

Anthropometric indicators of obesity and hyperglycaemia in Brazilian older people

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Previous research has looked at anthropometric indicators of obesity for the prediction of hyperglycaemia in the older people but there has not previously been a population-based investigation carried out in older people living in Brazil. The objectives of this study were to identify the anthropometric indicators of obesity most associated with hyperglycaemia in older people and to establish the indicators of hyperglycaemia and the “cutoff points”. This is a cross-sectional study based on the data of 316 older people from a household and population-based epidemiological study carried out in early 2011. The findings outlined in this article can be used by health professionals to identify diabetes in older people.

Diabetes is a chronic disease that is an important cause of morbidity and mortality among older people (Pilger et al, 2011). It is estimated that in 2030, diabetes will be the seventh main health risk factor (World Health Organization [WHO], 2008), and that Brazil will rank sixth in the world for number of people who have diabetes, with prevalence reaching 11.3 million people (Wild et al, 2004). According to data from the *System for Surveillance of Risk Factors and Protection for Chronic Diseases by Telephone Inquiry (Sistema de Vigilância de Fatores de Risco e Proteção para Doenças Crônicas por Inquérito Telefônico [VIGITEL])*, the prevalence of self-reported diabetes in 2010 was 22% in those who were 65 years or older (Ministério da Saúde, 2011).

Buildup of body fat and/or centralised obesity is considered a predictor of diabetes (Biggs et al, 2010), although a measure of obesity that can indicate which older people are at risk of metabolic diseases has not yet been established (Lee et al, 2008; The Decoda Study Group, 2008). Therefore, the use of anthropometric indicators of general obesity, for example BMI, and central obesity indicators, including waist circumference, waist/hip ratio

(WHR) and waist/stature ratio (WSR), helps predict risks associated with diabetes (Ho et al, 2003) and further metabolic dysfunction (Mota et al, 2011).

Some epidemiological studies have been conducted with the aim of identifying the best anthropometric indicators for the prediction of hyperglycaemia in the older people (Lee et al, 2008; The Decoda Study Group, 2008; Biggs et al, 2010). However, there has been no population-based investigation made in older people living in Brazil.

These predictive studies of older people are important in order to understand indicators of obesity so that changes can be made to clinical practice and preventive public health measures, especially as the use of anthropometric measurements is cost effective as a diagnostic tool.

Aims

The objectives of this study were:

- To identify the best anthropometric indicator of obesity associated with hyperglycaemia in community-dwelling older people in Brazil.
- To evaluate the best anthropometric indicator of obesity found as a discriminator of hyperglycaemia.

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Article points

1. In 2030, diabetes will be the seventh main health risk factor and Brazil will rank sixth in the world for number of people with diabetes, with numbers reaching 11.3 million people in Brazil.
2. Obesity (global or centralised) is considered a predictor of diabetes, but a measurement of obesity that is better able to discriminate older people who are at risk has not yet been established.
3. The study showed that BMI was the best anthropometric marker of hyperglycaemia, for both males and females.
4. The findings can be used by health professionals working in geriatrics and/or gerontology when screening for diabetes in older people.

Key words

- Anthropometry
- Hyperglycaemia
- Obesity
- Older people

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Page points

1. The study population consisted of 355 older people (aged ≥ 60 years) residing in Lafaiete Coutinho, Brazil. Of the 355 older people in the study population, 316 participated in the survey (89.0%).
2. The dependent variable was hyperglycaemia and was measured by fasting blood glucose test. Anthropometric indicators, including BMI, waist circumference, waist/hip ratio and waist/stature ratio, were also measured.
3. Other independent variables, including age, gender, literacy, smoking and alcohol intake were also measured.

Method

Setting and study population

This is a cross-sectional study that analysed data from a home-based epidemiological survey called “Nutritional status, risk behaviors and health conditions of the elderly of Lafaiete Coutinho-BA” (Leal Neto et al, 2013). Details of the place and population of the study can be found in a previously published paper (Santos et al, 2012). Briefly, the study population consisted of 355 older people (aged ≥ 60 years) residing in Lafaiete Coutinho, Brazil. Of the 355 older people in the study population, 316 participated in the survey (89.0%); 17 refusals were registered (4.8%), and 22 (6.2%) individuals were not successfully contacted after three home visits on alternate days.

The survey complied with the Declaration of Helsinki (World Medical Association, 2008) and was approved by the Committee of Ethics in Surveys with Human Beings; participation in the study was voluntary and all subjects gave informed consent.

Measures

Hyperglycaemia (dependent variable)

Plasma glucose levels were assessed in each participant after a 12-hour fast. The capillary blood samples were collected by transcutaneous puncture on the medial side of the middle finger tip, using a disposable hypodermic lancet. The individual measurements were taken by trained graduating and post-graduate students, with good knowledge of the health area; instructions from the manufacturer were followed closely. High fasting glycaemia was defined according to the current guidelines for diagnosing diabetes in Brazil: ≥ 126 mg/dL (≥ 7 mmol/L), and/or use of oral medication or insulin for glycaemia control (Sociedade Brasileira de Diabetes, 2009).

Anthropometric indicators of obesity (independent variables)

The anthropometric indicators were: BMI (kg/m^2); waist circumference; WHR; WSR; conicity index, which evaluates waist circumference in relation to height and weight (Valdez, 1991); and body adiposity index (BAI; Bergman et al, 2011).

For the body mass evaluation, a portable digital scale was used, with the individual wearing as few clothes as possible and no shoes. The stature was measured using a portable compact stadiometer. The

waist circumference was measured at the height level of the navel and the hip circumference according to standardised procedure (Callaway et al, 1988) using a non-elastic anthropometric tape. All anthropometric measurements, except body mass, were done three times, and the average values were used in the analyses.

The anthropometric data were obtained by three physical education students who received theoretical and practical training, applying the standardisation of the anthropometric techniques used in the survey. The precision and accuracy of the evaluators was confirmed with the analysis of the technical errors of measurement (TEM) inter- and intra-examiner (Pederson and Gore, 1996). This was done prior to data collection, using 20 volunteers. All of the trainee evaluators presented variations that were compatible with those acceptable for experienced evaluators: TEM-inter $\leq 1.5\%$ and TEM-intra $\leq 1\%$.

Adjustment variables

The variables included age (continuous variable), gender, literacy (yes and no), smoking (smoker, former or never), and alcohol consumption (none or ≥ 1 times per week). The level of physical activity was assessed using the International Physical Activity Questionnaire (IPAQ; Craig et al, 2003). Those older people with less than 150 minutes per week of moderate to vigorous exercise were considered insufficiently active, whereas those with more than 150 minutes per week were classified as active. The systolic blood pressure (SBP) and the diastolic blood pressure (DBP) were measured according to standardised procedures (Sociedade Brasileira de Cardiologia et al, 2010) using the digital automatic blood pressure monitor. A high blood pressure (SBP ≥ 140 mmHg and/or DBP ≥ 90 mmHg and/or use of medication for blood pressure control) was defined according to the current guidelines in Brazil (Sociedade Brasileira de Cardiologia et al, 2010).

Data analysis

For descriptive analysis of the population, frequencies, averages, medians, standard deviations and interquartile range were calculated. The differences between genders were compared by the chi-squared tests for the qualitative variables and Mann–Whitney *U* test or *t*-tests for independent samples (quantitative variables), after verification of normality using the

Kolmogorov-Smirnov test. The association between the anthropometric indicators of obesity (independent variables) and hyperglycaemia (dependent variable) was tested by means of the Poisson regression technique (Coutinho et al, 2008). Robust models adjusted to estimate the ratio of prevalence (PR) were calculated (confidence interval 95%). Receiver operating characteristic (ROC) curves were used to demonstrate the power of anthropometric indicators in diagnosing hyperglycaemia. Also, ROC curves were used to select the optimal anthropometric cut-off values that identified individuals with hyperglycaemia

The data were tabulated and analysed using the SPSS for Windows, version 15 (SPSS Inc, 2006) and MedCalc, version 9.1.0.1 (MedCalc Software, 2006).

Results

A total of 173 women (54.7%) and 143 men (45.3%), aged between 60 and 105 years (74.2±9.8 years), participated in the survey. The average age for women and men were 74.9±10.0 and 73.4±9.4 years, respectively. The frequency of literacy, smokers and former smokers, and those who drank alcohol at least once a week was higher among men. The values of the anthropometric variables were higher among women, except in relation to WHR (Table 1).

The prevalence of high fasting glycaemia was 11.7%, with no significant difference observed among women (14.1%) and men (8.6%). The median of glycaemia was 83.0 ± 21.0 mg/dL (4.61 ± 1.17 mmol/L).

Table 2 presents the ratios of high fasting glycaemia prevalence according to the indicators of obesity. For the females, BMI, waist circumference, WHR and WSR were indicators associated with high fasting glycaemia, with BMI being the indicator with the highest power of association. For the males, only BMI was associated with high fasting glycaemia.

After the regression analysis indicated that BMI was the anthropometric indicator of obesity that is primarily associated with high fasting glycaemia, in both men and women, we decided to proceed with the ROC curve analysis in order to identify the cutoff points, which better discriminate hyperglycaemia. The best indicated cutoff points of BMI and the respective discriminatory capacities of high fasting glycaemia can be observed using the parameters of the ROC curve (Figure 1 and Table 3). It has been verified that for the females, the best cutoff point of

Table 1. Descriptive statistics of the study population.

Variables	Total	Female	Male	P-value
Literacy (%)				
Yes	33.2	27.7	39.9	0.031
No	66.8	72.3	60.1	
Smoker (%)				
Smoker	11.1	4.0	19.7	<0.001
Ex-smoker	46.7	36.4	59.2	
Never smoked	42.2	59.6	21.1	
Alcohol intake (%)				
≥1 day/ week	8.6	3.5	14.8	0.001
None	91.4	96.5	85.2	
Physical activity (%)				
Insufficiently active	47.7	47.3	48.2	0.967
Active	52.3	52.7	51.8	
High blood pressure (%)				
Yes	83.7	87.0	79.6	0.112
No	16.3	13.0	20.4	
BMI (kg/m²)	24.5 ± 4.7	25.3 ± 4.1	23.7 ± 4.1	0.003*
Waist circumference (cm)	91.8 ± 18.2	94.3 ± 17.9	89.3 ± 18.2	<0.001 [†]
WHR	0.97 ± 0.08	0.98 ± 0.08	0.97 ± 0.09	0.073 [†]
WSR	0.59 ± 0.12	0.63 ± 0.13	0.55 ± 0.08	<0.001 [†]
Conicity index	1.37 ± 0.14	1.42 ± 0.12	1.32 ± 0.12	<0.001 [†]
BAI	30.6 ± 9.56	35.0 ± 8.8	26.5 ± 4.7	<0.001 [†]

BMI=body mass index; WHR=waist/hip ratio; WSR=waist/stature ratio; BAI=body adiposity index. * *t*-tests; [†] Mann Whitney *U* test.

The values are expressed in median ± interquartile range or percentage. BMI is expressed as a mean ± standard deviation.

BMI presented with an elevated sensitivity value and a moderate specificity value. For men, a balance among the values of sensitivity and specificity was observed.

Discussion

This is the first home-based population study of older people in Brazil to investigate the anthropometric obesity indicators that are mostly associated with elevated fasting glycaemia, and to establish the best cutoff points for hyperglycaemia in this population. The results showed that out of the four indicators (BMI, waist circumference, WHR, WRH) associated with hyperglycaemia among women, BMI was the indicator with the highest power of association. For

“Each increase of kg/m² of BMI was associated with an increase of 19% and 9% in the prevalence of elevated fasting glycaemia in men and women, respectively.”

Table 2. Prevalence ratios for hyperglycaemia with increasing obesity indicators in older people.

Variables	Female			Male		
	PR	95% CI	P-value	PR	95% CI	P-value
BMI (kg/m ²)	1.09	1.02–1.16	0.014	1.19	1.03–1.37	0.020
Waist circumference (cm)	1.03	1.00–1.07	0.038	1.03	0.99–1.07	0.150
WHR	1.08	1.00–1.17	0.043	1.01	0.99–1.04	0.341
WSR	1.05	1.01–1.10	0.026	1.04	0.98–1.11	0.176
Conicity index	1.02	0.99–1.06	0.145	1.01	0.99–1.02	0.497
BAI	1.05	0.99–1.11	0.084	1.11	0.98–1.26	0.111

PR=prevalence ratio; 95% CI=95% confidence interval; BMI=body mass index; WHR=waist/hip ratio; WSR=waist/stature ratio BAI=body adiposity index. *Adjusted for age, literacy, smoking, alcohol, physical activity and high blood pressure

the males, only BMI was associated with elevated fasting glycaemia. Each increase of kg/m² of BMI was associated with an increase of 19% and 9% in the prevalence of elevated fasting glycaemia in men and women, respectively.

In a meta-analysis of studies from 1966 to 2004, BMI showed a strong association with the incidence of diabetes in a similar form to the waist circumference and waist/hip ratio (Vazquez et al, 2007). In other studies conducted with older people (Nemesure et al, 2008; Sanchez-Viveros et al, 2008), BMI presented a strong association with diabetes. The build-up of general body fat can increase the risk of diabetes because the excess fat acts like a blockade of the insulin receptors in the cells, therefore maximising the increase of resistance to insulin (US Department of Health and Human Services, 2008).

In this population, the BMI cutoff points that

best determined the high fasting glycaemia were 25.9 kg/m² and 24.5 kg/m², for men and women, respectively. The obtained values resemble the classification of WHO for overweight in adults (WHO, 2006). These values reinforce the premise that the same BMI value may not correspond to the same fat quantity or health risk in different populations (WHO, 2006). It is worth remembering that the percentage of body fat increases with the advance of age in both genders (Meeuwssen et al, 2010). That is, the cutoff points to define the risk of morbidity/mortality seem to be different among populations/age groups (Troiano et al, 1996).

The observed area under the curve (AUC) of the BMI was 0.67 in women and 0.74 in men. These values were similar to the data in the meta-analysis involving nine studies with adults and elderly, where the AUC pool of BMI was 0.69 and 0.67 in women and men, respectively (Lee et al, 2008). However, in a study conducted with Asian adults and older people, BMI demonstrated a predictive capacity of diabetes lower than other anthropometric indicators (The Decoda Study Group, 2008).

The prevalence of high fasting glycaemia found in this study (11.7%) stands out. In Brazil, according to data from VIGITEL, the prevalence of self-referred diabetes by people 65 years or older increased from 18.9% in 2006 to 22% in 2010 (Ministério da Saúde, 2007; Ministério da Saúde, 2011). It was estimated that the increase of people with diabetes will continue to grow, especially in people 65 years or older, in the developed as well as developing countries

Table 3. Parameters of the ROC curve for BMI as a discriminator of hyperglycaemia in older people.

Variables	Female	Male
AUC (95% CI)	0.67 (0.59–0.74)	0.74 (0.66–0.81)
P-value	0.011	0.004
Cutoff point	24.5 kg/m ²	25.9 kg/m ²
Sensitivity	81.8%	75.0%
Specificity	53.2%	76.8%

AUC=area under the ROC curve; 95% CI=95% confidence interval

(Wild et al, 2004). Thus, it is important to monitor the increase of body fat as a preventive measure, considering the feasibility and the low cost of the use of anthropometric measures, or the possibility of using self-referred measurements of weight and height. However, self-reporting of these measurements may be influenced by gender, age and education (Del Duca et al, 2012).

A limitation of this study is that the blood sample analysis is only looking at hyperglycaemia. However, the study does not expand to the diagnosis of diabetes, which requires the fulfillment of three criteria (casual glycaemia >200 mg/dL; fasting glycaemia \geq 126 mg/dL; glycaemia after 2 hours of overcharge of glucose >200 mg/dL) as outlined by the Sociedade Brasileira de Diabetes (2009). The strengths of the study refer to the accuracy of the anthropometric measurements, a response ratio of over 80% and the direct measurement of fasting glycaemia.

Conclusions

According to the results of this study we conclude that BMI was the best anthropometric indicator of obesity associated with hyperglycaemia in community-dwelling older people of both sexes. We also conclude that BMI was able to discriminate hyperglycaemia in older people of both sexes, presenting satisfactory sensitivity and specificity values.

Implications for practice

The results presented in this paper can be used by healthcare professionals involved in the care of older people as a preventive measure for diabetes, and may have implications for clinical practices and public health actions. BMI is an easily obtainable indicator and is a cost-effective measurement. Further studies looking at older people from different Brazilian regions is suggested in order to compare the estimates observed in the present study. ■

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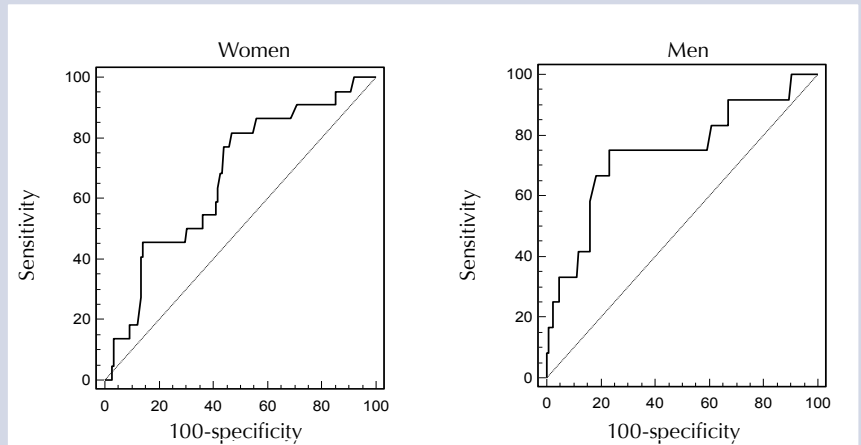


Figure 1. ROC curves of BMI as discriminators of hyperglycaemia in older people.

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