The Impact of Obesity and Adiposity on Mortality Risk in Older Adults: A Ten-year Survival Analysis

Letícia Almeida Nogueira Moura
Federal University of Goiás

Valéria Pagotto
Federal University of Goiás

Cristina Camargo Pereira
Federal University of Goiás

Rômulo Roosevelt da Silva Filho
Federal University of Goiás

César de Oliveira
University College London

Erika Aparecida Silveira (erikasil@terra.com.br)
Federal University of Goiás

Research Article

Keywords: Aging, Obesity, Adiposity, Cardiovascular Diseases, Cancer, Mortality

Posted Date: August 18th, 2021

DOI: https://doi.org/10.21203/rs.3.rs-777627/v1

Abstract

There are not much information about the impact of obesity on all-cause, cardiovascular and cancer mortality in older adults. We have investigated the impact of obesity and adiposity on all-cause, cardiovascular and cancer mortality, in older adults after a 10-year follow-up. Prospective cohort study has been carried out with individuals ≥ 60 years. Sociodemographic characteristics, lifestyle, clinical history, laboratory tests and anthropometric data were collected. Adiposity was defined as tertiles of the percentage of body fat assessed by multifrequency bioimpedance. For obesity, three classifications were considered using the body mass index (BMI) as follows: ≥ 25.0 kg/m² in men and ≥ 26.6 kg/m² in women, ≥ 27.0 kg/m² and ≥ 30.0 kg/m². The BMI ≥ 30.0 kg/m² was associated a reduction in the all-cause mortality risk in non-ajusted Cox regression (HR: 0.65; 95% CI: 0.43 - 0.97) and in the Kaplan-Meier curves (p = 0.032). However, in multivariate Cox regression none of the diagnostic criteria for obesity and adiposity were significantly associated with all-cause, cardiovascular or cancer mortality. This 10-year survival analysis has showed that obesity and adiposity were not associated with an increased risk of all-cause, cardiovascular or cancer mortality in the older adults.

1. Introduction

The increase in the proportion of older adults in the population occurs worldwide. Currently, approximately 727 million people (9.3%) of the global population are 65 years of age or older, with an expectation of growth to 1.5 billion (16%) by 2050 [1]. In the European Union, people over 65 represent 20.3% [2], in the United States of America 16% [3] and, in Brazil, 29 million (14.3%) of the population are aged 60 years or over [4]. In addition, there is also an increase in the prevalence of obesity and chronic diseases in this age group [5]. Complex interactions, such as endocrine and metabolic changes, result in body composition changes in older adults, such as increased adiposity, that is, the percentage of body fat [6, 7]. Obesity is a risk factor for the development of non-communicable diseases (NCDs) such as cardiovascular diseases (CVD) and several types of cancer. However, in older adults, this association is controversial and limited [8–10].

It is well established that in older adults non-communicable diseases such as cardiovascular disease and cancer are among the main causes of death [11]. However, studies that explored the association between obesity and mortality showed conflicting findings, demonstrating that the impact of obesity in this group is still not well understood [12, 13]. A study carried out with older Brazilian and English adults, identified a greater survival of those who were overweight and obese [14]. However, a study carried out in the United Kingdom found an increased mortality risk in individuals aged between 60 and 69 years with a diagnosis of grade I obesity [15]. While another study carried out in Pennsylvania with people over 60 years of age, only grade III obesity was associated with an increased risk of all-cause mortality [16]. The results of these studies reveal how controversial is the impact of obesity on mortality risk of older adults.

The diagnosis of obesity in population studies is usually carried out using the body mass index (BMI) as it is a measure of easy applicability and low cost [17]. However, in older adults, the diagnosis of obesity using BMI does not yet have well-established cut-off points [18, 19]. In this sense, it is necessary to use more specific and sensitive cut-off points for obesity in older adults [18]. In the context of mortality studies, evaluating obesity using more precise and accurate methods is very relevant and can help to clarify the controversies of this association between obesity and mortality in older adults [20]. There is a significant prevalence of obesity in older adults, which represents a serious public health problem worldwide. Thus, the development of research that can clarify the impacts of obesity on mortality risk of older adults is relevant since there are controversies around its potential causal association with mortality. Therefore, the present study aims to assess the impact of obesity using different diagnostic criteria and adiposity on all-cause, cardiovascular and cancer mortality risk in community-dwelling older Brazilian adults over a 10-year follow-up period.

2. Results

The analytical sample comprised of 418 older adults. In 2018/19, the follow-up average age was 70.69 ± 7.13 years. The follow-up time was 10.8 years. The sociodemographic data evaluated showed that 54.8% lived with a partner, 41.2% had up to 4 schooling years, 46.9% belonged to the socioeconomic class “C”, 84.7% did not consume alcoholic beverages, 47.4% were non-smokers and 64.3% were sedentary. In relation to chronic diseases, 60.3% had hypertension and 23.4% were diabetic.

The prevalence of obesity in our sample ranged from 27.0% to 57.4%, according to the different classification criteria used. The highest prevalence of obesity was observed by applying the classification criteria defined for the study population itself [18] (57.4%). The mortality rate from all-cause was 35.2%, while from CVD and cancer were 11.2% and 5.3%, respectively (Table 1).

Table 1. Distribution of participants according to sociodemographic characteristics, lifestyle, obesity status (BMI criteria), adiposity and mortality.

Variables	n (%)
Sex	
Man	142 (34,0)
Woman	276 (66,0)
Age group	
60 - 69	203 (48,6)
70 - 79	168 (40,2)
80 +	47 (11,2)
BMI	26,97 ± 5,11*
Obesity BMI ≥ 27,0 kg/m²	
No	213 (51,0)
Yes	205 (49,0)
Obesity BMI ≥ 25,0 kg/m² man and BMI ≥ 26,6 kg/m² Woman	
No	178 (42,6)
Yes	240 (57,4)
Obesity BMI ≥ 30,0 kg/m²	
No	305 (73,0)
Yes	113 (27,0)
% Body Fat	42,71 ± 9,31*
Adiposity	
1st and 2nd tertiles	260 (66,7)
3rd tertile	130 (33,3)
Mortality - all-cause	147 (35,2)
Mortality - CVD	49 (11,2)
Mortality - cancer	22 (5,3)

* Mean and standard deviation

Adiposity was not associated with all-cause mortality. For the different diagnostic criteria for obesity using the BMI, we observed a significant reduction in the risk of mortality from all causes with obesity classified by BMI ≥30.0 kg /m² (HR: 0.65; 95% CI: 0.43 - 0.97). There was no significant association between the three different cut-off points for BMI with mortality from cardiovascular disease or cancer (Table 2).

Table 2. Unadjusted association between obesity, adiposity and causes of mortality - Cox regression.

Variables	Causes of mortality					
	All-cause		CVD		Cancer	
	HR (95%CI)	P-value	HR (95%CI)	P-value	HR (95%)CI	P-value
BMI ≥27,0 kg/m²	0,80 (0,58-1,11)	0,180	1,33 (0,75-2,35)	0,325	0,48 (0,19-1,17)	0,107
BMI ≥25,0 kg/m² in men e ≥26,6 kg/m² in women	0,78 (0,57-1,08)	0,143	1,34 (0,74-2,41)	0,333	0,60 (0,26-1,39)	0,236
BMI ≥30,0 kg/m²	0,65 (0,43-0,97)	**0,034**	0,91 (0,48-1,72)	0,773	0,75 (0,27-2,04)	0,574
Adiposity (3rd tertile)	0,99 (0,69-1,42)	0,980	0,98 (0,52-1,86)	0,954	0,61 (0,22-1,63)	0,319

The Kaplan-Meier curves for all-cause mortality according to the different parameters for obesity showed that only obesity determined by a BMI ≥ 30.0 kg/m² was significantly associated with a lower mortality risk, when compared with non-obese older adults (p = 0.032). In the other survival analyses, there were no significant associations between obesity and mortality risk using the other two obesity classification criteria: BMI ≥ 25.0 kg/ m² in men and ≥ 26.6 kg/m² in women (p = 0.140) and BMI ≥ 27.0 kg/m²; (p = 0.177) (Figure 1). The Kaplan-Meier curves were also used to assess the effect of adiposity on mortality and there was no significant association even for the tertile of greater adiposity (p = 0.979) (Figure 2).

In the mortality risk from CVD and obesity and adiposity analysis, the Kaplan-Meier curves showed no significant associations using the three different parameters of obesity as follows: BMI ≥25.0 kg/m² in men and ≥26.6 kg/m² in women (p = 0.3307), BMI ≥ 27.0 kg/m² (p = 0.3226), BMI ≥30.0 kg/m² (p = 0.7728). The association was not significant for the highest adiposity tertile (p = 0.9536). For cancer mortality risk, we did not find significant associations with BMI ≥25.0 kg/m² in men and ≥26.6 kg/m² in women (p = 0.2311), BMI ≥ 27.0 kg/m² (p = 0.0997), BMI ≥30.0 kg/m² (p = 0.5724) and adiposity (p = 0.3138) (supplementary material).

In the multivariate Cox regression analysis, the association between BMI ≥ 30 kg/m² and mortality risk did not remain significant in the fully adjusted models. There were also no significant associations between the other two obesity BMI classification, adiposity and all-cause, CVD and cancer mortality risk (Table 3).

Table 3. Multivariate Cox regression for the association between different obesity criteria, adiposity and of all-cause, CVD and cancer mortality risk

Causes of mortality	BMI ≥27,0 kg/m² [a]		BMI ≥25,0 kg/m² (men) and ≥26,6 kg/m² (women)[b]		BMI ≥30,0 kg/m² [c]		Adiposity [d]	
	HR (95%CI)	P value	HR (95% CI)	P value	HR (95% CI)	P value	HR (95% CI)	P value
All-cause								
Model 1	0,95 (0,68-1,33)	0,780	0,87 (0,64-1,20)	0,414	0,81 (0,54-1,22)	0,318	0,95 (0,64-1,42)	0,816
Model 2	0,94 (0,67-1,32)	0,732	0,86 (0,63-1,18)	0,356	0,73 (0,48-1,09)	0,126	0,99 (0,51-1,93)	0,998
CVD								
Model 1	1,73 (0,95-3,14)	0,073	1,61 (0,90-2,88)	0,109	1,18 (0,61-2,31)	0,618	0,92 (0,46-1,83)	0,814
Model 2	1,78 (0,95-3,32)	0,071	1,48 (0,82-2,69)	0,197	1,09 (0,54-)	0,807	1,23 (0,44-3,86)	0,640
Cancer								
Model 1	0,50 (0,21-1,22)	0,128	0,61 (0,26-1,42)	0,250	0,86 (0,31-2,35)	0,765	0,58 (0,19-1,,74)	0,336
Model 2	0,71 (0,23-2,19)	0,548	0,89 (0,26-3,01)	0,849	1,98 (0,66-5,95)	0,223	1,23 (0,25-6,69)	0,755

Note: CVD: Cardiovascular diseases; HR: Hazard Ratio; CI: Confidence interval; BMI: Body Mass Index.

a BMI ≥27.0 kg/m². Model 1: sex and age; Model 2: model 1 + smoking, diabetes mellitus, self-reported stroke, self-reported infarction, adiposity, TG and HDL.

b BMI ≥25.0 kg/m² in man and ≥26.6 kg/m² in women. Model 1: sex and age; Model 2: model 1 + smoking, physical activity, diabetes mellitus, self-reported stroke, self-reported infarction, adiposity, TG, HDL and LDL.

c BMI ≥30.0 kg/m². Model 1: sex and age; Model 2: model 1 + smoking, physical activity, diabetes mellitus, adiposity and TG.

d Adiposity. Model 1: sex and age; Model 2: model 1 + consumption of alcoholic beverages, smoking, physical activity, self-reported infarction, HDL and LDL.

3. Discussion

The present survival analysis did not find a significant association between obesity, adiposity and all-cause, cardiovascular and cancer mortality risk in older adults after a 10-year follow-up period. To the best of our knowledge, no other study was found assessing the impact of obesity on overall mortality risk due to CVD and cancer in

community-dwelling older adults in Latin America. The present study differs from previous studies carried out on this theme because it adopts different diagnostic criteria for obesity, in addition to its long follow-up period. The findings of the present research contribute to elucidate the controversial results of previous research on the impact of obesity on mortality risk in older adults [12–16].

In our study, the highest prevalence of general obesity (57.4%) was identified through the application of BMI values ≥ 25.0 kg/m² in men and ≥ 26.6 kg/m² in women. This cut-off point was established previously for the sample used in this study [18] and that is why we consider the most accurate data on the prevalence of obesity for this population. Compared with a European study that evaluated the prevalence of obesity in older adults, the present is closer to the result found when adopting a BMI ≥ 25.0 kg/m², which found a prevalence of 60.3% [21]. The high prevalence of obesity in older adults can be attributed to the increase in body weight throughout life up to the age group of 70-80 years of age [22]. In addition, the decrease in the resting metabolic rate and energy expenditure plays an important role in the aetiology of obesity later in life [5].

Our findings showed a significant impact of obesity on all-cause mortality risk. Those participants with a BMI ≥ 30 kg/m² had a greater survival rate compared to the non-obese counterparts. However, in the multivariate analyses, this association did not remain significant after adjustments for potential covariates. Our results from the Kaplan-Meier analysis are similar to another study with Caucasian older adults who found lower mortality rate in people aged 80 years and older with grade I and II obesity ($p < 0.001$) [13]. Our result from the multivariate analysis was similar to a study carried out in the USA, in which people ≥ 75 years old with grade I and II obesity did not present a higher risk of all-cause mortality [16]. A review of 18 studies showed a trend towards lower mortality in older adults with a BMI ≥ 30 kg/m², but without a statistically significant association [23]. Similarly, two systematic reviews, including cohort studies, found that grade I obesity was not associated with a higher mortality risk in people aged ≥ 65 years [24,25]. On the other hand, a research carried out in the United Kingdom with people aged between 60 and 69 years, showed a significant association between grade I obesity and all-cause mortality [15] which contradicts ours and previous studies [23-25]. The possible explanation for this divergence may be due to the fact this UK study was conducted in a white population, which makes it difficult a comparison with our sample comprised of a highly admixed population. Our finding showing a longer survival in obese older adults can be explained by the protective effect of obesity exclusively in the older adults, which happens through greater metabolic reserve, increased bone density and cushioning promoted by fat tissue in falls [23,26].

With regards to the non-significant associations found between obesity and mortality risk from cardiovascular diseases, our results corroborate the ones from another Brazilian study that did not find a significant association between BMI ≥ 27 kg/m² and mortality due to CVD in individuals aged ≥ 80 years [27]. Our result was also similar to a Chinese study that found no significant association between BMI ≥ 30 kg/m² and mortality in those aged ≥ 65 years [28]. Although the prevalence of CVD increases with aging [29], there is evidence to suggest a protective effect of obesity against mortality from cardiovascular diseases [26,30]. This reduction in the risk of mortality from cardiovascular diseases can be understood by the “obesity paradox”, which is observed more consistently in grade I obesity. The obesity paradox consists of physiological adaptations that guarantee a better prognosis, such as a reduction in vascular resistance, favouring greater survival in older adults with CVD [31].

In our study, no association was found between obesity and cancer mortality. This result is similar to a study that investigated an association between grade I obesity and breast cancer mortality in participants aged between 50 and 71 years old and did not find a significant association [32]. However, it differs from a cohort study with 30 years of follow-up conducted with participants between 50 and 80 years of age, in Minnesota, USA, in which high BMI values increased the risk of mortality from colorectal cancer [33]. A systematic review and meta-analysis study observed a slight association between obesity, diagnosed by BMI, and the development of different types of cancer in the older adults

(HR: 1.11; 95% CI: 1.02 - 1.21) [34]. There are few studies [35, 36] similar to ours that have assessed obesity as a risk of mortality from any type of cancer, that is, without evaluating specific types of cancer as a potential risk. However, these studies did not investigate the association exclusively in older adults, making it difficult to compare them with our study. The absence of risk of cancer mortality in obese older adults also points to the paradox of obesity, that is, the accumulation of adipose tissue in the older adults can act as a protective energy reserve, an important factor in view of the level of tumour aggressiveness and may offer a greater advantage during the acute phase of the disease and resulting in greater survival in obese patients diagnosed with cancer [37–39].

In our study, we did not observe a higher mortality risk from all causes, CVD or cancer in older adults with excess adiposity, that is, a high percentage of body fat. This finding is in agreement with a United Kingdom cohort study in middle-aged and older adults' participants that found no association between the second, third and fourth quartiles of distribution and all-cause mortality [40]. However, our result was inconsistent with a cohort with men aged 40 - 75 years that found an association between the fifth quintile of body fat percentage and risk of mortality from cardiovascular disease and mortality from cancer [41]. The lack of an association between mortality in older adults and greater body adiposity in our study could be explained by the distribution of body fat, as there are differences in the effect of the distribution of visceral and subcutaneous fat, the latter being a potential energy reserve with less cardiometabolic risk [42].

As a potential limitation of this study, we can mention the reduced number of deaths from cancer, which may partially compromise the findings related to this condition. We emphasize that this study sought to take all the methodological precautions to avoid and reduce bias, as already demonstrated in detail in previous publications using data from the same study population. Another positive aspect was the use of different diagnostic criteria for obesity and the inclusion of adiposity, which allows to deepen the inferences, strengthens the results found and differentiates them from other studies carried out to date.

Therefore, in this 10-year survival analysis we showed that obesity and adiposity were not associated with an increased risk of all-cause, cardiovascular or cancer mortality in the older adults. We suggest further research to deepen and strengthen the evidence on this topic, such as: analysis stratified by sex, evaluation of weight loss history, analysis of metabolically healthy obese older adults and application of other body composition parameters. The results of the present research help to understand that obesity in the older adults does not seem to play a risky role in mortality, a finding that helps us to direct health interventions towards older people with a focus on other aspects that will act as a greater risk.

4. Methods

2.1 Study Design

Prospective cohort study, inserted in the Goiânia Older Adults Project, which evaluated health conditions and nutritional aspects of a representative sample of community-dwelling older adults. The first phase of the project took place in 2008, and these individuals were followed for 10 years. Methodological details, and sampling details have been described in previous studies [43–47].

2.2 Study population

People aged 60 years or older, of both sexes, non-institutionalized, living in Goiânia, capital of the State of Goiás, mid-west of Brazil, were included. Older adults who had health conditions that made it impossible to measure anthropometric measures or with impaired cognitive and/or auditory ability to answer the questionnaires were excluded.

4.3 Study variables

Sociodemographic data, lifestyle, clinical history, anthropometric data, body composition and biochemical analyses were collected at participants' homes. For the data collection, researchers were trained regarding the application of a structured questionnaire, as well as anthropometric measurements, in order to obtain inter- and intra-examiner precision, with the calculation of a technical measurement error. Data were collected during home visits. Biochemical and multifrequency electrical bioimpedance tests were performed later, in a nutritional assessment laboratory at the Faculty of Nutrition of the Federal University of Goiás.

The sociodemographic data collected were sex, age, colour/race, marital status, living with a partner, education (quantified in schooling years), and socioeconomic class (A, B, C, D and E) [48]. The lifestyle data were physical activity, alcohol consumption and smoking status [49]. Among self-reported diseases, infarction, stroke and cancer were considered.

Investigation was carried out for the presence of diabetes and hypertension, as pre-existing chronic diseases. For the diagnosis of diabetes, fasting glycemia ≥ 126 mg/dl and/or HbA1c ≥ 6.5% and/or use of oral drugs to reduce blood glucose were considered [50]. Hypertension was defined as systolic BP ≥ 140 mmHg and/or diastolic BP ≥ 90 mmHg and/or use of blood pressure lowering drugs [51]. Triglyceride (TG), HDL-cholesterol (HDL-c) and LDL-cholesterol (LDL-c) tests were evaluated, with altered values considered when TG ≥ 150 mg / dl; low HDL-c when < 40 for men and < 50 for women; elevated LDL-c when ≥ 130 mg/dl [52].

To measure weight (kilograms), a portable digital electronic scale, calibrated, with a capacity of up to 150 kg and precision of 100 kg was used. Height was measured using a measuring tape measuring 2 meters in length and accurate to 0.1 cm, fixed to a smooth wall, without a baseboard, with the support of a plumb line and square. The measurements of weight and height were performed in duplicate, with the arithmetic mean of the measurements being considered as the final value. The Body Mass Index (BMI) was calculated from the division of weight (kg) by the square of height (kg/m²). The measurement of body fat was performed using a multifrequency electric bioimpedance device (BIA).

For the diagnosis of obesity, BMI and body fat percentage (% BF) were considered. In the case of BMI, three cut-off points were adopted: ≥ 27.0 kg/m² [53]; BMI ≥ 25.0 kg/m² in men and ≥ 26.6 kg/m² [18] in women [18], this cut-off being established for the study population itself, and BMI ≥ 30.0 kg/m² [19]. For the body fat percentage, the cut-off point for defining excess adiposity was calculated from the largest tertile, according to sex, being considered for men ≥ 48.1% and for women ≥ 47.7%.

2.4 Mortality ascertainment

The cohort study began in 2008. In 2018, new home visits were carried out to follow up participants. During this home visit, the occurrences of deaths were identified. Since we already had all personal information about those older adults from our cohort we just extract the cause and date of death from on mortality Brazilian database (SIM- Datasus), avaliable online.

2.5 Statistical analysis

The database was structured using the SPSS version 25.0 program. The typing was performed in double entry in the same software, and afterwards, all inconsistencies were checked. The data were analysed using the STATA program, version 12.0. First, all variables were analysed in a descriptive way by means of absolute, relative frequency, means and standard deviations (SD).

To analyse the impact of obesity on mortality, Cox's bivariate analysis was performed between the dependent variable (mortality) and the independent variable obesity. Subsequently, a Cox regression model was adjusted to verify the potential association between the study hypothesis variable (presence of obesity) and mortality. Variables with p-value

< 0.20 verified in the analysis of factors associated with obesity were adjusted in the model. The results of the Cox's regression analysis were presented as Hazard Ratios (HR) and their respective 95% confidence intervals (95% CI). Finally, survival curves were estimated for participants with and without obesity using the Kaplan-Meier method and compared statistically using the log rank test. Variables with a p-value < 0.05 were considered statistically significant.

2.6 Ethical aspects

The present study was carried out with methodological rigor, with all methods being carried out using appropriate guidelines and regulations. The study report was drafted in accordance with the guidelines of the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE). All study participants signed the Informed Consent Form, as per Resolution nº 466/2012 of the National Health Council of Brazil. The Goiânia Older Adults Project [43–47] which this study is part had received completely approved of was approved by the Research Ethics Committee of the University Federal de Goiás, protocol nº 031/2007 and 2.500.441/2018.

Declarations

Acknowledgments: The authors thank the Postgraduate Program in Health Sciences, Faculty of Medicine, Federal University of Goiás, The Brazilian National Council for Scientific and Technological Development (CNPq), and all the technical team of the Older Adults Project (Projeto Idosos – Goiânia).

Authors' contribution:

LANM participated in the planning process, statistical analysis, data interpretation and writing of the manuscript. CCP participated in data collection and statistical analysis. RRSF participated in the writing of the article. CO collaborated in the interpretation of the data and writing of the manuscript. EAS and VP conceived the Idosos Goiânia project, coordinated, obtained financing and collaborated in the writing of the manuscript. EAS raised the question of the study, participated in the planning, statistical analysis, interpretation of results and writing of the manuscript.

Funding: The Brazilian National Council for Scientific and Technological Development (CNPq). Universal Call MCT, CNPq 14/2008, Banda B, number 480927/2208-1. Dr de Oliveira is supported by the Economic and Social Research Council (ESRC) (grant number ES/T008822/11), UK.

Conflict of interest: None declared.

References

[1] United Nations. World Population Ageing 2020: Highlights. *Department of Economic and Social Affairs, Population Division.* http://www.un.org/development/desa/pd/sites/www.un.org.development.desa.pd/files/undesa_pd-2020_world_population_ageing_highlights.pdf. (2020).

[2] EUROSTAT; Population structure and ageing. *Explained, Statistics 2020*. https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Population_structure_and_ageing. (2020).

[3] Administration for Community Living. 2020 Profile of older americans. Preprint at: https://acl.gov/sites/default/files/Aging%20and%20Disability%20in%20America/2020ProfileOlderAmericans.Final_.pdf. (2020).

[4] Instituto Brasileiro de Geografia e Estatística. Projeções e estimativas da população do Brasil e das Unidades da Federação. Preprint at: https://www.ibge.gov.br/apps/populacao/projecao/index.html. (2020).

[5] McKee, A. *et al*. Obesity in the Elderly. Preprint at: https://pubmed.ncbi.nlm.nih.gov/30379513/. (2018).

[6] DiMilia. P.R., Mittman, A.C., Batsis, J.A. Benefit-to-Risk Balance of Weight Loss Interventions in Older Adults with Obesity. *Curr. Diab. Rep.* **19**, 114 (2019). doi: 10.1007/s11892-019-1249-8.

[7] Batsis, J.A, Zagaria, A.B. Addressing Obesity in Aging Patients. *Med. Clin. N.* **102,** 65-85 (2018) doi: 10.1016/j.mcna.2017.08.007.

[8] Lauby-Secretan, B., Scoccianti, C., Loomis, D., Grosse, Y., Bianchini, F., Straif, K. Body Fatness and Cancer — Viewpoint of the IARC Working Group. *NEJM.* **375**, 794 – 798 (2016). doi:10.1056/NEJMsr1606602.

[9] Caleyachetty, R. *et al*. Metabolically Healthy Obese and Incident Cardiovascular Disease Events Among 3.5 Million Men and Women. *J Am Coll Cardiol.* **70**, 1429 - 1437 (2017). doi: 10.1016/j.jacc.2017.07.763.

[10] Silveira, E.A., Kliemann, N., Noll, M., Sarrafzadegan, N., Oliveira, C. Visceral obesity and incident cancer and cardiovascular disease: An integrative review of the epidemiological evidence. *Obes Rev.* **22,** 1-17 (2021). doi: 10.1111/obr.13088.

[11] Cheng, X. et al. Population ageing and mortality during 1990–2017: A global decomposition analysis. *PLoS Med.* **17,** 1-17 (2020). doi: 10.1371/journal.pmed.1003138.

[12] de Almeida Roediger, M. et al. Body Composition Changes and 10-Year Mortality Risk in Older Brazilian Adults: Analysis of Prospective Data from the SABE Study. *J Nutr Health Aging.* **23,** 51-59 (2019). doi: 10.1007/s12603-018-1118-1.

[13] Puzianowska-Kuznicka, M. et al. Obesity Paradox in Caucasian Seniors: Results of the PolSenior Study. *J Nutr Health Aging.* **23,** 796-804 (2019). doi: 10.1007/s12603-019-1257-z.

[14] da Silva Alexandre, T., Scholes, S., Ferreira Santos, J.L., de Oliveira Duarte, Y. A., de Oliveira, C. Dynapenic Abdominal Obesity Increases Mortality Risk Among English and Brazilian Older Adults: A 10-Year Follow-Up of the ELSA and SABE Studies. *J Nutr Health Aging.* **22,** 138-144 (2018). doi: 10.1007/s12603-017-0966-4.

[15] Bowman, K. et al. Central adiposity and the overweight risk paradox in aging: follow-up of 130,473 UK Biobank participants. *Am. J. Clin. Nutr.* **106,** 130-135 (2017). doi: 10.3945/ajcn.116.147157.

[16] Cheng, F. W. et al. Body mass index and all-cause mortality among older adults. *Obesity.* **24,** 2232 – 2239 (2016). doi:10.1002/oby.21612.

[17] Chooi, Y. C., Ding, C., Magkos, F. The epidemiology of obesity. *Metabolism.* **92**, 6-10 (2019). doi: 10.1016/j.metabol.2018.09.005.

[18] Silveira, E. A., Pagotto, V., Barbosa, L.S., Oliveira, C., de, Pena, G.G., Velasquez-Melendez, G. Accuracy of BMI and waist circumference cut-off points to predict obesity in older adults. *Cien Saude Colet* **25,** 1075 – 1082 (2020). doi: 10.1590/1413-81232020253.13762018.

[19] World Health Organization. Physical Status: The Use and Interpretation of Anthropometry. Preprint at: https://apps.who.int/iris/handle/10665/37003?locale-attribute=pt&. (1995).

[20] Adab, P., Pallan, M., Whincup, P.H. Is BMI the best measure of obesity? *BMJ.* **361,** 1-2 (2018)

doi: 10.1136/bmj.k1274.

[21] Peralta, M., Ramos, M., Lipert, A., Martins, J., Marques, A. Prevalence and trends of overweight and obesity in older adults from 10 European countries from 2005 to 2013. *Scand. J. Public Health*. **46,** 522 – 529 (2018). doi:10.1177/1403494818764810.

[22] Reinders, I., Visser, M., Schaap, L. Body weight and body composition in old age and their relationship with frailty. *Curr. Opin. Clin. Nutr. & Metab. Care.* **20,** 11 – 15 (2017). doi: 10.1097/MCO.0000000000000332.

[23] Javed, A. A., Aljied, R., Allison, D.J., Anderson, L.N., Ma, J., Raina, P. Body mass index and all-cause mortality in older adults: A scoping review of observational studies. *Obes. Rev.* **21,** 1 – 12 (2020). doi:10.1111/obr.13035.

[24] Winter, J.E., MacInnis, R.J., Wattanapenpaiboon, N., Nowson, C.A. BMI and all-cause mortality in older adults: a meta-analysis. *Am. J. Clin. Nutr.* **99,** 875 – 890 (2014). doi: 10.3945/ajcn.113.068122.

[25] Flegal, K.M., Kit, B.K., Orpana H., Graubard, B.I. Association of All-Cause Mortality With Overweight and Obesity Using Standard Body Mass Index Categories. *JAMA.* **309,** 71 – 82 (2013). doi:10.1001/jama.2012.113905.

[26] Chapman, I.M. Body Composition and Aging. *S. Karger AG.* **37,** 20-36. (2010). https://doi.org/10.1159/000319992.

[27] David, C.N., de Mello, R.B, Bruscato, N.M., Moriguchi, E.H. Overweight and abdominal obesity association with all-cause and cardiovascular mortality in the elderly aged 80 and over: A cohort study. *J Nutr Health Aging.* **21,** 597 – 603 (2017). doi:10.1007/s12603-016-0812-0.

[28] Wu, C-Y., Chou, Y-C., Huang, N., Chou, Y-J., Hu, H-Y., Li, C-P. Association of Body Mass Index with All-Cause and Cardiovascular Disease Mortality in the Elderly. *PLoS One.* **9,** 1 – 10 (2014) doi: 10.1371/journal.pone.0102589.

[29] Rodgers, J.L. et al. Cardiovascular Risks Associated with Gender and Aging. *J Cardiovasc Dev Dis* **6,** 1 - 18 (2019). doi:10.3390/jcdd6020019.

[30] Dorner, T.E., Rieder, A. Obesity paradox in elderly patients with cardiovascular diseases. *Int J Cardiol.* **23,** 56 – 65 (2012). doi:10.1016/j.ijcard.2011.01.076.

[31] Elagizi, A. et al. An Overview and Update on Obesity and the Obesity Paradox in Cardiovascular Diseases. *Prog Cardiovasc Dis.* **61,** 142 – 150 (2018). doi: 10.1016/j.pcad.2018.07.003.

[32] Cifu, G., Arem, H. Adherence to lifestyle-related cancer prevention guidelines and breast cancer incidence and mortality. *Ann. Epidemiol*. **28,** 767 – 773 (2018). doi:10.1016/j.annepidem.2018.09.002.

[33] Shaukat, A., Dostal, A., Menk, J., Church, T.R. BMI Is a Risk Factor for Colorectal Cancer Mortality. *Dig. Dis. Sci..* **62,** 2511 – 2517 (2017). doi:10.1007/s10620-017-4682-z.

[34] Freisling, H. et al. Comparison of general obesity and measures of body fat distribution in older adults in relation to cancer risk: meta-analysis of individual participant data of seven prospective cohorts in Europe. *Br. J. Cancer*. **116,** 1486 - 1497 (2017). doi: 10.1038/bjc.2017.106.

[35] Calle, E.E., Rodriguez, C., Walker-Thurmond, K., Thun, M.J. Overweight, Obesity, and Mortality from Cancer in a Prospectively Studied Cohort of U.S. Adults. *NEJM.* **348,** 1625 – 1638 (2003). doi:10.1056/NEJMoa021423

[36] Taghizadeh, N. et al. BMI and lifetime changes in BMI and cancer mortality risk. *PLoS One*. **10,** 1 – 16 (2015). doi:10.1371/journal.pone.0125261

[37] Lee, D.H., Giovannucci, E.L. The Obesity Paradox in Cancer: Epidemiologic Insights and Perspectives. *Curr. Nutr. Rep.* **8,** 175 – 181 (2019) doi:10.1007/s13668-019-00280-6.

[38] Shachar, S.S., Williams, G.R. The Obesity Paradox in Cancer—Moving Beyond BMI. *Cancer Epidemiol Biomarkers Prev.* **26,** 13 – 16 (2017). doi:10.1158/1055-9965.

[39] Lennon, H., Sperrin, M., Badrick, E., Renehan, A.G. The Obesity Paradox in Cancer: a Review*. Curr. Oncol. Rep.* **18,** 1 – 8 (2016). doi:10.1007/s11912-016-0539-4.

[40] Myint, P.K., Kwok, C.S., Luben, R.N., Wareham, N.J., Khaw, K-T. Body fat percentage, body mass index and waist-to-hip ratio as predictors of mortality and cardiovascular disease. *Heart.* **100,** 1613 – 1619 (2014). doi:10.1136/heartjnl-2014-305816.

[41] Lee, D.H. et al. Predicted lean body mass, fat mass, and all cause and cause specific mortality in men: prospective US cohort study. *BMJ.* **362,** 1 - 10 (2018). doi:10.1136/bmj.k2575.

[42] Wang, S., Ren, J. Obesity Paradox in Aging: From Prevalence to Pathophysiology. *Prog. Cardiovasc. Dis..* **61,** 182 – 189 (2018). doi:10.1016/j.pcad.2018.07.011.4

[43] Silveira, E. A., Dalastra, L., Pagotto. V. Polypharmacy, chronic diseases and nutritional markers in community-dwelling older. *Rev. bras. epidemiol.* **17,** 818 – 829 (2014). doi: 10.1590/1809-4503201400040002.

[44] Pagotto, V., Silveira, E.A., Velasco, W.D. The profile of hospitalizations and associated factors among elderly users of the Brazilian Unified Health System. **18,** 3061 – 3069. *Cien Saude Colet* (2013). doi: 10.1590/S1413-81232013001000031.

[45] Pagotto, V., Nakatani, A.Y.K., Silveira, E.A. Factors associated with poor self-rated health in elderly users of the Brazilian Unified National Health System. *Cad. Saúde Pública.* **27,** 1593 – 1602 (2011). doi:10.1590/S0102-311X2011000800014.

[46] Pagotto, V., Santos, K.F. dos, Malaquias, S.G., Bachion, M.M., Silveira, E.A. Calf circumference: clinical validation for evaluation of muscle mass in the elderly. *Rev. Bras. Enferm.* **71,** 322 - 328 (2018). doi: 10.1590/0034-7167-2017-0121.

[47] Silveira, E.A., Vieira, L.L., Souza, J.D. de. High prevalence of abdominal obesity among the elderly and its association with diabetes, hypertension and respiratory diseases. *Cien Saude Colet*. **23,** 903 – 912 (2018). doi: 10.1590/1413-81232018233.01612016.

[48] Associação Brasileira de Empresas de Pesquisas. Critério de Classificação Econômica Brasil. https://www.abep.org/criterio-brasil. (2008).

[49] MINISTÉRIO DA SAÚDE. INSTITUTO NACIONAL DE CÂNCER. Abordagem e tratamento do fumante – consenso. https://www.inca.gov.br/publicacoes/livros/abordagem-e-tratamento-do-fumante-consenso. (2001).

[50] American Diabetes Association. 2. Classification and Diagnosis of Diabetes: Standards of Medical Care in Diabetes. *Diabetes Care*. **41,** S13-S27(2018). doi: 10.2337/dc18-S002.

[51] Drozda, Jr. J. et al. ACCF/AHA/AMA–PCPI 2011 Performance Measures for Adults With Coronary Artery Disease and Hypertension. *Circulation.* **124,** 248 – 270 (2011). doi: 10.1161/CIR.0b013e31821d9ef2

[52] National Cholesterol Education Program Expert Panel on Detection, Evaluation and T of HBC in A Adult TPI. Third Report of the National Cholesterol Education Program (NCEP) Expert Panel on Detection, Evaluation, and Treatment of

High Blood Cholesterol in Adults (Adult Treatment Panel III) final report. *Circulation.* **106,** 3143 – 3421 (2002). doi: 10.1161/CIR.0b013e31821d9ef2.

[53] LIPSCHITZ, D.A. Screening for nutritional status in the elderly. *Prim. Care.* **21,** 55-67 (1994).Silveira, E. A., Dalastra, L., Pagotto. V. Polypharmacy, chronic diseases and nutritional markers in community-dwelling older. *Rev. bras. epidemiol.* **17,** 818 – 829 (2014). doi: 10.1590/1809-4503201400040002.

[54] Pagotto, V., Silveira, E.A., Velasco, W.D. The profile of hospitalizations and associated factors among elderly users of the Brazilian Unified Health System. **18,** 3061 – 3069. *Cien Saude Colet* (2013). doi: 10.1590/S1413-81232013001000031.

[55] Pagotto, V., Nakatani, A.Y.K., Silveira, E.A. Factors associated with poor self-rated health in elderly users of the Brazilian Unified National Health System. *Cad. Saúde Pública.* **27,** 1593 – 1602 (2011). doi:10.1590/S0102-311X2011000800014.

[56] Pagotto, V., Santos, K.F. dos, Malaquias, S.G., Bachion, M.M., Silveira, E.A. Calf circumference: clinical validation for evaluation of muscle mass in the elderly. *Rev. Bras. Enferm.* **71,** 322 - 328 (2018). doi: 10.1590/0034-7167-2017-0121.

[57] Silveira, E.A., Vieira, L.L., Souza, J.D. de. High prevalence of abdominal obesity among the elderly and its association with diabetes, hypertension and respiratory diseases. *Cien Saude Colet*. **23,** 903 – 912 (2018). doi: 10.1590/1413-81232018233.01612016.

[58] Associação Brasileira de Empresas de Pesquisas. Critério de Classificação Econômica Brasil. https://www.abep.org/criterio-brasil. (2008).

[59] MINISTÉRIO DA SAÚDE. INSTITUTO NACIONAL DE CÂNCER. Abordagem e tratamento do fumante – consenso. https://www.inca.gov.br/publicacoes/livros/abordagem-e-tratamento-do-fumante-consenso. (2001).

[60] American Diabetes Association. 2. Classification and Diagnosis of Diabetes: Standards of Medical Care in Diabetes. *Diabetes Care*. **41,** S13-S27(2018). doi: 10.2337/dc18-S002.

[61] Drozda, Jr. J. et al. ACCF/AHA/AMA–PCPI 2011 Performance Measures for Adults With Coronary Artery Disease and Hypertension. *Circulation.* **124,** 248 – 270 (2011). doi: 10.1161/CIR.0b013e31821d9ef2.

[62] National Cholesterol Education Program Expert Panel on Detection, Evaluation and T of HBC in A Adult TPI. Third Report of the National Cholesterol Education Program (NCEP) Expert Panel on Detection, Evaluation, and Treatment of High Blood Cholesterol in Adults (Adult Treatment Panel III) final report. *Circulation.* **106,** 3143 – 3421 (2002). doi: 10.1161/CIR.0b013e31821d9ef2.

[63] LIPSCHITZ, D.A. Screening for nutritional status in the elderly. *Prim. Care.* **21,** 55-67 (1994).

[64] Peralta, M., Ramos, M., Lipert, A., Martins, J., Marques, A. Prevalence and trends of overweight and obesity in older adults from 10 European countries from 2005 to 2013. *Scand. J. Public Health*. **46,** 522 – 529 (2018). doi:10.1177/1403494818764810.

[65] Reinders, I., Visser, M., Schaap, L. Body weight and body composition in old age and their relationship with frailty. *Curr. Opin. Clin. Nutr. & Metab. Care.* **20,** 11 – 15 (2017). doi: 10.1097/MCO.0000000000000332.

[66] Javed, A. A., Aljied, R., Allison, D.J., Anderson, L.N., Ma, J., Raina, P. Body mass index and all-cause mortality in older adults: A scoping review of observational studies. *Obes. Rev.* **21,** 1 – 12 (2020). doi:10.1111/obr.13035.

[67] Winter, J.E., MacInnis, R.J., Wattanapenpaiboon, N., Nowson, C.A. BMI and all-cause mortality in older adults: a meta-analysis. *Am. J. Clin. Nutr.* **99,** 875 – 890 (2014). doi: 10.3945/ajcn.113.068122.

[68] Flegal, K.M., Kit, B.K., Orpana H., Graubard, B.I. Association of All-Cause Mortality With Overweight and Obesity Using Standard Body Mass Index Categories. *JAMA.* **309,** 71 – 82 (2013). doi:10.1001/jama.2012.113905.

[69] Chapman, I.M. Body Composition and Aging. *S. Karger AG.* **37,** 20-36. (2010). https://doi.org/10.1159/000319992.

[70] David, C.N., de Mello, R.B, Bruscato, N.M., Moriguchi, E.H. Overweight and abdominal obesity association with all-cause and cardiovascular mortality in the elderly aged 80 and over: A cohort study. *J Nutr Health Aging.* **21,** 597 – 603 (2017). doi:10.1007/s12603-016-0812-0.

[71] Wu, C-Y., Chou, Y-C., Huang, N., Chou, Y-J., Hu, H-Y., Li, C-P. Association of Body Mass Index with All-Cause and Cardiovascular Disease Mortality in the Elderly. *PLoS One.* **9,** 1 – 10 (2014) doi: 10.1371/journal.pone.0102589.

[72] Rodgers, J.L. et al. Cardiovascular Risks Associated with Gender and Aging. *J Cardiovasc Dev Dis* **6,** 1 - 18 (2019). doi:10.3390/jcdd6020019.

[73] Dorner, T.E., Rieder, A. Obesity paradox in elderly patients with cardiovascular diseases. *Int J Cardiol.* **23,** 56 – 65 (2012). doi:10.1016/j.ijcard.2011.01.076.

[74] Elagizi, A. et al. An Overview and Update on Obesity and the Obesity Paradox in Cardiovascular Diseases. *Prog Cardiovasc Dis.* **61,** 142 – 150 (2018). doi: 10.1016/j.pcad.2018.07.003.

[75] Cifu, G., Arem, H. Adherence to lifestyle-related cancer prevention guidelines and breast cancer incidence and mortality. *Ann. Epidemiol*. **28,** 767 – 773 (2018). doi:10.1016/j.annepidem.2018.09.002.

[76] Shaukat, A., Dostal, A., Menk, J., Church, T.R. BMI Is a Risk Factor for Colorectal Cancer Mortality. *Dig. Dis. Sci..* **62,** 2511 – 2517 (2017). doi:10.1007/s10620-017-4682-z.

[77] Freisling, H. et al. Comparison of general obesity and measures of body fat distribution in older adults in relation to cancer risk: meta-analysis of individual participant data of seven prospective cohorts in Europe. *Br. J. Cancer*. **116,** 1486 - 1497 (2017). doi: 10.1038/bjc.2017.106.

[78] Lee, D.H., Giovannucci, E.L. The Obesity Paradox in Cancer: Epidemiologic Insights and Perspectives. *Curr. Nutr. Rep.* **8,** 175 – 181 (2019) doi:10.1007/s13668-019-00280-6.

[79] Shachar, S.S., Williams, G.R. The Obesity Paradox in Cancer—Moving Beyond BMI. *Cancer Epidemiol Biomarkers Prev.* **26,** 13 – 16 (2017). doi:10.1158/1055-9965.

[80] Lennon, H., Sperrin, M., Badrick, E., Renehan, A.G. The Obesity Paradox in Cancer: a Review. *Curr. Oncol. Rep.* **18,** 1 – 8 (2016). doi:10.1007/s11912-016-0539-4.

[81] Myint, P.K., Kwok, C.S., Luben, R.N., Wareham, N.J., Khaw, K-T. Body fat percentage, body mass index and waist-to-hip ratio as predictors of mortality and cardiovascular disease. *Heart.* **100,** 1613 – 1619 (2014). doi:10.1136/heartjnl-2014-305816.

[82] Lee, D.H. et al. Predicted lean body mass, fat mass, and all cause and cause specific mortality in men: prospective US cohort study. *BMJ.* **362,** 1 - 10 (2018). doi:10.1136/bmj.k2575.

[83] Wang, S., Ren, J. Obesity Paradox in Aging: From Prevalence to Pathophysiology. *Prog. Cardiovasc. Dis..* **61,** 182 – 189 (2018). doi:10.1016/j.pcad.2018.07.011.4

[84] Calle, E.E., Rodriguez, C., Walker-Thurmond, K., Thun, M.J. Overweight, Obesity, and Mortality from Cancer in a Prospectively Studied Cohort of U.S. Adults. *NEJM.* **348,** 1625 – 1638 (2003). doi:10.1056/NEJMoa021423

[85] Taghizadeh, N. et al. BMI and lifetime changes in BMI and cancer mortality risk. *PLoS One*. **10,** 1 – 16 (2015). doi:10.1371/journal.pone.0125261

Figures

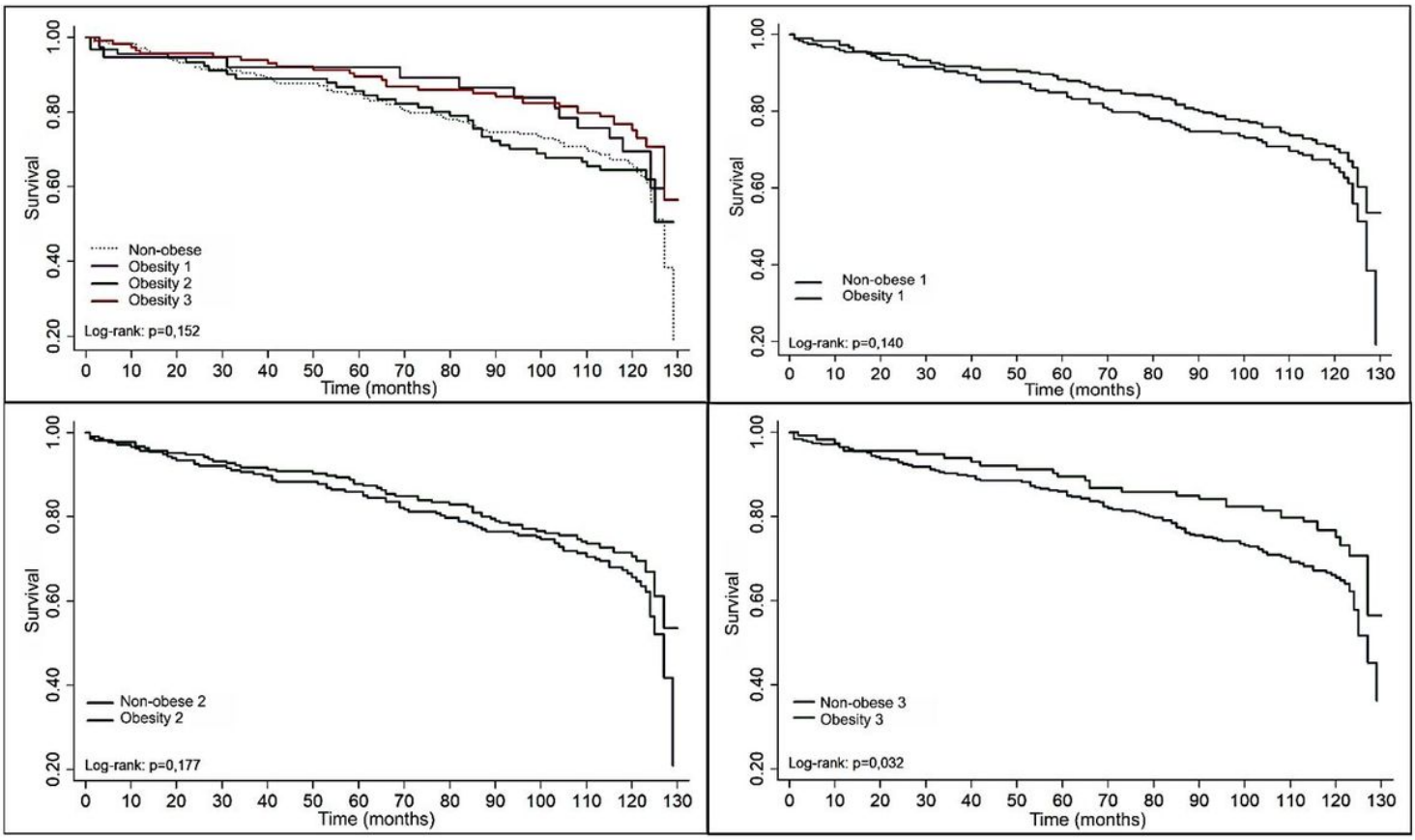

Figure 1

Survival curves according to three different diagnostic criteria for classifying obesity. Note: Obesity 1: BMI ≥25.0 kg/m² in men and ≥26.6 kg/m² in women; Obesity 2: BMI ≥27.0 kg/m²; Obesity 3: BMI ≥30.0 kg/m².

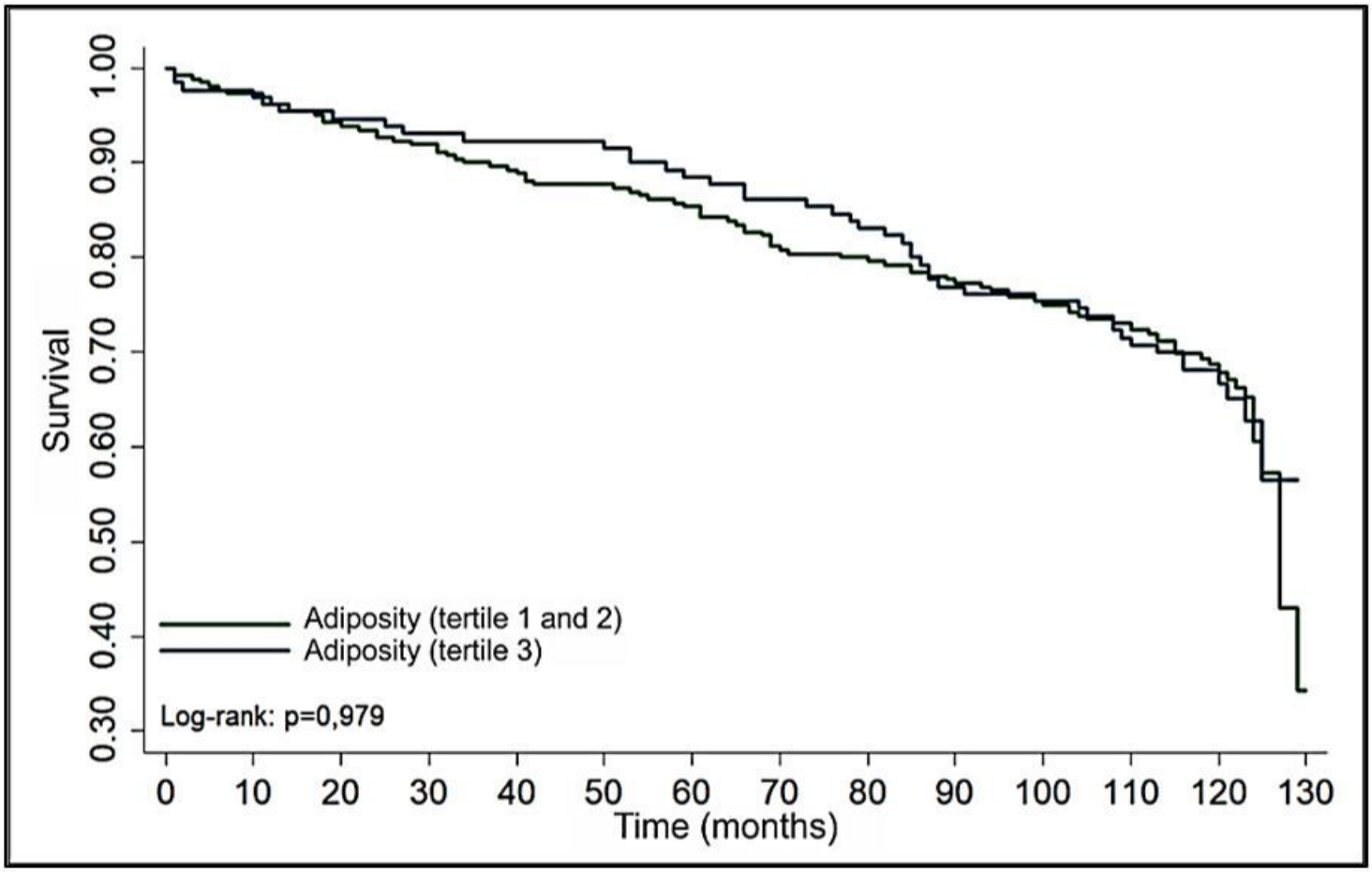

Figure 2

Survival curve according to body fat percentage (adiposity). Note: The largest tertile, according to sex, for men ≥ 48.1% and for women ≥ 47.7%

Supplementary Files

This is a list of supplementary files associated with this preprint. Click to download.

- Supplementary.docx