Anthropometric indicators in identification of insulin resistance in elderly men

Indicadores antropométricos na identificação de resistência à insulina em homens idosos

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Abstract

Insulin resistance (IR) increases with advancing age, yet the underlying mechanism is not well established. Anthropometric and body composition indicators are alternative tools for assessing insulin resistance in a fast, non-invasive and inexpensive way. This study aimed to evaluate the association between anthropometric indicators and insulin resistance in older men. This cross-sectional study included 62 men aged between 60 and 92 years. We evaluated waist circumference (WC), sagittal abdominal diameter (SAD), body mass index (BMI), sagittal index (SI), conicity index (CI), body fat percentage (BF%), waist-to-hip ratio (WHR), waist-to-height ratio (WHtR) and waist-to-thigh ratio (WTR). IR was determined by homeostasis model assessment (HOMA-IR). Statistical analysis consisted of correlation coefficient. All anthropometric indicators correlated with HOMA-IR, highlighting the SAD (r = 0.680), BF% (r = 0.651) and WC (r = 0.591), which showed the highest correlations with the index. All measurements showed significant differences and progressive increase with increasing HOMA-IR. The differences between quartiles of HOMA-IR were even more pronounced for WC, SAD and BF%. BF% was a significant predictor for insulin resistance. Thus, obesity indicators correlated with the HOMA-IR index. We emphasize the stronger relationship between measures of central adiposity and insulin resistance, suggesting the usefulness of SAD in evaluating elderly subjects.

Keywords: Elderly. Anthropometry. Body Composition. HOMA.

Resumo

A resistência à insulina (RI) aumenta com o avanço da idade, no entanto os mecanismos não estão bem estabelecidos. Os indicadores antropométricos e de composição corporal são instrumentos alternativos para a avaliação da resistência à insulina de maneira rápida, não-invasiva e de baixo custo. O objetivo deste estudo foi avaliar a associação entre os indicadores antropométricos e a resistência à insulina em homens idosos. Estudo transversal com 62 homens com idade entre 60 e 92 anos. Foram avaliados perímetro da cintura (PC), diâmetro abdominal sagital (DAS), índice de massa corporal (IMC), índice sagital (IS), índice de conicidade (ICO), percentual de gordura corporal (%GC) e as relações cintura-quadril (RCQ), cintura-estatura (RCE) e cintura-coxa (RCC). RI foi determinada pelo índice de resistência à insulina (HOMA-IR). Análises estatísticas consistiram de análises de correlação e regressão linear. Todos os indicadores antropométricos avaliados correlacionaram-se com o HOMA-IR, destacando-se o DAS (r = 0,680), o %GC (r = 0,651) e o PC (r = 0,591), que apresentaram as maiores correlações com o índice. Todos os indicadores apresentaram aumento progressivo e diferenças significativas com o aumento do HOMA-IR, sendo que para o PC, DAS e %GC as diferenças entre os quartis do HOMA-IR foram ainda mais acentuadas. %PC foi preditor significativo para resistência à insulina. Portanto, os indicadores de obesidade correlacionaram com o índice HOMA-IR. Ressalta-se a relação mais forte das medidas de adiposidade central com resistência à insulina, sugerindo a utilidade do diâmetro abdominal sagital na avaliação de idosos.

Palavras-chave: Idoso. Antropometria. Composição Corporal. HOMA.

DOI: 10.15343/0104-7809.20153902157163

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The authors declare no conflicts of interest.

O Mundo da Saúde, São Paulo - 2015;39(2):157-163

INTRODUCTION

Insulin resistance (IR) is defined as a defect in insulin action with consequent compensatory hyperinsulinemia to maintain normal glucose levels[1]. Insulin resistance occurs in many tissues including liver, muscle and adipose tissue[2]. An important contributor to IR is the presence of elevated serum levels of free fatty acids from the increased mobilization of triglycerides from adipose tissue[1].

Evidences suggest that aging is closely associated with insulin resistance and this is an important risk factor for diabetes, cardiovascular disease and other age-related diseases[3,4]. Greater age has been associated with an increase in post-challenge plasma glucose levels and postprandial hyperglycaemia, reflecting an underlying age-related increase in peripheral insulin resistance[3]. Although the exact molecular mechanisms driving the onset of insulin resistance are not yet fully understood, it is evident that overweight/obesity and aging are the main risk factors for development of type 2 diabetes mellitus[4].

In this context, the IR evaluation has received considerable attention since the early identification of this metabolic alteration implies the possibility of disease prevention, improved quality of life and lower health costs[5]. The euglycemic hyperinsulinemic clamp is the gold standard method for determining the IR. However, it is a costly, time consuming, invasive and highly complex technique. An alternative to the evaluation of IR is the homeostatic model assessment index of insulin resistance (HOMA-IR), is a validated method which predicts insulin sensitivity by simple measurements of fasting blood glucose and insulin, is easier to apply and has a strong correlation with the clamp method. HOMA-IR is a suitable method for large-scale studies[6].

Anthropometric and body composition indicators are alternative instruments to evaluate IR in an accessible, fast and non-invasive manner[5]. The anthropometric indicators that have been associated with insulin resistance are sagittal abdominal diameter (SAD), waist circumference (WC), body mass index (BMI), body fat percentage (BF%), conicity index (CI), sagittal index (SI) and waist-hip ratio (WHR), waist-to-height ratio (WHtR) and waist-to-thigh ratio (WTR)[5,7-11].

However, few studies have evaluated the relationship of these indicators with insulin resistance in the elderly. Thus, the present study aimed to evaluate the behavior of anthropometric indicators and body composition in relation to the values of HOMA-IR in elderly men.

METHODS

This is a cross-sectional study performed in Viçosa, Minas Gerais, Brazil, from July 2011 to February 2012, with the participation of men aged ≥ 60 years enrolled in the Family Health Program, because this comprises the cut-off classification for elderly individuals in Brazil.. The sample size was calculated considering 4.3% as the frequency of MS observed in a previous study[12], an acceptable range of variation of 5% and 95% as the alpha risk, resulting in a minimum sample of 62 elderly men. Exclusion criteria were: previous coronary events and use of medications that could interfere with glucose homeostasis, blood pressure and/or lipid metabolism. We conducted home visits to elderly subjects for them to complete a questionnaire containing questions related to health status and lifestyle.

The study protocol was approved by the Ethics Committee on Human Research of the Universidade Federal de Viçosa (Viçosa, Brazil) and all participants provided written informed consent.

Anthropometry and body composition

The anthropometric measurements were performed by a single professional. Body weight and height were measured according to procedures proposed by Jelliffe[13] and BMI was calculated as weight divided by height squared (kg/m^2). Waist circumference (WC) was measured at the midpoint between the iliac crest and the last rib, and hip circumference (HC) was measured at the level of maximum protrusion of the gluteal muscles. Tight circumference (TC) was measured on the right leg, at the midpoint between the inguinal fold and the proximal border of the patella. The sagittal abdominal diameter (SAD) was measured at the midpoint between the iliac crests with a portable, sliding beam, abdominal caliper (Holtain Kahn Abdominal Caliper®, Holtain Ltd., Dyfed, Wales, UK). All measurements were taken in duplicate and an average was calculated. If the difference between the two measurements was >1 cm, a third measurement was performed and the two closest values were used.

The following relationships between measurements were used: waist-to-hip ratio (WHR) calculated as WC divided by HC; waist-to-height ratio (WHtR) as WC divided by height; conicity index (CI) was calculated according to the formula proposed by Valdez[14]; sagittal index (SI) as SAD divided by TC; and waist-to-thigh ratio (WTR) was calculated as WC divided by TC.

The body fat percentage (BF%) was measured by dual energy x-ray absorptiometry (DEXA) (Lunar Densitometry, GE®, software Encore 2010, version 13.3).

Clinical and biochemical measurements

Blood pressure was measured on the participant's left arm using an aneroid sphygmomanometer by a single skilled professional and the procedure was performed according to recommendations of the Brazilian Society of Cardiology.

Blood samples were collected after fasting overnight, centrifuged for 10 min at 2250 g and were stored at -80 °C for subsequent assays. Fasting insulin concentrations were analyzed by electrochemiluminescence, using enzymatic kit (Roche®, Brazil). The HOMA-IR (homeostasis model assessment – insulin resistance) was calculated according to the formula proposed by Matthews et al.[15]. Insulin resistance was defined as HOMA-IR > 2.7[6].

Statistical Analysis

Statistical analyzes were performed using SPSS software, version 17.0 9 (SPSS Inc., Chicago, IL, USA). $P < 0.05$ (two-tailed) was considered statistically significant. The distribution normality of the variables was determined by the Kolmogorov–Smirnov test.

Analysis of variance (Anova) was used to compare the quartiles of the HOMA-IR index and the anthropometric indicators, followed by Tukey test. Spearman's correlations and multiple linear regression were used to evaluate the correlation between anthropometric indicators and HOMA-IR. Age-adjusted correlations were also examined. For variables with a nonnormal distribution, data were transformed to a natural logarithm (Ln).

RESULTS

The study sample consisted of 62 men aged between 60 and 92 years (Table 1). According to BMI, 21% were overweight and 54.8% were eutrophic.

Table 1. Characteristics of the study sample (n = 62). Viçosa/MG, 2012.

Variable	Values
Age	66 (60 – 92)
Weight (kg)	67.32 (10.73)
Height (cm)	1.65 (0.06)
BMI (kg/m²)	24.79 (3.51)
WC (cm)	(91.77) (10.35)
SAD (cm)	20.17 (2.79)
WHR	0.94 (0.07)
SI	0.42 (0.06)
CI	1.32 (0.07)
WHtR	0.56 (0.06)
WTR	1.91 (0.19)
BF%	22.19 (7.65)
Systolic blood pressure (mmHg)	120 (110 – 160)
Fasting blood glucose (mg/dL)	81.5 (70 – 160)
Triglycerides (mg/dL)	92.40 (44.69)
HDL-c (mg/dL)	47.48 (14.47)
HOMA-IR	1.09 (0.17 – 9.97)

BMI: body mass index; WC: waist circumference; SAD: Sagittal abdominal diameter; WHR: waist-to-hip ratio; SI: sagittal index; CI: conicity index; WHtR: waist-to-height ratio; WTR: waist-to-thigh ratio; BF%: body fat percentage; HDL-C: high density lipoprotein cholesterol; HOMA-IR: homeostasis model assessment for insulin resistance. Values expressed as mean or median depending on the variable distribution in the normal curve.

All anthropometric indicators increased and differed with the progressive increase in

HOMA-IR index (Table 2). For the WC, SAD and BF% the differences between HOMA-IR quartiles were even more pronounced.

Table 2. Correlations between anthropometric and body composition indicators and HOMA-IR in the elderly subjects (n = 62). Viçosa/MG, 2012.

Variable	HOMA-IR
WC (cm)	0.591*
SAD (cm)	0.680*
BMI (kg/m²)	0.543*
WHR	0.494*
SI	0.530*
CI	0.497*
WHtR	0.537*
WTR	0.398*
BF%	0.651*

WC: waist circumference; SAD: Sagittal abdominal diameter; BMI: body mass index; WHR: waist-to-hip ratio; SI: sagittal index; CI: conicity index; WHtR: waist-to-height ratio; WTR: waist-to-thigh ratio; BF%: body fat percentage. *p<0.05.

In general, the anthropometric indicators were correlated with HOMA-IR (p<0.01), highlighting SAD and BF%, which were strongly correlated, followed by WC (Table 3). The WTR showed the lowest correlation with HOMA-IR. After adjusting for age, all indicators were correlated with HOMA-IR, mainly the SAD (Table 4).

After testing all the variables that showed significant correlations, the results show that the body fat percentage significantly predicted 41% of the variation in HOMA-IR index (Table 5).

DISCUSSION

The indicators of central obesity, SAD and WC, and the BF% showed the best correlation with the HOMA-IR index, while all other indicators have shown moderate correlations. Another study observed better efficacy for SAD and WC, respectively, to identify insulin resistance in men as compared to BMI and WHR[16]. Vasques et al.[5] evaluated 138 adult men and observed that central obesity indicators in particular SAD and WC, showed better correlations to HOMA-IR. In ROC curve analysis, the WC had the best performance.

Table 3. Partial correlations between anthropometric and body composition indicators and HOMA-IR, adjusted for age in the elderly subjects (n = 62). Viçosa/MG, 2012.

Variável	HOMA-IR
WC (cm)	0.565*
SAD (cm)	0.623*
BMI (kg/m²)	0.502*
WHR	0.383*
SI	0.525*
CI	0.431*
WHtR	0.501*
WTR	0.520*
BF%	0.588*

WC: waist circumference; SAD: Sagittal abdominal diameter; BMI: body mass index; WHR: waist-to-hip ratio; SI: sagittal index; CI: conicity index; WHtR: waist-to-height ratio; WTR: waist-to-thigh ratio; BF%: body fat percentage. *p<0.05.

Anthropometric and body composition indicators showed significant differences with the progressive increase in HOMA-IR index, especially the WC, SAD and BF%, in which the differences between HOMA-IR quartiles were even more pronounced. Another study also observed a progressive increase for all indicators with increased HOMA-IR, and for BMI and for central obesity indicators the differences between the quartiles were even more pronounced[5].

Correlations between anthropometric indicators and HOMA-IR were consistent with expectations, since it is known that adiposity deteriorates insulin sensitivity[17]. Waist circumference positively correlated with HOMA-IR index, even when adjusting for age (r = 0.591, r = 0.565, respectively). In adult men the WC was significantly correlated with HOMA-IR (r = 0.464)[5]. Other studies involving older adults verified that the WC positively correlated with HOMA-IR[10,11,18]. These findings indicate that not only the amount of adipose tissue, but its distribution, may influence insulin resistance and metabolic alterations caused by hyperinsulinemia.

Table 4. Distribution of anthropometric indicators according to the quartiles of HOMA index (n = 62). Viçosa/MG, 2012.

	HOMA-IR			
	≤0.70	0.80-1.08	1.09-1.76	≥1.77
WC (cm)*	83.62 (6.34)^{a}	88.81 (9.24)^{abc}	94.33 (7.04)^{bc}	96.82 (12.26)^{c}
SAD (cm)**	18.13 (1.64)^{a}	19.30 (1.90)^{ab}	20.95 (1.64)^{bc}	22.02 (3.29)^{c}
BMI (kg/m^{2})*	22.55 (2.56)^{a}	23.53 (2.88)^{ab}	25.50 (2.07)^{ab}	26.09 (4.46)^{b}
WHR*	0.89 (0.05)^{a}	0.92 (0.05)^{ab}	0.96 (0.06)^{ab}	0.96 (0.08)^{b}
SI**	0.38 (0.04)^{a}	0.40 (0.04)^{a}	0.43 (0.05)^{ab}	0.46 (0.06)^{b}
CI*	1.27 (0.05)^{a}	1.30 (0.07)^{ab}	1.33 (0.06)^{ab}	1.35 (0.07)^{b}
WHtR*	0.51 (0.05)^{a}	0.53 (0.05)^{ab}	0.57 (0.04)^{ab}	0.58 (0.08)^{b}
WTR*	1.76 (0.12)^{a}	1.86 (0.18)^{a}	1.92 (0.14)^{ab}	1.99 (0.18)^{b}
BF%**	15.52 (6.26)^{a}	19.72 (5.95)^{ab}	25.78 (4.85)^{bc}	26.34 (6.86)^{c}

Data presented as mean (sd). ANOVA followed by Tukey test: * p <0.01; ** p <0.001. Pairs of means followed by different letters differ statistically and when followed by at least one same letter are not statistically different at p <0.05.

Table 5. Multiple linear regression coefficient and associated p-value of anthropometric variables and HOMA-IR index in elderly men. Viçosa/MG, 2012.

Variables	Independent Variable coefficients (β)	p value	R-squared
Body Fat percentage	0.073	<0.001	0.414
Waist-to-hip ratio	-1.343	0.470	

This model was adjusted for age.

The body fat percentage, which provides estimates of generalized fat, correlated significantly with HOMA-IR (r = 0.651) and was a significant predictor of insulin resistance. Wannamethee et al.[7] observed that BF% assessed by bioelectrical impedance also correlated with HOMA-IR in elderly men (r = 0.32, p <0.05). However, the WC was a better predictor of metabolic abnormalities than BF%. Although the BF% is an excellent measure of adiposity and energy reserves, it may not reflect risks to health when compared to other anthropometric indicators[19].

The SAD strongly correlated with HOMA-IR index, even after adjustment for age (r = 0.680, r = 0.623, respectively). Others studies also showed that SAD positively correlated with HOMA-IR in adult men[5] and in overweight subjects[10].

The WC and SAD are measures that directly assess the extent of abdominal obesity and exhibit strong correlation with the amount of visceral fat[20], which is directly related to metabolic disorders, such as insulin resistance. One of the advantages of SAD is that such measurement is made while the subject is lying down, which avoids that subcutaneous fat overlaps the abdominal fat, reflecting the amount of visceral adipose tissue (Pimentel et al., 2010). It is worth mentioning the technical advantages of the WC and SAD measurements, as the quick execution and the non-use of formulas. The SAD has the disadvantage of requiring an abdominal caliper and a solid surface table for their measurement, unlike the WC, which only requires proper tape.

CONCLUSION

In general, the anthropometric indicators correlated with HOMA-IR index. The sagittal abdominal diameter, waist circumference and

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body fat percentage were the anthropometric indicators that best correlated with HOMA-IR index in older men. The body fat percentage was a significant predictor of insulin resistance.

We emphasize the strongest relationship of central adiposity measures with insulin resistance, suggesting the usefulness of SAD in evaluating elderly subjects. It is suggested that longitudinal studies be conducted in search of best cutoff points for anthropometric indicators identifying the risk of insulin resistance in the elderly population.

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O Mundo da Saúde, São Paulo - 2015;39(2):157-163

Recebido em: 02 de fevereiro de 2015.
Aprovado em: 20 de agosto de 2015.