 min/week), insufficient physical activity (60–149 min/week), or physically active (≥ 150 min /week). In the ENSPA study, physical activity was addressed using the global physical activity questionnaire (GPAQ) following the WHO Stepwise Approach to Surveillance.[28]

Statistical analysis

Categorical variables were reported as percentages and their respective 95% confidence intervals (CI).

Unconditional logistic regression models were used to estimate the association between each CO definition and CVD risk factors expressed as Odds Ratio (OR) with 95% CI. All models were adjusted by age (continuous), tobacco use in the last 30 days (yes/no) and ethnicity (Afro-Panamanian, mixed-ethnicities, Indigenous, White, Asian and others). In addition, family history of hypertension, hypercholesterolemia or diabetes was included as a potential confounding factor for each of the respective diseases. Further a multinomial logistic regression model was performed to evaluate the crude and adjusted association between the CO definitions and the CVD risk factors clusters.

Prevalence and general characteristics are presented weighted but association results using OR are presented without considering survey weights.[30–32] Nevertheless, we also present the weighted estimates of the models in the supplementary material. All analysis were sex-stratified, and general characteristics of excluded persons for missing data were also described. Calculations were performed using STATA software (version 14; Stata Inc., College Station, TXs).

Statement of Ethics

Ethical approval to conduct both studies was obtained from the Ethics Review Committee of the Gorgas Memorial Institute for Health Studies. All participants were informed about the objectives of the studies and gave their written informed consent.

Role of the funding source

This work was supported by an institutional research grant from Panama (019910.002).

The ENSPA study was funded by the Inter-American Development Bank and the PREFREC study by the Ministry of Economy and Finance. IMV, and HQ are supported by the Sistema Nacional de Investigación (SNI), National Secretary of Science, and Technology (SENACYT), Panamá. The funding sources were not involved in the study design, collection, analysis, interpretation of data, writing of the report, or in the decision to submit the article for publication.

Results

The flowchart summarizing the inclusion and exclusion criteria are described in Figures. 1 and 2. After exclusion criteria, a total of 1,240 and 3,826 study participants had normal weight in the in the PREFREC and ENSPA studies, respectively.

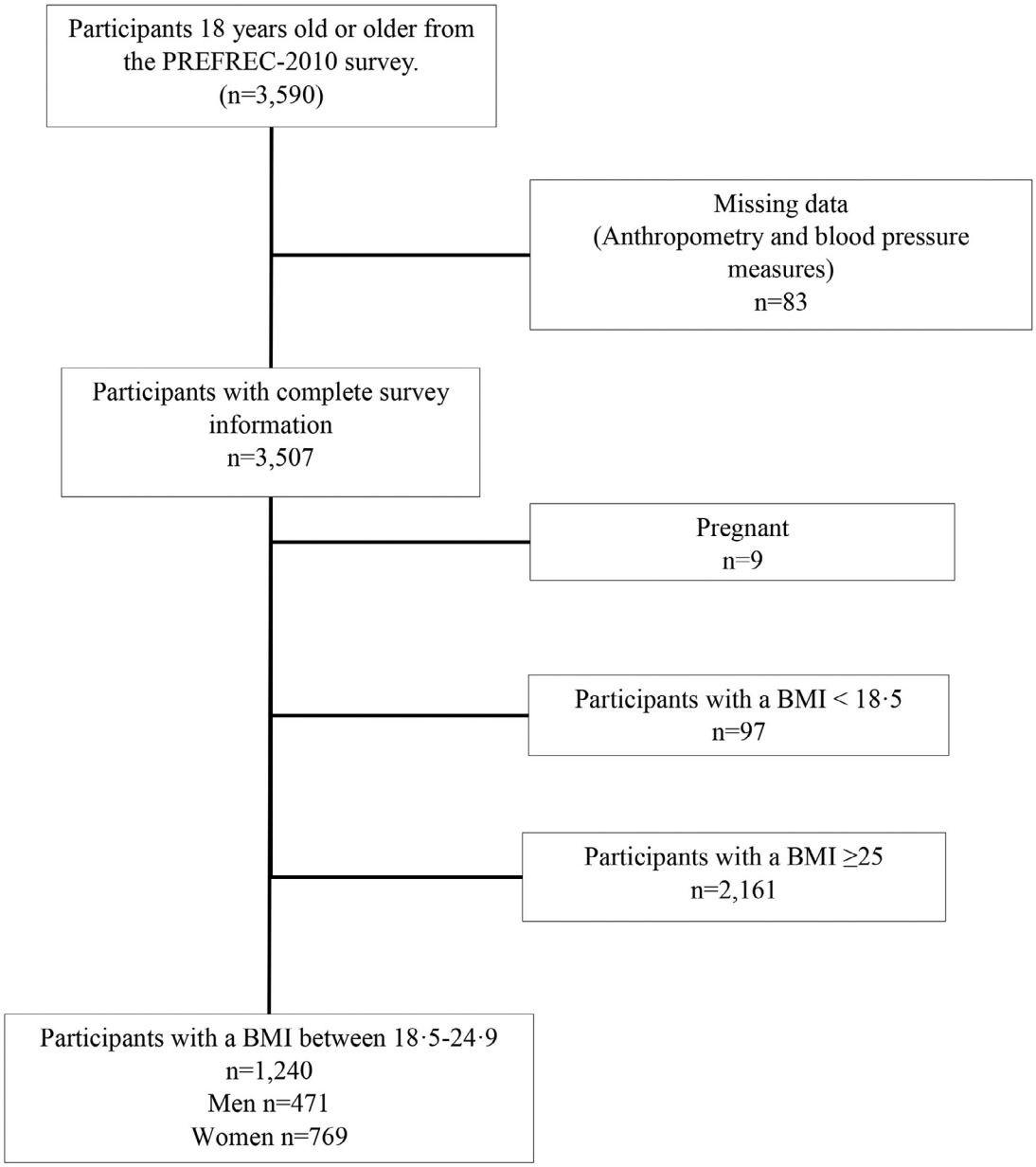

Figure 1. Flowchart summarizing the inclusion and exclusion criteria of the PREFREC-2010 survey.

Table 1 presents the baseline characteristics and anthropometric measurements of our study population that comprises normal weight individuals. There were more women in the PREFREC study while the proportion of people aged ≥ 60 years was bigger in the ENSPA study. Persons from the PREFREC study lived mainly in urban areas and presented a higher percentage of university and short cycle tertiary education degree than people from the national ENSPA study.

In both study groups, more than 50·0% identified their ethnic group mostly as Mixed or Afro-Panamanian but in the ENSPA study, the Indigenous group was more represented. For the ENSPA study, more people reported having a family income of US$ 601·00-999·00 while the proportion of those having > US$1000·00 was lower. In both studies, more than 50·0 % of people reported being married but the proportion of single status was bigger in ENSPA group.

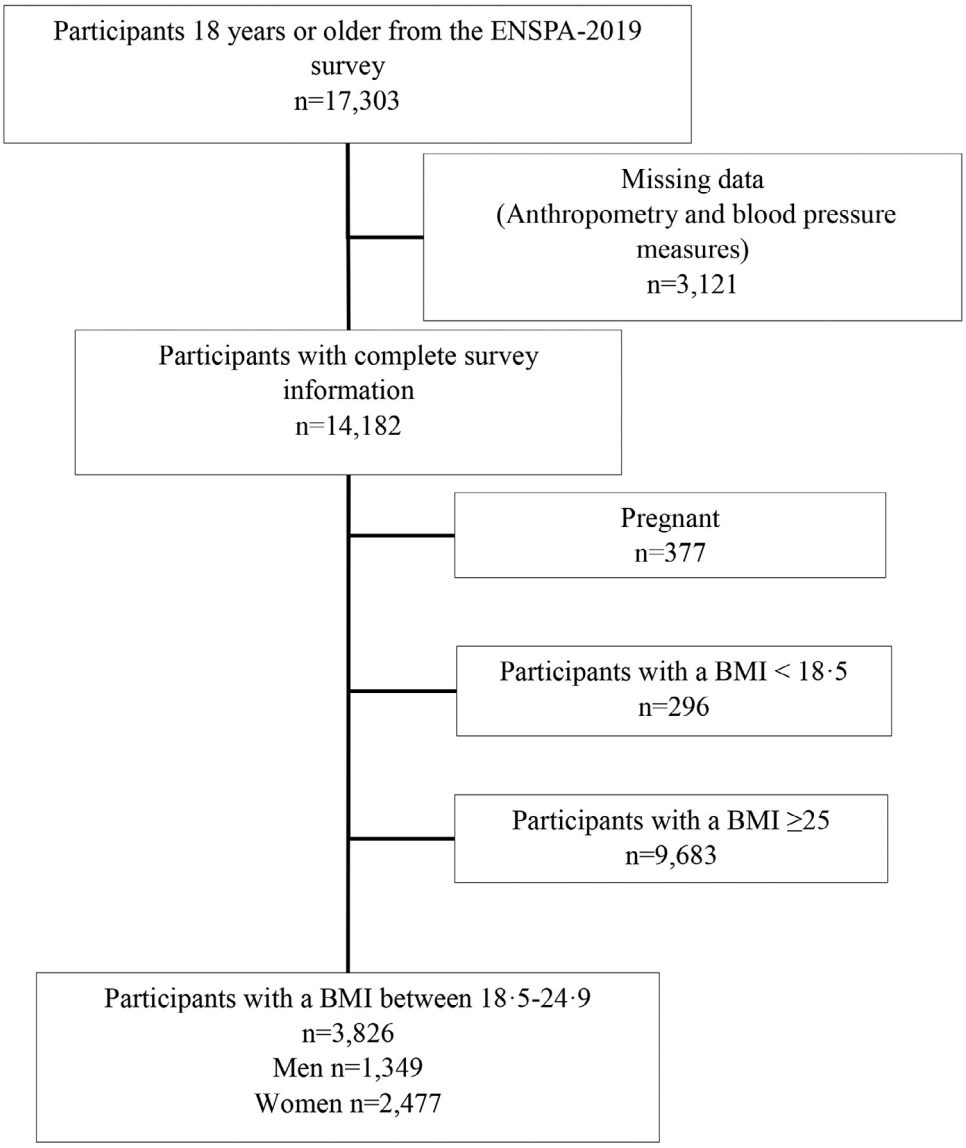

Figure 2. Flowchart summarizing the inclusion and exclusion criteria of the ENSPA-2019 survey.

In general, the median value of weight, height, WC and WHtR was greater for men and for the PREFREC study group.

As presented in the *Supplementary Table* 1 study participants with missing data on anthropometric measurements were n=83 in PREFREC study and n= 3,121 in ENSPA study. Overall, for the PREFREC study, the proportion for most of the baseline characteristics were similar in both the completed and the missing anthropometric data group, but proportion of people aged ≥ 60 years was bigger in the missing data group, as well as, for the Caucasian group. For the ENSPA study, no major differences were observed regarding the baseline characteristics of the excluded population in comparison with the study population of our main analysis, except for the proportion of Caucasian ethnicity and the percentage of participants with a family income ≥US$ 601·00 that was higher in the missing data group. The proportion of participants aged between 18 and 29 years old was smaller in the missing data group.

Prevalence of normal weight central obesity

Table 2 present the prevalence of NWCO according to their different definitions in both studies. In men from the PREFREC study, NWCO ranged from 5·5%, defined by a WC ≥94 cm, up to 50·8% defined as a WHtR ≥0·5. No men were classified as having NWCO according to a

Baseline Characteristics	Study			
	PREFREC-2010-11 Panama & Colon n=1,240		ENSPA-2019 National Level n=3,826	
	n	%* (95% CI)	n	%* (95% CI)
Sex				
Male	471	38·2 (33·6-43·0)	1,349	55·4 (52·7-58·2)
Female	769	61·8 (56·9-66·3)	2,477	44·6 (41·8-47·3)
Age (in years)				
18-29	344	26·3 (22·2-30·7)	1,333	31·1 (28·5-33·8)
30-59	593	50·3 (45·5-55·1)	1,508	38·2 (35·5-41·1)
≥ 60	303	23·4 (19·6-27·7)	985	30·7 (28·1-33·4)
Area of residence				
Urban	520	84·3 (82·9-85·5)	1,479	62·8 (60·7-64·8)
Non-Urban	720	15·7 (14·4-17·0)	2,347	37·2 (35·2-39·3)
Schooling				
No Schooling	82	3·5 (2·0-5·8)	286	3·8 (3·2-4·6)
Elementary	444	25·1 (21·4-29·1)	1,250	27·1 (24·9-4·6)
Secondary education	488	43·7 (38·9-48·5)	1,661	49·3 (46·7-52·5)
Short-cycle tertiary education	31	3·4 (2·0-5·6)	46	1·5 (1·0-2·4)
University	185	22·9 (19·1-27·2)	532	17·1 (14·9-19·7)
Others	10	1·4 (0·5-3·3)	29	0·4 (0·2-0·8)
Ethnic group				
Afro-Panamanian	218	20·8 (17·1-24·9)	428	15·6 (13·3-18·1)
Mixed ethnicities	661	55·7 (50·8-60·4)	1,783	51·0 (48·2-53·9)
Indigenous	173	4·0 (2·3-6·8)	900	12·0 (10·7-13·4)
Caucasian	149	14·0 (10·9-17·7)	584	16·9 (14·9-19·2)
Asian and others	38	5·5 (3·6-8·3)	121	4·3 (3·1-5·8)
Monthly family income (USD; $)				
< 250	601	30·5 (26·5-34·8)	2,010	36·7 (34·2-39·3)
250-600	436	41·7 (37·0-46·5)	959	32·2 (29·5-35·0)
601-999	68	8·2 (5·8-11·3)	423	15·4 (13·3-17·8)
> 1000	74	12·7 (9·7-16·4)	222	9·5 (7·7-11·6)
Not know /Not Answered	61	6·9 (4·7-9·9)	212	6·2 (4·9-7·8)
Marital status				
Single	311	25·0 (21·1-29·3)	1,170	36·0 (33·3-38·9)
Free union/married	814	63·3 (58·5-67·8)	2,260	54·0 (51·2-56·9)
Separated/divorced	62	8·0 (5·5-11·2)	124	3·4 (2·5-4·5)
Widow	50	3·6 (2·2-5·9)	262	6·3 (5·1-7·9)
Anthropometric Measurements	PREFREC-2010-11 Panama & Colon n=1,240		ENSPA-2019 National Level n=3,826	
	Men	Women	Men	Women
Weight (Kg)	63·0 (58·5-69·5)	55·0 (51·0-60·0)	60·0 (57·0-67·1)	53·4 (49·3-58·6)
Height (cm)	167·7 (163·4-174·0)	157·1 (152·2-161·0)	166·3 (160·9-171·9)	154·5 (149·6-159·4)
BMI(Kg/m2)	22·5 (21·3-23·9)	22·7 (21·1-23·8)	22·8 (21·1-23·9)	22·8 (21·1-24·0)
Waist circumference (cm)	83·5 (78·2-88·3)	82·1 (78·0-86·5)	80·7 (75·5-85·1)	77·1 (72·0-82·2)
WHtR	0·50 (0·46-0·52)	0·52 (0·49-0·55)	0·48 (0·45-0·51)	0·49 (0·46-0·53)

***Table 1*: Baseline characteristics and anthropometric measurements of study participants with a BMI between 18·5-24·9 kg/?m2 in the PREFREC and ENSPA studies.**

Values are presented as frequencies (n), and weighted prevalence (% *) with their respective 95% CI. Anthropometric measurements are presented as median (interquartile range). Mixed ethnicity included: mulato, trigueño, culizo, mestizo· Missing data for PREFREC included ethnic group n=1 and marital status n=3. Missing data for ENSPA included schooling n=22, ethnic group n=10 and marital status n=10. WHtR: Waist-to-Height Ratio.

WC ≥ 102 cm. In women, the NWCO prevalence ranged from 20·3% as reported by a WC ≥ 88 cm, up to 68·1% according to a WHtR≥0·5. For ENSPA study, the estimation of NWCO in adult men was 0·6%, defined by a WC ≥ 102 cm, and the highest estimated prevalence was 39·5% according to a WHtR ≥0·5. In the female group, the prevalence of NWCO ranged from 8·0% (WC ≥88 cm) up to 49·6% (WHtR≥ 0·5).

Abdominal adiposity diagnosis	Survey					
	PREFREC-2010-11 Panama & Colón			ENSPA-2019 National level		
	All N=339,780	Men N=129,837	Women N=209,943	All N=646,625	Men N=358,518	Women N=288,106
WHO 2000	41·2 (36·7-45·9)	5·5 (3·3-9·2)	63·3 (57·3-68·9)	17·7 (15·9-19·7)	2·9 (1·8-4·7)	36·1 (32·9-39·4)
ATP III 2001	12·6 (9·7-16·1)	0·0	20·3 (15·8-25·7)	3·9 (3·0-5·1)	0·6 (0·1-2·7)	8·0 (6·3-10·2)
IDF 2006	46·3 (41·5-51·1)	18·7 (13·3-25·6)	63·3 (57·3-68·9)	21·7 (19·6-24·0)	10·1 (7·7-13·3)	36·1 (32·9-39·4)
WHtR	61·5 (56·7-66·1)	50·8 (42·8-58·7)	68·1 (62·1-73·5)	43·9 (41·2-46·8)	39·5 (35·2-43·9)	49·6 (46·3-52·9)

***Table 2*: Prevalence of central obesity according to different cutoff points among normal weight adults from a regional and national Panama survey in 2010-11 and 2019.**
Values are percentages based on weighted data and accounted for sampling design. WHO 2000: WC ≥ 94 cm (men)/ ≥ 80 cm (women); ATP III 2001: WC ≥ 102 cm (men) / ≥ 88 cm(women); IDF 2006: ≥90 cm (men) / ≥80 cm (women); WHtR: Waist-to-Height Ratio (≥0·5).

Associations of NWCO and high blood pressure in PREFREC and ENSPA

Table 3 presents the association of NWCO with the likelihood of having HBP. In women from the PREFREC study, after adjustment NWCO defined as WC ≥ 80 cm, was statistically significantly associated with HBP (OR: 2·39; 95%-CI 1·40-4·11), SBP (OR: 2·15; 95%-CI 1·08-4·25) and DBP (OR: 3·55; 95%-CI 1·46-8·61) (adjusted models). Similarly, NWCO in women defined as WHtR ≥ 0·5, was associated with HBP (OR: 2·05; 95%-CI 1·10-3·82) and DBP (OR: 3·62; 95%-CI 1·25-10·49). These associations were also present in men (crude model), however the associations were no longer statistically significant after adjustments.

In the ENSPA study, after adjustment, an association with HBP was found when NWCO was defined as WHtR ≥ 0·5 (OR: 1·47; 95%-CI 1·08-1·99) in men. Similarly, in women, NWCO defined as WC ≥ 80 cm, was associated with HBP (OR: 1·45; 95%-CI 1·15-1·84), SBP (OR:1·46; 95%-CI 1·07-1·98) and DBP (OR: 1·69; 95%-CI 1·19-2·39). Increased odds of HBP and SBP were also observed when NWCO was defined as WC ≥ 88 cm (OR: 1·85; 95%-CI 1·21-2·83), and (OR 1·75; 95%-CI 1·12-2·75), respectively. Lastly, in women, NWCO defined as WHtR ≥ 0·5, had an increased likelihood of having HBP (OR: 1·39; 95%-CI 1·09-1·78), SBP (OR 1·71; 95%-CI 1·20-2·41) and DBP (OR: 1·56; 95%-CI 1·07-2·26).

Associations of NWCO with dyslipidemias and diabetes in PRFREC and ENSPA

Tables 4 and 5 present the crude and adjusted associations of NWCO with the likelihood of having dyslipidemias and diabetes in the PREFREC and ENSPA studies. After adjustment, NWCO defined as WHtR ≥ 0·5 was associated to a 2 or more folds OR of having elevated concentrations of TC, TG, LDL-C, and low HDL-C in men. Likewise, NWCO defined as WC ≥ 90 cm was associated with elevated TG (OR: 2·43; 95%-CI 1·30-4·52) and low HDL-C (OR: 1·94; 95%-CI 1·02-3·69). Lastly, NWCO defined as WC ≥ 94 cm was associated with elevated concentration of TG (OR: 2·64; 95%-CI 1·00-6·98).

In women, after adjustment, NWCO defined as WC ≥ 80 cm was associated with 1·5 folds OR of having elevated concentrations of TC, TG, and low HDL-C. Similarly, NWCO defined as WHtR ≥ 0·5 was associated to high TC (OR: 1·71; 95%-CI 1·11-2·63) and high TG (OR: 1·79; 95%-CI 1·07-3·01). Further NWCO defined as WC ≥ 88 cm was associated with elevated LDL-C (OR: 1·68; 95%-CI 1·10-2·57) in women. In the PREFREC study, NWCO defined as WC ≥ 90 or 94 cm was associated with more than 3· folds OR of having diabetes, diagnosed diabetes, and elevated FBG only in men.

In the ENSPA study, having NWCO defined as WHtR ≥ 0·5, WC ≥ 90 or 94 cm was associated with a 2·54-folds OR of having elevated TG concentration in men (adjusted models). Further NWCO defined as WC ≥ 94 cm was associated with low concentration of HDL-C (OR: 2·91; 95% CI 1·04-8·05).

In women, NWCO defined as WC ≥ 80 cm was associated with elevated TG (OR: 1·85; 95%-CI 1·26-2·71) and NWCO defined as WHtR ≥ 0·5 was associated with low LDL-C (OR: 1·39; 95%-CI 1·01-1·92).

After adjustment, NWCO defined as WC ≥ 90 or 94 cm was associated with elevated concentration of FBG (OR: 5·81; 95%-CI 1·35-25·05 and OR: 5·31; 95%-CI 1·04-26·91 respectively). Also, NWCO defined as WC ≥ 94 cm was associated with having diabetes (OR: 4·27; 95%-CI 1·25-14·58) and having been diagnosed with diabetes (OR: 6·61; 95% CI 1·86-23·41) in men group.

In women, NWCO defined as WC≥ 88 cm was associated with diabetes (OR: 2·81; 95%-CI 1·21-6·50), self-report medical diagnosis of diabetes (OR: 2·71; 95%-CI 1·11-6·60) and having an elevated FBG (OR:3·07; 95%-CI 1·10-8·57). Likewise, a NWCO defined as WC ≥ 80 cm was associated with having diabetes (OR: 2·31; 95%-CI 1·25-4·27) and having an elevated FBG (OR: 3·21; 95%-CI 1·38-7·46).

In a complementary analysis, we evaluated the association of NWCO with the likelihood of having one, two or at least three CVD risk factors in both studies (Supplementary Table 2). After adjustment, in the PREFREC

	High blood pressure variables					
	HBP		SBP ≥ 140 mm/Hg		DBP ≥ 90 mm/Hg	
	Crude OR (95% CI)	Adjusted OR (95% CI)	Crude OR (95% CI)	Adjusted OR (95% CI)	Crude OR (95% CI)	Adjusted OR (95% CI)
Panama & Colón provinces in 2010-11						
Men	n=471	n=424	n=471	n=424	n=471	n=424
WC ≥ 90 cm	2·08 (1·23-3·53)	1·04 (0·56-1·96)	2·46 (1·43-4·23)	1·34 (0·71-2·53)	2·28 (1·25-4·15)	1·56 (0·79-3·06)
WC ≥ 94 cm	2·84 (1·26-6·42)	1·14 (0·44-2·96)	3·61 (1·60-8·14)	1·59 (0·62-4·12)	1·59 (0·61-4·11)	0·84 (0·28-2·51)
WHtR ≥ 0·5	2·86 (1·91-4·28)	1·22 (0·73-2·04)	3·05 (1·96-4·76)	1·41 (0·82-2·44)	2·34 (1·41-3·86)	1·41 (0·76-2·61)
Women	n=769	n=735	n=769	n=714	n=769	n=735
WC ≥ 80 cm	3·41 (2·17-5·35)	2·39 (1·40-4·11)	3·57 (2·01-6·32)	2·15 (1·08-4·25)	5·42 (2·30-12·78)	3·55 (1·46-8·61)
WC ≥ 88 cm	3·02 (2·04-4·47)	1·28 (0·78-2·07)	2·62 (1·66-4·12)	0·92 (0·52-1·63)	1·98 (1·11-3·53)	0·97 (0·51-1·86)
WHtR ≥ 0·5	3·77 (2·22-6·43)	2·05 (1·10-3·82)	2·79 (1·52-5·12)	0·91 (0·43-1·89)	5·70 (2·03-15·92)	3·62 (1·25-10·49)
National level in 2019						
Men	n=1,332	n=1326	n=1,332	n=1,326	n=1,332	n=1,326
WC ≥ 90 cm	2·94 (1·98-4·38)	1·10 (0·70-1·72)	1·74 (1·12-2·68)	0·68 (0·43-1·11)	1·62 (0·97-2·71)	0·88 (0·51-1·50)
WC ≥ 94 cm	2·09 (1·04-4·18)	0·91 (0·43-1·92)	1·51 (0·69-3·28)	0·77 (0·34-1·75)	1·54 (0·63-3·80)	0·92 (0·37-2·29)
WHtR ≥ 0·5	3·17 (2·49-4·03)	1·47 (1·08-1·99)	2·56 (1·94-3·36)	1·14 (0·81-1·59)	2·19 (1·58-3·04)	1·42 (0·97-2·07)
Women	n=2,418	n=2,413	n=2,418	n=2,413	n=2,418	n=2,413
WC ≥ 80 cm	2·74 (2·27-3·33)	1·45 (1·15-1·84)	3·06 (2·36-3·96)	1·46 (1·07-1·98)	2·22 (1·60-3·07)	1·69 (1·19-2·39)
WC ≥ 88 cm	4·07 (2·89-5·74)	1·85 (1·21-2·83)	4·24 (2·91-6·20)	1·75 (1·12-2·75)	1·49 (0·82-2·70)	0·94 (0·51-1·75)
WHtR ≥ 0·5	2·42 (1·99-2·94)	1·39 (1·09-1·78)	3·73 (2·77-5·02)	1·71 (1·20-2·41)	1·79 (1·28-2·51)	1·56 (1·07-2·26)

***Table 3*: Crude and adjusted[1] associations between high blood pressure and different cutoff points to define central obesity among normal weight adults living in Panama & Colon provinces in 2010-11 and at national level in 2019 stratified by sex· Odd Ratio (OR) and 95% Confidence intervals (CI).**

[1] Model adjusted for age, tobacco use in last 30 days, family history of HBP and sociocultural group. HBP: High blood pressure defined as self-reported diagnosis, or Systolic Blood Pressure (SBP) ≥ 140 mmHg or a Diastolic Blood Pressure (DBP) ≥90 mmHg or the current use of antihypertensive medications.

	Dyslipidemias							
	Total Cholesterol ≥ 200 mg/dL		Triglycerides ≥ 150 mg/dL		LDL-C ≥ 130 mg/ dL		Diminished HDL-C	
	Crude OR (95% CI)	Adjusted OR (95% CI)	Crude OR (95% CI)	Adjusted OR (95% CI)	Crude OR (95% CI)	Adjusted OR (95% CI)	Crude OR (95% CI)	Adjusted OR (95% CI)
Men	n=471	n=417	n=471	n=419	n=471	n=419	n=471	n=417
WC ≥ 90 cm	2·31 (1·36-3·91)	1·46 (0·79-2·69)	2·50 (1·47-4·25)	2·43 (1·30-4·52)	1·32 (0·74-2·36)	0·89 (0·45-1·74)	1·37 (0·80-2·35)	1·94 (1·02-3·69)
WC ≥ 94 cm	1·71 (0·76-3·85)	1·02 (0·39-2·68)	2·81 (1·24-6·33)	2·64 (1·00-6·98)	1·23 (0·50-3·02)	0·76 (0·26-2·24)	1·63 (0·69-3·86)	2·54 (0·85-7·52)
WHtR ≥ 0·5	2·86 (1·93-4·23)	2·00 (1·22-3·27)	2·47 (1·64-3·27)	2·37 (1·41-4·01)	2·93 (1·88-4·59)	2·22 (1·27-3·90)	1·60 (1·11-2·32)	2·39 (1·45-3·92)
Women	n=769	n=735	n=769	n=735	n=769	n=735	n=769	n=735
WC ≥ 80 cm	2·28 (1·65-3·15)	1·57 (1·07-2·30)	2·31 (1·56-3·43)	1·71 (1·10-2·65)	2·06 (1·44-2·96)	1·47 (0·98-2·22)	1·37 (0·96-1·95)	1·54 (1·04-2·26)
WC ≥ 88 cm	2·51 (1·75-3·59)	1·22 (0·79-1·88)	2·24 (1·52-3·30)	1·21 (0·78-1·87)	2·89 (1·99-4·18)	1·68 (1·10-2·57)	1·63 (1·01-2·64)	2·12 (1·26-3·58)
WHtR ≥ 0·5	2·75 (1·91-3·96)	1·71 (1·11-2·63)	3·15 (1·95-5·09)	1·79 (1·07-3·01)	2·45 (1·61-3·72)	1·56 (0·97-2·50)	1·14 (0·78-1·68)	1·12 (0·73-1·72)
	Diabetes							
	Diabetes		Prediabetes		Self-report medical diagnosis diabetes		FBG ≥126 mg/dL	
	Crude OR (95% CI)	Adjusted OR (95% CI)	Crude OR (95% CI)	Adjusted OR (95% CI)	Crude OR (95% CI)	Adjusted OR (95% CI)	Crude OR (95% CI)	Adjusted OR (95% CI)
Men	n=471	n=429	n=471	n=429	n=471	n=429	n=471	n=371
WC ≥ 90 cm	5·27 (2·44-11·38)	3·02 (1·28-7·06)	1·87 (0·98-3·55)	1·33 (0·66-2·65)	4·52 (1·77-11·51)	3·11 (1·12-8·60)	6·24 (2·43-16·00)	3·89 (1·38-10·99)
WC ≥ 94 cm	8·65 (3·38-22·14)	5·90 (2·04-17·13)	1·46 (0·53-4·04)	1·05 (0·36-3·05)	7·18 (2·37-21·73)	5·66 (1·67-19·13)	10·52 (3·60-30·69)	10·04 (2·97-33·80)
WHtR ≥ 0·5	3·39 (1·48-7·74)	2·15 (0·81-5·66)	2·56 (1·49-4·38)	1·59 (0·85-2·97)	3·44 (1·23-9·63)	2·12 (0·66-6·80)	4·32 (1·41-13·22)	3·29 (0·89-12·18)
Women	n=769	n=740	n=769	n=740	n=769	n=740	n=769	n=694
WC ≥ 80 cm	2·09 (0·94-4·64)	1·41 (0·61-3·27)	2·40 (1·31-4·39)	1·53 (0·79-2·92)	2·40 (0·97-5·93)	1·57 (0·61-4·06)	1·41 (0·54-3·68)	0·84 (0·29-2·36)
WC ≥ 88 cm	2·23 (1·11-4·49)	1·31 (0·61-2·83)	2·41 (1·42-4·01)	1·31 (0·73-2·36)	2·60 (1·23-5·49)	1·53 (0·67-3·50)	2·01 (0·79-5·07)	1·04 (0·38-2·88)
WHtR ≥ 0·5	2·02 (0·83-4·92)	1·26 (0·48-3·28)	2·77 (1·35-5·69)	1·63 (0·75-3·52)	2·65 (0·91-7·66)	1·65 (0·53-5·11)	1·22 (0·44-3·38)	0·68 (0·22-2·10)

***Table 4*: Crude and adjusted[1] associations of high blood lipids concentration, diabetes and different cutoff points to define abdominal adiposity among normal weight adults living in Panama & Colon provinces PREFREC-2010-11· Odd Ratio (OR) and 95% Confidence intervals (CI).**

[1] For dyslipidemias, the model was adjusted for age, tobacco use in last 30 days, family history of high blood cholesterol concentration and sociocultural group. For diabetes, model was adjusted for age, family history of diabetes and sociocultural group. LDL-C: low density lipoprotein; Diminished HDL-C: HDL-C< 40 mg/dL in men and < 50 mg/dL in women. HDL: high density lipoprotein; FBP: fasting blood glucose; Diabetes: self-report medical diagnosis or fasting blood glucose levels ≥ 126 mg/dL or a Hemoglobin A1c (HbA1C) ≥ 6·5%, or current use of diabetes medication treatment.

	Dyslipidemias							
	Total Cholesterol ≥ 200 mg/dL		Triglycerides ≥ 150 mg/dL		LDL-C ≥ 130 mg/ dL		Diminished HDL-C	
	Crude OR (95% CI)	Adjusted OR (95% CI)	Crude OR (95% CI)	Adjusted OR (95% CI)	Crude OR (95% CI)	Adjusted OR (95% CI)	Crude OR (95% CI)	Adjusted OR (95% CI)
Men	n=285	n=284	n=285	n=419	n=285	n=284	n=285	n=284
WC ≥ 90 cm	1·75 (0·87-3·55)	1·09 (0·52-2·34)	2·93 (1·45-5·92)	2·58 (1·22-5·43)	1·17 (0·58-2·38)	0·71 (0·33-1·52)	1·11 (0·53-2·32)	1·73 (0·77-3·86)
WC ≥ 94 cm	1·07 (0·39-2·94)	0·74 (0·26-2·08)	2·87 (1·09-7·54)	2·77 (1·02-7·45)	1·08 (0·40-2·87)	0·74 (0·27-2·02)	1·90 (0·72-5·00)	2·91 (1·04-8·05)
WHtR ≥0·5	1·93 (1·17-3·20)	1·23 (0·67-2·25)	2·89 (1·73-4·85)	2·54 (1·37-4·70)	1·68 (1·03-2·72)	1·24 (0·69-2·25)	1·06 (0·34-1·76)	1·44 (0·75-2·74)
Women	n=793	n=792	n=793	n=792	n=793	n=792	N=793	N=792
WC ≥ 80 cm	1·92 (1·40-2·63)	1·15 (0·80-1·64)	2·67 (1·88-3·80)	1·85 (1·26-2·71)	1·55 (1·14-2·10)	1·06 (0·75-1·49)	1·01 (0·74-1·37)	1·10 (0·80-1·52)
WC ≥ 88 cm	2·64 (1·44-4·86)	0·99 (0·49-2·00)	3·54 (1·92-6·55)	1·73 (0·88-3·39)	2·16 (1·17-3·97)	1·09 (0·56-2·11)	0·77 (0·42-1·42)	0·88 (0·47-1·66)
WHtR ≥0·5	2·22 (1·64-2·99)	1·31 (0·92-1·86)	2·40 (1·68-3·41)	1·40 (0·94-2·08)	1·86 (1·39-2·49)	1·39 (1·01-1·92)	1·18 (0·89-1·57)	1·26 (0·93-1·71)
	Diabetes							
	Diabetes		Prediabetes		Self-report medical diagnosis		FBG ≥126 mg/dL	
	Crude OR (95% CI)	Adjusted OR (95% CI)	Crude OR (95% CI)	Adjusted OR (95% CI)	Crude OR (95% CI)	Adjusted OR (95% CI)	Crude OR (95% CI)	Adjusted OR (95% CI)
Men	n=287	n=258	n=285	n=284	n=1,343	n=1140	n=285	n=242
WC ≥ 90 cm	3·41 (1·29-8·96)	2·51 (0·89-7·10)	1·90 (0·91-3·97)	1·05 (0·46-2·38)	6·47 (2·35-17·87)	2·95 (0·99-8·77)	7·59 (2·08-27·67)	5·81 (1·35-25·05)
WC ≥ 94 cm	5·36 (1·72-16·72)	4·27 (1·25-14·58)	0·91 (0·28-2·85)	0·57 (0·17-1·88)	13·76 (4·23-44·76)	6·61 (1·86-23·41)	7·43 (1·74-31·64)	5·31 (1·04-26·91)
WHtR ≥ 0·5	1·21 (0·51-2·83)	0·79 (0·29-2·11)	2·61 (1·49-4·57)	1·32 (0·67-2·57)	2·97 (1·09-8·08)	1·75 (0·58-5·25)	3·10 (0·79-12·26)	2·28 (0·49-10·50)
Women	n=794	n=793	n=794	n=782	n=2,472	n=2,472	n=790	n=653
WC ≥ 80 cm	4·02 (2·32-6·97)	2·31 (1·25-4·27)	2·64 (1·67-4·18)	1·62 (0·98-2·68)	3·32 (1·63-6·77)	1·91 (0·89-4·06)	5·28 (2·44-11·39)	3·21 (1·38-7·46)
WC ≥ 88 cm	7·24 (3·59-15·58)	2·81 (1·21-6·50)	2·25 (1·04-4·84)	0·88 (0·38-2·06)	5·60 (2·47-12·70)	2·71 (1·11-6·60)	8·21 (3·53-19·12)	3·07 (1·10-8·57)
WHtR ≥ 0·5	2·60 (1·46-4·62)	1·25 (0·63-2·49)	2·87 (1·76-4·70)	1·55 (0·90-2·68)	3·01 (1·35-6·74)	2·11 (0·88-5·08)	3·29 (1·45-7·44)	2·12 (0·83-5·41)

***Table 5*: Crude and adjusted[1] associations of high blood lipids concentration, diabetes and different cutoff points to define abdominal adiposity among normal weight adults at national level in 2019· Odd Ratio (OR) and 95% Confidence intervals (CI).**

[1] For dyslipidemias, the model was adjusted for age, tobacco use in last 30 days, family history of high blood cholesterol concentration and sociocultural group. For Diabetes, model was adjusted for age, family history of diabetes and sociocultural group. LDL: low density lipoprotein; Diminished HDL-C: HDL-C< 40 mg/dL in men and < 50 mg/dL in women. HDL: high density lipoprotein; FBP: fasting blood glucose; Diabetes: self-report diagnosis or fasting blood glucose levels ≥ 126 mg/dL or a Hemoglobin A1c (HbA1C) ≥ 6·5%, or current use of diabetes medication treatment; Prediabetes: fasting blood glucose ≥ 100 mg/dL and and <126 mg/dL or HbA1C ≥5·7% and <6·5%.

study, all NWCO definitions showed increased odds with having at least three CVD risk factors: the prevalence odds ratio for men with a WC ≥ 90 cm was 3·65 (95%-CI 1·04-12·77) and prevalence odds ratio for those with WHtR ≥ 0·5 was 9·39 (95%-CI 3·48-25·33).

In addition, all men with a WHtR ≥0·5 presented also increased odds of having two and one CVD risk factors (OR: 3·59; 95% CI 1·59-8·05 and OR: 2·53; 95% CI 1·15-5·57 respectively), while all men with a WC ≥ 94 cm had one or more CVD risk factor. Among women from the PREFREC study, the odds of having a WC ≥ 80 cm, a WC ≥ 88 cm and a WHtR ≥ 0·5 and at least three CVD risk factors were 3·56 (95%-CI 1·78-7·15), 2·97 (95%-CI 1·18-7·41) and 2·49 (95%-CI 1·10-5·64) respectively. In the ENSPA study, normal weight women with a WHtR ≥ 0·5 and a WC ≥ 80 or ≥88 cm was associated with at least 3 CVD risk factors (OR: 2·00; 95% 1·13-3·51, OR: 2·27; 95% 1·28-4·02 and OR: 6·22; 95% 1·26-30·55, respectively). Further a NWCO defined as WC ≥ 80 cm and a WHtR ≥ 0·5was associated with 2 CVD risk factors (OR: 2·07; 95% CI 1·27-3·35 and OR: 2·60; 95% CI 1·65-4·09 respectively). No significant association was found between CO and cluster CVD risk factors in men in the ENSPA study.

Sociodemographic variables associated to NWCO in both studies showed a higher OR of having NWCO among women than men, sedentary people than non-sedentary, Afro-Panamanians than Whites and married people than singles (*Supplementary Table* 3 and 4).

Discussion

In the present study, we found CO among people classified as normal weight according to BMI. In addition, NWCO, according to all analyzed definitions, was associated with cardiometabolic risk factors, particularly elevated TG concentration in both sexes.

Currently the most utilized CO cutoff point by national health campaigns to identify individuals at risk of cardiometabolic diseases is a WC ≥ 102 cm for men and a WC ≥ 88 cm for women.[33] Our results suggest that the current threshold for WC could not identify NWCO among men. While in women, NWCO defined as WC ≥ 80 cm showed a more consistent co-occurrence with CVD risk factors in both studies.

Overall, estimated prevalence of NWCO was higher in PREFREC than ENSPA study, nevertheless this variation is difficult to assess given the differences in the year of survey, baseline characteristics and WC technique used in both study groups.

Our prevalence results of NWCO, defined as WC ≥ 80 cm among women in the ENSPA study, was in agreement with the ones reported in the Chilean National Health Survey (data collected between October 2009-September 2010).[34] However, our NWCO prevalence from the ENSPA study was 15·1 and 6·0 percentages points lower among men and women respectively compared to a multicentric Latin America and The Caribbean (LAC) WC study of 2005.[35] Nevertheless, due to scarce of literature assessing NWCO defined with WHtR in the LAC region it is difficult to make comparisons.

Prevalence of NWCO defined as WC ≥ 80 cm in women from China in 2011 was 13·1%, while in men (defined as WC ≥ 85 cm) was 16·0%. This prevalence increased up to 22·1% in women and 17·5% in men when NWCO was defined as WHtR ≥ 0·5.[36] In contrast, in two population based health surveys conducted in Canada, prevalence of NWCO decreased from 22·8% (when defined as WC ≥ 80 cm) to 17·7% (when defined as WHtR ≥ 0·5) in women, but it increased in men from 6·3% (when defined as WC ≥ 94 cm) up to 20·3% (when defined as WHtR ≥0·5),[37] whereas in a longitudinal study in Australia, the prevalence of NWCO (defined as WHtR ≥ 0·5) was 12·6% in women and 13·8% in men.[38] Our higher prevalence of NWCO defined by a WHtR observed in ENSPA study (43·9%), might be ethnicity or cultural related due to a higher WC, a smaller height, or a combination of both among our study population.

Even though we cannot elucidate which of the two components of WHtR are substantially different from other studies, it is well known that the mean heights for men and women differ worldwide and are higher than the mean heights presented in our study populations.[39,40] In addition, estimates of the median and IQR of the WC (cm) from our normal weight ENSPA group was 80·7 cm (75·5-85·1) among men and 77·1 cm (72·0-82·2) among women.

Consistent with our results, the NWCO was higher among women than men from China when using the WHtR.[36] Sex differences in body fat mass have been well established.[41] Men present greater lean mass and lower fat mass than women, while women present more total adipose tissue than men. Fat mass distribution is also different, as it is mainly located peripherally in women and centrally in men.[36,42] Sex differences in diet and/or physical activity might also play a role in the differences observed in our results.

In both PREFREC and ENSPA studies, associations were found between NWCO, defined as WC ≥ 94 cm, with diabetes and elevated FBG among men. Even though association of diabetes and NWCO among women was observed only in the ENSPA study, our findings are similar with a cross-sectional study among 35-75 years old women in Switzerland, where normal weight obesity (NWO), defined as a BMI < 25kg/m^2 and a body fat percentage ≥ 66th percentile, was associated with a higher prevalence of dyslipidemia, blood pressure and glycaemia levels, after adjusting for confounder variables. Interestingly, in the same study women with NWO had also larger WC than lean women.[43]

Waist-to-Hip Ratio (WHR), used as a proxy measure of intra-abdominal fat depot, is positively correlated

with metabolic abnormalities, while subcutaneous fat in the femorogluteal area showed a negative correlation.[6] A longitudinal study in the Australian population found that NWCO defined by WHR and WHtR resulted in similar prevalence, nevertheless the WHR was a better prediction for all-cause and cardiovascular mortality.[38]

A previous analysis of a matrix combining BMI ranks and the WC cutoff points to identified people with early health risk factors in comparison to WHtR alone, showed that WHtR identified more people with cardiometabolic risk factors.[44,45] The advantage of the WHtR over the WC alone is that for the WHtR a unique cutoff point could be used for both sexes, thus making easier to promote the public health message "keep your waist circumference to less than half your height" as stated by other authors.[19] The disadvantage is that the height measure is needed to compute the ratio; nevertheless, currently height is a regular measurement assessed at the primary health care level.

In agreement with findings from an Australian study from 2001-2009, we also found an association between NWCO and sex, age, and physical activity.[38] Although CO association with CVD risk factors among different ethnic groups has been previously published, population-based studies of NWCO are recently gaining relevance and a smaller number of publications are now available.

All analyzed CO definitions presented a co-occurrence with having at least three CVD risk factors among normal weight individuals of both sexes from the PREFREC study and the female group of the ENSPA study. These results underscore the evaluation of CO among people classify as normal weight with the BMI.

Several limitations should be acknowledged. First, both studies, were cross-sectional designs and causality should not be inferred. Therefore, we could not analyze the best cutoff to identify people at risk of developing CVD. Second, ENSPA study was designed to estimate biomarkers levels at a national level rather than at a province-level, thus comparison with PREFREC study for biomarkers related outcome cannot be assessed. Third, most of the literature about CO evaluates the waist circumference at the mid-point of the lower rib and the top of the iliac crest and seldomly uses the measurement of waist circumference at umbilicus level among normal weight population, hence comparison of PREFREC results with other studies was difficult. Fourth, we do not have information regarding menopause status. Lastly, we evaluate a surrogate measure of visceral fat mass and a non-direct assessment of body composition, yet sophisticated measures are expensive and rarely used at the primary health care level.

However, we underscored the fact that for the present study the two population-based surveys have a large number of participants, representing for the PREFREC study a large segment of the Panamanian population and in the case of ENSPA, a study of the whole country. For both studies, standardized anthropometric measurement were performed by trained personnel despite there were two different methods regarding the waist circumference.

Conclusion

The present study underscores the importance of using different anthropometric measures to identify persons classified as normal according to the BMI, but with metabolically obese characteristics in NWCO population, and thus with the need of counseling and clinical follow-up at the primary health care level.

Taking our results altogether, the question if a WC ≥ 102 cm among normal weight men adequately assesses CVD risk factor in our population may be asked. It is possible that NWCO defined as WHtR ≥ 0·5 could be a message to stress more in public health campaigns than defining it with WC. Further observational analytic studies are required to better define the best cutoff point for defining NWCO.

Contributors

RM conceptualized, and investigated and performed data curation, programming, formal analysis, and validation and wrote the original draft. RM, IMV, FF and HKQ worked on the methodology. HKQ supervised and all the authors contributed equally to the reviewing and editing.

Data sharing statement

General results for both studies are publicly available in Spanish. Results from the PREFREC study are available at: http://www.gorgas.gob.pa/prefrec/, and for the ENSPA study at: http://www.gorgas.gob.pa/SIGENSPA/Inicio.htm. The datasets used and/or analyzed during the current study are available from the authors on reasonable request via email.

Editorial note

The *Lancet* Group takes a neutral position with respect to territorial claims in published maps and institutional affiliations.

Declaration of interests

The authors have no conflicts of interest to declare.

Acknowledgement

The authors thanks to all the ENSPA and PREFREC participants as well as the staff who participated in both studies as well as Mr. Christopher Rathbone for proofreading this manuscript.

Supplementary materials

Supplementary material associated with this article can be found in the online version at doi:10.1016/j.lana.2022.100215.

References

1 Calle EE, Thun MJ, Petrelli JM, Rodriguez C, Heath CW. Body-mass index and mortality in a prospective cohort of U.S. adults. *N Engl J Med*. 1999;341(15):1097–1105.
2 Berrington de Gonzalez A, Hartge P, Cerhan JR, et al. Body-mass index and mortality among 1.46 million white adults. *N Engl J Med*. 2010;363(23):2211–2219.
3 Whitlock G, Lewington S, Sherliker P, et al. Body-mass index and cause-specific mortality in 900 000 adults: collaborative analyses of 57 prospective studies. *Lancet*. 2009;373(9669):1083–1096.
4 WHO Consultation on Obesity (1999: Geneva, Switzerland). Obesity: Preventing and Managing the Global Epidemic: -report of a WHO consultation. (WHO technical report series; 894).
5 Romero-Corral A, Somers VK, Sierra-Johnson J, et al. Normal weight obesity: a risk factor for cardiometabolic dysregulation and cardiovascular mortality. *Eur Heart J*. 2010;31(6):737–746.
6 Bosomworth NJ. Normal-weight central obesity: Unique hazard of the toxic waist. *Can Fam Physician*. 2019;65(6):399–408.
7 Sun Y, Liu B, Snetselaar LG, et al. Association of normal-weight central obesity with all-cause and cause-specific mortality among postmenopausal women. *JAMA Netw Open*. 2019;2:(7) e197337.
8 Coutinho T, Goel K, Correa de Sa D, et al. Combining body mass index with measures of central obesity in the assessment of mortality in subjects with coronary disease: role of "normal weight central obesity". *J Am Coll Cardiol*. 2013;61(5):553–560.
9 Ross R, Neeland IJ, Yamashita S, et al. Waist circumference as a vital sign in clinical practice: a consensus statement from the IAS and ICCR working group on visceral obesity. *Nat Rev Endocrinol*. 2020;16(3):177–189.
10 Oliveros E, Somers VK, Sochor O, Goel K, Lopez-Jimenez F. The concept of normal weight obesity. *Prog Cardiovasc Dis*. 2014;56(4):426–433.
11 Hamer M, O'Donovan G, Stensel D, Stamatakis E. Normal-weight central obesity and risk for mortality. *Ann Intern Med*. 2017;166(12):917–918.
12 Sahakyan KR, Somers VK, Rodriguez-Escudero JP, et al. Normal-weight central obesity: implications for total and cardiovascular mortality. *Ann Intern Med*. 2015;163(11):827–835.
13 International Diabetes Federation (IDF). The IDF consensus worldwide definition of the Metabolic Syndrome 2006 [internet]. Brussels, Belgium: IDF; 2006. Available from: https://www.idf.org/e-library/consensus-statements/60-idfconsensus-worldwide-definitionof-the-metabolic-syndrome.html.
14 Expert Panel on Detection Evaluation, Treatment of High Blood Cholesterol in Adults. Executive summary of the third report of the national cholesterol education program (NCEP) expert panel on detection, evaluation, and treatment of high blood cholesterol in adults (adult treatment panel III). *JAMA*. 2001;285(19):2486–2497.
15 Ashwell M, Gibson S. Waist to height ratio is a simple and effective obesity screening tool for cardiovascular risk factors: Analysis of data from the British National Diet And Nutrition Survey of adults aged 19-64 years. *Obes Facts*. 2009;2(2):97–103.
16 Ashwell M, Mayhew L, Richardson J, Rickayzen B. Waist-to-height ratio is more predictive of years of life lost than body mass index. *PLoS One*. 2014;9:(9) e103483.
17 Lee CM, Huxley RR, Wildman RP, Woodward M. Indices of abdominal obesity are better discriminators of cardiovascular risk factors than BMI: a meta-analysis. *J Clin Epidemiol*. 2008;61(7):646–653.
18 Huxley R, Mendis S, Zheleznyakov E, Reddy S, Chan J. Body mass index, waist circumference and waist:hip ratio as predictors of cardiovascular risk-a review of the literature. *Eur J Clin Nutr*. 2010;64(1):16–22.
19 Ashwell M, Hsieh SD. Six reasons why the waist-to-height ratio is a rapid and effective global indicator for health risks of obesity and how its use could simplify the international public health message on obesity. *Int J Food Sci Nutr*. 2005;56(5):303–307.
20 Ashwell M, Gunn P, Gibson S. Waist-to-height ratio is a better screening tool than waist circumference and BMI for adult cardiometabolic risk factors: systematic review and meta-analysis. *Obes Rev*. 2012;13(3):275–286.
21 Sasson M, Lee M, Jan C, Fontes F, Motta J. Prevalence and associated factors of obesity among Panamanian adults. 1982-2010. *PLoS One*. 2014;9(3):e91689.
22 Mc Donald A, Bradshaw RA, Fontes F, et al. Prevalence of obesity in Panama: some risk factors and associated diseases. *BMC Public Health*. 2015;15:1075.
23 Mc Donald Posso AJ, Bradshaw Meza RA, Mendoza Morales EA, et al. Diabetes in panama: epidemiology, risk factors, and clinical management. *Ann Glob Health*. 2015;81(6):754–764.
24 Moreno Velasquez I, Castro F, Gomez B, Cuero C, Motta J. Chronic kidney disease in panama: results from the PREFREC study and national mortality trends. *Kidney Int Rep*. 2017;2(6):1032–1041.
25 Instituto Conmemorativo Gorgas de Estudios de la salud (ICGES). Sistema de información de la Encuesta Nacional de Salud de Panamá (ENSPA) 2019-2021[internet]. Panamá: Departamento de Investigación y Evaluación de Tecnología Sanitaria; c 2021 [Update 2021 Nov 11; cited 2021 Aug 13]. Available from: http://gorgas.gob.pa/SIGENSPA/Inicio.htm.
26 Gibson S, Ashwell M. A simple cut-off for waist-to-height ratio (0.5) can act as an indicator for cardiometabolic risk: recent data from adults in the Health Survey for England. *Br J Nutr*. 2020;123(6):681–690.
27 Mason C, Katzmarzyk PT. Effect of the site of measurement of waist circumference on the prevalence of the metabolic syndrome. *Am J Cardiol*. 2009;103(12):1716–1720.
28 World Health Organization. Noncommunicable Diseases and Mental Health Cluster. *WHO STEPS surveillance manual: the WHO STEPwise approach to chronic disease risk factor surveillance /Noncommunicable Diseases and Mental Health, World Health Organization*. World Health Organization; 2005. https://apps.who.int/iris/handle/10665/43376.
29 American Diabetes A. Diagnosis and classification of diabetes mellitus. *Diabetes Care*. 2014;37(Suppl 1):S81–S90.
30 Faiella I. The use of survey weights in regression analysis (January 11, 2010) . Bank of Italy Temi di Discussione (Working Paper) No. 739, Available at SSRN: https://ssrn.com/abstract=1601936 or 10.2139/ssrn.1601936.
31 Pfeffermann D. The role of sampling weights when modeling survey data. *Int Stat Rev*. 1993;61(2):317–337.
32 Winship C. Sampling weights and regression analysis. *Sociol Methods Res*. 1994;23(2):230–257.
33 Panama. Ministerio de Salud. Normas técnico-administrativas de los programas de salud de adulto y adulto mayor. I ed. Panamá: Programa Nacional de Salud de Personas Adultas y Adultas Mayores; 2018. [Cited 2021 Apr 15]. Available from: https://www.educacioninterprofesional.org/sites/default/files/fulltext/2018/2018_pan_norma_adulto_adulto_mayor.pdf.
34 Villanueva B, Arteaga A, Maiz A, Cortes VA. Abdominal obesity is a common finding in normal and overweight subjects of Chile and is associated with increased frequency of cardiometabolic risk factors. *PLoS One*. 2018;13:(3) e0194644.
35 Aschner P, Ruiz A, Balkau B, et al. Association of abdominal adiposity with diabetes and cardiovascular disease in Latin America. *J Clin Hypertens (Greenwich)*. 2009;11(12):769–774.
36 Song P, Li X, Bu Y, et al. Temporal trends in normal weight central obesity and its associations with cardiometabolic risk among Chinese adults. *Sci Rep*. 2019;9(1):5411.
37 Shields M, Tremblay MS, Connor Gorber S, Janssen I. Measures of abdominal obesity within body mass index categories, 1981 and 2007-2009. *Health Rep*. 2012;23(2):33–38.
38 Haregu TN, Nanayakkara S, Carrington M, Kaye D. Prevalence and correlates of normal body mass index central obesity among people with cardiovascular diseases in Australia. *Public Health*. 2020;183:126–131.
39 WorldData.info. Average height and weight by country [cited 2021 15/11/2021]. Available from: https://www.worlddata.info/average-bodyheight.php#by-population.
40 Abarca-Gómez L, Abdeen ZA, Hamid ZA, et al. Worldwide trends in body-mass index, underweight, overweight, and obesity from 1975 to 2016: a pooled analysis of 2416 population-based

measurement studies in 128·9 million children, adolescents, and adults. *Lancet*. 2017;390(10113):2627–2642.
41 Appelman Y, van Rijn BB, Ten Haaf ME, Boersma E, Peters SA. Sex differences in cardiovascular risk factors and disease prevention. *Atherosclerosis*. 2015;241(1):211–218.
42 World Health Organization (2011). Waist Circumference and Waist-Hip Ratio: report of a WHO expert Consultation, Geneva 8-11 December 2008. World Health Organization. Available from: https://apps.who.int/iris/handle/10665/44583.
43 Marques-Vidal P, Pecoud A, Hayoz D, et al. Normal weight obesity: relationship with lipids, glycaemic status, liver enzymes and inflammation. *Nutr Metab Cardiovasc Dis*. 2010;20(9):669–675.
44 Ashwell M, Gibson S. Waist-to-height ratio as an indicator of 'early health risk': simpler and more predictive than using a 'matrix' based on BMI and waist circumference. *BMJ Open*. 2016;6:(3) e010159.
45 Correa MM, Facchini LA, Thume E, Oliveira ERA, Tomasi E. The ability of waist-to-height ratio to identify health risk. *Rev Saude Publica*. 2019;53:66.