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# Hypertriglyceridemic waist phenotype: association with metabolic disorders and visceral fat in adults

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**Abstract**

***Objective:*** **To evaluate the association of Hypertriglyceridemic waist with metabolic disorders and visceral fat in adults.**

***Methods:*** **Cross-sectional study with 191 individuals of both sexes. Subjects were grouped according to Waist Circumference (WC) ratings (Men: > 90 cm; Women: > 80 cm) and triglycerides (TG) (> 150 mg/dl) in Group 1 (HTW Phenotype): elevated WC and TG; Group 2 (absence of HTW Phenotype): elevated WC and normal TG or normal WC and elevated TG or normal WC and TG. Metabolic alternations, visceral adipose tissue (VAT) and visceral/subcutaneous fat index (VF/SF) measured by computed tomography were evaluated as cardiovascular risk factors between the groups.**

***Results:*** **Individuals with HTW phenotype, 82% had three or more cardiovascular risk factors. The association between cardiovascular risk factors with HTW phenotype revealed that among men 73.7% had hypercholesterolemia, 94.9% elevated non-HDLc and 78.9% excess of VAT area (p = 0.001). Among women, 65% had elevated Sistolic Blood Plessure, 80% hypercholesterolemia and 90% elevated non-HDLc (p < 0.02).**

***Conclusion:*** **The HTW phenotype associated with the metabolic alternations and VAT excess. Individuals with HTW had higher number of cardiovascular risk factors. The Hypertriglyceridemic waist can be used in clinical practice for investigating cardiovascular risk and visceral adipose tissue in individuals.**

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Key words: *Hypertriglyceridemic waist. Metabolic profile. Visceral adipose tissue. Tomography computed. Cardiovascular diseases.*

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## FENOTIPO CINTURA HIPERTRIGLICERIDÉMICA: RELACIÓN ENTRE CAMBIOS METABÓLICOS Y GRASA VISCERAL EN ADULTOS

**Resumen**

***Objetivo:*** **Evaluar la relación entre Cintura Hipertrigliceridémica (CHT) con cambios metabólicos y grasa visceral en adultos.**

***Métodos:*** **Estudio transversal con 191 personas de ambos sexos. Los participantes fueron agrupados según clasificación de Circunferencia de Cintura (CC) (Hombres: > 90 cm; Mujeres: > 80 cm) y triglicéridos séricos (TG) (>150 mg/dl) en el Grupo 1 (Fenotipo CHT): Elevación en CC y TG; Grupo 2 (ausencia del Fenotipo CHT): Aumento en CC y TG normal, o CC normal y TG elevado o CC y TG normales. Cambios metabólicos, área del tejido adiposo visceral (TAV) y índice de grasa visceral/subcutáneo (GV/GS), medidas por tomografía computadorizada, fueron evaluados como factores de riesgo cardiovascular entre los grupos.**

***Resultados:*** **De los participantes con el Fenotipo CHT, 82% presentaban tres o más factores de riesgo cardiovascular. La relación entre los factores de riesgo cardiovascular y el Fenotipo CHT demostró que entre los hombres 73,7% presentaban hipercolesterolemia, 94,9% no-HDLc elevado y 78,9% exceso de área TAV (p = 0,001). Entre las mujeres, 65% presentaban presión arterial sistólica alta, 80% hipercolesterolemia y 90% no-HDLc elevado (p < 0,02).**

***Conclusión:*** **El Fenotipo CHT se relacionó con cambios metabólicos y exceso de TAV. Personas con CHT presentaron más factores de riesgo cardiovascular. La Cintura Hipertrigliceridémica puede ser utilizada en la práctica clínica para investigar el riesgo cardiovascular y el depósito del tejido adiposo visceral en las personas.**

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Palabras clave: *Cintura hipertrigliceridémica. Perfil metabólico. Tejido adiposo visceral. Enfermedades cardiovasculares.*

## Abbreviations

TG: Triglycerides.
LDLc: LDL Cholesterol.
WC: Waist circumference.
VAT: Visceral adipose tissue.
HTW: Hypertriglyceridemic waist.
CVD: Cardiovascular disease.
UFBA: Universidade Federal da Bahia (Federal University of Bahia).
BMI: Body Mass Index.
SBP: Systolic Blood Plessure.
DBP: Diastolic Blood Plessure.
Non-HDLc: Non-HDL cholesterol.
TC: Total Cholesterol.
HDLc: HDL cholesterol.
Group 1 (HTW Phenotype): elevated WC and TG.
Group 2 (Absence of HTW Phenotype): Elevated WC and normal TG or normal WC and elevated TG or normal WC and TG.
CT: Computerd Tomography.
TAT: Total Adipose Tissue.
SAT: Subcutaneous Adipose Tissue.
VF/SF: visceral fat/subcutaneous fat index.
MS: Metabolic Syndrome.

## Introduction

Hypertriglyceridemia is a factor known as potentially risk for cardiometabolic alterations, since triglycerides level (TG) is a good marker of LDL cholesterol (LDLc) particles size, these potentially atherogenic and components of the metabolic triad (characterized by increased levels of insulin, apolipoprotein B and a predominance of small and dense particles of LDLc)[1-4]. The Waist Circumference (WC) is used as a simple tool to identify individuals with high cardiovascular risk (CV), by its association with visceral adipose tissue (VAT) and concentrations of insulin and Apo B[4-6].

The hypertriglyceridemia and an elevated WC, known as Hypertriglyceridemic Waist (HTW) could represent a simple clinical phenotype to identify individuals with excess visceral adipose tissue. Indeed, the presence of HTW identifies individual characterized by metabolic triad[4,7-9]. On the other hand, little has been revealed whether individuals without the phenotype also express such consequences.

In clinical practice, measurement of the metabolic triad elements and VAT precise quantification, through image methods, presented limitations of use due to the high cost and time spent, on the other hand, HTW is easily obtained and offers possibility of diagnosis in screening and follow-up to identify potentially risk individuals for cardiovascular disease (CVD).

In order to contribute for the adoption of a viable method to estimate accurately the global cardio metabolic risk, the objective of this study was to evaluate the association of hypertriglyceridemic waist with metabolic disorders and visceral fat in adults.

## Methods

### *Sample and Study Design*

Cross-sectional study conducted by the School of Nutrition of the Universidade Federal da Bahia (UFBA) during the first quarter of 2009, conducted by the team of the Center of Studies and Intervention in Aging of UFBA in Salvador, the third largest city of Brazil.

Two-hundred individuals were randomly selected through equal inclusion by sex, age and body mass (estimated by BMI: Body Mass Index), based on the inclusion criteria: age ≥ 20 years and BMI < 40 kg/m$^2$. For this study, 9 individuals were excluded as they have value of TG ≥ 400 mg/dL and individuals with VAT area equal to or lesser than 10cm$^2$, remaining a total of 191 evaluated individuals.

The non-inclusion criteria were: severely malnourished and suffering from dystrophy and neural sequel; patients with amputation or any other physical or postural problem that compromise the verification of anthropometric measurements and abdominal fat; that had recently undergone abdominal surgery, pregnant women or who gave birth during the last six months; patients with abdominal injuries and tumors, hepatomegaly and/or splenomegaly and ascites.

All subjects underwent anthropometric, biochemical and imaging assessments by computed tomography for measurements of abdominal adipose tissue areas.

The measurement of systolic (SBP) and diastolic (DBP) blood pressure followed the technique recommended by the VIth Brazilian Guidelines in Hypertension[10].

### *Anthropometric evaluation-indicator of abdominal fat*

It has been performed by a properly trained staff and consisted in the measurement of WC, collected using tape measure of inelastic synthetic material (TBW Importing Ltda), measured at the midpoint between the lower costal margin and the iliac crest[11], with a reading taken at the time of expiration.

### *Laboratory Evaluation*

The lipid profile and uric acid were measured in serum using a colorimetric system, dry chemistry method using kits manufactured by Ortho-Clinical Diagnostics®, collected in a private laboratory, with patients in a 12-hour overnight fast. The LDLc value was measured by the Friedewald[12] equation and the non-HDL cholesterol value (non-HDLc) was obtained by calculating the difference between total cholesterol (TC) and HDL cholesterol (HDLc)[3].

*Ratings of waist circumference, triglyceride level, the hypertriglyceridemic waist phenotype (HTW phenotype)*

The WC was classified according to criteria suggested by the International Diabetes Federation (IDF)[13] for the South-American ethnic groups, being considered high when > 80 cm for females. For TG classification, it was considered high when the serum level > 150 mg/dL[3,13]. Thus, subjects were stratified in 2 groups: Group 1 (HTW Phenotype): elevated WC and TG; Group 2 (Absence of HTW Phenotype): Elevated WC and normal TG or normal WC and elevated TG or normal WC and TG.

*CT scans- an indicator of visceral adipose tissue*

Computed tomography was performed in the Department of Radiology of the University Hospital of the UFBA and analyzed by a radiologist. To perform the exam it was necessary to complete the 4-hours fasting, with the subject in supine position and the arms extended overhead. No barium or organoiodine contrast medium were administered.

A single CT cut was taken at the level of L4-L5 vertebrae for delineation of total adipose tissue (TAT), visceral (VAT) and subcutaneous (SAT) areas. With the free electronic cursor, the external edges that limit the abdominal circumference were delimited, and the total abdominal area calculated. Then, the visceral abdominal area was delimited through the abdominal cavity marking; using as limits the muscles of the rectus abdominis, internal oblique and square lumbar[14]. The tomography program was used with X-ray CT scanner parameters 140 kV and 45 mA; being used the density of -50 and -150 Hounsfields units for the identification of adipose tissue.

*Cardiovascular risk factors*

The following metabolic alternations and in the visceral fat area were considered as cardiovascular risk factors, according to criteria already established in the literature[3,13,15,16]: SBP > 120 mmHg; DBP > 80 mmHg; TC > 200 mg/dl; LDLc > 160 mg/dl; HDLc < 40 mg/dL for men and < 50 mg/dL for women, non-HDL-C > 130 mg/dl, uric acid > 8.5 mg/dl for men and > 6.2 mg/dl for women; VAT area > 130 $cm^2$; visceral fat/subcutaneous fat index (VF/SF) > 0.4. For analysis of cardiovascular risk factors the number of metabolic alternations that individuals presented was considered, being categorized into: no factor, 1-2 factors, 3-4 factors and > 5 risk factors for development of CVD.

*Statistical analysis*

Analyses were performed with the Statistical Package for Social Science (SPSS), version 16.0. In order to characterize the study population, the variables were expressed by descriptive analysis of data, with the frequency distribution, calculation of central tendency and dispersion, analyzes stratified according to the sex and HTW Phenotype classification (Group 1 and 2). The coefficient of variation was calculated to assess inter and intra examiner variability of anthropometric measures (Inter-class coefficient > 0.90). Data normality was verified by the Kolmogorov-Smirnov's test for all the analyzed variables. The *t-student's* test has been used for independent samples, to compare the mean results of the variables of normal distribution and the *chi-square* test to verify the existence of an association between the number of cardiovascular risk factors and the presence and absence of HTW Phenotype. The significance level was less than 5%.

*Ethic Aspects*

This study was approved by the Ethic Committee (Committee of Ethics in Research of the Federal University of Bahia, School of Nutrition - CEPNUT/UFBA), declaration number 01/09, and all participants provided their written informed consent to participate in this study, after approval of the process by the ethics committee.

## Results

The study included 191 individuals, of both sexes, aged between 21 and 95 years old. Among the participants, women had a higher percentage of elevated WC (74.2% *versus* 52.1% in men, p = 0.002). Hypertriglyceridemia was present in 28.7% and 25.8% of men and women, respectively, with no statistically significant difference. HTW Phenotype was similar between both sexes (men - 20.2% and women - 20.6%; p > 0.05). Men had higher means of uric acid, VAT area, VF/SF index and WC than women (p<0.01) (data not shown).

The analysis comparing the means of variables considering cardiovascular risk factors between groups 1 and 2 (table I) showed that, for both sexes, individuals with HTW phenotype (Group 1) showed higher means (p < 0.01). Among men, the mean values of TC (223.9 mg/dl), non-HDLc (182.6 mg/dl) and VAT area (187.2 $cm^2$) were higher than the cut-offs points established in the literature. Among women, the same was observed for SBP (130.0 mmHg), TC (240.2 mg/dl), LDLc (151 mg/dl), non-HDLc (190.9 mg/dl) and VAT area (133.7 $cm^2$).

In figure 1 the cardiovascular risk factors frequency was presented among individuals with or without HTW phenotype. It was observed that among individuals with HTW phenotype (Group 1), 82% had three or more cardiovascular risk factors, 53.8% had 3-4 risk

**Table I**
*Comparison between means of metabolic risk factors in the presence and absence of HTW Phenotype, by gender*

| | *Men* | | |
|---|---|---|---|
| | *Group 1* | *Group 2* | *p-value* |
| SBP | 133.2 (20.8) | 127.3 (17.9) | 0.225 |
| DBP | 84.7 (12.6) | 80.5 (13.4) | 0.221 |
| TC | 223.9 (31.1) | 188.2 (36.1) | 0.000 |
| LDLc | 139.3 (28.1) | 117.5 (32.3) | 0.008 |
| HDLc | 41.3 (5.5) | 49.7 (12.9) | 0.001 |
| Non-HDL | 182.6 (30.0) | 138.4 (37.4) | 0.000 |
| Uric Acid | 6.6 (0.9) | 5.4 (1.2) | 0.000 |
| TAT | 736.4 (109.5) | 582.5 (151.3) | 0.000 |
| VAT | 187.2 (62.0) | 112.3 (77.3) | 0.000 |
| SAT | 549.2 (100.9) | 470.3 (98.1) | 0.002 |
| Rate VF/SF | 0.35 (0.12) | 0.23 (0.14) | 0.001 |
| | *Women* | | |
| | *Group 1* | *Group 2* | *p-value* |
| SBP | 135.0 (23.3) | 122.2 (13.4) | 0.002 |
| DBP | 82.0 (12.4) | 78.9 (8.2) | 0.182 |
| TC | 240.2 (68.9) | 203.5 (41.1) | 0.003 |
| LDLc | 151.5 (70.6) | 123.2 (38.0) | 0.017 |
| HDLc | 49.3 (9.7) | 60.2 (14.6) | 0.002 |
| Non-HDL | 190.9 (70.8) | 143.2 (42.5) | 0.000 |
| Uric Acid | 5.8 (1.4) | 4.2 (0.9) | 0.000 |
| TAT | 684.5 (119.6) | 592.4 (155.2) | 0.015 |
| VAT | 133.7 (40.6) | 88.3 (51.6) | 0.000 |
| SAT | 550.8 (95.8) | 504.2 (128.6) | 0.133 |
| Rate VF/SF | 0.24 (0.07) | 0.18 (0.10) | 0.001 |

Data presented in Mean (Standard Deviation).
Group 1 (HTW Phenotype):Elevated WC and TG; Group 2 (Absence of HTW Phenotype): elevated WC and normal TG or normal WC and elevated TG or normal WC and TG.
* Independent Samples *t-test*
SBP: Systolic Blood Pressure (mmHg); DBP: Diastolic Blood Pressure (mmHg); TC: Total Cholesterol (mg/dL); LDL: Low Density Lipoprotein (mg/dL); HDL: High Density Lipoprotein (mg/dL); TG: Triglycerides (mg/dL); TAT: Total area of Adipose Tissue (cm²); VAT: Total area of Visceral Tissue (cm²); SAT: Total area of Subcutaneous Tissue (cm²); VF/SF: Visceral Fat/Subcutaneous Fat index.

factors and 28.2% had five or more risk factors. While from individuals without the HTW phenotype (Group 2), 37.5% had 3 or more risk factors, and 7.2% had five or more risk factors, with statistically significant difference between groups ($p < 0.000$).

The association between cardiovascular risk factors with the HTW phenotype showed high percentage of individuals, of both sexes, having changes of cardiovascular risk factors (table II). Among men with the phenotype, 73.7% had hypercholesterolemia, 94.9% high non-HDLc and 78.9% excess VAT area, when compared with men without the phenotype ($p < 0.01$). Among women with the phenotype, 65% had elevated SBP, 80% hypercholesterolemia and 90% high non-HDLc ($p < 0.02$).

## Discussion

HTW phenotype, the indicator used in this study, had an association with metabolic alternations and VAT excess, which are cardiovascular risk factors, in men and women. There are few researches on this topic using computed tomography as an imaging method for quantification of VAT, which underscores the relevance of this study.

In the present study, the HTW phenotype prevalence was 20.2% in men and 20.6% in women, this data agrees with other studies conducted with adults of both sexes, with the prevalence ranging from 12.7% to 36.5%[2,17-19]. It is noteworthy that studies in Brazil are scarce, with a prevalence of HTW ranging from 4.5% to 33%[20-22]. Note that variations in prevalence may be due to the use of different cut-offs for WC and serum TG levels, as well as ethnic differences and use of hypolipidemic.

For both sexes, individuals with HTW phenotype (Group 1) had higher means for metabolic variables and adipose tissue area ($p < 0.01$), with mean values higher than the cutoffs points established in literature. This result was similar to that demonstrated by Sam et

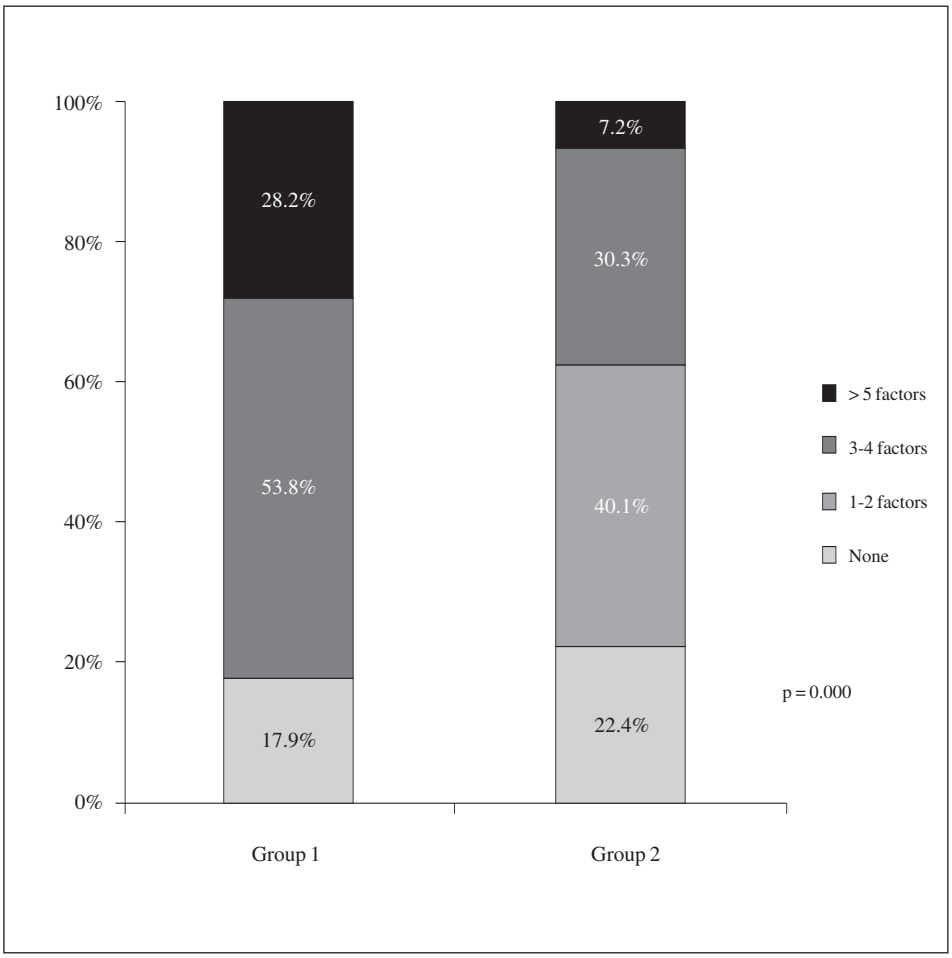


*Fig. 1.—Frequency of cardiovascular risk factors according to the presence and absence of HTW Phenotype. Group 1 (HTW Phenotype): Elevated WC and TG; Group 2 (Absence of HTW Phenotype): elevated WC and normal TG or normal WC and elevated TG or normal WC and TG.*

al.[7] who found statistically significant difference in the means of components of the lipid profile and adipose tissue volume among different groups of classification on WC and TG of individuals with type 2 diabetes, so that those ones with HTW had higher mean.

Blackburn et al.[23], compared the HTW ability in relation to the National Cholesterol Education Program-Adult Treatment Panel III (NCEP-ATP III) in predicting the CVD risk in women (32-82 years) and Solati et al. [24], analyzing cardiovascular risk factors in men (18 to 70 years old) with HTW, also found similar results, although these authors had developed the study only with female and male subjects, respectively, and using other parameters and criteria of cardiovascular risk factors classification. These results show that the metabolic profile of individuals with HTW phenotype predispose the development of metabolic syndrome (MS) and increased cardiovascular risk.

Solati et al.[24] observed that 75% of individuals with WC and high TG had four or more cardiovascular risk factors. In the present study it has been observed that 82% of individuals in Group 1 had three or more cardiovascular risk factors, thus, highlighting the importance of the simultaneous analysis of WC and TG in clinical nutritional screening of individuals at risk for developing cardiovascular and metabolic alternations.

Most evaluated risk factors in the present study are part of the MS and when the percentage of individuals that had alternations in these risk factors has been analyzed, it was observed that most individuals who possessed the HTW phenotype had significant changes in lipid profile (especially TC and non-HDLc) and VAT area, with a percentage higher than 70% for men and women ($p < 0.01$).

Hypercholesterolemia and its association with HTW has also been observed in other studies, as in the one performed by Tankó et al.[25], which found that 76.1% of individuals with HTW had hypercholesterolemia ($p < 0.01$). In other studies, also performed in Brazil, there was a percentage ranging from 64.3% and 80.6% of the studied population with high levels of CT with significant association with HTW[20,21].

Non-HDL cholesterol is composed of potentially atherogenic lipoproteins rich in TG, making it a good TG predictor of the "worst" profile and is therefore associated with the VAT excess and increased cardiovascular risk[26]. This result is similar to the one found by Bos et al.[27] who found that the risk associated with HTW increased in 50% in the presence of

**Table II**
*Association between metabolic alterations and visceral adipose tissue with HTW phenotype by gender*

| | *Men* | | |
|---|---|---|---|
| | *Group 1* | *Group 2* | *p-value* |
| SBP > 120 mmHg | 12 (63.2) | 32 (42.7) | 0.110 |
| DBP > 80 mmHg | 7 (36.8) | 17 (22.7) | 0.243 |
| TC ≥ 200 mg/dl | 14 (73.7) | 22 (29.3) | 0.011 |
| LDL ≥ 160 mg/dl | 3 (15.8) | 8 (10.7) | 0.689 |
| HDL < 40 mg/dl | 11 (57.9) | 17 (22.7) | 0.005 |
| Non-HDL > 130mg/dl | 18 (94.7) | 44 (58.7) | 0.002 |
| Uric acid ≥ 8.5 mg/dl | 0 (0.0) | 3 (4.0) | 1.000 |
| VAT ≥ 130 cm² | 15 (78.9) | 27 (36.0) | 0.001 |
| VF/SF ≥ 0.4 | 7 (36.8) | 12 (16.0) | 0.043 |
| | *Women* | | |
| | *Group 1* | *Group 2* | *p-value* |
| SBP > 120 mmHg | 13 (65.0) | 26 (33.8) | 0.020 |
| DBP > 80 mmHg | 6 (30.0) | 14 (18.2) | 0.351 |
| TC ≥ 200 mg/dl | 16 (80.0) | 36 (46.9) | 0.001 |
| LDL ≥ 160 mg/dl | 6 (30.0) | 14 (18.2) | 0.351 |
| HDL < 50 mg/dl | 9 (45.0) | 21 (23.7) | 0.174 |
| Non-HDL > 130mg/dl | 18 (90.0) | 44 (57.1) | 0.008 |
| Uric acid ≥ 6.2 mg/dl | 6 (30.0) | 2 (2.6) | 0.001 |
| VAT ≥ 130 cm² | 9 (45.0) | 18 (23.4) | 0.090 |
| VF/SF ≥ 0.4 | 0 (0.0) | 2 (2.6) | 1.000 |

Data presented in Absolute Value (Frequency)
Group 1 (HTW Phenotype):Elevated WC and TG; Group 2 (Absence of HTW Phenotype): elevated WC and normal TG or normal WC and elevated TG or normal WC and TG.
*Chi-Square Test
SBP: Systolic Blood Pressure (mmHg); DBP: Diastolic Blood Pressure (mmHg); TC: Total Cholesterol (mg/dL); LDL: Low Density Lipoprotein (mg/dL); HDL: High Density Lipoprotein (mg/dL); VAT: Total area of Visceral Tissue ($cm^2$); VF/SF: Visceral Fat/Subcutaneous Fat index.

high concentrations of non-HDLc, for men and women ($p < 0.05$).

Solati et al.[24] also observed a higher percentage of metabolic changes in individuals with characteristics similar to the present study, however different cut-off points were used for the analyzed biochemical variables.

In the same way that the present study did, other authors[7,28,29] demonstrated an association between the VAT and the presence of HTW phenotype, which confirms the principle of HTW in identifying viscerally obese subjects, with metabolic alternations and with the risk of developing CDV.

Individuals with high WC not always had excess in VAT or high cardiovascular risk, because the accumulation of adipose tissue can be subcutaneous. Data presented here corroborates with scientific literature when describing high serum levels of TG as a marker for a variety of atherogenic lipoprotein disorders and insulin resistance[2,4,28], especially when associated with high WC, strengthen the use of HTW as a global cardio metabolic risk.

The hypertriglyceridemic waist has a low cost, thus making it an available and easily applicable indicator in clinical practice. Thus, WC and TG standardization for acceptable values brings positive and beneficial effects on cardio metabolic risk factors.

The use of HTW can be useful for health professionals to identify individuals with high cardiovascular risk who may benefit from early intervention. Therefore, further researches should be conducted, whether of epidemiological studies, so that larger samples can be analyzed in order to assess the HTW.

## Potential Conflict of Interest

No potential conflict of interest relevant.


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