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Original Article

Body Adiposity Indicators Are Associated to Triglyceride/Glucose Index in Community-Dwelling Older Adults

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ABSTRACT

Background/Purpose: To investigate the association between different indicators of body adiposity and TyG in community-dwelling older adults.

Methods: One hundred and fifty-seven older adults voluntaries in the present study. Height, total body mass, waist and hip circumference were used to obtain the body mass index (BMI) and 6 other indexes related to body fat, waist-to-hip ratio (WHR), waist-to-height ratio (WHtR), conicity index, and more recent anthropometric indicators such as the body roundness index (BRI) and the body shape index (ABSI). The linear regression technique adjusted for sex and age was used. The regression model adequacy was verified through the analysis of normality of the residues (Kolmogorov-Smirnov test with significance level of p <0.05), in addition to the visual inspection to identify extreme observations in the histograms of the residues.

Results: The linear regression analysis indicated that all adiposity indicators were significantly associated with TyG. The residue analysis indicated a good fit of the regression models obtained for the TyG, which could be confirmed by the low standard error values of estimative. Waist Circumference, WHR, and WHtR were the predictors with the best regression parameters.

Conclusion: Body adiposity indicators are significantly associated to TyG in community-dwelling older adults. Waist Circumference, WHR, and WHtR are simple and low-cost anthropometric indicators that seem to be promising predictors of TyG, which could be candidate for future studies as screening tool for older adults prone to develop insulin resistance.

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1. INTRODUCTION

The populational aging is a worldwide reality that lead to an increase in the prevalence of chronic noncommunicable diseases commonly associated with the aging process. This global phenomenon brings higher government costs, thus configuring a challenge for health.[1,2]

The aging process occurs in a gradual way and involves many anthropometric, cardiovascular and metabolic changes.[3–5] The ageing-associated changes in body composition are widely reported[6–8] and are characterized by a lean mass decline (bone and muscle) and adiposity increase.[6,7,9] Worryingly, the volume of adipose deposits are associated to the production of a wide range of cytokines such as TNF-α, IL-1, IL-6, IL-8, PAI-1 among others,[10] which may induce proinflammatory effects, increased peripheral vascular resistance, and are able to induce an insulin resistance state.[6,7,9]

Anthropometric measures and various anthropometric adiposity / obesity-related index have been widely reported as predictors of several cardiovascular outcomes, such as hypertension[11,12] Diabetes Mellitus (DM)[13] and even mortality from general causes.[14,15] Nevertheless, the use of anthropometric measures is seen as a useful tool to screening of several clinical outcomes,[14] with a low cost.[16]

Hip and waist circumference, as well as the its ratio (waist-to-hip ratio), the body mass index (BMI), waist-to-height ratio (WtHR), the conicity index and the body adiposity index, are widely recognized and used along last decades as health indicators, especially as predictors of carbohydrate metabolism impairments [17-20]. Novel anthropometric indicators related to body adiposity, such as the body roundness index (BRI) and the body shape index (ABSI), have been developed and also evaluated as possible predictors of carbohydrates metabolism impairments.[19,21,22]

It is well established that the aging process is associated with insulin resistance.[18,23] The biological bases of this association are still studied,[23] however, it seems clear the negative influence of body adiposity on the glycemic control.[18,24]

Insulin resistance is in the genesis of metabolic abnormalities involved in Type II DM and in the various metabolic syndrome related disorders.[7,25–27] For this reason, methods proposed to evaluate insulin resistance are of great clinical interest, since it may allow the early identification, and the monitoring of the effect of therapeutic interventions to the glycemic impairments.

The homeostatic model assessment (HOMA) is the widely used method to measure insulin resistance, for both scientific and clinical purposes, however, this method requires plasma insulin measurement, which is not accessible in all settings especially in low-income or developing countries.[18,25] In addition, a valid alternative to identify and monitor insulin resistance in many populations and age range[25,28] have raising in relevance and have been reported by the acronym "TyG" (TyG=ln(fasting triglycerides (mg/dl) × fasting glucose (mg/dl)/2)).[28]

Considering that TyG is recognized as an early marker of insulin resistance, and that body adiposity, which tends to increase with aging,[26,27] favors the establishment of insulin resistance, the present study aimed to investigate the association between different body adiposity indicators and TyG in community-dwelling older adults.

2. METHODS

2.1. Studied Population

All community-dwelling old adults (≥60 years old) from Aiquara, Bahia, Brazil were invited to take part in this survey study. Two hundred eighty-nine (289) subjects were screened, however, bedridden individuals and/or those with severe cognitive impairment (n=20) were excluded. An extensive health questionnaire, as well as a clinical and physical examination was conducted in old people that volunteered, but only 157 older adults (60 to 95 years old, 66 men/91 women) were eligible for inclusion in the present study. Nine older adults refusal to participate in the study, while bedridden older adults (4 individuals), neurological impairments (15 older adults), auditory impairments that compromise the questions comprehension (3 older adults), absence of circumference measures, as well as the diagnostic of DM (75 older adults) were the reasons for exclusions. Diabetic older adults were excluded from the analysis because this presupposes an insulin resistance state, which may be a bias in our study.

All procedures were conducted in accordance with the Declaration of Helsinki and the study was submitted and approved by the Human Research Ethics Committee from the State University of Southwest Bahia (protocol # 10786212.3.0000.0055). Written informed consent was obtained from all subjects, and all volunteers underwent the experimental procedures under the same instructions and conditions.

2.2. Data Collection

Data collection was carried out from January to July 2015, and involved three groups of variables: questionnaires, clinical assessment and collection of biological samples. Questionnaires included data recordings from sociodemographic characteristics: sex, age, lifestyle habits (smoking), self-reported health status (previous diagnosis of Diabetes Mellitus) and hypertension and medications currently in use. The presence of hypertension and DM were defined based on the self-reported disease and/or the use of antihypertensive and antidiabetic medications.
After recording questionnaires during home visit, participants were scheduled to attend to Aiquara Municipal Hospital, where they underwent a venous blood withdrawal (10 ml from the antecubital vein) and anthropometric assessment. Blood samples were used for measure of serum glucose, triglycerides

and thyroid hormones (thyroxine [T4 and free T4]; triiodothyronine [T3]), as well the thyroid stimulating hormone (TSH), using standard laboratory methods. Blood sample was collected after 8 to 12 hours of fasting. TyG was calculated as proposed by Guerrero-Romero[28]: TyG=ln(fasting triglycerides (mg/dl) × fasting glucose (mg/dl)/2). The serum levels of T3, T4, free T4 and TSH were used to characterize the studied population regarding to the thyroid function, since hypothyroidism impacts the adiposity.

From anthropometric assessment, height and body mass, waist (WC) and hip (HC) circumferences were used in this study. From these anthropometric measures, 7 indexes were calculated (see Table 1): Body Mass Index (BMI) (WHO, 2013), Waist-to-hip ratio (WHR)[6], Waist-to-height ratio (WHtR),[29] Conicity Index (CI)[30], Body Adiposity Index (BAI),[31] Body Shape Index (BSI)[32] e Body Roundness Index (BRI).[33]

2.3. Statistical Analysis

For the description of sample characteristics, the absolute and relative frequencies were used for the categorical variables and the mean±standard deviations were used for continuous variables.

Linear regression was adjusted by sex (1=men, 2=women) and age (60 to 95 years). The adequacy of the regression models were verified through the analysis of the residues by the normality test (*Kolmogorov-Smirnov test*), in addition, a visual inspection was carried out to identify extreme observations in the histograms of the residues. In all analyzes, the significance level adopted was 5% ($p \leq 0.05$). Data were analyzed in SPSS software version 21.0 (SPSS, Inc., Chicago, IL).

Table 1. Anthropometric indexes related to body adiposity used in this study and their respective formulas.

Anthropometric Index	Equation
Body Mass Index (BMI)	$\frac{\text{BM (Kg)}}{\text{Height}^2\text{ (m)}}$
Waist-to-hip ratio (WHR)	$\frac{\text{Waist Circumference (cm)}}{\text{Hip Circumference (cm)}}$
Waist-to-height ratio (WHtR)	$\frac{\text{Waist Circumference (cm)}}{\text{Height (cm)}}$
Conicity Index (CI)	$\frac{\text{Waist Circumference (cm)}}{0.109 \times \sqrt{\text{(Weight (Kg) / Height (m)}}}$
Body Adiposity Index (BAI)	$\frac{\text{Hip Circumference (cm)}}{(\text{Height}^{1.5}) - 18}$
Body Shape Index (ABSI)	$\frac{\text{Waist Circumference (cm)}}{(\text{BMI}^{2/3}) \times (\text{Height}^{1/2})}$
Body Roundness Index (BRI)	BRI=364.2 – (365.5 × Ɛ) where: $\varepsilon = 1 - \frac{(\textit{Waist Circumference} / (2\varpi))^2}{(0.5 \times \text{Height})^2}$

The anthropometric parameters related to body adiposity were used as predictor variables (i.e., independent variables), while TyG was used as a dependent variable in the present study.

3. RESULTS

The characteristics of studied population are presented in Table 2.

The age and sex-adjusted linear regression analysis indicated that all adiposity indicators were significantly associated with TyG (Table 3). The residuals analysis showed a normal distribution of residues (p >0.05) for all indicators of obesity indicating good adequacy of the regression models obtained for TyG.

4. DISCUSSION

The present study investigated the association between different body adiposity indicators and

Table 2. Demographic and clinical characteristics of the studied community-dwelling older adults. Mean±SD of age, blood pressure, anthropometric indicators of body adiposity, glycemia, triglyceridemia, triglyceride/glucose index, cholesterol and indicators of thyroid function are presented.

Variable	All (n=157)	Men (n=66)	Women (n=91)
Age (years)	72.5±7.8	71.9±7.6	72.7±8.1
SBP (mmHg)	140.0±52.6	143.9±47.3	137.3±56.3
DBP (mmHg)	79.4±29.8	81.3±26.9	78.1±31.7
Height (cm)	155.1±8.6	155.9±8.8	154.7±8.5
Total Body Mass (Kg)	61.6±13.7	62.8±14.7	61.0±13.1
Waist Circumference (cm)	91.8±13.5	92.1±14.1	91.8±13.3
Hip Circumference (cm)	95.6±10.1	95.5±10.2	95.7±10.1
Waist-to-hip ratio	0.96±0.09	0.97±0.08	0.96±0.10
Body Mass Index (Kg/m^2)	25.6±5.3	25.7±5.1	25.5±5.4
Waist-to-height ratio	0.59±0.09	0.59±0.09	0.59±0.09
Conicity Index	1.34±0.10	1.34±0.09	1.34±0.10
Body Adiposity Index	31.7±6.8	31.3±6.7	32.1±6.9
Body Shape Index	0.09±0.01	0.08±0.00	0.09±0.01
Body Roundness Index	5.4±2.1	5.4±2.1	5.5±2.2
T3 (ng/mL)*	1.40±0.20	1.42±0.18	1.37±0.18
T4*	7.05±1.38	7.20±1.14	6.99±1.32
Free T4*	1.16±0.15	1.18±0.13	1.16±0.15
TSH*	1.88±1.37	1.79±1.18	2.04±1.68
Total cholesterol (mg/dl)	214.5±46.3	214.7±44.9	214.0±47.5
LDL-cholesterol (mg/dl)	134.6±41.2	136.7±42.1	133.1±40.7
HDL-cholesterol (mg/dl)	50.1±16.0	48.8±10.6	51.3±18.6
Glucose (mg/dl)	100.7±28.4	103.6±35.1	98.5±19.7
Triglycerides (mg/dl)	140.1±76.0	142.8±80.7	138.3±73.0
TyG	8.72±0.53	8.8±0.50	8.7±0.50

(*) There were no older adults out of reference values of T3 (0.60-1.71 ng/mL), T4 (4.5-10.9 mcg/dL), free T4 (0.89 A 1.76 ng/dL), TSH (0.48-5.60 µUI/mL).

TyG in community-dwelling older adults. Our results showed a significant and directly proportional relationship between all studied body adiposity indicators and the TyG index.

The TyG index is proposed as a suitable predictor of IR, since its predictive capacity to IR is similar to the HOMA-IR index, which is proposed as the gold standard clinical method to identify IR.[25] This result opened the field for the development of several subsequent studies[34,35] applying this indicator of excellent cost-benefit ratio (i.e., TyG), since it is obtained from two low cost biochemical parameters that are routinely measured in clinical practice.

Vasques[25] observed a significant association between the TyG index and the anthropometric indicators: BMI and waist circumference. In fact, as in the aforementioned study, the relationship between body adiposity and IR has been widely demonstrated,[6,7] however, it is necessary to emphasize two points: 1) the association measures obtained by correlation methods do not allow an inference of how much one parameter influences a variable of interest (i.e., the outcome), which is feasible through regression methods, allowing the development of predictor equations for variables of interest; 2) body adiposity is modified throughout life, increasing during the aging process, which limits the analysis of association between anthropometric indicators of adiposity and other biological variables in samples that include young and old individuals.

Aiming to achieve the two points exposed above, the present study identified a significant association between 9 anthropometric indicators of adiposity and the TyG index, and obtained prediction equations for this index in the elderly population. In our analysis, the 9 anthropometric studied indicators were able to predict the TyG index adequately, with a good fit of the regression models. The association between body adiposity and IR have been proposed for a long time[36], however, only recently the association between the TyG index, as a IR indicator, and obesity indicators was established, as in the study by Guerrero-Romero [28], which observed a parallel increase between BMI and TyG index in young adults.

Within the panel of 9 anthropometric indicators related to body adiposity, which included some simple measures, such as waist and hip circumferences, as well as anthropometric indicators derived from equations, as BMI and others involving the body circumferences, the regression parameters involving the waist circumference as a predictive variable (i.e., independent variable), presented the highest determination coefficients. In addition, the WHR and WHtR also presented coefficients of determination that allow explaining 15.9 and 19.7%, respectively, of the observed values of the TyG index. It is interesting to note that both indices (i.e., WHR and WHtR) present in common the presence of waist circumferences in their construction.

The waist circumference is an anthropometric indicator of central adiposity, and therefore has a close relationship with the accumulation of visceral adipose tissue.[37] As previously explained, adipose tissue, especially the visceral tissue, secretes a wide range of cytokines capable to inducing IR,[6,7,9] which may justify our results. It is interesting to note that our study did not include diabetic subjects because DM already characterizes a carbohydrate metabolism impairment and even IR in the case of type II DM.

It should be noted in our results that the prediction equations obtained presented a small standard error of estimation, not exceeding 5.6 and 6.2% of the TyG average of the studied population , which was 8.72, denoting an excellent fit of the equations obtained here and therefore, prospecting their reliability to predict the dependent variable (i.e., TyG).

The interest in identifying cut-off points for TyG values

Table 3. Statistical parameters obtained from the regression models.

Variable	β (95% CI) of constant and idependent variable from each Regression Model		Adjusted R^2	*P* value	Standard error of estimation (SEE)
	Constant	Independent variable (anthropometric indicator)			
Waist Circumference	7.64 (6.66 to 8.61)	0.014 (0.008 to 0.020)	0.120	*P* <0.001	0.497
Hip Circumference	7.93 (6.65 to 9.20)	0.010 (0.002 to 0.019)	0.022	*P* <0.001	0.524
WHRφ	7.00 (5.95 to 8.06)	2.42 (1.57 to 3.28)	0.159	*P* <0.001	0.486
BMIφ	7.85 (6.87 to 8.82)	0.034 (0.018 to 0.049)	0.094	*P* <0.001	0.504
WHtRφ	7.91 (6.97 to 8.83)	1.98 (1.12 to 2.83)	0.197	*P* <0.001	0.540
Conicity Index	7.15 (5.92 to 8.38)	1.72 (0.88 to 2.57)	0.084	*P* <0.001	0.510
Body Adiposity Index	8.71 (7.79 to 9.63)	0.011 (-0.001 to 0.024)	0.008	*P* <0.001	0.530
Body Shape Index	7.82 (6.48 to 9.16)	19.54 (3.41 to 35.66)	0.023	*P* <0.001	0.520
Body Roundness Index	8.66 (7.86 to 9.47)	0.078 (0.041 to 0.115)	0.089	*P* <0.001	0.510

(φ) WHR=Waist-to-hip ratio; WHtR=Waist-to-height ratio; BMI=Body Mass Index;

associated to IR has increased. Guerrero-Romero,[28] in a study involving young people (~19 years), identified TyG cutoff points at 4.55 and 4.68 for women and men, respectively. These values are well below the mean of TyG observed in our sample (i.e., 8.72), however, our study involved only the older adults and, in fact, previous studies involving adults from 45 years old have presented mean TyG values equivalent to those found in our population.[27,38,39]

The metabolic changes associated with aging may lead to higher values of the TyG in old adults, compared to young populations. High values of the TyG suggest an impaired metabolic control of carbohydrates and lipids, which tends to culminate in IR, since glycotoxicity and lipotoxicity are recognized as key mechanisms to the development of IR.[26] Notwithstanding, the accumulation of adipose tissue may facilitate the installation of both conditions (i.e., glycotoxicity and lipotoxicity), especially visceral adipose tissue.[40] In fact, our results showed a clear association between higher body adiposity and higher values of TyG in the old adults.

Curiously, in line with our results, Jian,[38] studying people over 40 years old (mean age 60 years) showed that high TyG values was associated to a greater chance of hypertension and the presence of central obesity concomitantly with high TyG values influenced significantly in this association, increasing the chance of hypertension and isolated systolic hypertension. Then, the results from Jian[38] shed light on our results, since we have shown that it is possible to screen older adults with higher values of the TyG from anthropometric indicators of adiposity.

The TyG, as many other metabolic indicators, is influenced by many factors, such as metabolic basal rate/resting energy expenditure, daily physical activity level, anabolic or catabolic effect of diverse hormones, among others, which were not accounted in our regression model, explaining the relatively low coefficients of determination (R^2) obtained in our study. However, it is important to emphasize that we choice to present our results through coefficient of determination (R^2) instead of coefficient of correlation (R), which trend to lead to lower coefficients. Notwithstanding, the use of coefficient of determination (R^2) allow to state that the WHR and WHtR could explain 15.9 and 19.7% of TyG from older adults, respectively. Further studies should expand our analysis with greater sample, aiming to confirm or refute our findings.

The results of the present study showed an association between anthropometric indicators of body adiposity and TyG in community-dwelling older adults. Waist Circumference, WHR, and WHtR are simple and low-cost anthropometric indicators that seem to be promising predictors of TyG, which could be candidate for future studies as screening tool for older adults prone to develop insulin resistance.

CONFLICTS OF INTEREST

None.

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