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Waist-to-height ratio (WHtR) and triglyceride to HDL-c ratio (TG/HDL-c) as predictors of cardiometabolic risk

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Abstract

Introduction: **The excessive concentration of fat in the abdominal region is related to a higher risk of developing cardiovascular disease (CVD). Studies have been performed to identify simple and effective indicators of abdominal obesity and associated cardiometabolic risk through the use of simple parameters such as anthropometric and biochemical measures. The Triglyceride / High-density Lipoprotein Cholesterol (TG/HDL-c) has been proposed as a more practical and easy to use atherogenic marker, along with the Waist-to-Height Ratio (WHtR), which makes a superior tool for separating cardiometabolic risk related to overweight/obesity when comparing to Body Mass Index (BMI).**

Objective: **To verify the applicability of the WHtR and the TG/HDL-c ratio as predictors of cardiometabolic risk.**

Methods: **This cross-sectional study was performed at the Department of Nutrition of the UNIVATES University Center, where the participant's anthropometric and biochemical data were collected. Statistical analysis was performed by the *Statistical Package for the Social Sciences* software (SPSS) 20.0, with a significance level of 5% ($p < 0.05$).**

Results: **A total of 498 individuals took part on this research, 77.5% female and with a mean age of 25.5±6.5. A high percentage of fat was found in both men and women (19.9 ±5.80% and 29.24±5.43%, respectively). The prevalence of overweight/obesity (BMI ≥ 25Kg/m²) was 35.05%. The WHtR marker was significantly correlated to Low-density Lipoprotein Cholesterol (LDL-c), Triglyceride (TG) and Anthropometric BMI values, waist circumference (WC) and body fat percentage (BF%). For the TG/HDL-c ratio, there was a positive and significant correlation to the same markers, beyond TC. There was also a correlation between WHtR and TG/HDL-c, and**

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RAZÓN CINTURA-ESTATURA (RCA) Y LOS TRIGLICÉRIDOS EN COMPARACIÓN CON EL HDL-C (TG / HDL-C): COMO PREDICTORES DE RIESGO CARDIOMETABÓLICO

Resumen

Introducción: **La concentración excesiva de grasa en la región abdominal se relaciona con un mayor riesgo de desarrollar enfermedad cardiovascular (ECV). Se han realizado estudios para identificar los indicadores simples y eficaces de la obesidad abdominal y el riesgo cardiometabólico asociados con el uso de parámetros simples, como las medidas antropométricas y bioquímicas. El / alta densidad de colesterol de lipoproteínas de triglicéridos (TG / HDL-c) se ha propuesto como un enfoque más práctico y fácil de usar marcador aterogénico, junto con la relación cintura-estatura (RCEst), lo que hace que una herramienta superior para separar cardiometabólico riesgos relacionados con el sobrepeso / obesidad cuando se compara con el índice de masa corporal (IMC).**

Objetivo: **Verificar la aplicabilidad de la RCEst y la relación TG / HDL-c como predictores de riesgo cardiometabólico.**

Métodos: **Este estudio transversal se llevó a cabo en el Departamento de Nutrición del Centro Universitario UNIVATES, donde se recogieron datos antropométricos y bioquímicos de los participantes. El análisis estadístico se realizó mediante el paquete estadístico para el software de Ciencias Sociales (SPSS) 20,0, con un nivel de significación del 5% (p <0,05).**

Resultados: **Un total de 498 personas participaron en esta investigación, el 77,5% de mujeres y con una edad media de 25,5 ± 6,5. Un alto porcentaje de grasa se encuentra en hombres y mujeres (19,9 ± 5,80% y 29,24 ± 5,43%, respectivamente). La prevalencia de sobrepeso / obesidad (IMC ≥ 25 kg / m²) fue 35,05%. El marcador RCEst se correlacionó significativamente con baja densidad de colesterol de lipoproteínas (LDL-c), triglicéridos (TG) y antropométricos IMC valores, la circunferencia de la cintura (CC) y el porcentaje de grasa corporal (% GC). Para la relación TG / HDL-c, hubo una correla-**

both presented a negative and significant correlation with HDL-c.

Conclusion: **WHtR and TG/HDL-c values were found to be good markers for the cardiometabolic risk ratio in the studied sample. Several studies, original articles and academic reviews confirm the use of the WHtR or TG/HDL-c markers for that purpose in adults.**

Key-words: **Waist-to-Heigth Ratio (WHtR); Triglyceride/High-density-lipoprotein Cholesterol (TG/HDL-c) Ratio; Cardiometabolic Risk.**

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Key words: *Body composition. Nutritional status. Body weight and measures.*

ción positiva y significativa para los mismos marcadores, más allá de TC. También hubo una correlación entre la RCEst y TG / HDL-c, y ambos presentaron una correlación negativa y significativa con el HDL-c.

Conclusión: **No se encontraron valores RCEst y TG / HDL-c para ser buenos marcadores de la razón de riesgo cardiometabólico en la muestra estudiada. Varios estudios, artículos originales y revisiones académicas confirman el uso de la RCEst o marcadores TG / HDL-c para tal fin en los adultos.**

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Palabras clave: *La composición corporal. El estado nutricional. El peso corporal y medidas.*

Abbreviations

AMI: Acute Myocardial Infarction
BF%: Body Fat Percentage
BMI: Body Mass Index
WC: Waist Circumference
CVD: Cardiovascular Disease
TC: Total Cholesterol
DEXA: Dual-energy X-rayabsorptiometry
DM2: Diabetes mellitus Type 2
HDL-c: High-density Lipoprotein Cholesterol
IBGE: Instituto Brasileiro de Geografia e Estatística, Brazilian Institute for Geography and Statistics
LDL-c: Low-density Lipoprotein Cholesterol
MS: Metabolic Syndrome
TG: Triglycerides
TG/HDC-c: Triglyceride and HDL-c Ratio
WHtR: Waist-to-Height Ratio
WHR: Waist-to-Hip Ratio

Introduction

The excessive concentration of fat in the abdominal region is related to the presence of metabolic changes caused by obesity, such as an increase in insulin resistance, hypertriglyceridemia, low levels of H*igh-density Lipoprotein* C*holesterol* (HDL-c), and blood pressure changes directly related to a higher risk of cardiovascular disease.[1,2,3]

Approximately 2.8 million people die every year due do diseases caused by overweight or obesity. The epidemiologic data concerning cardiovascular disease (CVD) accounted for, until 2010, around 16.7 million deaths per year around the world. In Brazil as well as in the rest of the world, CVD accounts for more that 30.0% of adult deaths.[4,5]

According to a survey performed by the Brazilian Institute for Geography and Statistic (*Instituto Brasileiro de Geografia e Estatística*, IBGE)[6] about anthropometrics and nutritional status in all of the Brazilian territory, approximately 56 thousand homes were analyzed between 2008 and 2009, a percentage 49.05% overweight and 14.65% obese people was established for both genders for a population over 20 years.

There are established parameters for measuring abdominal fat, such as the gold standard Dual-energy X-rayabsorptiometry (DEXA), as well as Computed Tomography or Magnetic Resonance. Due to the cost of such equipment, the lack of availability and the sophistication of these methods, their use for epidemiologic studies or even for clinical practice is not viable, a number of times.[1,7]

Some studies use validated scores to estimate the degree of risk of cardiovascular events, such as the Framingham Score and HeartSCORE. However, specific data are needed, such as biochemical data, blood pressure values and lifestyle information for the calculations.[8]

Anthropometric measures such as weight, height and circumferences are often used in clinical practice due to their low cost and high convenience, and also as tools of cardiovascular risk screening using abdominal fat markers such as Waist Circumference (WC), Waist-to-Hip Ratio (WHR), and Body Fat Percentage (%BF).[1]

However, one marker for abdominal fat has been supported as a superior tool in the evaluation of Cardiometabolic Risk, Waist-to-Height Ratio (WHtR), for it has shown specificity and sensitivity to the factors of cardiovascular risk, as well as limitations of other markers through the inclusion of height in the index and the adequacy to different ethnicities.[7,9,10,11]

The use of an index determined through the lipid profile of the patient has demonstrated a strong correlation with cardiovascular risk: the triglyceride/HDL-c ratio (TG/HDL-c),[12,13,14] AIM strongly predicts risk of acute myocardial infarction (IAM)[15] and has been proposed as a more practical and easy to use atherogenic marker.[16]

Objective

Within this perspective, through the combination of two simple and low-cost measurements that can be used in the clinical practice to evaluate and monitor cardiovascular risk in young adults, the objective of the present study is to verify of WHtR and TG/HDL-c as predictors of cardiometabolic risk in a population of young adults.

Methods

The study was performed in the Department of Nutrition of the Centro Universitário Univates of Lajeado, Rio Grande do Sul, Brazil, following approval by the Committee of Ethics of the Institution (COEP/Univates), accredited by the National Counsel of Health, under the protocol 110/11. It is a cross-sectional study, with a sample made of academics and public workers, patients of the Ambulatory of Nutrition of the Institution, totaling 498 individuals. The data was collected between April, 2012 and March, 2014. Participants were included by signing a written informed consent, and were forwarded to the Department of Nutrition of the Institution for nutritional assessment.

The collection of data was made through anamnesis and assessing of anthropometric measures. At the same time, participants were referred to blood work, after an 8-12h fast, and to a bioimpedance exam, both performed in scheduled dates.

Weight and height measurements were takeng according to the original technique recommended by Lohman *et al.* [17]

Weight was measured with an anthropometric platform-like scale, with an attached *Welmy*® stadiometer with a maximum capacity of 150 kg and 100 g divisions. Height was measured with the stadiometer attached to the anthropometric *Welmy*® scale. Nutritional status classification was performed by the body mass index (BMI), according to the values indicated by the World Health Organization (WHO).[18]

Waist circumference (WC) was measured with a CESCORF inextensible metric tape with 1 mm precision, at the natural waist level, the mid point between the superior anterior iliac crest and the last rib, with precision of 0.1 cm. The reference values were established by the WHO, < 80 cm for females and < 94 cm for males.[19]

The measurement of the circumference of the waist belt was performed by three researchers trained always observing the same locations to measure

To verify the body fat percentage (BF%), each individual underwent an tetrapolar bioimpedance exam in a BIODYNAMICS® device MODEL 310. The reference for fat percentage was Pollock and Wilmore,[20] ideal between 23 and 25% for females and 14 to 16% for males, at the sampled age.

For the WHtR, the cut point used for defining abdominal obesity was ≥ 0.5 for both genders. The WHtR is a unique and stable measure because it is adjusted by height, and does not depend on gender, age, or ethnicity.[21]

The dosages for the lipid profile were counted according to the protocol of the commercial Bioclin® kit using Mindray BS120 equipment in the Clinical Analysis Laboratory of the Institution, by the colorimetric enzymatic method, and the readings were performed in an automated device.Through an enzymatic test, Total Cholesterol (TC), High-density lipoprotein Cholesterol (HDL-c), and Triglycerides (TG) were determined. The concentration of Low-density Lipoprotein Cholesterol (LDL-c) was determined according to the Friedwald formula: LDL-c = CT- HDL-c - (TG/5).

The criteria for abnormality used for the lipid profile values were those defined by the dosage kits and the V Brazilian Guidelines on Dyslipidemia and Atherosclerosis[22]: CT ≥ 200 mg/dl; HDL-c ≤ 60 mg/dl; LDL-c ≥ 100 mg/dl; and TG ≥ 150 mg/dl. TG/HDL-c was obtained from the TG and HDL-c values, according to the previously stablished equation, considering as CVD risk when TG/HDL-c ≥ 3.88.[13]

The statistical analysis was performed through Spearman's correlation coefficient to test non-parametric variables and Pearson's correlation coefficient to test parametric variables. The ANOVA test was used to check nutritional status between lipid profile and anthropometric indexes. The data were analyzed in the Statistical Package for the Social Sciences 20.0 software (SPSS Inc., Chicago, IL, USA), and results were considered significant when $p < 0.05$ (5%).

Results

Of the 498 individuals which took part on this research, 77.5% were female and the mean age was 25.5±6.5.

Table I shows the means and standard deviation (SD) of the anthropometric and biochemical characteristics of the sample, according to sex.

As for nutritional status, 60.22% of the individuals were eutrophic, 25.38% were overweight, 9.67% were in one of the three degrees of obesity, and 4.73% were underweight.

The analyzed sample showed a high percentage of fat in both men and women (19.9 ±5.80% and 29.24±5.43%, respectively), deviating from the ideal mean.

The biochemical values found were within the parameters of normality. However, the mean value found for HDL-c in males was 50.49 mg/dl, bellow the reference value.

In comparing the parameters of the lipid and anthropometric profile and nutritional status, we observed that the individuals classified as overweight/obese displayed significantly lower values of HDL-c ($p < 0.000$) than the other individuals, as well as significantly higher values for TG ($p < 0.0001$), WHtR ($p < 0.001$), TG/HDL-c ($p < 0.001$), WC ($p < 0.001$), and BF% ($p < 0.001$).

Tables II and III displays an analysis of the correlation between the lipid and anthropometric profile parameters. It can be observed that both **WHtR** and **TG/HDL-c** presented positive and significant correlations with the anthropometric and biochemical variables.

Table I
Description of the sample in relation to anthropometric and lipid profiles

	Males			*Females*		
	N	*Mean*	*SD*	*N*	*Mean*	*SD*
BMI	112	25.38	3.92	384	23.87	4.15
WC	108	84.15	9.73	374	73.45	8.96
WHtR	108	0.47	0.05	375	0.44	0.06
BF%	114	19.90	5.80	392	29.24	5.43
TC	107	166.66	38.51	364	177.36	39.52
HLD-c	107	50.49	12.50	364	63.66	15.79
LDL-c	107	98.03	33.67	364	94.43	32.35
TG	107	92.92	53.26	364	98.41	45.96
TG/HDL-c	107	1.98	1.30	364	1.63	0.86

BMI = body mass index (kg/m²); WC = waist circumference (cm); WHtR = waist-to-height ratio; BF% = body fat percentage (%); TC = total cholesterol (mg/dl); HDL-c = high-density lipoprotein cholesterol (mg/dl); LDL-c = low-density lipoprotein cholesterol (mg/dl); TG = triglyceride (mg/dl); TG/HDL-c = triglyceride and HDL-c ratio; SD = standard deviation.

Analyzing the correlation of WHtR with the other anthropometric variables, we observed a positive significant correlation between: BMI (r = 0.859, p < 0.001), WC (r = 0.907, p < 0.001) and BF% (r = 0.435, p < 0.001); there was also a positive significant correlation between WHtR and biochemical variables (lipid profile): LDL-c (r = 0.165, p < 0.001) and TG (r = 0.144, p = 0.002).

TG/HDL-c showed a positive significant correlation between the following biochemical variables: **TC** (r = 0.169, p < 0.001), LDL-c (r = 0.235, p < 0.001),TG (r = 0.830, p < 0.001); and anthropometrical: BMI (r = 0.259, p < 0.001), WC (r = 0.239, p < 0.001), BF% (r = 0.150, p = 0.001); and

We observed a significant and **inverse correlation** of **HDL-c** for both **WHtR** (r= -0.244 , p < 0.001) and **TG/HDL-c** (r= -0.481, p < 0.001).

There was also a positive significant correlation between the **WHtR** and **TG/HDL-c** (r = 0.260, p < 0.001) indicators.

Discussion

In regards to the anthropometric and biochemical characteristics of the sample, the prevalence of overweight/obesity was of 35.06%, and the mean values of fat percentage were high for both males and females. As for the lipid profile, the mean HDL-c levels found in males were below the recommended values. A cross-sectional study performed at the University of Guadalajara evaluated the prevalence of overweight/obesity and lipid profile alterations in university students. Of the 620 individuals evaluated, approximately

Table II
Analysis of the correlation between the parameters of anthropometric and lipid profiles

	TC		*HDL-c*		*LDL-c*		*TG*		*WHtR*		*TG/HDL-c*	
	r	*p*	*r*	*p*	*r*	*p*	*r*	*p*	*r*	*p*	*r*	*p*
WHtR	0.082	0.079	-0.244	***<0.001***	0.165	***<0.001***	0.144	***0.002***	-	-	0.260	***<0.001***
TG/HDL-c	0.169	***<0.001***	-0.481	***<0.001***	0.235	***<0.001***	0.830	***<0.001***	0.260	***<0.001***	-	-
BMI	0.046	0.321	-0.240	***<0.001***	0.113	***0.014***	0.154	***0.001***	0.859	***<0.001***	0.259	***<0.001***
WC	0.020	0.663	-0.294	***<0.001***	0.124	***0.008***	0.088	0.060	0.907	***<0.001***	0.239	***<0.001***
BF%	0.180	***<0.001***	0.088	0.057	0.108	***0.018***	0.227	***<0.000***	0.435	***<0.001***	0.150	***0.001***

r = correlation coefficient; Intensity of correlation = low (0-0.3), regular (0.3-0.6), strong (0.6-0.9), and very strong (0.9-1.0); values in **bold** and ***italic*** represent significant values; WHtR= waist-to-height ratio; TG/HDL-c= triglyceride and HDL-c ratio; BMI= body mass index (kg/m²); WC= waist circumference (cm); BF%= body fat percentage (%); TC= total cholesterol (mg/dl); HDL-c = high-density lipoprotein cholesterol (mg/dl); LDL-c = low-density lipoprotein cholesterol (mg/dl); and TG= triglycerides (mg/dl). Pearson's correlation test (parametric variables) or Spearman's correlation (non-parametric variables) for the correlation between variables, considering significance when p < 0.05 (5%).

a third was overweight or obese, and the males also showed higher BMIs and lower plasmatic levels of HDL-c.[23]

Lianping He *et al.*[24] performed a cross-sectional study between 2004 and 2010 with 9,979 individuals of a university with the objective of estimating the prevalence of overweight and obesity. Using references from China and from the WHO, the prevalence found was 36.1% overweight and 25.5% obesity.

When classifying individuals regarding their nutritional status, we found that individuals who are overweight or obese show lower HDL-c levels and higher WHtR, TG/HDL-c, TG, WC, and BF% values. In another study,[25] the authors found significant correlations between BMI and WC, BMI and BF%, and WC and BF%.

In our study, the analysis of the correlation between WHtR and anthropometric values showed a strong significant correlation for values of BMI and WC, and a regular one for BF%.

Ashwell M., Gunn P. and Gibson S. [26] wrote a systematic review and meta-analysis of 31 studies involving data on over 300 thousand individuals which used the receiver operating characteristics (ROC) curve to evaluate the classifying potential of anthropometric indexes for detecting cardiometabolic risk factors in individuals of both sexes and of different ethnic groups. The results found indicate that the WHtR is a better predictor, more sensitive and specific, when compared to anthropometric measurements of BMI and WC, to detect cardiometabolic risk factors.

The studies of Flegal et al.,[10] with a sample of 12,901 adults from NHANES, determined the correlation of the WHtR indicator with the WC, BF%, and BMI measurement and found a more significant correlations between WHtR and WC and BMI, than with BF%.

To determine the best anthropometric index among BMI, WC, WHR, and WHtR in relation to cardiovascular risk factors, Ho et al.[11]. performed a study with 2,895 Chinese people from Hong Kong and analyzed the data collected through correlation and ROC curves. The results demonstrated the positive correlation with PAS, PAD, TC, LDL-c, TG, and fast glycaemia ($p = 0.01$) and negative correlation with HDL-c ($p = 0.01$) for both sexes. The authors evaluated the WHtR as the best anthropometric index for predicting a wide range of cardiovascular risk factors.

Rodrigues et al.[27] evaluated the association between RCE and hypertension and metabolic syndrome and also compared this indicator with other classic indicators for obesity. The authors assured, in general, that the main discovery was that the RCE is, on it's own, the best anthropometric indicator to identify hypertension and metabolic syndrome in the population, regardless of sex.

Gharakhanlou et al.[28] performed a cross-sectional study in which their objective was to identify the prevalence of overweight and obesity and the best anthropometric indicator related to CVD risk factors in an Iranian population. The results show that apart from CC and WHtR, the WHtR had more significant correlations with most serial lipid values and a negative correlation with HDL-c.

In the study of Santos et al.,[29] who made a correlation between anthropometric variables and lipid profile of 550 patients cared for at the Ambulatory of Nutrition, to define the best predictors for tracking cardiovascular risk, found significant negative correlation results for HDL-c and positive ones for TG to the parameters of WHtR, BMI and WC. In our study we found yet another significant correlation between LDL-c and anthropometric variables.

TG/HDL-c is a quite new lipoprotein index, that may serve as a predictor for cardiovascular disease.[14] We observed in our study that TG/HDL-c showed a significant correlation to the lipid and anthropometric profile parameters analyzed and a negative correlation with HDL-c.

The limitations of this study may be related to the fact that the subjects are students and employees of a university, they are young, and the most of them are eutrophic, because they look for nutritional care and they have a greater concern about their health and to prevent diseases. Survey data of Vigitel[30] in Brazil show that frequency of overweight and obese adults in the age group of 18-24 years was found to be 13.9%, while males genre almost triples the 18-24anos for 55-64 years old. Among women, the frequency of obesity is in the age group 18-24 – 18.4% for the 55-64 years 18.4%. The tendency is more and more young obese. This sample is an exception.

Table III
Analysis between nutritional status in the comparison between the parameters of anthropometric and lipid profiles

	p value
TC	0.178
HDL-c	***<0.001*** [a]
LDL-c	0.064
TG	***<0.001*** [b]
WHtR	***<0.001*** [b]
TG/HDL-c	***<0.001*** [b]
WC	***<0.001*** [b]
BF%	***<0.001*** [b]

Values in **bold** and ***italic*** represent significant values; [a]Individuals classified as Pre-Obese or Obese present ↓ HDL-c; [b]Individuals classified as Pre-Obese or Obese present ↑ TG, WHtR, TG/HDL-c, WC, and BF%; TC= total cholesterol (mg/dl); HDL-c = high-density lipoprotein cholesterol (mg/dl); LDL-c = low-density lipoprotein cholesterol (mg/d.); TG= triglycerides (mg/dl); WHtR= waist-to-height ratio; TG/HDL-c = triglyceride and HDL-c ratio; WC = waist circumference (cm); BF% = body fat percentage (%). Variance Analysis (ANOVA), significant when $p < 0.05$ (5%).

Another important limitation is related to the difference that could be regarded to the result of the measurement of waist circumference, where studies[31,32] show that the variation of the anatomical location where was measured the circumference of the waist can have significant differences in measurements, depending on the local where it was measured, that may underestimate or overestimate central obesity, especially among women. More studies are needed considering all circumferences and differences or similarities in relation to the objective of this study.

Early prevention of obesity, with simple tools for diagnosis of central obesity are important for the promotion of health and prevention of chronic diseases, so, this study is very important as a beginning for new studies of these indexes.

Conclusion

From the results obtained, we can conclude that both the WHtR and the TG/HDL-c are effective screening tools for the evaluation of abdominal adiposity and associated cardiometabolic risk, and are simple, low cost, and of great academic applicability , for they are significantly related to other biochemical and anthropometric markers, even in individuals within the parameters of normality for WC and BMI.

Conflict of Interest

None declared

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