

## Relationship between neck circumference and hypertension in the National Hypertension Registry (the RENATA study)

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### ABSTRACT

#### Background

Hypertension (HT) is associated with a greater proportion of body fat. Neck circumference might provide additional clinical information to other measurements of body fat.

#### Objective

The aim of this study was to compare the relationship between abdominal and neck obesity and hypertension.

#### Methods

In the RENATA study, 4006 adults from seven cities (Buenos Aires, Córdoba, Tucumán, Mendoza, Resistencia, Corrientes and Neuquén) were randomly selected. Neck and waist circumferences were measured in 3987 subjects. Abdominal obesity (AO) was defined following the ATP III recommendations and neck obesity (NO) was considered as the upper tertile of neck circumference ( $\geq 35$  cm in women and  $\geq 41$  cm in men). Hypertension was defined as average blood pressure measurements  $\geq 140$  and/or 90 mm Hg or use of antihypertensive drug therapy.

#### Results

In patients with normal abdominal adipose tissue, the prevalence of HT was 20.3% with normal neck circumference vs. 38.8% with NO, while in subjects with AO, the prevalence of HT was 43.7% with normal neck circumference vs. 57.4% with NO (chi square,  $p < 0.001$ ). Logistic regression analysis showed that, for each standard deviation of neck circumference, the risk of HT adjusted for age and gender was greater in the absence than in the presence of AO (67% vs. 17%;  $p < 0.001$ ).

#### Conclusion

The prevalence of HT was greater in subjects with obesity in both regions of the body. The association between neck circumference and the prevalence of HT was greater in subjects with normal waist circumference.

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**Key words >** Abdominal Obesity – Hypertension - Neck

### Abbreviations >

<b>ATP III:</b>	Adult Treatment Panel III	<b>BMI:</b>	Body mass index
<b>SD:</b>	standard deviation	<b>AO:</b>	Abdominal obesity
<b>HT:</b>	Hypertension	<b>NO:</b>	Neck obesity
<b>IDF:</b>	International Diabetes Federation	<b>BP:</b>	Blood pressure

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## BACKGROUND

Hypertension (HT) is associated with a greater proportion and abnormal distribution of body fat. (1) Ectopic fat accumulation in the viscera, mediastinum and epicardium might be responsible for the concomitant increase in blood pressure (BP) and reduction in insulin sensitivity. (2, 3)

Waist circumference, a clinical surrogate of visceral obesity, constitutes one of the five diagnostic criteria for metabolic syndrome. However, the cutoff values for waist circumference recommended by the National Cholesterol Education Program Expert Panel on Detection, Evaluation, and Treatment of High Blood Cholesterol in Adults (NCEP ATP III) to define abdominal obesity (AO) are different from those proposed by the International Diabetes Federation (IDF). (4) Moreover, the clinical usefulness of waist circumference may vary according to the contribution of subcutaneous fat. (5)

Recent studies have suggested that measurement of neck circumference might have a complementary clinical value to other body measurements. (6, 7) Another recently published study has demonstrated that increased neck circumference, a marker for upper-body subcutaneous fat, surpasses waist circumference as a marker of both visceral obesity and insulin resistance. (8) Moreover, neck circumference and obstructive sleep apnea are associated independently of body mass index (BMI) and waist circumference. (9, 10)

The RENATA study included both measurements in a representative community sample in order to compare the relationship between abdominal obesity and cervical obesity with HT.

## METHODS

The RENATA study was a cross-sectional survey conducted on a randomized sample of adult subjects, older than 18 years of age, attending the Documentation Department of the Argentine Federal Police. The distribution by gender and age was proportional to that of the general population according to the 2001 National Census. The survey was conducted in two stages. The first stage was performed in the city of Buenos Aires (year 2008) and the second stage included inland cities: Córdoba, Tucumán, Mendoza, Resistencia, Corrientes and Neuquén (year 2009). Previously trained nurses and cardiovascular technologists were in charge of the survey. Blood pressure was measured using an Omron HEM 705 CP sphygmomanometer and three readings in print were acquired. Waist circumference was determined at the intermediate point between the inferior edge of the costal margin and the iliac crests, and neck circumference was determined at the base of the neck using a fabric measuring tape. Survey-respondents were asked about awareness of their blood pressure levels, medications, other risk factors, level of education and medical coverage. From a total of 4006 respondents, data from 3987 subjects with measurements of neck and waist circumference were analyzed.

The average of the last two BP readings was analyzed. Hypertension was defined as BP  $\geq 140$  and/or  $\geq 90$  mm Hg or use of antihypertensive drug therapy. Waist circumference was measured in the standing position at the midpoint between the lower rib margin and the iliac crest.

Abdominal obesity (AO) was defined following the ATP III recommendations ( $\geq 88$  cm in women and  $\geq 102$  cm in men) and the IDF guidelines ( $\geq 80$  cm in women and  $\geq 94$  cm in men). Neck obesity (NO) was defined as the upper tertile of neck circumference ( $\geq 35$  cm in women and  $\geq 41$  cm in men).

## Statistical Analysis

Quantitative data are expressed as mean  $\pm$  standard deviation (SD) and qualitative data as numbers and percentages. Independent samples t test was used to compare continuous variables and the chi square test was used to compare differences between categorical variables. The prevalence of HT was estimated in slim and obese subjects defined following the recommendations of the IDF and ATP and according to the neck circumference tertile (tertile limits for women 32 and 35 cm and for men 38 and 41 cm). The prevalence of HT stratified by age, gender and participating cities was estimated.

Pearson's correlation coefficient was used to analyze the correlation between waist circumference and neck circumference. ANOVA and the chi square test were used to evaluate the differences in quantitative and qualitative parameters, respectively, between patients grouped by body distribution (slim patients, obesity discordance and obesity concordance).

A logistic regression model was used to estimate the risk of HT for increased waist circumference and neck circumference. Crude odds ratio (OR) and adjusted OR (age and gender) were calculated with their corresponding 95% confidence intervals (95% CI). Multiple logistic regression analysis was stratified for the presence or absence of abdominal obesity with the corresponding interaction term. The OR for HT is presented for one standard deviation increase in neck circumference (1 SD = 4.68 cm) and waist circumference (1 SD = 14.96 cm). A p value  $< 0.05$  was considered statistically significant.

## RESULTS

The prevalence of AO and HT is summarized in Table 1. Thirty three percent of the patients had AO as defined by ATP III, while 54% fulfilled the IDF definition. The prevalence of AO was significantly higher in women compared to men (45% according to ATP III and 22% to IDF). Although men had lower obesity occurrence, the prevalence of HT was 51% greater in men compared to women.

Obesity, as defined by ATP III, IDF or increased neck circumference, was associated with greater occurrence of HT in both genders ( $p < .001$ ; Figure 1). The greater proportion of hypertensive subjects associated with obesity was higher in women, bringing the prevalence of HT in women closer to the one seen in men. The greater prevalence of HT associated with increase in waist circumference (ATP III) and neck circumference was consistent in each of the five age groups (Figure 2) and in each of the cities studied (Figure 3).

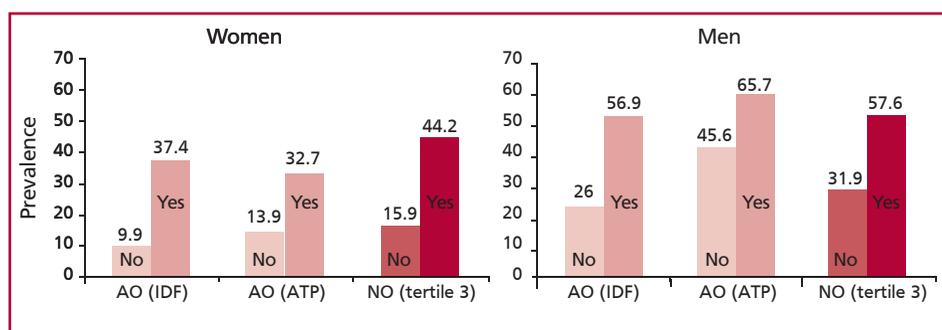
Waist circumference had a moderate correlation with neck circumference in both genders ( $R = 0.60$  in men and  $0.69$  in women;  $< 0.001$ ). Four age groups were defined according to the presence or absence of AO and/or NO (Table 2). Twenty percent of subjects with normal abdomen had NO, while 25% of those with AO (by ATP III) had thin neck.

**Table 1.** Sample characteristics

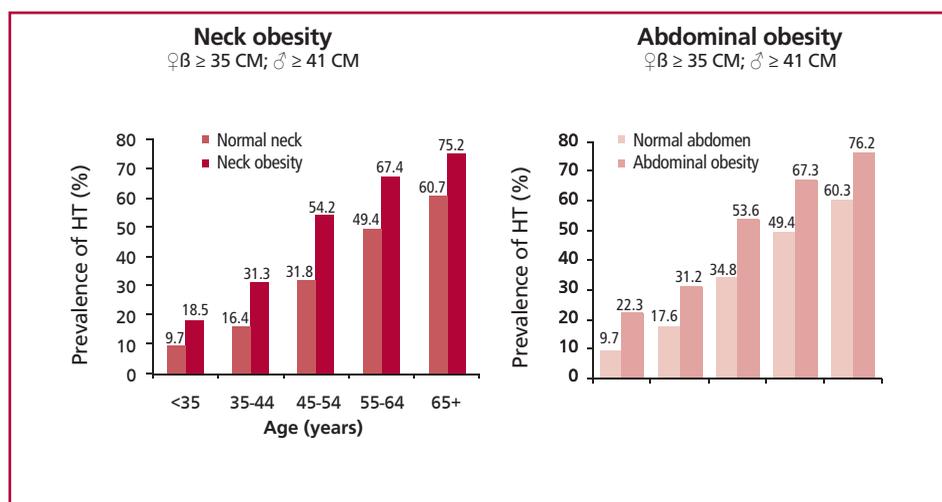
	Total	Men	Women	p
n (%)	3.987	1.928 (48.4)	2.059 (51.6)	ns
Age (years)	43.8 ± 17	43.9 ± 17	43.6 ± 16	ns
ATP AO, n (%)	1.301 (32.6)	530 (27.4)	771 (37.4)	< 0.001
IDF AO, n (%)	2.171 (54.4)	978 (50.7)	1193 (57.9)	< 0.001
SBP/DBP	126.5/76.8	132.3/79.5	121.1/74.4	< 0.001
± SD (mm Hg)	18/11	17/12	17/11	
HT (%)	1.337 (33.5)	805 (41.8)	532 (25.8)	< 0.001

Data are expressed as mean ± standard deviation and compared using Student's t test.

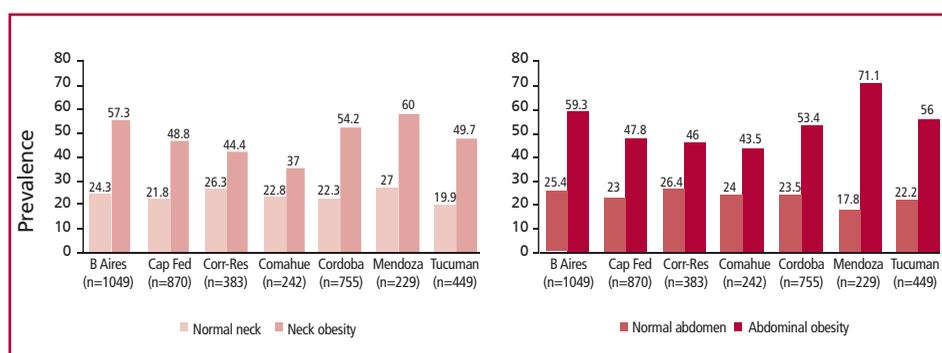
**Fig. 1.** Prevalence of hypertension (HT) according to the presence or absence of abdominal obesity (AO) defined by the IDF and the ATP and of neck obesity (NO defined as tertile 3 of neck circumference) in women and men.



**Fig. 2.** Prevalence of hypertension (HT) by age groups in the absence or presence of neck obesity (tertile 3) and abdominal obesity (ATP).



**Fig. 3.** Prevalence of hypertension (HT) by cities in the absence or in the presence of neck obesity (tertile 3) and abdominal obesity (ATP).



In average, the groups without AO (AO-NO- and AO-NO+) were significantly younger than the groups with AO (AO+NO- and AO+NO+). Among those without AO, subjects with normal neck (AO-NO-) were younger than those who had only high neck circumference (AO-NC+).

Neck obesity increased the occurrence of HT independently of the presence or absence of AO. The proportion of hypertensive subjects under antihypertensive treatment was higher in subjects with neck obesity; however, BP values were greater compared to those without NO, independently of the presence or absence of AO. The group with combined abdominal obesity and neck obesity had the greatest prevalence of HT and the highest BP level.

Logistic regression analysis showed that for 1 SD increase in waist circumference (14.96 cm), the unadjusted OR for HT was 2.53 (95% CI 2.33-2.74;  $p < 0.001$ ), while the risk of HT adjusted for age and gender was 1.77 (95% CI 1.61-1.93;  $p < 0.001$ ). Similarly, for 1 SD increase in neck circumference (4.68 cm) the unadjusted OR for HT was 2.27 (95% CI 2.10-2.45;  $p < 0.001$ ), while the risk of HT adjusted for age and gender was 1.88 (95% CI 1.67-2.10;  $p < 0.001$ ). The risk of HT was greater in subjects with increased neck circumference and in the absence of AO compared to the risk in the presence of AO (interaction  $p < 0.001$ ). These data are shown in Table 3.

## DISCUSSION

The goal of this study was to compare the relationship between abdominal obesity, neck circumference and hypertension. These findings can be summarized as

follows: 1) obesity, either measured in the abdomen or neck, was associated with a greater prevalence of HT, 2) the occurrence of HT was even greater when obesity coexisted in both regions of the body, and 3) the association between increased neck circumference and the prevalence of HT was greater in subjects with normal waist circumference.

Waist circumference is a clinical surrogate of intra-abdominal obesity and constitutes one of the diagnostic criteria for metabolic syndrome. Different cutoff values are used by the IDF and the ATP III to define AO. However, anatomical heterogeneity of the abdomen hampers waist circumference measurement standardization and its reproducibility. In addition, waist circumference cannot distinguish abdominal subcutaneous fat from intra-abdominal fat which is more clinically relevant. (5) Among subcutaneous fat depots, upper body fat distribution exceeds abdominal fat as a source of free fatty acid release and delivery to the liver. (11) Measurement of the neck circumference is easier and can be made with the patient in the sitting position. Neck circumference represents the upper body fat and fat deposition around the upper airway and its increase is suggestive of obstructive sleep apnea. (9, 10)

The RENATA study did not include weight and height measurements to calculate BMI due to operational reasons. BMI, a crude measurement of body fat, has a high correlation with waist circumference. Data from 221934 participants in 58 prospective studies reported that BMI, waist circumference, and waist-to-hip ratio have a similar association with the risk of cardiovascular disease. (12)

	AO- NO-	AO- NO+	AO+ NO-	AO+ NO+	p
n	2.188	498	339	962	
Age (years)	38.1 (15)	46.7 (16)	50.3 (15)	52.8 (15)	< 0.001
Women (%)	54	8.5	11	26.5	< 0.001
HT (%)	20.3	38.8	43.7	57.4	< 0.001
Under medication (%)	43.7	59.6	56.7	65	< 0.001
Controlled (%)	49	48.7	50	45.1	ns
SBP (mm Hg)	122 (16)	129 (17)	129 (18)	135 (20)	< 0.001
>DBP (mm Hg)	75 (11)	78 (11)	78 (12)	81 (12)	< 0.001
HR (bpm)	73 (12)	74 (12)	74 (12)	75 (12)	< 0.001

Data are expressed as mean  $\pm$  standard deviation. Data were compared using ANOVA or chi square test, as applicable.

Abdomen	unadjusted OR (95% CI)	OR (95% CI) adjusted for gender and age	Interaction
All	2.27* (2.10-2.45)	1.88* (1.67-2.10)	
Normal abdomen	2.44* (2.17-2.74)	1.67* (1.41-1.99)	
Abdominal obesity (AO)	1.69* (1.48-1.92)	1.17*† (1.14-1.64)	< 0.001

MRS: Myocardial revascularization surgery; ns: non significant

**Table 2.** Characteristics of survey respondents according to the absence or presence of abdominal obesity (AO) and neck obesity (NO)

**Table 3.** Logistic regression analysis to evaluate the risk of hypertension for 1 standard deviation increase in neck circumference (4.68 cm) stratified by the absence or presence of abdominal obesity.

The results of our study reveal that neck circumference is complementary but does not replace waist circumference measurement. Although the variation in neck and waist circumference was concordant in most cases, one of five subjects with normal waist circumference had neck obesity, while one of four subjects with abdominal obesity had normal neck circumference. The greatest diagnostic yield of measuring neck circumference was obtained from subjects with normal abdomen, in whom neck circumference was useful to distinguish between hypertensive and normotensive individuals. However, the prevalence of HT was greater in subjects with combined obesity, indicating that neck obesity had an additive effect.

A recent analysis of the Framingham study cohort reported that neck circumference was associated with all the criteria for metabolic syndrome, even after adjusting for BMI and visceral adipose tissue measured by computed tomography. (13) In this cohort, subjects with increased neck circumference and visceral abdominal tissue had greater risk profile abnormalities, indicating that neck obesity had an independent yet synergistic pathogenic role with regard to visceral obesity.

Slim women had a relatively low prevalence of HT. However, the occurrence of HT was three times greater in obese women and two times greater in obese men. In summary, the presence of HT was more related to obesity in women compared to men. Although the prevalence of NO, by definition, affected one third of women and men, the proportion of women in the subgroup with obesity discordance was low (AO with normal neck and NO with normal abdomen).

There are some limitations to be considered in this study. Firstly, the cross-sectional nature of this study cannot demonstrate causality. Secondly, weight and height were not measured due to operational reasons and consequently no measurements are available on overall obesity. Thirdly, no blood samples were taken to evaluate the other components of the metabolic syndrome. Finally, although BP was measured in a single interview, values were obtained from three readings in print, eliminating operator bias.

## CONCLUSIONS

High neck circumference is associated with a parallel increase in the prevalence of HT. Measurement of neck circumference is especially useful in subjects not considered obese by waist circumference measurement.

## RESUMEN

**Relación entre la circunferencia del cuello y el diagnóstico de hipertensión arterial en el Registro Nacional de Hipertensión Arterial (RENATA)**

### Introducción

La hipertensión arterial (HTA) se asocia con una proporción mayor de grasa corporal. La circunferencia del cuello podría

agregar información clínica adicional a la aportada por otras medidas de grasa corporal.

### Objetivos

Comparar la relación entre la obesidad abdominal y cervical y la hipertensión arterial.

### Métodos

El estudio RENATA encuestó aleatoriamente a 4.006 adultos en siete ciudades (Buenos Aires, Córdoba, Tucumán, Mendoza, Resistencia, Corrientes y Neuquén). De ellos, 3.987 individuos contaron con mediciones de la circunferencia del cuello y de la cintura. La obesidad abdominal (OA) se definió según el ATP III y la obesidad cervical (OC), como el tercil superior de la circunferencia del cuello ( $\geq 35$  cm en mujeres y  $\geq 41$  cm en hombres). Se definió HTA a la medición de valores promedio de presión arterial  $\geq 140$  y/o 90 mm Hg o al consumo de fármacos antihipertensivos.

### Resultados

En el análisis de percentiles, valores de ApoA de 126 y 147 mg/dl se correspondieron con metas recomendadas de HDL-C en hombres y mujeres, respectivamente. El modelo de regresión lineal mostró que 40 y 50 mg/dl de HDL-C se correspondieron con 140 y 158 mg/dl de ApoA en hombres y mujeres, respectivamente.

### Conclusiones

La prevalencia de HTA fue mayor en los sujetos con obesidad en ambas regiones corporales. La asociación entre circunferencia del cuello y prevalencia de HTA fue mayor en sujetos con perímetro abdominal normal.

**Palabras clave >** Obesidad abdominal - Hipertensión arterial

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