

Waist Circumference Above 80 cm Predicts Increased Systolic Blood Pressure in Healthy Young Adult Women

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Abstract

Background: Among anthropometric measures for assessing adiposity-related risk, waist circumference (WC) is simple and fast to perform. Cut-off values for WC proposed by the International Diabetes Federation (IDF), and the Adult Treatment Panel III of the National Cholesterol Education Program (NCEP-ATP III) are categorized by gender and are not age-specific.

Objective: To analyze the association between WC and cardiometabolic risk factors in adult women.

Methods: A total of 164 healthy adult women were grouped by WC according to IDF and NCEP-ATP III cutoff values. Continuous variables were described as mean \pm standard deviation or median (interquartile range). The Shapiro-Wilk test was used to assess the normality of data. Variables were analyzed by unpaired Student's t-test, Mann-Whitney U and Kruskal-Wallis tests. The correlation of WC categories with systolic (SBP) and diastolic (DBP) blood pressure, fasting blood glucose, high-density lipoprotein cholesterol (HDL-c), and triglycerides were examined by Spearman's rho correlation coefficient and linear regression analysis. A p value < 0.05 was considered statistically significant.

Results: Increased WC showed a significant correlation with SBP, DBP, glucose, HDL-c, and triglycerides. In bivariate linear regression, approximately 63.0 % of the variability of SBP (≥ 130 mmHg) among the age group 20-40 years was predicted by increased WC according to both criteria.

Conclusion: A WC above 80 cm in women aged 20-40 years strongly predicted variability in SBP, calling attention to the importance of measuring WC for the monitoring and prevention of cardiovascular and metabolic diseases in women in this age group. (Int J Cardiovasc Sci. 2020; 33(4):340-347)

Keywords: Body Weight and Measures; Anthropometry/instrumentation; Young Adult; Women; Abdominal Circumference; Blood Pressure; Risk Factors.

Introduction

For a long time, several studies have indicated a correlation of waist circumference (WC) with abdominal (subcutaneous and intra-abdominal) fat mass^{1,2} and accumulation of visceral adipose tissue.^{3,4} Subsequent studies have confirmed that WC, a simple measurement, is the best surrogate marker of visceral adiposity.^{5,6} In fact, a panel promoted by the Association for Weight

Management and Obesity Prevention (NAASO), the Obesity Society, the American Society for Nutrition, and the American Diabetes Association has encouraged the use of WC in clinical practice.⁷

It has become evident that WC is more linked to cardiovascular risk factors than body mass index (BMI). A survey assessing 168,000 primary care patients across 63 countries⁸ has demonstrated that BMI, and particularly WC, are strongly associated with cardiovascular disease

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and diabetes mellitus. Similarly, a recent population-based Australian survey with 4,487 women aged 20-69 years has concluded that central obesity measures (mainly WC) are more strongly correlated with cardiovascular risk when compared with measures of general obesity like BMI.⁹

In addition to WC, blood pressure, fasting glucose, HDL-cholesterol, and triglyceride levels have become important allies in clinical practice due to the increasing prevalence of metabolic disorders, such as overweight, obesity, and hypertension. All these risk factors are present in metabolic syndrome (MS), which has become a concern for many health organizations.

Following the World Health Organization (WHO)'s recommendations, the National Cholesterol Education Program Adult Treatment Panel III (NCEP-ATPIII) and the International Diabetes Federation (IDF) have emphasized the importance of fat in the etiology of MS, and WC is a crucial component of MS definition.

In addition, it is interesting to note that the cut-off values for WC proposed by the IDF and NCEP-ATPIII are categorized by gender but are not age-specific, although changes in WC with age have been reported for many years.¹⁰

To address this issue, this study aimed to investigate the relationship between WC and individual components of cardiometabolic diseases and to assess the ability of WC to predict cardiometabolic risk factors across age groups in adult women.

Methods

This observational, cross-sectional study was approved by the Research Ethics Committee of the Federal University of Goiás with protocol number 784.446/2014. The cohort comprised 164 women aged 20-78 years, who responded to an invitation to participate in physical exercise program for women's health, promoted by the university and the municipal administration of the city of Santo Antônio de Goiás (Goiás, Brazil).

A sample size of 164 participants was calculated considering a number of 850 women in this age range (online data published by the *Instituto Brasileiro de Geografia e Estatística*, IBGE¹¹), with a margin of error of 7% and confidence interval of 95%. When the sample was divided into age groups, the margin of error increased to 15%.

The exclusion criteria comprised women younger than 19 years, pregnant women, and women with a diagnosis of infectious or contagious disease, neurological or cognitive deficit, cardiac disease, or hypertension.

Anthropometric and blood pressure measurements

All WC measurements were performed by the same researcher using a flexible, inelastic tape placed directly on the skin, with the participant in a standing position and with abdominal muscles relaxed. WC was measured by placing the measuring tape around the abdomen at a midpoint between the top of the iliac crest and the lowest rib. Blood pressure measurements at rest were obtained with a sphygmomanometer by the same researcher with the patient in the sitting position. Two measurements were obtained from each patient, and average of both measurements was used in the analysis.

Biochemical analysis

Fasting blood was collected before breakfast for measurement of glucose, HDL-cholesterol, and triglycerides. Eight milliliters of blood was collected by venipuncture and aliquoted in two Vacutainer[®] tubes with EDTA (Vacuplast CRAL, São Paulo/Brazil). Samples were conditioned in a refrigerated thermal box and transported in less than one hour to our laboratory to separate plasma by centrifugation. Levels of glucose were measured by the glucose oxidase (GOD) -Trinder and of HDL-cholesterol and triglycerides by glycerol phosphate oxidase (GPO) -Trinder commercial colorimetric methods using an automated analyzer (LabMax 240).

International Diabetes Federation and National Cholesterol Education Program Adult Treatment Panel III cut-off values

Both IDF¹² and NCEP-ATPIII¹³ adopt similar cut-off values for all MS components, with the exception of WC. In order to include both WC cut-off values in our analysis, we divided the participants into two groups: "increased WC," defined by WC \geq 80 cm (IDF) or $>$ 88 cm (NCEP-ATPIII); and "normal WC," defined by WC levels below those mentioned above. Other values considered to be "altered" for the purpose of this study included SBP \geq 130 mmHg, DBP \geq 85 mmHg, fasting glucose \geq 100 mg/dL, triglycerides \geq 150 mg/dL, and HDL-cholesterol $<$ 50 mg/dL according to both IDF and NCEP-ATPIII criteria.

Statistical analysis

Continuous variables with normal distribution are presented as mean \pm standard deviation (SD) and as median and interquartile range (IQR) when data followed a non-normal distribution. Initially, participants were

distributed into two WC categories according to the IDF and NCEP-ATPIII cut-off values. The Shapiro-Wilk test was used to assess the normality of all dependent variables (age, WC, SBP, DBP, serum glucose, HDL-cholesterol, and triglycerides) distributed into the WC categories and age groups. Comparison of data between WC categories were made by unpaired Student's *t* test (with Levene's test for equality of variance) and the Mann-Whitney U-test for data with normal and non-normal distribution, respectively. Values between age groups were compared with Kruskal-Wallis test.

For correlation and regression analyses, WC was the independent variable and SBP, DBP, glucose, HDL-cholesterol, and triglycerides the dependent variables. The strength of the association between WC (categorized as normal or increased) and the variables SBP, DBP, serum glucose, HDL-cholesterol, and triglycerides was measured by Spearman's rho (ρ) correlation coefficient. The size of the correlation coefficient was interpreted according to Mukaka¹⁴ in which the correlation between 0.00 and 0.30 was considered as negligible, 0.30 and 0.50 as low, 0.50 and 0.70 as moderate, 0.70 and 0.90 as high, and 0.90 and 1.00 as very high.

Participants were divided into three age groups: < 40, 40-50, and > 50 years, and correlations between WC and other variables were also assessed according to these groups. Simple and hierarchical linear regression analysis was used to examine the relationship between

increased WC and cardiometabolic risk factors, and to estimate the explained variance (R square, R^2) of these risk factors by WC. First, on simple linear regression analysis, the anthropometric measure (normal and increased WC) was included as an independent variable, and then each variable (SBP, DBP, serum glucose, HDL-cholesterol, and triglycerides) was tested as a dependent variable. All data related to cardiometabolic risk factors were also divided into normal and altered groups according to the IDF and NCEP-ATPIII criteria. On regression studies, all variables were log transformed to meet the requirements of the analysis. A *p* value < 0.05 was considered statistically significant.

Results

The study included 164 participants with a median age of 44.0 years [IQR13.75]. Median [IQR] of WC, SBP, DBP, glucose, HDL-c and triglycerides in the overall cohort was 94.2 [IQR18.5]cm, 127.0 [IQR 20] mm Hg, 81.0 [IQR 14] mm Hg, 86.0 [IQR 18] mg/dL, 48.0 [IQR 13] mg/dL and 117.5 [IQR 68.5] mg/dL, respectively.

Results of the median or mean \pm SD of age, SBP, DBP, glucose, HDL-c and triglycerides values were compared according to WC categories defined by IDF and NCEP-ATP III criteria (Table 1). Compared with normal WC participants, the group with increased WC was older, and showed higher levels of WC, SBP and DBP (all *p* < 0.05). In contrast, levels of glucose, HDL-cholesterol,

Table 1 - Distribution of clinical characteristics of women's participants (n = 164) by WC categories according to IDF and NCEP-ATPIII cutoff points

	IDF		NCEP-ATPIII	
	WC < 80 cm n = 26	WC \geq 80 cm n = 138	WC \leq 88 cm n = 53	WC > 88 cm n = 111
Age (years)	35.11 \pm 10.5	44.6 \pm 10.1*	39.7 \pm 10.8	44.7 \pm 10.3*
WC (cm)	73.3 \pm 4.4	100.4 \pm 14.3*	79.3 \pm 7.0	104.1 \pm 13.5*
SBP (mmHg)	116.0 \pm 10.7	128.7 \pm 15.3 [†]	120.4 \pm 15.2	129.7 \pm 14.4 [†]
DBP (mmHg)	74.7 \pm 8.4	84.9 \pm 11.0*	77.3 \pm 9.4	86.1 \pm 10.9*
Glucose (mg/dL)	93.1 \pm 57.3	90.7 \pm 40.0 [#]	88.9 \pm 42.1	92.1 \pm 43.5
HDL-c (mg/dL)	49.2 \pm 9.4	49.2 \pm 11.2*	50.6 \pm 9.0	48.5 \pm 11.6
Triglycerides (mg/dL)	111.4 \pm 51.6	130.4 \pm 74.5*	115.2 \pm 47.1	133.2 \pm 80.3

Data are expressed as mean \pm SD. WC: waist circumference; SBP: systolic blood pressure; DBP: diastolic blood pressure; HDL-c: high density lipoprotein-cholesterol. [#] *p* < 0.05, compared with normal WC (Student's *t* test), assuming equal variances. * *p* < 0.05, compared with normal WC (Mann-Whitney U test).

and triglycerides showed no difference between the two categories of WC defined by both criteria.

Values of age, SBP, DBP, fasting glucose, HDL-c and triglycerides values in the overall cohort was distributed by age group (Table 2). Significant changes were observed between the three age groups in WC ($p = 0.036$), SBP ($p < 0.001$) and DBP ($p = 0.011$).

Table 3 shows the correlation coefficients of the studied variables with each WC category according to the IDF and NCEP-ATPIII cut-off values. For participants with increased WC, the analysis showed that the WC categorized by IDF criteria had low correlation with DBP ($\rho = 0.425$, $p = 0.000$) and a negligible correlation with SBP, HDL-cholesterol ($\rho = 0.285$, $p < 0.01$; $\rho = -0.270$, $p < 0.001$, respectively). As for the WC defined by the IDF

criteria, we observed a low correlation with SBP, DBP ($\rho = 0.315$, $p = 0.001$; and $\rho = 0.442$, $p = 0.000$, respectively) and a negligible correlation with HDL-cholesterol and triglycerides ($\rho = -0.227$, $p = 0.017$; and $\rho = 0.225$, $p = 0.018$, respectively), by the NCEP-ATPIII criterion.

Bivariate regression analysis showed that for both criteria, IDF and NCEP-ATPIII, only the variability of SBP, DBP, and HDL-cholesterol levels could be explained by increased WC (Table 4). Among them, DBP showed the highest percentage of variability in the age group > 50 years (27% and 30.5%, respectively). A total of 22.7% and 18.4% in the SBP variability was explained by increased WC in participants aged < 40 years, while 9.8% and 8.5% of the variability in HDL-cholesterol levels was explained by increased WC among participants aged 40-50 years.

Table 2 - Distribution and comparison of clinical characteristics between age groups

	Age groups			p-value ^a
	< 40 yrs n = 54	40-50 yrs n = 69	> 50 yrs n = 41	
WC (cm)	91.9 ± 16.7	97.7 ± 17.9	99.0 ± 12.8	0.036
SBP (mmHg)	120.9 ± 13.14	126.4 ± 15.3	134.7 ± 14.9	< 0.001
DBP (mmHg)	80.6 ± 10.6	82.7 ± 10.6	87.7 ± 11.9	0.011
Glucose (mg/dL)	96.8 ± 61.3	88.9 ± 20.7	86.9 ± 41.6	0.077
HDL-c (mg/dL)	47.9 ± 8.5	48.9 ± 10.3	51.3 ± 14.0	0.562
Triglycerides (mg/dL)	126.7 ± 62.3	117.8 ± 63.3	144.5 ± 92.1	0.162

^aKruskal Wallis test.

Table 3 - Spearman's rho correlation coefficients (ρ) between increased waist circumference according to the IDF and NCEP-ATPIII criteria and blood pressure, fasting glucose, lipoprotein levels and triglycerides values

	Total n = 164		IDF				NCEP-ATPIII			
			WC < 80 cm n = 26		WC ≥ 80 cm n = 138		WC ≤ 88 cm n = 53		WC > 88 cm n = 111	
	ρ	p-value	ρ	p-value	ρ	p-value	ρ	p-value	ρ	p-value
SBP (mmHg)	0.411	0.000	0.520	0.006	0.285	0.001	0.406	0.003	0.315	0.001
DBP (mmHg)	0.506	0.000	0.411	0.037	0.425	0.000	0.406	0.003	0.442	0.000
Glucose (mg/dL)	0.184	0.018	0.011	0.957	0.183	0.032	0.09	0.524	0.224	0.018
HDL-c (mg/dL)	-0.213	0.006	0.026	0.901	-0.270	0.001	0.215	0.122	-0.227	0.017
Triglycerides (mg/dL)	0.172	0.028	-0.031	0.879	0.164	0.056	0.059	0.676	0.225	0.018

Table 4 - Bivariate linear regression analysis

Variables	IDF					
	< 40 yrs		40-50 yrs		> 50 yrs	
	R ²	p-value	R ²	p-value	R ²	p-value
SBP	0.227	0.002	0.096	0.016	0.009	0.553
SBP ≥ 130 mmHg	0.638	0.002	0.002	0.826	0.000	0.921
DBP	0.227	0.003	0.147	0.002	0.270	0.001
DBP ≥ 85 mmHg	0.057	0.393	0.145	0.061	0.361	0.003
HDL	0.076	0.093	0.098	0.015	0.054	0.150
HDL-cholesterol < 50 mg/dL	0.031	0.554	0.17	0.014	0.059	0.274
	NCEP-ATPIII					
	< 40 yrs		40-50 yrs		> 50 yrs	
	R ²	p-value	R ²	p-value	R ²	p-value
SBP	0.184	0.023	0.080	0.044	0.084	0.107
SBP ≥ 130 mmHg	0.630	0.011	0.000	0.980	0.063	0.286
DBP	0.212	0.014	0.124	0.011	0.305	0.001
DBP ≥ 85mmHg	0.263	0.025	0.079	0.163	0.359	0.005
HDL	0.028	0.391	0.085	0.038	0.048	0.228
HDL-cholesterol < 50 mg/dL	0.077	0.471	0.180	0.031	0.023	0.525

When dependent variables were categorized according to the cut-off value of each criterion, the percentage of variability of the risk factor in the altered category, explained by increased WC, was always greater than the variability of the non-categorized variable (as observed in Table 4). Thus, increased WC (≥ 80 cm by the IDF or > 88 cm by the NCE-ATPIII) correlated only with three health risk factors – SBP, DBP, and HDL-cholesterol. Increased WC explained 63.8% and 63% of the variability of increased SBP (in women aged < 40 years), 36.1% and 35.9% of that of increased DBP (in women > 50 years), and 17% and 18% of that of altered HDL-c (in women aged 40-50 years), respectively for IDF and NCEP-ATPIII.

Discussion

The women participating in the present study were grouped according to categories of WC based on cut-off values determined by the IDF and NCEP-ATPIII criteria. The purpose of this distribution was to assess the association of WC categories with the following health

risk factors: age and levels of SBP, DBP, HDL-cholesterol, fasting glucose, and triglycerides.

The prevalence of increased WC categorized according to the IDF criteria (≥ 80 cm) was superior to that of increased WC categorized according to the NCEP-ATPIII criteria (> 88 cm): 84% *versus* 68%, respectively. This was already expected, considering the lower cut-off recommended by the IDF compared with the NCEP-ATPIII. Considering that the WC is a crucial criteria for the diagnosis of MS, the higher prevalence of increased WC found in this population of women is concerning.

We also observed that median SBP, DBP, and WC values increased significantly with age. These results are aligned with data from the literature that show a continuous increase in SBP between the ages of 30 and 84 years and over. Although DBP values have a varying pattern with aging, they also increased until the fifth decade.¹⁵ In contrast, increases in WC with increasing age are more difficult to evaluate, since this evaluation require longitudinal studies and repeated measures

analysis, which are uncommon in cross-sectional studies.¹⁶ A 5-year longitudinal cohort study including Australian adults reported an increase in mean WC of 0.46 cm/year.¹⁷ In our study, we observed that, in addition to the increase in mean WC with increasing age, mean WC values were above the normal values in all groups (for both IDF and NCEP-ATPIII criteria), corroborating the high prevalence of increased WC in our study.

In the association analysis, we showed a significant correlation between WC and all risk factors evaluated. The same was also observed with increased WC.

Several studies have reported a relationship between WC and risk factors for cardiovascular disease. A classic study, conducted with 70 women aged 23-50 years, reported that WC correlates moderately with plasma triglycerides and HDL-cholesterol levels and weakly with fasting glucose levels (blood pressure was not evaluated in the study).⁴ Significant correlations between WC and cardiovascular risk factors (HDL-cholesterol, total cholesterol, SBC, and DBP) have also been reported in subjects aged 20-59 years.³

Some authors have reported correlations of WC with indicators of MS. Shen et al.,¹⁸ evaluated 1,010 healthy men and women and found weak but significant correlations between WC and each MS component (SBP, DBP, and serum levels of glucose, TG, HDL-cholesterol, and insulin). Another population-based study published in 2002 by Zhu et al.,¹⁹ including 9,019 American men and women found that WC correlated weakly but significantly with SBP, DBP, and levels of serum LDL-cholesterol, HDL-cholesterol, and plasma glucose.

A substantial limitation of all the studies mentioned above was the lack of WC categorization, as done in our study. Only a few authors have assessed individuals grouped into normal and increased WC categories. For example, Elbassuoni²⁰ reported an association of increased WC with cardiovascular risk factors (SBP, DBP, fasting glucose, triglycerides, and HDL-cholesterol) among 68 pre-menopausal women with a mean age of 32 years. Also, using previous data from a large cohort representative of the US population (US Department of Health and Human Services, National Center) and gender-specific WC cut-off points according to the NIH guidelines, Janssen et al.,²¹ showed that the health risks associated with increased WC (> 102 cm for men and > 88 cm for women) in men were limited to overweight individuals, but in women, the risks affected those with normal weight, overweight, and class 1 obesity. This

finding emphasizes the importance of incorporating WC measurements into clinical practice.

Considering that in the present study the cut-off values for WC in both IDF and NCEP-ATPIII criteria showed correlations with SBP, DBP, and HDL-cholesterol levels, WC values ≥ 80 cm (which would also include those above 88 cm), could potentially be included as a regular measurement in clinical practice.

On regression analysis, we found that increased WC could explain the variability of high SBP (> 60%), high DBP (> 35%) and low HDL-cholesterol levels ($\geq 17\%$) among young adult women. To the best of our knowledge, this is the first study to report such finding.

In 2010, Stevens et al.,¹⁶ pointed out that the inclusion of separate cut-off values by gender was appropriate and that the same is not adequate for age, since the inclusion of age-specific WC cut-off values in adults would require an examination of disease risk and use of different cut-off values for different age groups, compromising the simplicity of this useful health risk indicator.

Limitations of the present study include the small sample size, which does not allow inference of a causal relationship. Future studies with greater sample size should be conducted to confirm our findings.

The results from our study, if confirmed in a larger cohort, emphasize the importance of categorizing WC values by age groups and indicate that two simple measurements – blood pressure and WC – should be performed in young adult women in preventive health programs.

Conclusions

This study showed an association of WC ≥ 80 cm with SBP, DBP, and HDL-cholesterol levels in adult women and is in line with population-based studies aimed at simplifying the identification of health risk factors in daily practice. Additionally, the detection of SBP ≥ 130 mmHg and WC ≥ 80 cm in a young adult women patient should trigger further investigation of health risks factors, particularly cardiometabolic ones.

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Author contributions

Conception and design of the research: Silva GRA, Silva MS, Guillo LA. Acquisition of data: Silva GRA. Analysis and interpretation of the data: Silva GRA, Silva MS, Guillo LA. Statistical analysis: Silva GRA, Guillo LA. Obtaining financing: Silva MS. Writing of the manuscript: Silva GRA, Guillo LA. Critical revision of the manuscript for intellectual content: Silva MS, Guillo LA.

Potential Conflict of Interest

No potential conflict of interest relevant to this article was reported.

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Study Association

This article is part of the thesis of Doctoral submitted by Gilberto Reis Agostinho Silva, from *Universidade Federal de Goiás*.

Ethics approval and consent to participate

This study was approved by the Ethics Committee of the *Universidade Federal de Goiás* under the protocol number 784.446/2014. All the procedures in this study were in accordance with the 1975 Helsinki Declaration, updated in 2013. Informed consent was obtained from all participants included in the study.

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