Body Mass Index and Survival in Men and Women Aged 70 to 75

Leon Flicker, PhD,[*,†,‡] *Kieran A. McCaul, PhD,*[*] *Graeme J. Hankey, MD,*[§] *Konrad Jamrozik, PhD,*[||] *Wendy J. Brown, PhD,*[#] *Julie E. Byles, PhD,*[†,**] *and Osvaldo P. Almeida, PhD*[*,††,‡‡]

OBJECTIVES: To examine in an older population all-cause and cause-specific mortality associated with underweight (body mass index (BMI) <18.5), normal weight (BMI 18.5–24.9), overweight (BMI 25.0–29.9), and obesity (BMI ≥ 30.0).

DESIGN: Cohort study.

SETTING: The Health in Men Study and the Australian Longitudinal Study of Women's Health.

PARTICIPANTS: Adults aged 70 to 75, 4,677 men and 4,563 women recruited in 1996 and followed for up to 10 years.

MEASUREMENTS: Relative risk of all-cause mortality and cause-specific (cardiovascular disease, cancer, and chronic respiratory disease) mortality.

RESULTS: Mortality risk was lowest for overweight participants. The risk of death for overweight participants was 13% less than for normal-weight participants (hazard ratio (HR) = 0.87, 95% CI = 0.78–0.94). The risk of death was similar for obese and normal-weight participants (HR = 0.98, 95% CI = 0.85–1.11). Being sedentary doubled the mortality risk for women across all levels of BMI (HR = 2.08, 95% CI = 1.79–2.41) but resulted in only a 28% greater risk for men (HR = 1.28 (95% CI = 1.14–1.44).

CONCLUSION: These results lend further credence to claims that the BMI thresholds for overweight and obese are overly restrictive for older people. Overweight older people are not at greater mortality risk than those who are normal weight. Being sedentary was associated with a greater risk of mortality in women than in men. **J Am Geriatr Soc 58:234–241, 2010.**

Key words: body mass index; mortality; risk; sedentary; older

From the *Western Australian Centre for Health and Ageing, Centre for Medical Research, Western Australian Institute for Medical Research, Perth, Western Australia; †School of Medicine and Pharmacology, ††School of Psychiatry and Clinical Neurosciences, University of Western Australia, Perth, Western Australia; ‡Department of Geriatric Medicine, §Stroke Unit, Department of Neurology, and ‡‡Department of Psychiatry, Royal Perth Hospital, Perth, Western Australia; ||School of Population Health and Clinical Practice, University of Adelaide, Adelaide, South Australia; #School of Human Movement Studies, University of Queensland, Brisbane, Queensland; and **Research Centre for Gender, Health and Ageing, Faculty of Health, University of Newcastle, Newcastle, New South Wales.

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Address correspondence to Leon Flicker, Professor of Geriatric Medicine, Western Australian Centre for Health & Ageing (M573), The University of Western Australia, 35 Stirling Highway, Crawley, Perth, Western Australia 6009. E-mail: leon.flicker@uwa.edu.au

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Obesity is a global epidemic that is prevalent in developed and developing countries; affects people of both sexes and all ages; and has negative health consequences (ill health, disability, and mortality), economic costs, and social implications.[1] In industrialized countries, the prevalence of overweight and obesity in older people is a growing public health concern, particularly because sustained aging of their populations is expected to continue for many decades, and obesity and aging represent large components of healthcare spending.[1]

Based on the latest available data involving clinical measurements, Australia has the third highest prevalence of adult obesity of the Organisation for Economic Co-operation and Development countries (21.7% in 1999), behind the United States (34.3% in 2006) and the United Kingdom (24% in 2006).[2,3] Of older Australians, 28% of men and 38% of women aged 55 to 64 are obese, as are 22% of men and 32% of women aged 65 to 74 and 14% of men and 17% of women aged 75 and older.[4] The prevalence of obesity in older Australians tripled during the 20 years to 2004, representing a gain in weight of approximately 6 to 7 kg.[5]

Obesity and overweight are most commonly defined according to body mass index (BMI), also known as Quetelet's Index, a simple anthropometric measurement that is calculated by dividing body weight (in kg) by the square of height (in meters). The World Health Organization (WHO) defines the following four principal categories: less than 18.5 kg/m^2 = underweight; 18.5 to 24.9 kg/m^2 = normal weight; 25.0 to 29.9 kg/m^2 = overweight; and 30.0 kg/m^2 or more = obese.[6] These thresholds were primarily based on evidence from studies of morbidity and mortality risk in younger and middle-aged adults, but it remains unclear whether the overweight and obese cut points are overly restrictive measures for predicting mortality in older

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people,[7] and concerns have been raised about encouraging apparently overweight older people to lose weight.[8]

Two systematic reviews and a meta-analysis of selected articles on BMI and mortality spanning 1966 to 2004 have concluded that BMI in the overweight range is not a risk factor for all-cause mortality in older people,[9,10] but methodological differences complicate the comparability of individual studies.

The objective of this study was to examine a major unresolved question;[11] what level of BMI is associated with the lowest mortality risk in older people? A secondary objective was to determine whether the relationship between BMI and mortality risk differed between older men and women. Two large representative population-based cohorts of community-dwelling older Australians, followed for a decade or until death (if sooner), were used. To the authors' knowledge, this is one of the most detailed studies of its kind conducted, particularly in people aged 70 and older.

METHODS

Ethical Approval

The human research ethics committee of the University of Western Australia approved the protocol for the Health in Men Study (HIMS), and ethics committees at the University of Newcastle and the University of Queensland approved that for the Australian Longitudinal Study on Women's Health (ALSWH).

Data Sources

Data were used from two population-based longitudinal studies that began in 1996: the HIMS and the older cohort from the ALSWH. The detailed methods for both studies are published elsewhere.[12,13]

The men who were screened for abdominal aortic aneurysm in a randomized controlled trial conducted in Perth, Western Australia, in 1996 formed the HIMS cohort. In this trial, eligible men were aged 65 to 79, resident in Perth (the capital of Western Australia), and not in long-stay institutional accommodation. A list of all potentially eligible men was drawn from an electronic copy of the electoral roll in 1996 (voting is compulsory for adult Australians); after excluding 8,801 who were no longer resident in Perth and 2,296 who had died before being contacted, the remaining men were randomized into the screening group (n = 19,352) or control group (n = 19,352). Of those invited to be screened, 1,846 were ineligible, 5,303 did not respond or refused, and 12,203 were screened. These 12,203 screened men formed the HIMS cohort and have been followed since their recruitment. The sample size was based on the number of men required to be screened to demonstrate 50% lower mortality from abdominal aortic aneurysm than in the control group.

In the ALSWH study, three cohorts of women were randomly selected in 1996 from electronic records of Australia's universal health insurance scheme, Medicare, which covers all citizens and permanent residents. In the oldest cohort, aged 70 to 75, 39,000 women were invited to participate; of these 1,100 were not contactable, and 2,366 were ineligible. Of those women remaining (35,534), 12,614 responded. Sample size was based on the available funding for the three cohorts.

For this analysis to achieve comparability between the cohorts, only the men aged 70 to 75 at baseline (n = 4,931) and the women resident in metropolitan and urban areas (n = 5,042) were included. The overall response rate was 69.7% for the men and 35.5% for the women. In both cohorts, survival was better than in the populations from which they were recruited. At 10 years, survival of HIMS respondents was 16% higher than observed in the general population of this age and survival of ALSHW respondents was 8% higher.

The HIMS and ALSWH surveys collected self-reported measures of height and weight, which were used to calculate BMI. In addition, a variety of demographic (e.g., age, education, marital status), lifestyle (e.g., smoking status, alcohol consumption, exercise), and health status characteristics (e.g. self-reported history of hypertension, diabetes mellitus) were ascertained. Current alcohol use was categorized into three levels using the National Health and Medical Research Council of Australia guidelines,[14] which recommend no more than two standard drinks (each containing 10 g alcohol) per day for women and four standard drinks per day for men and, for both sexes, at least 2 alcohol-free days per week. Subjects were classified as nondrinkers, as drinking within recommended levels, or as having alcohol consumption exceeding recommended levels. Subjects answered questions relating to participation in a usual week in vigorous exercise, (e.g., jogging) and nonvigorous exercise (e.g., walking). Subjects were categorized as sedentary if they reported no time in either of these activities in a usual week.

Participants were followed for a decade or until death if sooner. Date of death and multiple causes of death were obtained from the Australian Bureau of Statistics, which allowed 100% ascertainment of cause-specific mortality status until the end of 2005. Causes of death were coded according to the International Classification of Diseases, Ninth Revision (ICD-9) or Tenth Revision (ICD-10). In this analysis, cause-specific mortality was determined using all causes of death documented on the death certificate rather than just the single underlying cause of death, which resulted in some individuals being counted in more than one category of cause-specific mortality. Deaths were grouped into three major categories: cardiovascular disease (ICD9: 390–434, 436–448; ICD10: I00–I78), cancer (ICD9: 140–208, ICD10: C00–C97), and chronic respiratory disease (ICD9: 490–494, 496, ICD10: J40–J47).

Statistical Analysis

Cox proportional hazards regression was used to model survival to death from all causes. Survival time was calculated in days from the date of entry into the relevant study to the date of death or the end of follow-up (December 31, 2005), whichever came first. Individuals still alive at the end of follow-up were censored and tied survival times were broken using Efron's method. The proportional hazards assumption was tested by examining the relationship between the scaled Schoenfeld residuals and survival time. The overall fit of the regression models was assessed by examining the Cox-Snell residuals.

To investigate the functional form of the association between BMI and mortality risk, BMI was modeled as a continuous variable using a restricted cubic spline with three knots. From this analysis, the BMI associated with the minimum mortality risk was predicted for men and women, and their associated 95% confidence intervals were estimated using bootstrapping. To ensure that the choice of knots was optimal, a series of sensitivity analyses was conducted, varying the number of knots used (3, 4, 5, or 6 knots) and their location. Results from these analyses were examined graphically and compared using the Bayesian information criterion (BIC).

Potential confounders and effect modifiers of the relationship between BMI (categorized according to WHO criteria) and mortality were investigated in the following way. Initially, the cohorts were combined, and each covariate, apart from sex, was modeled separately for its relationship with mortality risk. Subsequently, two separate models were fitted for each covariate. The covariate was modeled with BMI and an interaction term between the covariate and BMI. Then each covariate was modeled with sex and an interaction term between the covariate and sex. These analyses were performed to detect any interactions between sex and any covariate. Any interaction that achieved nominal significance at the .05 level (two-tailed) was retained for further modeling. Final modeling was an iterative process of adding covariates (and their relevant interaction terms) to a base model of sex, BMI, and an interaction between sex and BMI. Additional covariates were added to the baseline model if they altered any of the effect estimates in the baseline model by 10% or more.

A potential source of bias arises if, for some participants, illness has caused weight loss and this illness also increases the risk of mortality. To determine whether the presence of preexisting illness modified the relationship with BMI, men and women were categorized as healthy if they reported no prior history of diabetes mellitus, heart disease, stroke, hypertension, or chronic respiratory illness and if they were not current smokers. Regression models were also fitted conditional on 1-, 2-, and 3-year survival. This removed the influence of early mortality from the hazard ratio estimates, and these were compared with those obtained from the full cohort.

RESULTS

For the 4,931 men and 5,042 women in this study, height or weight was missing for 254 men (5.2%) and 479 women (9.5%), and these were excluded from further analysis, leaving 4,677 men and 4,563 women aged 70 to 75 and resident in metropolitan areas. There was no major difference in the mean age of the two groups (women 72.1; men 72.3), but there were minor differences in the age distribution, mainly due to a paucity of 75-year-old women and a less-apparent excess of 70-year-old men. Characteristics of the men and women at baseline are shown in Table 1. At baseline, more than 80% of men reported being married, compared with only 54% of women, whereas almost 35% of women reported being widowed, compared with only 7.6% of men. More men (15.1%) than women (5.1%) reported some level of tertiary education. Women were less likely than men to report being sedentary (18.1% vs 24.9%). With regard to medical history, there were no striking differences between men and women apart from the higher proportion of men (24.1%) than women (18.3%) reporting bronchitis or emphysema. More than 60% of women reported having never smoked, compared with only 26.4% of men, and many more men (63.1%) than women (30.7%) reported being former smokers. Men (41.4%) were more likely than women (11.5) to report levels of alcohol consumption that exceeded National Health and Medical Research Council guidelines and less likely to report no alcohol consumption (men 6.0%; women 32.7%). Based on the WHO classification of BMI, 50.3% of women were classified as normal weight (BMI 18.5–24.9), compared with 43.5% of men; 44.5% of men were classified as overweight (BMI 25.0–29.9), compared with 33.5% of women. For the covariates listed in Table 1, the extent of missing data was minimal in the men and generally between 1% and 2% in the women.

The men were observed for a total of 37,896.7 person-years (mean 8.1 years) and the women for a total of 43,816.9 person-years (mean 9.6 years). Over this time, 1,369 deaths occurred in the men and 939 in the women; of these, there were 776 deaths in men and 489 in women from cardiovascular disease, 608 deaths in men and 298 in women from cancer, and 189 deaths in men and 88 in women from stroke.

Relationship Between BMI and All-Cause Mortality

Figure 1 shows the relative risk estimated for all-cause mortality according to BMI at baseline. For men and women, mortality risk was lowest in those who were classified as overweight according to BMI. The minimum mortality risk was found at a BMI of 26.6 kg/m^2 (95% CI = 25.7–27.5) in men and 26.26 kg/m^2 (95% CI = 25.5–26.9) in women. For men and women with BMIs that were classified as normal, the risk of death increased as BMI decreased such that the estimated risk of death for men and women at the lower end of the normal range was almost double the risk in those who were overweight. This estimated risk was similar to that observed in obese men and women (BMI $\geq$35.0).

Categorizing subjects into healthy (n = 2,716) or nonhealthy (n = 6,094) (see Methods section) did not substantially alter the pattern of association between BMI and mortality (Figure 2). Although being nonhealthy increased the risk of all-cause mortality, there was no evidence of a major difference in the overall shape of the four curves after fitting the main effects and their interactions (sex $\times$ BMI; healthy $\times$ BMI; sex $\times$ healthy, and sex $\times$ healthy $\times$ BMI).

Examining the relationships with the covariates listed in Table 1, the only interaction effect detected was between sex and being sedentary, and only smoking was found to have a moderate confounding effect. Being sedentary increased the risk of mortality in men by 28% (HR = 1.28, 95% CI = 1.14–1.44) but doubled the risk in women (HR = 2.08, 95% CI = 1.79–2.41). Subjects who were underweight had a greater mortality risk (HR = 1.76, 95% CI = 1.39–2.22) than those who were normal weight, whereas those who were overweight had a lower risk (HR = 0.87, 95% CI = 0.78–0.94). The risk in those who were obese was little different from those who were normal weight (HR = 0.98, 95% CI = 0.85–1.11).

Table 1. Cohort Characteristics at Baseline

Characteristic	Men n	Men % (95% CI)	Women n	Women % (95% CI)
Overall	4,677	50.6 (49.6–51.6)	4,563	49.4 (48.4–50.4)
Age				
70	985	21.1 (19.9–22.2)	806	17.7 (16.6–18.8)
71	835	17.9 (16.8–19.0)	983	21.5 (20.3–22.7)
72	827	17.7 (16.6–18.8)	950	20.8 (19.6–22.0)
73	732	15.7 (14.6–16.7)	837	18.3 (17.2–19.5)
74	675	14.4 (13.4–15.4)	768	16.8 (15.7–17.9)
75	623	13.3 (12.3–14.3)	219	4.8 (4.2–5.4)
Marital status				
Married	3,799	81.2 (80.1–82.4)	2,426	54.2 (52.8–55.7)
De facto	33	0.7 (0.5–0.9)	31	0.7 (0.4–0.9)
Separated	83	1.8 (1.4–2.2)	65	1.5 (1.1–1.8)
Divorced	232	5.0 (4.3–5.6)	239	5.3 (4.7–6.0)
Widowed	355	7.6 (6.8–8.4)	1,545	34.5 (33.1–35.0)
Single	174	3.7 (3.2–4.3)	168	3.8 (3.2–4.3)
Education*				
Primary	1,102	23.6 (22.3–24.8)	1,356	31.2 (29.8–32.6)
Secondary	2,870	61.4 (60.0–62.8)	2,771	63.7 (62.3–65.2)
Tertiary	705	15.1 (14.0–16.1)	221	5.1 (4.4–5.7)
Past history				
Diabetes mellitus	579	12.4 (11.4–13.3)	370	8.2 (7.4–9.0)
Hypertension	1,907	40.8 (39.4–42.2)	2,101	46.6 (45.2–48.1)
Stroke	374	8.0 (7.2–8.8)	241	5.4 (4.7–6.0)
Asthma	524	11.2 (10.3–12.1)	554	12.3 (11.4–13.3)
Bronchitis or emphysema	1,129	24.1 (22.9–25.4)	822	18.3 (17.2–19.5)
Heart disease	979	20.9 (19.8–22.1)	750	16.8 (15.7–17.9)
Smoking				
Never	1,222	26.1 (24.9–27.4)	2,652	61.4 (60.0–62.9)
Former	2,950	63.1 (61.7–64.5)	1,325	30.7 (29.3–32.1)
Current	504	10.8 (9.9–11.7)	340	7.9 (7.1–8.7)
Alcohol use†				
Nondrinker	271	6.0 (5.3–6.6)	1,443	32.7 (31.3–34.1)
Within guidelines	2,396	52.6 (51.2–54.1)	2,461	55.7 (54.3–57.2)
Exceeded guidelines	1,885	41.4 (40.0–42.8)	512	11.6 (10.6–12.5)
Exercise‡				
Sedentary	1,163	24.9 (23.6–26.1)	800	18.1 (16.9–19.2)
Nonsedentary	3,514	75.1 (73.9–76.4)	3,630	81.9 (80.8–83.1)
Body mass index, kg/m^2				
$<$18.5 (underweight)	60	1.3 (1.0–1.6)	142	3.1 (2.6–3.6)
18.5–24.9 (normal)	2,034	43.5 (42.1–44.9)	2,293	50.3 (48.8–51.7)
25.0–29.9 (overweight)	2,070	44.3 (42.8–45.7)	1,529	33.5 (32.1–34.9)
$\geq$30.0 (obese)	513	11.0 (10.1–11.9)	599	13.1 (12.1–14.1)
Height, cm, mean (95% CI)		173.6 (173.4–173.8)		161.0 (160.8–161.2)
Weight, kg, mean (95% CI)		77.6 (77.2–77.9)		65.4 (65.0–65.7)
Body mass index, kg/m^2, mean (95% CI)		25.7 (25.6–25.8)		25.2 (25.1–25.4)

* Education was determined according to the age of leaving school and type of school attended.

† Alcohol use was categorized according to National Health and Medical Research Council guidelines, which recommend no more than two standard drinks per day for women and four standard drinks per day for men. For both sexes, recommendations include at least 2 alcohol-free days per week.

‡ Sedentary was defined as no vigorous or nonvigorous exercise in a usual week.

CI = confidence interval.

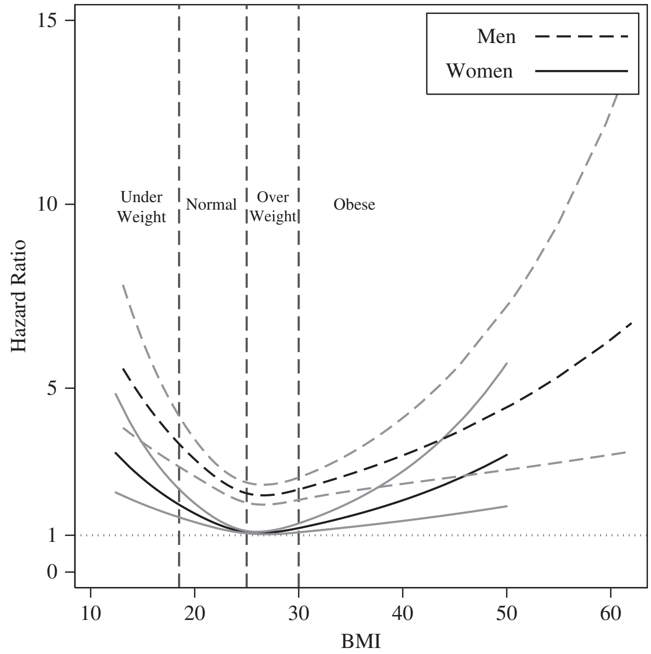

Figure 1. Hazard ratios of all-cause mortality according to body mass index (BMI) in men and women aged 70 to 75 (lines are 95% confidence intervals).

The results from this model, unadjusted and adjusted for smoking, are shown in Table 2. All risk ratios are relative to women with normal BMI who were not classified as sedentary. Adjusting for smoking attenuated all HR estimates but more so in those estimated for sedentary men. The lowest risks of all-cause mortality were observed in nonsedentary women; in every BMI category, risk estimates were lower for nonsedentary than for sedentary women.

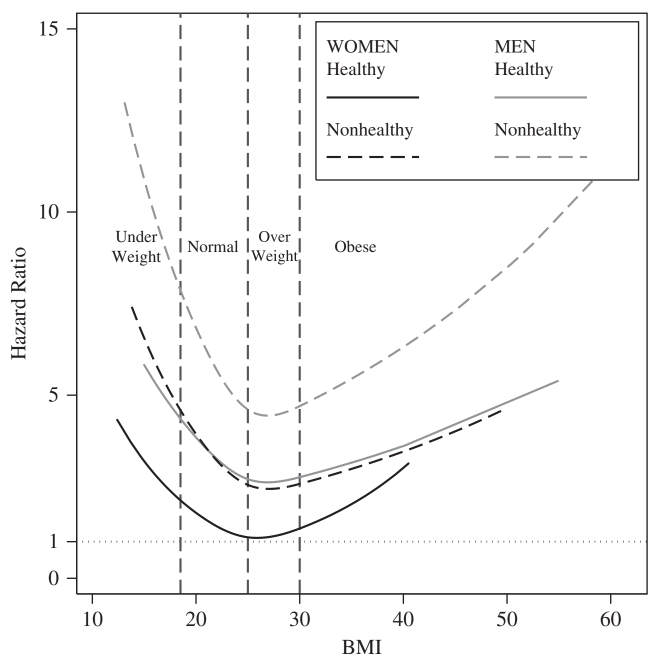

Figure 2. Hazard ratios of all-cause mortality according to body mass index (BMI) in healthy and nonhealthy men and women aged 70 to 75.

Similarly, nonsedentary men had lower risks of all-cause mortality than sedentary men in all BMI categories. In contrast, across all BMI categories, there was little difference in all-cause mortality risks between sedentary women and nonsedentary men (chi-square = 2.50, 1 degree of freedom, $P = .11$). Nevertheless, although being sedentary had clear effects on mortality risk for men or women who were sedentary or not, the lowest risk of mortality was consistently seen in those classified as overweight.

The relationship between BMI and risk of dying from cardiovascular disease, cancer, or chronic respiratory disease is shown in Figure 3. The lowest risks for men and women were again those with a BMI in the overweight range of the WHO classification.

A series of sensitivity analyses were conducted. For the spline models, the number and location of the knots used were varied, but this did not alter the finding that the minimum mortality risks were observed in those who were classified as overweight. The analyses were also repeated to see whether weight loss due to latent disease, which in turn could carry significant risk of early mortality, affected the results. The analysis were restricted to participants who were alive 1 year after recruitment, but no evidence was found of any alteration in the relationship between BMI and survival, nor was any evidence found when the analysis was restricted to those alive 2 years after recruitment or 3 years after; the lowest risk of mortality remained in those classified as overweight.

DISCUSSION

This study has demonstrated that, for people who have survived to the age of 70, mortality risk is lowest in those with a BMI classified as overweight according to the WHO. People who were classified as normal weight according to their BMI had a higher risk of death than the overweight group. This association remained for the common categories of mortality in the Australian population, including cardiovascular disease and cancer. Even after removing the effects of early mortality, those who were overweight were still at lowest risk, a finding consistent with the observation that weight loss in older age groups is associated with greater mortality.[15]

These results further recent work of a preformed meta-analysis of 32 previous studies over 30 years.[10] The results suggested that people aged 65 and older who were classified as overweight had mortality similar to that of those who were classified as normal. This meta-analysis included individuals aged 65 and older, but those who reach the age of 70, as in the current study, may exhibit a more-pronounced selection effect, having survived an additional 5 years. The current study has shown that older people with a BMI within the normal weight range may have higher mortality than those who are overweight. Reasons for these differences are uncertain, but lower mortality in those who are overweight has also been observed in older people with chronic conditions. In a meta-analysis of patients with existing coronary artery disease, overweight and obesity were associated with better survival, potentially because of the importance of metabolic and nutritional reserves for sick older people.[16] It may also be possible that there is less association between being overweight and mortality with time, as evidenced by a recent report of successive National Health and Nutrition Examination Surveys.[17]

Table 2. All-Cause Mortality in Men and Women Aged 70 to 75 According to Body Mass Index (BMI) and Exercise (Sedentary or Nonsedentary) Adjusted for Smoking

	Hazard Ratio (95% Confidence Interval)			
	Sedentary		Nonsedentary	
BMI	Men	Women	Men	Women
Unadjusted for smoking				
<18.5 (underweight)	5.27 (4.05–6.86)	3.95 (3.02–5.16)	3.89 (3.02–5.03)	1.88 (1.49–2.36)
18.5–24.9 (normal)	2.81 (2.47–3.19)	2.10 (1.82–2.43)	2.07 (1.87–2.30)	Reference
25.0–29.9 (overweight)	2.40 (2.07–2.79)	1.80 (1.52–2.12)	1.77 (1.56–2.02)	0.85 (0.78–0.94)
≥30.0 (obese)	2.67 (2.24–3.19)	2.00 (1.66–2.40)	1.97 (1.67–2.33)	0.95 (0.83–1.09)
Adjusted for smoking				
<18.5 (underweight)	4.15 (3.16–5.45)	3.65 (2.78–4.80)	3.25 (2.50–4.22)	1.76 (1.39–2.22)
18.5–24.9 (normal)	2.36 (2.07–2.70)	2.08 (1.79–2.41)	1.85 (1.66–2.06)	Reference
25.0–29.9 (overweight)	2.03 (1.74–2.37)	1.78 (1.51–2.11)	1.59 (1.39–1.82)	0.86 (0.78–0.94)
≥30.0 (obese)	2.30 (1.92–2.76)	2.03 (1.68–2.44)	1.80 (1.52–2.14)	0.98 (0.85–1.11)

In this study, sex did not alter the relationship between BMI and mortality. Although women experienced lower mortality for all categories of BMI than men, the relative effect of BMI within each sex was similar. The effect on mortality of being sedentary was different for men and women. The protective effect of participating in any exercise was much greater in women than in men. Although previous work[18] has found protective effects for men and women, the differences in effect between men and women that the were found in the current are difficult to explain. Whether this is due to a discrepancy between ability and performance in this age group is unknown. For example, women who are sedentary might be unable to exercise because of ill health, whereas men who are sedentary might be capable of exercising but choose not to do so.

One of the major problems in observational studies of this type is reverse causality (i.e., older people who become unwell for any reason often lose weight before death). This study attempted to mitigate this by contrasting subjects who were relatively healthy with those who had major chronic diseases or smoked. The analyses were also performed conditional on 1-, 2-, and 3-year survival. These further analyses did not reveal any apparent differences in the relationship between BMI and mortality. Other studies have estimated the association between BMI and mortality after adjusting for the effects of conditions such as hypertension, diabetes mellitus, and hypercholesterolaemia, but this practice has been criticized because they are sequelae of obesity and hence in the causal pathway from obesity to mortality. Controlling for the biomedical variables removes some of the effect of being overweight and leads to biased estimates of the mortality risk associated with BMI.[19]

The current study has some limitations. Height and weight were collected only once, at study entry, and there were no data pertaining to weight fluctuations (gain or loss) before or during the follow-up period, whether such changes in weight were intentional or unintentional (e.g., due to underlying disease), and whether they had occurred recently or over a prolonged period. A second limitation was the use of BMI, which although well accepted as a surrogate measure of body fat, is also known to be imperfect. Contrary to its design assumption, BMI is age- and sex-dependent.[20] It is also insensitive to changes in body fat distribution, which commonly occur with aging as bone mineral density and fat-free mass (e.g., muscle) diminish while fat mass increases.[21] Additionally, only self-reported height and weight were available for the men and women, and self-report and measured BMI have been shown to differ. In adult populations (≥18), the overall trend with self-reported data has been to underestimate weight and overestimate height, thus underestimating BMI[22] and biasing the results to underestimate any inverse association between being overweight and mortality. Although correction equations for self-reported BMI have been proposed, there is no consensus on the most-appropriate method.[23–25] Arguably, large waist circumference, which is an equally safe, inexpensive, and practical measure of obesity in large samples, would have been a better measure of visceral and total fat, but these data were not available for the ALSWH cohort.

The results from this study come from cohorts in which mortality was lower than observed in the general population from which they were recruited, as is observed frequently in cohorts of older people.[26] This suggests that, in these cohorts, a principal reason for nonresponse was ill health, and the results need to be interpreted with this in mind. The relationship between BMI and mortality described may not apply to older people who are frail and at risk of death.

A greater risk was found for extreme obesity. A recent report has also described such a U-shaped pattern[27] but also described a lower mortality risk for overweight nondisabled adults aged 75 to 84. However, mortality risk must be balanced by the potential loss of physical function associated with obesity.[28]

In conclusion, these results add further credence to claims that the WHO BMI thresholds for overweight and obese are overly restrictive for older people. Overweight older people are not at greater mortality risk, and there is little evidence that dieting in this age group confers any benefit; these findings are consistent with the hypothesis that weight loss is harmful.

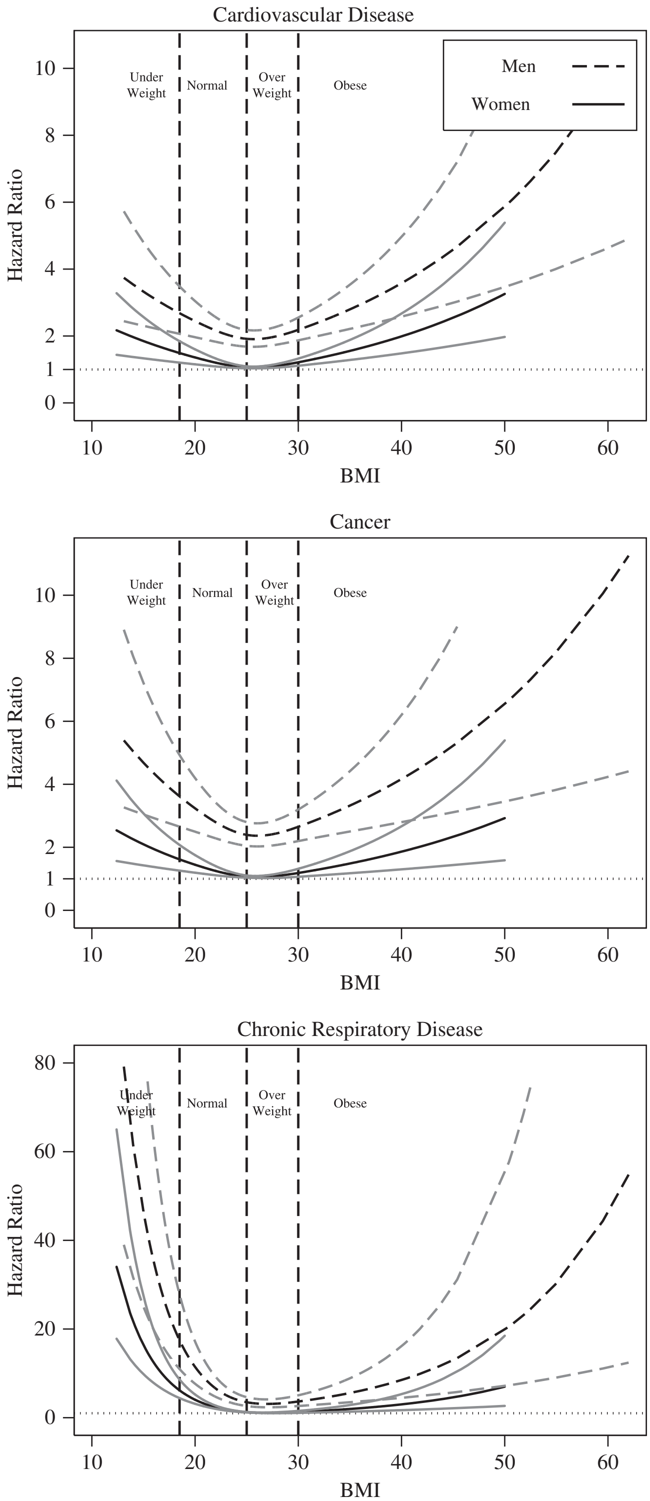

Figure 3. Hazard ratios of cause-specific mortality (cardiovascular, cancer, and chronic respiratory) according to body mass index (BMI) in men and women aged 70 to 75.

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Conflict of Interest: The editor in chief has reviewed the conflict of interest checklist provided by the authors and has determined that the authors have no financial or any other kind of personal conflicts with this paper.

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