OVERWEIGHT AND ABDOMINAL OBESITY ASSOCIATION WITH ALL- CAUSE AND CARDIOVASCULAR MORTALITY IN THE ELDERLY AGED 80 AND OVER: A COHORT STUDY

C.N. DAVID[1,2], R.B. MELLO[1,2], N.M. BRUSCATO[1], E.H. MORIGUCHI[1,2]

1. Universidade Federal do Rio Grande do Sul, Porto Alegre, Rio Grande do Sul, Brazil; 2. Hospital de Clinicas de Porto Alegre, UFRGS, Porto Alegre, Brazil Corresponding author: Renato Bandeira de Mello, Hospital de Clínicas de Porto Alegre, 2350, Ramiro Barcelos st., Division of Internal Medicine; room 700, Porto Alegre, Rio Grande do Sul 90035903, Brazil, rgbmello@hcpa.edu.br

Abstract: *Objective:* To evaluate the association between overweight and abdominal obesity with all-cause and cardiovascular mortality in the elderly aged 80 and over. *Design:* A prospective cohort study. *Setting:* A population-based study of community-dwelling very elderly adults in a city in southern Brazil. *Participants:* 236 very elderly adults, number that represents 85% of the population aged 80 and over living in the city in the period (mean age 83.4 ± 3.2). *Measurements:* Overweight and abdominal obesity were assessed using recommended cut-off points for body mass index (BMI), waist circumference (WC), waist-hip ratio (WHR) and waist-height ratio (WHtR). The association between these anthropometric measurements and all-cause and cardiovascular mortality were independently estimated by Cox proportional hazards model. Kaplan-Meier was used to assess survival time. *Results:* Increased WC (>80cm F and >94cm M) and WHtR (>0.53 F and >0.52 M) were associated with lower all-cause mortality, but only WHtR remained associated even after controlling for residual confounding (HR 0.55 CI95% 0.36-0.84; p<0.001). Additionally increased WC was independently associated with lower mortality from cardiovascular diseases (HR 0.57 CI95% 0.34-0.95; p<0.030). BMI and WHR did not show significant independent association with mortality in the main analysis. *Conclusion:* Greater abdominal fat accumulation, as estimated by WC and WHtR, presented an association with lower allcause and cardiovascular mortality in the elderly aged 80 and over, but not by BMI and WHR.

Key words: Aged 80 and over, anthropometry, overweight, abdominal obesity, mortality.

Introduction

Disorders related to body fat accumulation, especially abdominal fat mass, are known risk factors for all-cause and cardiovascular mortality (1-3). Despite the availability of evidence and biological plausibility, however, the last decade has seen some studies point to a possible inverse or null relationship between overweight and obesity with mortality in the elderly (4, 5). This supposed protective effect of fat accumulation for death is known as the obesity paradox. Initially this paradox was explained by the BMI low discriminatory power for body fat distribution (6) as well its low accuracy to diagnose obesity in the elderly (7), mainly due to age-related body composition changes, such as lean mass reduction and redistribution of adipose tissue (8). Nonetheless, some studies using more precise anthropometric measurements to assess abdominal fat accumulation, like waist circumference (WC), waist-hip ratio (WHR) and waist-to-height ratio (WHtR), found the same pattern of inverse association between increased anthropometric measures and mortality in the elderly (9, 10). However, other studies have shown opposite results exposing uncertainties regarding the predictive ability of anthropometric measurements in the elderly (11, 12).

The differing conclusions from the available evidence could be explained by the great heterogeneity between studies(13), where the clinical characteristics of the evaluated populations often vary considerably – a broad spectrum of elderly people ranging from the frail to more robust, as well as samples where very elderly were included and evaluated together with adults and younger elderly individuals. The measurement methods and cut-off points for anthropometric variables also varied across studies, as well as the statistical data analysis and controlling strategies for confounding factors. Despite these differences, there is consensus that the anthropometric measurements cut-off points adopted to identify overweight and abdominal obesity in adults have limited accuracy in the elderly population (11, 14, 15). Furthermore, higher abdominal fat content can, to some extent, identify those elderly individuals who are more robust, have better functional reserve and lower subclinical diseases prevalence, characterizing the "healthy cohort" effect (16).

Changes in body composition, together with specific characteristics in relation to health conditions, make the very elderly a peculiar subgroup. Therefore, the results found in studies with adults and younger elderly individuals can create an over- or underestimation of risk in this population. Associations between overweight and abdominal obesity, evaluated by anthropometric measurements, and mortality have been less studied, particularly in the elderly population over 80 years of age and especially taking into account important confounding factors that may interfere with the associations between body fat and mortality in this subgroup. This study aimed to evaluate the independent association between overweight and abdominal obesity with all-cause and

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cardiovascular mortality in the elderly aged 80 and over.

Methods

Data from Veranópolis Study Group was analyzed. It is a prospective population-based cohort that recruited participants in two waves: 1994 and 1996, when all individuals aged 80 and over living in the urban or rural area of the city of Veranópolis were invited to participate. Inclusion criteria were: being 80 years old by the recruitment wave period and dwelling in the territorial area of Veranópolis. The population of interest was identified through previous survey data from the "Instituto Brasileiro de Geografia e Estatística" (IBGE) - Brazilian Institute of Geography and Statistics available to date. Press publicity strategies were also adopted to reach those who moved from registered addresses. When identified, participants were invited by city health agents during home visits.

Measurements

The procedures were implemented by a previously trained staff. Participants were interviewed in the city community center through the application of standardized questionnaires in the presence of a caregiver who was allowed to assist with responses if the elderly individual was unable to remember and/or had difficulty in answering the questions. Standardized questionnaires were used to access sociodemographic characteristics (date of birth, schooling and sex), smoking status as well as information about medication in use (e.g.: antihypertensive and hypoglycemic agents), history of diabetes and self-reported cardiovascular disease were collected.

Baseline age as well as age at death was calculated from the date of birth. Educational level was obtained through number of years at school and categorized according to the calculated median. Smoking was assessed by self-reported use or not of tobacco and categorized into nonsmokers - people who never smoked; smokers or ex-smokers for those who smoke or smoked continuously in some lifetime moment. After the interview, participants were submitted to the clinical procedures.

Blood samples were collected after a 12-hour night fasting to assess plasma glucose, total cholesterol (TC), HDL-cholesterol (HDL-c), LDL-cholesterol (LDL-c), triglycerides (TG) and creatinine levels. Levels of TC, HDL-c, TG, creatinine and glucose were determined by enzymatic colorimetric methods using commercial kits. LDL-c was calculated according to the Friedewald equation (17) for TG values below 400 mg/dl (TG samples with values above 400 mg/dl were excluded). Hypercholesterolemia was defined as the presence of at least one altered blood cholesterol value. Diabetes mellitus was defined as fasting glucose ≥126 mg/dL or by hypoglycemic drug use. Glomerular filtration rate (GFR) was calculated using the Cockcroft-Gault equation (18) and a cut-off point of ≤60 mL/min was considered to define renal insufficiency (RI), and GFR ≤30 mL/min considered as severe RI (19).

Blood pressure was measured in a standardized way, in duplicate, using a mercury sphygmomanometer (Erka, Germany).Two measurements were taken with a 30-minute interval in between and the mean value calculated. Individuals were considered hypertensive when mean systolic arterial blood pressure was (SBP) ≥140 mmHg and/or diastolic arterial blood pressure (DBP) ≥90 mmHg, or if they were taking antihypertensive drug. Anthropometric measurements were performed at baseline with participants minimally dressed and barefoot. Standardized weight (kg) measurement was obtained to the nearest 100 g with a scale (Filizola, São Paulo). Height was measured in meters (m) using a stadiometer to the nearest 0.1 cm. Waist circumference (WC) was measured in centimeters (cm) using an inelastic tape placed midway between the iliac crest and the lowest costal rib, with the subject standing, and at the end of normal expiration. Hip circumference was measured in centimeters (cm) at the point of greatest bulge of the gluteus maximus.

BMI was calculated using the formula of ratio of weight in kilograms to squared height in meters (kg/m2). Overweight was defined as BMI ≥25 Kg/m2 (20) or BMI >27 Kg/m2 (21). Two different cut-off points were tested to estimate abdominal obesity by WC: 80 cm for women and 94 cm for men (WC-80/94), and 88 cm for women and 102 cm for men (WC-88/102) (22). The WHR was calculated as the ratio of waist circumference (cm) to that of the hips (cm) and the cut-off points used were 0.85 for women and 1 for men (23). WHtR was calculated through the ratio of waist circumference (cm) divided by height (cm) and the cut-off points used were 0.52 for men and 0.53 for women (24).

Outcomes

The outcomes evaluated were all-cause mortality (by any cause) and mortality due to cardiovascular disease - included in the codes I00-I99 of the tenth revision of the International Classification of Diseases and Related Health Problems (ICD-10). Vital status information was sought in four different periods. The first evaluation of deaths was performed in 1999 (25), this was carried out at the Municipal Department of Health, which annually registers mortality and health indicators. In the years 2006 to 2009, the vital status of all cohort participants was determined through home visits. Registration of the exact day and cause of death was performed based on the death certificate. Imprecise information regarding the cause of death was specified or confirmed through interviews with close relatives and specialist doctors, and through verification of hospital records for the period shortly before death(26). When persisting uncertainty about cause of death, outcomes committee composed of two independent researchers defined the outcome as cardiovascular or non-cardiovascular death. During 2011 and 2012, once again through home visits, another evaluation of vital status was performed. The final check took place between October 2014 and April 2015 via telephone contact and a request for duplicate death certificates. Early death was considered as a time ≤2 years between the baseline and death date.

Statistical analysis

Characteristics of the participants were presented as means and standard deviations or percentages, and analysis was conducted using the Statistical Package for the Social Sciences (SPSS® software, version 21, Somers, NY, USA). Multivariate analysis was undertaken using Cox proportional Hazard model with a constant for time including as potential confounding factors those variables which were associated with the outcomes according to the literature or a calculated P value <0.10 in the univariate analysis. After the tests, the following control variables were selected: gender, age (continuous variable), smoking, hypertension, diabetes, hypercholesterolemia and creatinine (continuous variable). Survival time was assessed by the Kaplan-Meier curve and comparison between the groups through use of the Log-rank chi-square test.

Exploratory analyses were conducted to test other predictor variables cut-off points and early death definition. In addition, tests were conducted and identify smoking and severe RI as being interaction factors. In light of this, statistical analysis was performed of associations after the exclusion of individuals with these characteristics and those whose death was considered premature (occurring in the first two years of follow-up). The aim of this strategy was to minimize the possible interference of variables that may be responsible for residual confounding(27, 28).

The study was approved by the Ethics Committees of the Hospital São Lucas, Pontifical Catholic University of Rio Grande do Sul and the Hospital de Clínicas de Porto Alegre, Federal University of Rio Grande do Sul - Brazil. All participants and/or their relatives signed an informed consent.

Results

A total of 236 elderly constitute the cohort, representing 85% of the population aged 80 and over living in the city in the period (29). Of those, 234 had died between the initial baseline evaluation and April 2015. Data for cause of death were accessed in 229 (97.8%) cases, with 109 (46.2%) of these outcomes due to cardiovascular events. Mean (±SD) age at death was 90.55 (±4.96) years and median survival was 6.45 years (range 5.64 to 7.26 years). The sample was predominantly composed of women, individuals with low schooling, and with a high prevalence of hypertension, central obesity and overweight. The baseline characteristics are described in Table 1. Table 2 presents the univariate analysis results for potential risk factors for mortality.

All-cause Mortality

Increased values of WC-80/94 and WHtR were associated with lower mortality (HR 0.70 CI95% 0.52-0.96; p=0.02 and HR 0.67 CI95% 0.49-0.93; p=0.01, respectively). However, only WHtR remained associated with all-cause mortality after controlling for possible residual confounding (HR 0.65 CI95% 0.44-0.98; p= 0.04). Overweight, assessed by BMI cut-off points, and WHR did not present a significant association with mortality. Graphs A and B of Figure 1 demonstrate the behavior of the anthropometric variables in relation to the outcome all-cause mortality after controlling for selected risk factors.

Table 1
Baseline characteristics of the elderly aged 80 and over living in the city of Veranópolis in the 1990s

	Mean ± SD or n (%)
Female	152 (64.4)
Age (years)	83.4 ± 3.2
Schooling ≤ 2years	114 (57.0)
Smoker (current or ex-smoker)	15 (6.4)
Hypertension[a]	210 (89.0)
Diabetes Mellitus[b]	24 (10.4)
Hypercholesterolemia[c]	192 (84.6)
Total cholesterol	197 ± 46.9
LDL cholesterol	128.1 ± 40.6
HDL cholesterol	43.2 ± 11.6
Triglycerides	130 ± 67.7
Creatinine	0.91 ± 0.22
RI (GFR ≤60)	156 (71.2)
Severe RI (GFR ≤30)	13 (5.9)
Previous stroke	10 (4.2)
Previous heart disease	48 (20.3)
Body Mass Index	26.3 ± 4.8
Waist circumference	90.2 ± 11.7
Waist-hip ratio	0.89 ± 0.07
Waist-to-height ratio	0.57 ± 0.07
Overweight (BMI ≥25 Kg/m^2)	133 (56.8)
Overweight (BMI >27 Kg/m^2)	101 (43.2)
Obese (BMI ≥30 Kg/m^2)	53 (22.5)
WC-80/94(>80 F and >94 M)	140 (63.1)
WC-88/102(>88 F and >102 M)	87 (39.2)
WHR (>0.85 F and >1 M)	108 (49.5)
WHtR (>0.53 F and >0.52 M)	163 (73.8)

RI= Renal Insufficiency; GFR= Glomerular filtration rate; aPrevious diagnosis with use of antihypertensive treatment or SBP ≥140 and/or DBP ≥90 mmHg. bPrevious diagnosis with use of hypoglycemic medication or fasting glucose ≥126 mg/dL. cPresence of alteration in one or more blood lipid values.

Increased WHtR conferred greater survival among the elderly (p=0.02), which remained significant after controlling for possible residual confounding (p=0.04) – graph A of Figure 2. Elderly individuals with a high WC also presented greater survival (p=0.02 for WC-80/94 and p=0.03 for WC-88/102),

Table 2
Risk ratio in the univariate analysis for all-cause and cardiovascular mortality in the presence of selected factors

	All-cause mortality		Cardiovascular mortality	
	HR (IC95%)	**P**	**HR (IC95%)**	**p**
Gender (M)	1.44 (1.09-1.89)	0.008	1.19 (0.78-1.80)	0.40
Continuous age (years)	1.12 (1.08-1.17)	<0.001	1.12 (1.08-1.17)	<0.001
Schooling ≤2years	0.83 (0.62-1.10)	0.211	0.87 (0.57-1.33)	0.53
Smoker[a] (Yes)	1.36 (0.80-2.31)	0.248	1.49 (0.72-3.07)	0.28
HDL (<50 F and<40 M)	1.24 (0.94-1.63)	0.126	1.21 (0.81-1.82)	0.34
LDL (≥160)	0.84 (0.60-1.18)	0.331	0.90 (0.57-1.43)	0.66
Total cholesterol (≥200)	0.64 (0.49-0.84)	0.001	0.68 (0.46-1.01)	0.06
Triglycerides (≥150)	1.17 (0.87-1.58)	0.272	0.96 (0.62-1.49)	0.86
Diabetes Mellitus[b]	1.90 (1.23-2.93)	0.004	2.23 (1.23-4.04)	<0.01
Hypertension[c]	0.68 (0.45-1.02)	0.067	0.81 (0.43-1.52)	0.52
Hypercholesterolemia[d]	0.78 (0.54-1.13)	0.202	071 (0.43-1.17)	0.18
Continuous creatinine	2.35 (1.35-4.10)	0.003	2.35 (1.35-4.10)	<0.01
GFR ≤30	2.51 (1.42-4.41)	0.001	1.51 (0.55-4.14)	0.42
Previous stroke(Yes)	1.26 (0.66-2.37)	0.477	1.02 (0.37-2.78)	0.96
Previous heart disease (Yes)	1.11 (0.81-1.53)	0.492	1.32 (0.84-2.07)	0.21

GFR= Glomerular filtration rate; aSmoker, current or ex-smoker; bFasting glucose ≥126 mg/dL or use of hypoglycemic medication; cSBP ≥140 and/or DBP ≥90 or use of antihypertensive drug; d Presence of one or more altered cholesterol values (TC, LDL-c or HDL-c).

however, after exclusion of premature deaths (≤2 years since baseline), smokers and severe RI, the results did not remain significant. For BMI and WHR, survival curves showed no significant differences for the cut-off points tested.

Cardiovascular Mortality

Only WC-88/102 was associated with cardiovascular mortality when both analysis were run: total sample (HR 0.62 CI95% 0.40-0.97; p=0.03); after controlling for possible residual confounding (HR 0.57 CI95% 0.34-0.95; p=0.03). Graphs C and D in Figure 1 demonstrate the behavior of anthropometric variables in relation to cardiovascular mortality after multivariate analysis. For this outcome, the survival curves for all the anthropometric variables showed a tendency toward greater survival in the classifications indicative of higher adiposity, however, the results remained statistically significative only for WC-88/102 after exclusion of early death, smoking and severe RI (p=0.03) - Graph B/Figure 2.

Exploratory and sensitivity analyses

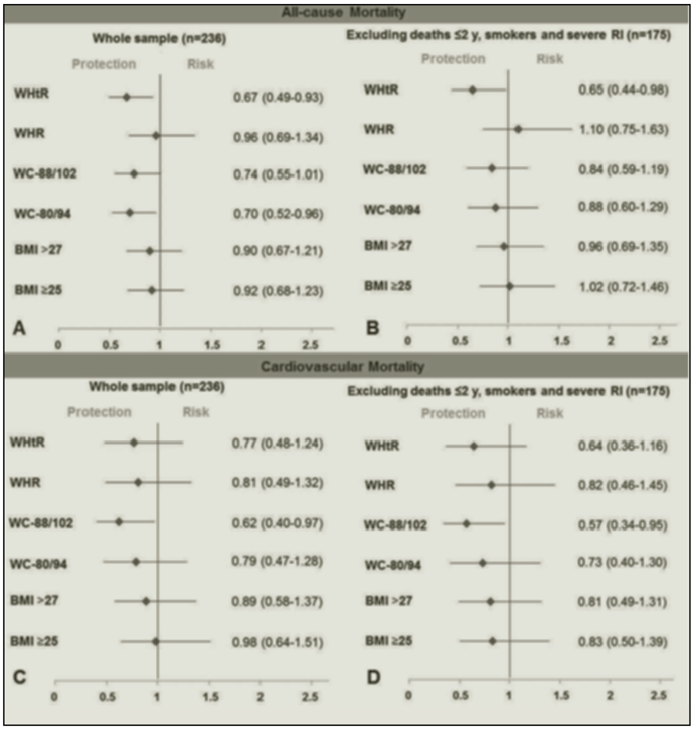
Other recommended cut-off points for all the anthropometric variables were tested, but were not different from those presented in this paper. The exclusion of deaths within the first five years for the definition of premature death was also tested, which showed no difference in results from those found for all-cause mortality. However, the results became significant for cardiovascular mortality when this criteria was adopted. Graph A of Figure 3 demonstrates the behavior of anthropometric variables in relation to cardiovascular mortality in multivariate models after exclusion of deaths ≤5 years, smokers and severe RI (n=133). Exclusion of death ≤5 years also identified greater survival for cardiovascular death in the elderly with a BMI >27 Kg/m2 (p=0.02) - Graph B/Figure 3.

Discussion

The results of this study showed an inverse association between anthropometric measures of abdominal fat accumulation, evaluated by cut-off points recommended for adults, and mortality in the very elderly. Increased values of WHtR (>0.53 F and > 0.52 M) were associated with a lower all-cause mortality risk, and increased WC values (>88 F and >102 M) with lower cardiovascular mortality. These findings indicate that anthropometric measurements present different predictive values in the very elderly population, even after controlling for potential confounding and interaction factors.

In line with that demonstrated in this study, Reis et al. (10), in analysis of a 65-102 years of age subgroup, found an association between increased values of abdominal adiposity and lower mortality – the opposite result to that evidenced in individuals of the 30-64 years of age subgroup. Moreover, studies conducted in institutionalized elderly (aged 60-101 years) demonstrated an inverse association between BMI and WC values with all causes of death (30). Similarly, research including people over 60 years (16.9% of the sample >80 years) found that high measures of adiposity identified those with lower risk of all-cause and cardiovascular mortality during follow-up(9).

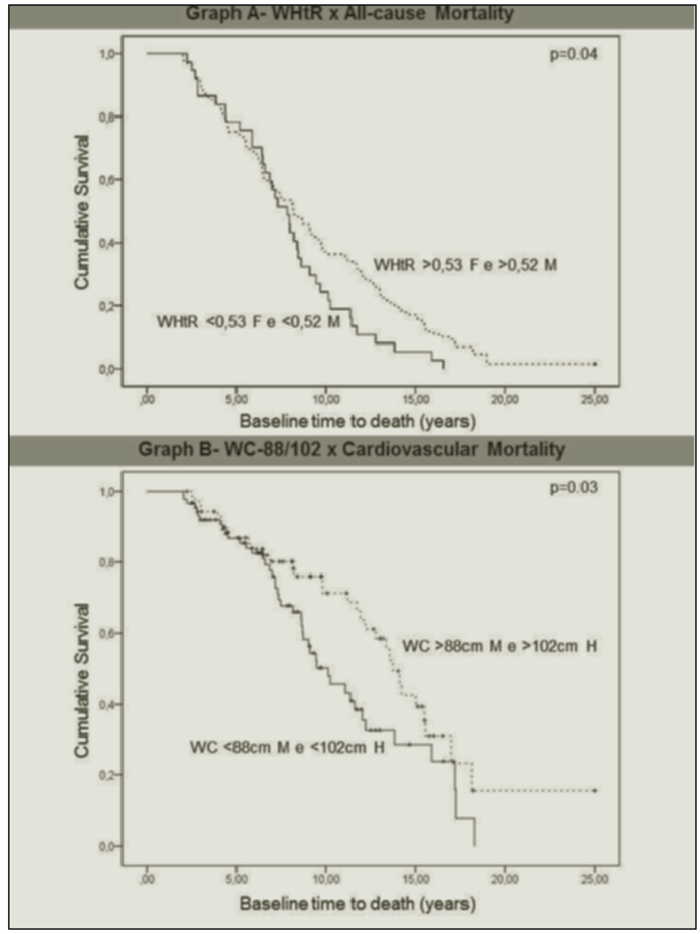
Figure 1
Adjusted risk of anthropometric variables for all-cause and cardiovascular mortality (HR and 95% CI)



WC-80/94: >80 cm women and >92 cm men; WC-88/102: >88 cm women and >102 cm men; WHR: >0.85 women and >1 men; WHtR: >0.53 women and >0.52 men. All models were adjusted for gender, age, smoking, hypertension, diabetes, hypercholesterolemia and creatinine, except for the results presented in figures B and D that had smoking removed from the model; A- Anthropometric variables risk for the outcome all-cause mortality in the whole sample; B- Anthropometric variables risk for the outcome all-cause mortality after exclusion of early deaths, current or ex-smoker and severe RI; C- Anthropometric variables risk for the outcome cardiovascular mortality in the whole sample; D- Anthropometric variables risk for the outcome cardiovascular mortality after exclusion of early deaths, current or ex-smoker and severe RI.

In the same direction, when premature death (within the first five years of follow-up) was excluded from the primary analysis, overweight – evaluated by a BMI >27 Kg/m2 – also became a predictor of lower cardiovascular mortality, as did WC and WHtR in the main analysis. A similar association was observed in a study with a younger elderly sample (31). But it was not found in an older elderly subgroup (80 years or more) in a cohort study (32). Studies that evaluated the predictive profile of anthropometric measurements for all-cause and cardiovascular mortality in different age groups showed a direct association between these variables in the adult population, however the results became statistically insignificant in the elderly, suggesting a different predictive capacity in this population (32-35).

Figure 2
Survival curves of anthropometric variables in relation to outcomes that remained significant after controlling for possible residual confounding (n=175)



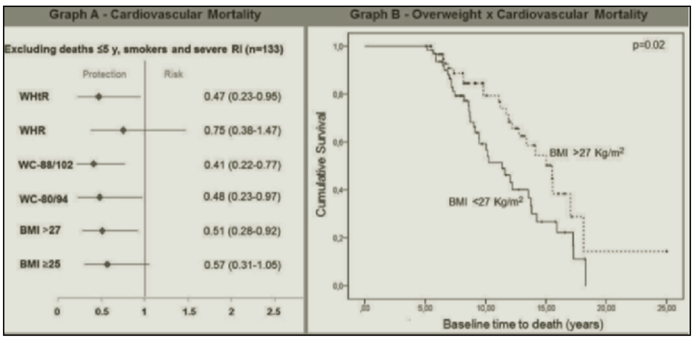
Graph A – Survival curve performance for WHtR at the cut-off points >0.53 for women and >0.52 for men in relation to the outcome all-cause mortality after exclusion of deaths ≤2 years, smokers, and severe RI (n=175). Graph B - Survival curves performance for WC at the cut-off points >88 cm for women and >102 cm for men in relation to the outcome cardiovascular mortality after exclusion of deaths ≤2 years, smokers and severe RI (n=175).

By contrast, abdominal fat, as evaluated by anthropometric measurements, has also already been associated with increased mortality in studies conducted in adults and younger elderly individuals (36, 37), as well as in those where subjects over 80 years were analyzed as part of the total sample (1, 38). Furthermore, a meta-analysis (11) evidenced a greater mortality risk for higher WC values (>88 cm F and >102 cm M) among elderly between 65-74 years old. It may be explained by selection of healthier old people composed for a more robust and fit population, with a higher lean body mass content (16). In this way, those with lower functional reserve and those with subclinical diseases in the baseline are not included, possibly avoiding the "sick cohort effect". A similar scenario was previously demonstrated when hypertension was tested as predictive factor for mortality: subjects were stratified according to their capacity to execute a walking test.

In those who not completed the test, hypertension behave as a protective factor; but, in contrast, was a risk factor in the medium and fast walking subgroup(39). Hence, the selection of participants could also impact over the predictive capacity of anthropometric measurements.

Figure 3

Performance of anthropometric variables in relation to cardiovascular mortality after exclusion of deaths ≤5 years, smokers and severe RI (n=133)



Graph A - WC-80/94: >80 women and >92 men; WC-88/102: >88 women and >102 men; WHR: >0.85 women and >1 men; WHtR: >0.53 women and >0.52 men. All models were adjusted for gender, age, hypertension, diabetes, hypercholesterolemia and creatinine; Graph B – Survival curve pattern for overweight evaluated by BMI >27 Kg/m2 in relation to the outcome cardiovascular mortality after exclusion of deaths occurring in the first five years, smokers and severe RI (n=133).

A few reasons may explain the discrepancies between the results available in the literature. Heterogeneity among the studies could possibly be the principle cause, especially in relation to the sample selection, the variables studied as well as the cut-off points tested. Another relevant issue is the control for potential confounding factors and possible interactions amongst the anthropometric measures with the aging process, mainly in the oldest individuals. In this subgroup, body composition changes during the aforementioned aging process can modify the estimation of fat accumulation, especially if evaluated using cut-off points validated for the general adult population. It could be also influenced by the lack of controlling for important prevalent geriatric factors, such as frailty, functional and cardiac reserve – known predictors of subclinical heart disease (40). In addition, the potential "sick cohort effect" must be considered in studies of large representative populations that exclusively include the very elderly, due to the high prevalence of diseases (41), including subclinical pathologies (42, 43). In this scenario, the elderly who are overweight and/or with abdominal obesity would present a greater functional metabolic reserve and a potentially better nutritional status than those with low weight or "normal weight". They could present a lower association with mortality, not because they are obese but because slimmer individuals would die sooner due to a low functional reserve or the presence of diseases that cause weight loss. Furthermore, the lack of association between overweight and central obesity with mortality in older individuals could be explained by the time of exposure to the risk factor (excess fat). Individuals with greater fat accumulation during adulthood may die earlier due to complications, not reaching older age groups.

Although, it is important to consider some other data regarding fat accumulation in the old population. Recent studies associate the accumulation of overall and abdominal fat with lower quality of life (44), declining functional capacity (45) and high levels of inflammatory factors (46). In addition, recent clinical trial showed that the reduction of abdominal fat (visceral or intermuscular) was associated with improved physical function in elderly submitted to intentional weight loss mediated by caloric restriction and physical activity (47). This demonstrates that even with this possible protective effect in relation to mortality in the elderly, overweight and abdominal obesity may have deleterious effects on other important outcomes in this population. This should be better explored in future studies – mainly through specific cut-off points for the long-lived population and taking into consideration other negative outcomes linked to health in this age group, such as those associated with functionality and better quality of life (48).

This study has some limitations that should be considered. One such is, even conducted by trained staff, measurement errors associated with body composition changes by the aging process cannot be ruled out and may have interfered in results found. Another possible limitation involves not having considered data that is more specific to functionality in the sample stratification, although in the 1990s (baseline period) this type of information was not usually evaluated in cohort studies. It was also not possible to use some risk variables to control for potential biases, such as physical activity and alcohol consumption, as these were not uniformly collected during the distinct waves of participant inclusion. However, such limitations should not have significantly influenced the final results as a previous study, which exclusively used data from the 1996 inclusion period, showed no significant association between different physical activity or alcohol consumption levels with all-cause and cardiovascular mortality (26). In addition, analysis after exclusion of early death, smokers and individuals with RI, in theory, would minimize the influence of unmeasured variables, such as frailty, reduced cardiac reserve and lower baseline functionality. Nonetheless, because they are very old individuals, even excluding early deaths, a residual effect of potential confounding factors cannot be ruled out.

In conclusion, increased abdominal fat accumulation estimated by WHtR showed an association with lower all-cause mortality, while higher WC presented an association with lower cardiovascular mortality in the elderly population aged 80 and over. After excluding deaths within the first five years, both BMI >27 kg/m2 and elevated WHtR and WC were associated with lower risk of cardiovascular mortality, although these results should be interpreted with caution. More studies are needed to assess the predictive power of the anthropometric measurements for mortality in the very elderly, especially using specific cut-off points for this population. Further studies should include measurement of other important potential confounding variables, such as functionality, frailty and cardiovascular reserve in order to minimize potential confounding aspects of the baseline physical condition of these individuals.

Conflict of interest: The authors do not have any conflicts of interest.

Ethical Standards: This research was carried out in accordance with the Declaration of Helsinki of the World Medical Association and received ethical approval by the local ethics committee.

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