Waist Circumference but Not Body Mass Index Predicts Long-Term Mortality in Elderly Subjects with Chronic Heart Failure

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OBJECTIVES: To examine whether waist circumference (WC) and body-mass index (BMI) can predict long-term mortality in elderly subjects with and without chronic heart failure (CHF).

DESIGN: Longitudinal evaluation with a 12-year follow-up.

SETTING: Campania, a region of southern Italy.

PARTICIPANTS: One thousand three hundred thirty-two subjects aged 65 and older selected from the electoral rolls of Campania.

MEASUREMENTS: The relationship between WC or BMI and mortality during a 12-year follow-up in 125 subjects with and 1,143 subjects without CHF.

RESULTS: Mortality increased as WC increased in elderly subjects without CHF (from 47.8% to 56.7%, $P = .01$), and the increase was even greater in patients with CHF (from 58.1% to 82.0%, $P = .01$). In contrast, mortality decreased as BMI increased in elderly subjects without CHF (from 53.8% to 46.1%, $P0\ = .046$) but not in those with CHF. According to Cox regression analysis, BMI protected against long-term mortality in the absence but not in the presence of CHF. In the absence of CHF, WC was associated with a 2% increased risk of long-term mortality for each 1-cm greater WC (Hazard Ratio (HR) = 1.02, 95% confidence interval (CI) = 1.01–1.03; $P < .001$), versus 5% increased in the presence of CHF (HR = 1.06, 95% CI = 1.02–1.10; $P < .001$).

CONCLUSION: WC, but not BMI, is predictive of long-term mortality in elderly individuals with CHF and to a lesser extent in those without CHF. **J Am Geriatr Soc 58:1433–1440, 2010.**

Key words: waist circumference; body mass index; chronic heart failure; mortality

Obesity is a cardiovascular risk factor associated with increased mortality[1,2] and is considered to be a major risk factor for the development of chronic heart failure (CHF).[3] CHF is a major public health issue in Western countries, especially in older adults.[4–6] Although the incidence of obesity is increasing worldwide and is expected to increase healthcare costs, hospitals and nursing homes are poorly equipped to meet this epidemic health challenge.[7]

Although obesity is associated with greater mortality in the general adult population, the relationship is less clear in older individuals. Indeed, several reports do not support the view that overweight, as assessed according to body mass index (BMI), is a risk factor for all-cause and cardiovascular mortality in older adults.[8–14] A higher BMI has been associated with higher cardiovascular mortality, but paradoxically, the correlation declines with age.[15,16] This phenomenon, the so-called "obesity paradox,"[17] is not restricted to elderly subjects with cardiovascular diseases but has been reported in a large sample of patients from in the Acute Decompensated Heart Failure National Registry,[18] in hypertension and coronary artery disease,[19] and in end-stage renal diseases.[20] These findings triggered a debate about the definition and assessment of obesity in older adults and its relationship with mortality.

BMI alone is not an accurate measure of obesity in older adults.[21,22] A review of the findings of 20 studies

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conducted between 1997 and 2004 concluded that body composition (abdominal fat and lean body mass) is more important than BMI alone in determining the mortality risk associated with obesity in older adults.[21] Consistent with this concept, another study found that lean body mass was significantly and inversely associated with mortality in men aged 60 to 79.[22] In the clinical setting, several authors recommend the use of BMI measurements in association with other measures of central adiposity, such as waist circumference (WC) and waist-to-hip ratio (WHR) in older adults.[23–25] Waist circumference has been reported to be a more-accurate predictor of obesity-related cardiovascular risks than WHR[11] and has the advantage of requiring only one measurement.

To the authors' knowledge, there are no data on the effect of obesity assessed according to WC on CHF mortality in elderly subjects in the short or the long term. This study therefore examined whether WC and BMI can predict long-term mortality in elderly subjects with and without CHF.

METHODS

Study Population

The "Osservatorio Geriatrico Regione Campania" was a cross-sectional study performed in 1992 in Campania, a region of southern Italy. The study design and population are described elsewhere.[26] Briefly, the study sample consisted of 1,780 individuals aged 65 and older randomly selected from the electoral rolls, resident in the five municipalities of Campania, and stratified using a three-step procedure according to age, sex, and size of urban unit. The sample consisted of 756 (42.5%) men and 1,024 (57.5%) women. Of these, 448 (25.2%) refused to participate in the study, resulting in a study sample of 1,332 subjects, an overall participation rate of 74.8%. The sample was followed for 12 years (to the end of 2003). Deaths were assessed by questioning general practitioners and confirmed by examination of death certificates. Of the 1,332 subjects enrolled in 1992, data on mortality and on social support were missing for 35 (2.6%) and nine (0.06%) subjects, respectively, resulting in a sample of 1,288 individuals (554 men and 734 women). Of these, 681 (52.9%) had died (324 men (58.5%) and 357 women (48.6%)). CHF diagnosis was uncertain in 20 of 1,288 individuals (1.6%), so 1,268 were examined. Data on WC were available for 1,238 individuals and on BMI for 1,184 individuals. Participants were contacted at home or in their institution and examined by physicians trained to administer a questionnaire that included tests of cognition and depression and to measure anthropometric variables.

Variables Evaluated

CHF Diagnosis

The diagnosis of CHF was considered possible when participants reported that a physician had told them they had CHF or they had received specific treatment with diuretics and digitalis or vasodilators. The diagnosis was subsequently confirmed according to a physical examination and a review of medical records to identify cardiomegaly and pulmonary edema on chest X-ray or evidence of dilated left ventricle and global or segmental wall motion abnormalities. Physical examination was performed to look for dyspnea, orthopnea, tachycardia, atrial fibrillation, jugular venous distension, abdominojugular reflux, pulmonary rales, third sound, and edema.

Social Support

Social support consisted of social networks, social relationships, and economic support. Social networks refer to everyday contacts, and information was collected on size, density, reciprocity, durability, intensity, and frequency of contacts. For social relationships, information was collected on the existence, quantity, and type of relationships.[27] Scores ranged from 0 to 17, with higher scores corresponding to lower levels of social support.

Concomitant Chronic Morbidities, Cognitive Function, Depression, and Disability

The presence of chronic comorbidities was evaluated from the medical history and confirmed by a trained physician in a physical examination. The Italian version of the Mini-Mental State Examination (MMSE), which has been previously validated,[28] was used to measure cognitive status. Cognitive impairment is defined as a score of less than 24 on the MMSE. The Geriatric Depression Scale (GDS)[29] was used to evaluate depressive symptoms. Data on drug consumption (class and administration) were recorded. Disability was evaluated according to the activity of daily living (ADL) index.[30] ADLs were bathing or showering, dressing, eating, getting in and out of bed, transferring from bed to chair, and using the toilet. For each item, a 4-point outcome score was assigned as follows: uses no help to perform the activity, uses a device to perform the activity, uses assistance of another person to perform the activity, and does not perform the activity. Subjects who could not perform the function without help were considered disabled. Subjects were considered to be disabled in ADLs if they could not perform one or more functions.

Anthropometric Measurements

Height and weight were measured with the participants standing without shoes and heavy outer garments. BMI was calculated as weight divided by height squared (kg/m^2). WC was measured at the level midway between the lower rib margin and the iliac crest with participants in a standing position without heavy outer garments and with emptied pockets, breathing out gently. Anthropometric variables were categorized and divided according to sex-specific cutoff points into three groups, as reported elsewhere.[31] The WC tertiles were less than 87 cm, 87 to 98 cm and greater than 98 cm in women and less than 95 cm, 95 to 103 cm, and greater than 103 cm in men. BMI tertiles were less than 25.6 kg/m^2, 25.6 to 29.8 kg/m^2, and greater than 29.8 kg/m^2 in women and less than 25.5 kg/m^2, 25.5 to 28.6 kg/m^2, and greater than 28.6 kg/m^2 in men.

Statistical Analysis

Data were collected and analyzed using the SPSS 13.0 statistics package (SPSS, Inc., Chicago, IL). The baseline characteristics of the sample are expressed as means $\pm$ standard deviations. Subjects were stratified according to tertiles of BMI and WC. Categorical variables were analyzed using chi-square testing and continuous variables using one-way analysis of variance. Cox regression analysis was used to evaluate the effect of WC and BMI on long-term mortality in the absence and presence of CHF independent of the effect exerted by age, sex, heart rate, pulse pressure, CHF, number of concomitant diseases, number of drugs taken, MMSE score, GDS score, and ADL disability. For a hazard ratio (HR) greater than 1, the independent variable was said to have a predictive effect on the dependent variable, whereas if the HR was less than 1, the independent variable was said to have a protective effect on the dependent variable. Survival and mortality curves were constructed stratified according to WC and BMI tertiles and according to the absence and presence of CHF. $P<.05$ was considered significant.

RESULTS

The baseline features of the study population are listed in Table 1. Individuals with CHF were older and had a higher heart rate than individuals without CHF. There were no differences between men and women. Participants with CHF had more diseases, higher GDS scores, and higher disability scores and took more drugs. In contrast, MMSE score was significantly lower in individuals with CHF than in those without. Moreover, CHF was associated with a significantly higher prevalence of death.

When participants without CHF were divided into WC tertiles, systolic, diastolic, mean and pulse blood pressure (BP), and the number of women were significantly higher with greater WC (Table 2). The number of drugs taken and disability, but not the number of concomitant diseases, was greater with greater WC. Mortality was greater with greater WC (47.8% in the first tertile, 56.7% in the third tertile, $P=.01$). When individuals without CHF were divided into BMI tertiles, systolic, diastolic, mean and pulse BP, number of diseases, and number of women was significantly greater with greater BMI (Table 2). Similarly, in these subjects, number of drugs, depression, disability, and social support score were greater with greater BMI. Mortality was progressively lower with greater BMI (from 53.8% to 46.1%, $P=.046$) (Table 2).

When participants with CHF were stratified according to WC and BMI tertile, higher systolic BP was associated with greater WC and BMI (Table 3). In these subjects, mean BP and social support score were greater with greater WC. Mortality was similar in the three BMI tertiles (from 79.6% to 73.5%, $P=.49$) but was greater with greater WC (from 58.1% to 82.0%, $P=.01$).

The Cox regression analysis showed that WC was predictive of long-term mortality in the absence (hazard ratio (HR) = 1.02, 95% confidence interval (CI) = 1.01–1.04; $P<.001$) and, to an even greater extent, in the presence of CHF (HR = 1.05, 95% CI = 1.01–1.08; $P<.001$) (Table 4, Figure 1A). In contrast, BMI appeared to protect against long-term mortality in the absence (HR = 0.94, 95% CI = 0.89–0.98; $P<.001$) but not in presence of CHF (HR = 0.94, 95% CI = 0.85–1.04; $P=.23$) (Table 4, Figure 1B).

In summary, high WC was associated with long-term mortality in elderly individuals with and without CHF, and the association was stronger in those with CHF. WC was associated with a 2% increased risk of long-term mortality for each 1-cm increase in WC in the absence of CHF, versus 5% increased risk in the presence of CHF. In contrast, greater BMI appeared to protect against long-term mortality in the absence but not in the presence of CHF.

DISCUSSION

Despite the growing interest in overweight and obesity assessment, particularly in light of the obesity paradox,[17] there is some discussion about the most-appropriate means with which to evaluate these conditions in elderly individuals.[8–14] Long-term imbalance in energy intake and

Table 1. Baseline Characteristics of 1,268 Subjects with and without Chronic Heart Failure (CHF)

Variable	All (N = 1,268)	Without CHF (n = 1,143, 90.1%)	With CHF (n = 125, 9.9%)	*P*-Value
Age, mean ± SD	74.2 ± 6.3	74.0 ± 6.3	75.8 ± 6.9	.002
Female, %	57.0	56.3	60.8	.34
Body mass index, kg/m^2, mean ± SD	26.5 ± 4.8	26.5 ± 4.7	27.2 ± 6.4	.15
Waist circumference, cm, mean ± SD	96.0 ± 16.8	95.7 ± 16.1	99.4 ± 22.4	.02
Heart rate, bpm, mean ± SD	75.3 ± 10.2	75.0 ± 9.6	78.9 ± 12.6	<.001
Systolic BP, mmHg, mean ± SD	145.6 ± 19.3	145.4 ± 19.1	148.2 ± 20.8	.12
Diastolic BP, mmHg, mean ± SD	82.3 ± 9.4	82.2 ± 9.2	82.8 ± 10.6	.47
Pulse pressure, mmHg, mean ± SD	63.3 ± 16.1	63.2 ± 16.0	65.3 ± 17.7	.14
Mean BP, mmHg, mean ± SD	118.2 ± 17.7	118.0 ± 17.5	120.5 ± 19.2	.11
Number of diseases, mean ± SD	2.4 ± 1.3	2.2 ± .1.1	4.8 ± 1.1	<.001
Number of medications, mean ± SD	2.2 ± 2.0	2.0 ± 1.9	4.7 ± 2.1	<.001
Mini Mental State Examination score, mean ± SD	25.3 ± 4.8	25.6 ± 4.6	23.4 ± 5.5	<.001
Geriatric Depression Scale score, mean ± SD	11.3 ± 6.6	10.8 ± 6.4	16.3 ± 6.1	<.001
Disability in >1 activity of daily living, %	6.4	5.1	18.5	<.001
Social support score, mean ± SD*	13.0 ± 2.7	13.1 ± 2.6	14.5 ± 2.5	<.001
Died, %	52.9	50.1	77.6	<.001

* Range 0–17, higher scores indicating lower social support.
SD = standard deviation; BP = blood pressure.

Table 2. Baseline Characteristics of Subjects without Chronic Heart Failure (CHF) Stratified According to Waist Circumference (WC) and Body Mass Index (BMI)

	WC (n = 1,117)				BMI (n = 1,070)			
Variable	1 (n = 423)	2 (n = 320)	3 (n = 374)	*P*-Value	1 (n = 503)	2 (n = 348)	3 (n = 219)	*P*-Value
Age, mean ± SD	73.8 ± 6.1	74.0 ± 6.5	73.9 ± 6.2	.79	74.5 ± 6.5	73.3 ± 5.8	73.7 ± 6.0	.04
Female, %	48.2	61.9	63.9	< .001	54.7	50.6	68.5	< .001
Heart rate, bpm, mean ± SD	75.2 ± 9.9	75.1 ± 10.1	74.7 ± 9.7	.48	75.1 ± 9.4	74.4 ± 9.8	74.7 ± 10.0	.48
Systolic BP, mmHg, mean ± SD	143.0 ± 18.8	147.2 ± 19.2	146.6 ± 19.0	.007	142.1 ± 19.0	148.1 ± 18.2	149.8 ± 19.1	< .001
Diastolic BP, mmHg, mean ± SD	81.5 ± 9.1	82.2 ± 9.2	82.2 ± 9.3	.04	80.8 ± 9.0	83.2 ± 9.2	84.0 ± 9.4	< .001
Mean BP, mmHg, mean ± SD	115.8 ± 17.4	119.7 ± 17.5	119.0 ± 17.6	.009	115.2 ± 17.5	120.3 ± 16.6	121.8 ± 17.6	< .001
Pulse pressure, mmHg, mean ± SD	61.5 ± 15.8	64.9 ± 15.6	63.8 ± 16.3	.04	61.3 ± 15.9	64.8 ± 15.1	65.7 ± 16.4	< .001
Number of Diseases, mean ± SD	1.1 ± 0.0	2.2 ± 1.0	2.2 ± 1.1	.68	2.0 ± 1.1	2.3 ± 1.1	2.4 ± 1.1	< .001
Number of Medications, mean ± SD	1.8 ± 1.8	2.0 ± 1.9	2.3 ± 1.9	< .001	1.8 ± 1.8	2.0 ± 1.8	2.3 ± 1.8	.004
Mini Mental State Examination score, mean ± SD	25.5 ± 4.7	25.8 ± 4.6	25.5 ± 4.7	.28	25.8 ± 4.4	25.7 ± 4.3	25.4 ± 5.0	.27
Geriatric Depression Scale score, mean ± SD	10.8 ± 6.3	10.8 ± 6.4	10.9 ± 6.6	.98	10.5 ± 6.3	10.9 ± 6.4	11.6 ± 6.4	.04
Disability in ≥1 activity of daily living, %	8.3	10.0	12.0	.04	7.4	12.1	14.2	.009
Social support score, mean ± SD*	12.9 ± 2.5	13.0 ± 2.6	13.0 ± 2.7	.62	12.7 ± 2.6	12.8 ± 2.5	13.4 ± 2.5	< .001
Died, %	47.8	46.6	56.7	.001	53.8	50.3	46.1	.046

*Range 0–17, higher scores indicating lower social support.
SD = standard deviation; BP = blood pressure.

expenditure leads to greater body mass, with the accumulation of subcutaneous and visceral fat. Accumulation of visceral fat is related to many health conditions, including cardiovascular disease and insulin resistance.[32] Visceral fat has greater proinflammatory properties than subcutaneous fat and has been related to metabolic syndrome because it induces the release of free fatty acids and glycerol.[33] Accordingly, selective removal of perinephric and epididymal fat pads prevents the development of type 2 diabetes mellitus in obesity-prone rodent models.[34] The foregoing considerations support the concept that anthropometric measures of abdominal obesity would be a more-accurate method with which to evaluate obesity than BMI in older adults.

Table 3. Baseline Characteristics of Subjects with Chronic Heart Failure (CHF) Stratified According to Waist Circumference (WC) and Body Mass Index (BMI)

	WC (n = 121)				BMI (n = 114)			
Variable	1 (n = 43)	2 (n = 28)	3 (n = 50)	*P*	1 (n = 49)	2 (n = 31)	3 (n = 34)	*P*
Age, mean ± SD	76.0 ± 6.0	76.5 ± 7.1	75.5 ± 7.0	.71	76.8 ± 6.9	75.7 ± 6.5	74.7 ± 6.7	.17
Female, %	55.8	57.1	66.0	.31	55.1	71.0	58.8	.64
Heart rate, bpm, mean ± SD	78.6 ± 13.7	76.5 ± 12.6	81.0 ± 11.9	.36	78.0 ± 12.4	80.4 ± 13.8	81.0 ± 12.7	.29
Systolic BP, mmHg, cm, mean ± SD	142.0 ± 23.1	151.5 ± 19.2	151.4 ± 18.9	.03	114.3 ± 21.6	148.8 ± 18.6	153.5 ± 22.2	.04
Diastolic BP, mmHg, bpm, mean ± SD	80.8 ± 10.5	82.9 ± 13.3	84.5 ± 9.1	.10	80.8 ± 12.0	82.6 ± 8.4	85.4 ± 11.1	.06
Mean BP, mmHg, mean ± SD	115.0 ± 20.6	123.8 ± 17.9	123.3 ± 18.0	.04	117.4 ± 20.1	121.3 ± 16.8	125.1 ± 20.3	.08
Pulse pressure, mmHg, mean ± SD	61.1 ± 16.7	68.6 ± 18.5	66.9 ± 17.5	.13	63.5 ± 19.4	66.1 ± 14.2	68.1 ± 18.4	.25
Number of Diseases, mean ± SD	4.7 ± 1.1	4.7 ± 1.1	4.9 ± 1.1	.73	4.6 ± 1.0	4.9 ± 1.1	4.9 ± 1.2	.54
Number of Medications, mean ± SD	5.5 ± 2.4	4.9 ± 2.2	4.3 ± 1.6	.10	5.0 ± 2.2	5.0 ± 2.0	4.0 ± 2.0	.06
Mini Mental State Examination score, mean ± SD	23.5 ± 6.1	23.7 ± 4.9	23.3 ± 5.5	.88	23.8 ± 5.2	23.1 ± 5.3	23.3 ± 6.2	.70
Geriatric Depression Scale score, mean ± SD	15.1 ± 6.5	16.3 ± 7.1	17.0 ± 5.5	.19	16.0 ± 6.5	16.5 ± 6.0	16.4 ± 6.0	.78
Disability in ≥1 activity of daily living, %	15.4	17.9	22.9	.37	21.3	9.7	20.6	.84
Social support score, mean ± SD*	13.9 ± 3.1	14.2 ± 2.0	15.0 ± 2.0	.04	14.3 ± 2.4	14.0 ± 2.9	15.0 ± 2.1	.25
Died, %	58.1	82.1	82.0	.001	79.6	67.7	73.5	.49

*Range 0–17, higher scores indicating lower social support.
SD = standard deviation; BP = blood pressure.

Table 4. Predictors of 12-Year Morality in Participants with and without Chronic Heart Failure (CHF)

Variable	Hazard Ratio (95% Confidence Interval) *P*-Value Without CHF	With CHF
Age	1.17 (1.14–1.21) .001	1.02 (0.95–1.11) .57
Female	0.48 (0.35–0.65) .001	0.54 (0.18–1.60) .27
Body mass index	0.94 (0.90–0.98) .001	0.94 (0.85–1.04) .23
Waist circumference	1.02 (1.01–1.04) .001	1.05 (1.01–1.08) .001
Heart rate	1.00 (0.98–1.02) .80	0.98 (0.94–1.01) .20
Pulse pressure	1.01 (1.00–1.02) .17	1.01 (0.98–1.04) .52
Number of diseases	1.12 (1.01–1.26) .046	1.01 (0.75–1.37) .93
Number of medications	1.07 (0.99–1.17) .10	1.04 (0.79–1.36) .80
Mini-Mental State Examination score	0.95 (0.92–0.99) .001	1.01 (0.91–1.12) .86
Geriatric Depression Scale score	1.02 (1.01–1.04) .03	1.04 (1.02–1.10) .02
Disability in >1 activity of daily living, %	7.38 (2.05–26.55) .02	1.34 (0.23–7.65) .74
Social support score	1.09 (1.02–1.18) .001	0.88 (0.69–1.12) .29

*Range 0–17, higher scores indicating lower social support.
SD = standard deviation; BP = blood pressure.

Obesity in Older Adults

The relationship between BMI and mortality is poorly defined in elderly subjects.[15,16,35–37] Lean elderly subjects tend to be frailer and more prone to age-associated illnesses and consequently have greater mortality.[38,39] Adults with higher BMI values are likely to die in middle age and are thus poorly represented in geriatric clinical studies.[40] A study of years of life lost to obesity[40] estimated that remaining life expectancy could be reduced by approximately 6 and 12 years in Caucasian men and women, respectively, who have a BMI greater than 40.0 kg/m^2 during the third decade of life. In elderly individuals without CHF in the current study, BMI was unrelated to mortality, whereas mortality was significantly greater and survival rates significantly lower as WC increased. A negative or no association between BMI and all-cause mortality has been reported in older adults.[8–14] On the contrary, higher BMI values have been reported to be positively related to mortality risk in young and middle-aged individuals.[41] A study of age-related changes in total and regional fat distribution showed that body weight, WC, and total adiposity increase in concert in middle-aged people, whereas in older adults, WC and total adiposity can continue to increase despite a decrease in BMI.[36] In other words, BMI does not reveal age-related increases in total adiposity and the apparent increase in abdominal adiposity. Abdominal adiposity is more closely related to mortality risk than total adiposity.[42] This may explain why WC is more predictive than BMI of mortality risk in elderly subjects.[16,25,36]

Obesity in Older Adults with CHF

The prevalence of CHF has been reported to be up to 10 times as high in individuals aged 65 to 74 and 20 times as high in individuals aged 85 and older as in the general population.[43,44] Average 5-year mortality in subjects with CHF is approximately 50%.[3] The prevalence of individuals with CHF in the current study was approximately 10%, with a mean age of 75.8 $\pm$ 6.9, and 12-year mortality was approximately 80%. Moreover, individuals with CHF had several clinical features typical of "geriatric" patients (more comorbidities, drug use, cognitive impairment, and depression). Thus, the data are consistent with previous observations that CHF is a geriatric disease.[45] In addition, the data indicate that disability is strongly predictive of mortality in the absence but not in the presence of CHF. It is conceivable that CHF in older adults may reduce the predictive power of some predictors of mortality (disability) because of its strong effect on survival in older adults.[43,44]

Obesity Paradox in Older Adults with CHF

A large body of evidence indicates that obesity plays an important role not only in worsening CHF, but also in contributing to CHF per se by inducing specific morphological and hemodynamic changes,[17,46] but obesity evaluated in terms of BMI led to problems in mortality risk assessment in middle-aged CHF subjects. Paradoxically, in such patients, mortality was lower with higher BMI. In middle-aged patients with CHF, obesity assessed according to BMI was not associated with greater mortality[47] and may confer, conversely, a more-favorable prognosis over a 2-year period. Another study found better event-free survival with higher BMI in 209 ambulatory patients with New York Heart Association Class I to III heart failure.[17] These observations focused attention on obesity measurements in term of fat distribution evaluation and not overall obesity.[21,22]

In this context, in a recent large systematic review of cohort studies, patients with low BMI ($<$20.0 kg/m^2) had a greater relative risk of all-cause mortality, whereas severely obese patients (BMI $\geq$35.0 kg/m^2) did not have greater total mortality but had the highest risk for cardiovascular mortality.[48] Because the better outcomes for cardiovascular and total mortality seen in the overweight and mildly obese individuals were not due to confounding factors, the authors concluded that BMI cannot differentiate between body fat and lean mass.[48] In addition, in elderly patients, lower BMI values have been related to low lean mass and therefore to sarcopenia, which is associated with greater total mortality.[49]

Alternatively, in the Heart Outcomes Prevention Evaluation Study, patients in the highest WC tertiles had a 38% greater adjusted relative risk of developing CHF.[31] Recently, it was reported that the WHR and WC are significantly associated with the risk of incident cardiovascular events; a meta-regression analysis of prospective studies found that a 1-cm increase in WC was associated with a 2% greater risk of future cardiovascular events.[50] Moreover, it was recently reported that in a cohort of well-functioning community-dwelling individuals aged 70 to 79, WC and not BMI was associated with incident CHF; it was concluded that abdominal body fat distribution may be a stronger risk factor for CHF than overall obesity.[51]

In the current sample, mortality of elderly subjects with CHF was not greater with higher BMI. In addition, Cox analysis showed that BMI exerted a protective effect on long-term mortality in the absence but not in the presence of CHF. Therefore, when obesity was assessed using BMI, the data were consistent with the obesity paradox. In contrast,

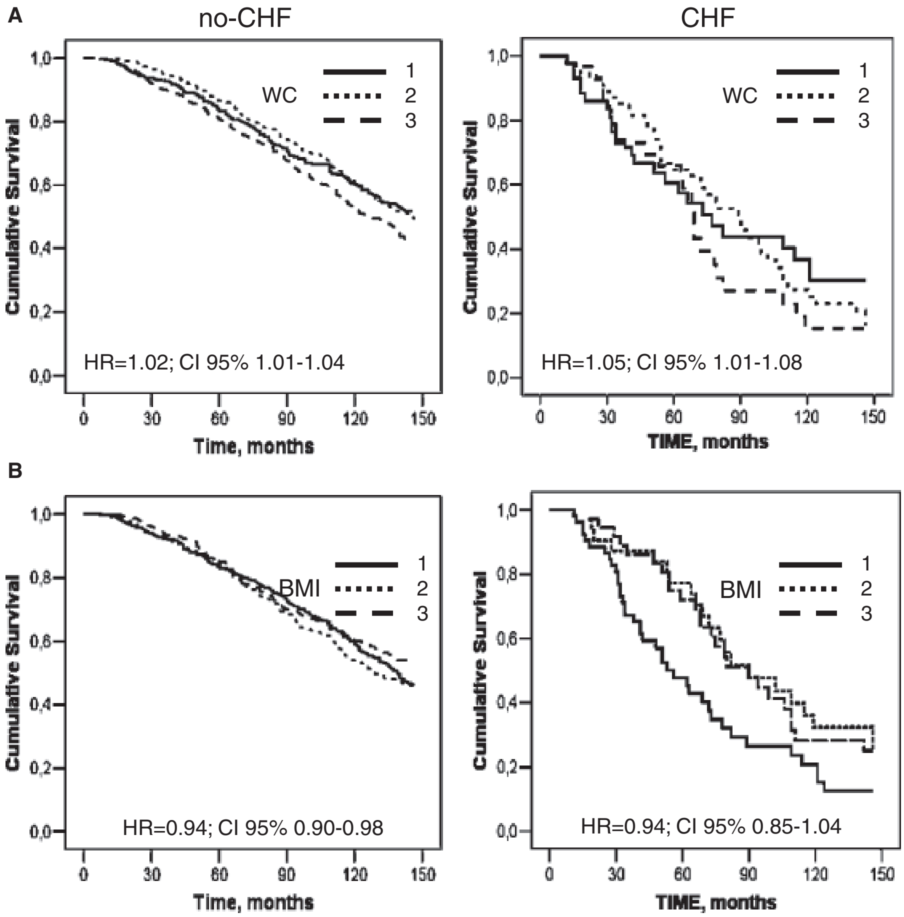

Figure 1. Cox regression analysis of mortality in elderly patients with and without chronic heart failure (CHF) stratified according to (A) body mass index (BMI) and (B) waist circumference (WC). HR = hazard ratio; CI = confidence interval.

when obesity was assessed using WC, it was a predictive factor for mortality in elderly individuals affected or not by CHF, and the predictive effect was more pronounced in the presence of CHF. Thus, the obesity paradox was overcome when obesity was measured using WC.

Limitations of the Study

The results of this study should be evaluated taking into account several limitations. First, only WC and not WHR was evaluated, although a recent study showed that WC and WHR are associated with a similar risk of cardiovascular disease in elderly men and women.[50] Second, the number of individuals with CHF may have been underestimated. Some subjects with CHF do not necessarily require vasodilators, digitalis derivatives, or diuretics and are in a euvolemic state. These subjects are not classified as having CHF, and hence, based on the criteria for CHF,[52] they could have been missed. Moreover, echocardiographic ejection fraction data and silent ischemia diagnosis were not available for all subjects, although other studies, including the Cardiovascular Health Study, enrolled subjects with CHF according to criteria similar to those used in the current study (self-report with medical record verification).[53] In particular, one study showed that self-reported CHF was confirmed in 73.3% of men and 76.6% of women in the Cardiovascular Health Study.[53] In any event, if the number of individuals with CHF was underestimated, the study sample is probably truly representative of a population with CHF. Finally, the power of this study would have been better had follow-up been extended to 20 years, but a 12-year follow-up was believed to be long enough in a population aged 65 and older at baseline, considering that average 5-year survival in elderly individuals with CHF is approximately 50%.[3] Mortality was 85% in the individuals with CHF in the highest WC tertile.

CONCLUSIONS

This study shows that obesity assessed according to BMI does not predict long-term mortality in elderly individuals with CHF and confirms the obesity paradox. In contrast, when obesity was measured as abdominal adiposity, assessed according to WC, it predicted long-term mortality in elderly subjects without CHF, and its predictive power was even more pronounced in elderly subjects with CHF. Hence, it appears that WC is more-appropriate than BMI for obesity evaluation in older adults, especially in the presence of CHF.

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REFERENCES

1. Kenchaiah S, Evans JC, Levy D et al. Framingham Heart Study, Framingham, Mass 01702, USA. Obesity and the risk of heart failure. N Engl J Med 2002;347:305–313.
2. Oreopoulos A, Padwal R, Kalantar-Zadeh K et al. Body-mass index and mortality in heart failure: A meta-analysis. Am Heart J 2008;156:13–22.
3. Gottdiener JS, Arnold AM, Aurigemma GP et al. Predictors of congestive heart failure in the elderly: The Cardiovascular Health Study. J Am Coll Cardiol 2000;35:1628–1637.
4. Croft JB, Giles WH, Pollard RA et al. Heart failure survival among older adults in the United States: A poor prognosis for an emerging epidemic in the Medicare population. Arch Intern Med 1999;159:2225–2226.
5. Rich MW. Heart failure in the 21st century: A cardiogeriatric syndrome. J Gerontol A Biol Sci Med Sci 2001;56A:M88–M96.
6. Curtis LH, Whellan DJ, Hammill BG et al. Incidence and prevalence of heart failure in elderly persons, 1994–2003. Arch Intern Med 2008;168:418–424.
7. Salihu HM, Bonnema SM, Alio AP. Obesity: What is an elderly population growing into? Maturitas 2009;63:7–12.
8. Bender R, Jockel KH, Trautner C et al. Effect of age on excess mortality in obesity. JAMA 1999;281:1498–1504.
9. Dey DK, Rothenberg E, Sundh V et al. Body mass index, weight change and mortality in the elderly: A 15 y longitudinal population study of 70 y olds. Eur J Clin Nutr 2001;55:482–492.
10. Grabowski DC, Campbell CM, Ellis JE. Obesity and mortality in elderly nursing home residents. J Gerontol A Biol Sci Med Sci 2005;60A:1184–1189.
11. Landi F, Onder G, Gambassi G et al. Body mass index and mortality among hospitalized patients. Arch Intern Med 2000;160:2641–2644.
12. Takata Y, Ansai T, Soh I et al. Association between body mass index and mortality in an 80-year-old population. J Am Geriatr Soc 2007;55:913–917.
13. Price GM, Uauy R, Breeze E et al. Weight, shape, and mortality risk in older persons: Elevated waist-hip ratio, not high body mass index, is associated with a greater risk of death. Am J Clin Nutr 2006;84:449–460.
14. Prospective Studies Collaboration,Whitlock G, Lewington S et al. Body-mass index and cause-specific mortality in 900,000 adults: Collaborative analyses of 57 prospective studies. Lancet 2009;373:1083–1096.
15. Stevens J, Cai J, Pamuk ER et al. The effect of age on the association between body-mass index and mortality. N Engl J Med 1998;338:1–7.
16. Calle EE, Thun MJ, Petrelli JM et al. Body-mass index and mortality in a prospective cohort of U.S. adults. N Engl J Med 1999;341:1097–1105.
17. Lavie CJ, Osman AF, Milani RV et al. Body composition and prognosis in chronic systolic heart failure: The obesity paradox. Am J Cardiol 2003;91:891–894.
18. Horwich TB, Fonarow GC, Hamilton MA et al. The relationship between obesity and mortality in patients with heart failure. J Am Coll Cardiol 2001;38:789–795.
19. Fonarow GC, Srikanthan P, Costanzo MR et al. An Obesity paradox in acute heart failure: Analysis of body mass index and in-hospital mortality for 108,927 patients in the Acute Decompensated Heart Failure National Registry. Am Heart J 2007;153:74–81.
20. Kalantar-Zadeh K, Block G, Horwich T et al. Reverse epidemiology of conventional cardiovascular risk factors in patients with chronic heart failure. J Am Coll Cardiol 2004;43:1439–1444.
21. Zamboni M, Mazzali G, Zoico E et al. Health consequences of obesity in the elderly: A review of four unresolved questions. Int J Obes 2005;29:1011–1029.
22. Wannamethee SG, Shaper AG, Lennon L et al. Decreased muscle mass and increased central adiposity are independently related to mortality in older men. Am J Clin Nutr 2007;86:1339–1346.
23. Janssen I, Katzmarzyk P, Ross R. Body mass index is inversely related to mortality in older people after adjustment for waist circumference. J Am Geriatr Soc 2005;52:2112–2118.
24. Kalmijn S, Curb JD, Rodriguez BL et al. The association of body weight and anthropometry with mortality in elderly men: The Honolulu Heart Program. Int J Obes Relat Metab Disord 1999;23:395–402.
25. Visscher TL, Seidell JC, Molarius A et al. A comparison of body-mass index, waist-hip ratio and waist circumference as predictors of all-cause mortality among the elderly: The Rotterdam Study. Int J Obes Relat Metab Disord 2001;25:1730–1735.
26. Cacciatore F, Abete P, Ferrara N et al. The role of blood pressure in cognitive impairment in an elderly population. J Hypertens 1997;15:135–142.
27. Mazzella F, Cacciatore F, Galizia G et al. Social support and long-term mortality in the elderly: Role of comorbidity. Arch Gerontol Geriatr, 2010 Feb 11. [Epub ahead of print].
28. Measso G, Cavarzeran F, Zappalà G. The Mini-Mental State Examination: Normative study of an Italian random sample. Dev Neuropsycol 1993;9:77–85.
29. Yesavage JA, Brink TL, Rose TL et al. Development and validation for geriatric depression screening scale: A preliminary report. J Psychiatric Res 1983;17:37–49.
30. Katz S, Ford AB, Moskowitz RW et al. Studies of illness in the aged. The index of BADL: A standardized measure of biological and psycological functions. JAMA 1963;185:94–99.
31. Dagenais GR, Yi Q, Mann JF et al. Prognostic impact of body weight and abdominal obesity in women and men with cardiovascular disease. Am Heart J 2005;149:54–60.
32. Carr DB, Utzschneider KM, Hull RL et al. Intra-abdominal fat is a major determinant of the National Cholesterol Education Program Adult Treatment Panel III criteria for the metabolic syndrome. Diabetes 2004;53:2087–2094.
33. Bjorntorp P. "Portal" adipose tissue as a generator of risk factors for cardiovascular disease and diabetes. Arteriosclerosis 1990;10:493–496.
34. Gabriely I, Ma XH, Yang XM et al. Removal of visceral fat prevents insulin resistance and glucose intolerance of aging: An adipokine-mediated process? Diabetes 2002;51:2951–2958.
35. Flegal KM, Graubard BI, Williamson DF et al. Excess deaths associated with underweight, overweight, and obesity. JAMA 2005;293:1861–1867.
36. Kuk JL, Saunders TJ, Davidson LE et al. Age-related changes in total and regional fat distribution. Ageing Res Rev 2009;8:339–348.
37. Kuk JL, Ardern CI. Influence of age on the association between various measures of obesity and all-cause mortality. J Am Geriatr Soc 2009;57:2077–2084.
38. Singh PN, Lindsted KD. Body mass and 26-year risk of mortality from specific diseases among women who never smoked. Epidemiology 1998;9:246–254.
39. Rexrode KM, Hennekens CH, Willett WC et al. A prospective study of body mass index, weight change, and risk of stroke in women. JAMA 1997;277:1539–1545.
40. Fontaine KR, Redden DT, Wang C et al. Years of life lost due to obesity. JAMA 2003;289:187–193.
41. Heiat A, Vaccarino V, Krumholz HM. An evidence-based assessment of federal guidelines for overweight and obesity as they apply to elderly persons. Arch Intern Med 2001;161:1194–1203.
42. Bigaard J, Frederiksen K, Tjonneland A et al. Waist circumference and body composition in relation to all-cause mortality in middle-aged men and women. Int J Obes Relat Metab Disord 2005;29:778–784.
43. Bleumink GS, Knetsch AM, Sturkenboom MC et al. Quantifying the heart failure epidemic: Prevalence, incidence rate, lifetime risk and prognosis of heart failure. The Rotterdam Study. Eur Heart J 2004;25:1614–1619.
44. Murphy NF, Simpson CR, McAlister FA et al. National survey of the prevalence, incidence, primary care burden, and treatment of heart failure in Scotland. Heart 2004;90:1129–1136.
45. Rich MW. Epidemiology, pathophysiology, and etiology of congestive heart failure in older adults. J Am Geriatr Soc 1997;45:968–974.
46. Alpert MA, Terry BE, Mulekar M et al. Cardiac morphology and left ventricular function in normotensive morbidly obese patients with and without congestive heart failure, and effect of weight loss. Am J Cardiol 1997;80:736–740.
47. Uretsky S, Messerli FH, Bangalore S et al. Obesity paradox in patients with hypertension and coronary artery disease. Am J Med 2007;10:863–870.
48. Romero-Corral A, Montori VM, Somers VK et al. Association of bodyweight with total mortality and with cardiovascular events in coronary artery disease: A systematic review of cohort studies. Lancet 2006;368:666–678.
49. Roubenoff R. Sarcopenia and its implications for the elderly. Eur J Clin Nutr 2000;54(suppl 3):40–47.

50. de Koning L, Merchant AT, Pogue J et al. Waist circumference and waist-to-hip ratio as predictors of cardiovascular events: Meta-regression analysis of prospective studies. Eur Heart J 2007;28:850–856.
51. Nicklas BJ, Cesari M, Penninx BW et al. Abdominal obesity is an independent risk factor for chronic heart failure in older people. J Am Geriatr Soc 2006;54:413–420.
52. Cacciatore F, Abete P, Ferrara N et al. Congestive heart failure and cognitive impairment in an older population. J Am Geriatr Soc 1998;46:1343–1348.
53. Psaty BM, Kuller LH, Bild D et al. Methods of assessing prevalent cardiovascular disease in the Cardiovascular Health Study. Ann Epidemiol 1995;5:270–277.