Relation of Low Body Mass to Death and Stroke in the Systolic Hypertension in the Elderly Program

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Background: There are scant data on the effect of body mass index (BMI) (calculated as weight in kilograms divided by the square of height in meters) on cardiovascular events and death in older patients with hypertension.

Objective: To determine if low body mass in older patients with hypertension confers an increased risk of death or stroke.

Patients: Participants were 3975 men and women (mean age, 71 years) enrolled in 17 US centers in the Systolic Hypertension in the Elderly Program trial, a randomized, double-blind, placebo-controlled clinical trial of low-dose antihypertensive therapy, with follow-up for 5 years.

Main Outcome Measures: Five-year adjusted mortality and stroke rates from Cox proportional hazards analyses.

Results: There was no statistically significant relation of death or stroke with BMI in the placebo group ($P = .47$), and there was a U- or J-shaped relation in the treatment group. The J-shaped relation of death with BMI in the treated group ($P = .03$) showed that the lowest probability of death for men was associated with a BMI of 26.0 and for women with a BMI of 29.6; the curve was quite flat for women across a wide range of BMIs. For stroke, men and women did not differ, and the BMI nadir for both sexes combined was 29, with risk increasing steeply at BMIs below 24. Those in active treatment, however, had lower death and stroke rates compared with those taking placebo.

Conclusions: Among older patients with hypertension, a wide range of BMIs was associated with a similar risk of death and stroke; a low BMI was associated with increased risk. Lean, older patients with hypertension in treatment should be monitored carefully for additional risk factors.

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There has been much emphasis on obesity as a risk factor for cardiovascular disease and mortality,1-4 but there has been no comparable focus on possible risks associated with leanness. Many studies5-8 have found a U- or J-shaped relation between body mass index (BMI) (calculated as weight in kilograms divided by the square of height in meters) and mortality. Others,2,9,10 however, have found a strong and direct relation between BMI and cardiovascular disease and mortality. These studies have helped to disseminate the widespread belief that losing weight is universally desirable. The association between low levels of BMI and mortality has often been explained as being due to confounding, by smoking, for example,6 or to preexisting illness. However, studies2,3 that control for confounders and that exclude events occurring during the first period of follow-up still find a residual J- or U-shaped relation. Whether early or chronic obesity confers the excess risk observed at high levels of BMI and whether weight loss or a low BMI per se confers the excess risk at low levels of BMI are not established. Little attention has been devoted to BMI and risk in older persons or in those with an existing recognized comorbid condition. This article presents data on the relation of BMI with death and stroke in a cohort of older persons enrolled in the Systolic Hypertension in the Elderly Program (SHEP), a placebo-controlled, randomized, clinical trial of antihypertensive therapy for isolated systolic hypertension.

Estimates of the prevalence of elevations in SBP of 160 mm Hg or higher with a normal diastolic blood pressure range from 6% to 18% depending on age,11 and prevalence is higher in women vs men and in blacks vs whites.12 This report includes information on the effect of anti-
PATIENTS AND METHODS

The primary objective of SHEP was to determine if drug treatment for isolated systolic hypertension in older people reduced the 5-year stroke incidence. The design is described in detail elsewhere.13 In summary, the clinical trial enrolled 4736 men and women aged 60 years and older who had SBPs of 160 mm Hg or higher and a diastolic blood pressure lower than 90 mm Hg. Participants were randomized to active treatment or matching placebo and followed up for 5 years, with a blood pressure measurement obtained every 4 months. The drugs used in active treatment were chlorthalidone, 12.5 mg, increased to 25 mg, and atenolol if necessary, 25 or 50 mg, to achieve a goal SBP of 160 mm Hg or 20 mm Hg less than the blood pressure at study entry. The final results of SHEP indicated a significant 37% reduction in stroke risk with treatment.14

The cohort analyzed to address the question of the relation of BMI to SHEP end points included all participants with complete data except those who died or had a stroke or myocardial infarction (MI) within 6 months of the baseline visit and those who died of cancer or had a cancer diagnosis at any time during the trial, to minimize the possible effect of underlying illness. There were 4022 persons who met those criteria. There were 47 persons with missing BMI values who were also excluded, resulting in 3975 persons in the analysis cohort.

First, the cohort was divided into sex-specific quintiles of BMI to determine stroke and death rates in each quintile. Five-year cumulative probabilities of event rates, adjusted for age, race, sex, and educational level, were obtained from Cox proportional hazards analyses for each quintile. The baseline characteristics of participants in the lowest quintile were compared with those of participants in the other quintiles and were tested for significance by the chi-square test for discrete variables and the t test for continuous variables. Multiple comparisons were adjusted for by the Bonferroni procedure.15,16

To adjust for additional confounders and to calculate relative risk, multivariate Cox proportional hazards analyses were done, with covariates being age, sex, race, and educational level; history of stroke, MI, or diabetes; and activities of daily living.17 Smoking status, serum cholesterol level, SBP attained in treatment as a time-dependent variable and its square term, and baseline BMI and its square term. In such an analysis, if the quadratic or square term is significant, it indicates that the relation between the independent variable of interest and the outcome variable is not linear but can better be fitted by a J or U shape. The reason that the square term of attained in-treatment SBP was included is that in a previous analysis a quadratic (J-shaped) relation was found between SBP, as a time-dependent variable, and death and cardiovascular disease within the treatment group. The lowest risk of death was at a treated SBP of 142 mm Hg and of cardiovascular disease at a treated SBP of 146 mm Hg. The risk relative to the nadir of attained blood pressure was slightly higher at blood pressures lower than the nadir and much higher at blood pressures higher than 160 mm Hg (S.W.-S., B.D., unpublished data, 1996). Hence, we controlled for that relation. In the present analysis of the restricted cohort that excluded persons who died within the first 6 months and those who had a cancer death or diagnosis at any time, the J-shaped SBP relation to death had a nadir at 145 mm Hg but was not statistically significant (P = .18) for men and women combined.

When the square term of BMI was significant (indicating a J or U relation), we calculated the value of BMI associated with the lowest risk (the nadir) and obtained the risk of event for different values of BMI relative to the nadir (the formula is available from the authors). To determine whether the BMI-mortality relation was different for control and treatment groups, several Cox proportional hazards models were run, including models with interaction terms for this variable. These analyses indicated that the BMI-mortality relation was different in the control and treatment groups, and these 2 groups were, therefore, analyzed separately. We performed similar tests to see whether the BMI-stroke relation was different for the control and treatment groups. These analyses indicated that the BMI-stroke relation was also different for the control and treatment groups; hence, these 2 groups were analyzed separately. Furthermore, for the outcome of death within the treatment group, the interaction term between sex and BMI was significant in the survival analysis (P = .04). Thus, it was appropriate to do separate analyses of men and women for death within the treatment group. Sex was not a significant (P = .46) covariate for stroke; hence, analyses of the end point of stroke were done for both sexes combined.

results

RELATION OF BMI TO DEATH AND STROKE

Table 1 shows the crude mortality and fatal plus nonfatal stroke rates by BMI quintiles and the rates adjusted for sex, age, race, and educational level. Mortality rates were higher in the lowest quintile of BMI than in the middle quintile for the total group and within the control and treatment groups separately. For stroke, rates were higher in the lowest quintile than in either the middle or the highest quintile of BMI in the control and treat-
Since the BMI and BMI\textsuperscript{2} randomization group interaction was significant for mortality and stroke, analyses were done separately for the treatment and control groups.

In the control group, the relation between BMI and death was inverse and significant, with control for age, sex, race, and educational level ($P = .05$), and became non-significant when smoking was added to the model and when all the other covariates were also included. These findings were unchanged in an analysis of the subcohort of never smokers only ($n = 1852$) or of current and past smokers; the quadratic term of BMI was not significant in the control group, for all participants, for never smokers only, or for current and past smokers. Thus, with control of multiple confounders, there was no significant relation of BMI to death in the placebo group, although the crude and age, sex, race, and educational level adjusted rates indicate that in the control and the treatment groups, the highest mortality was in the lowest BMI quintile. The same findings were true for stroke, with no statistically significant relation of BMI to stroke in the placebo group, with control for all covariates, but with crude and age, sex, race, and educational level adjusted rates indicating higher stroke rates in the lowest BMI quintile (Table 1).

### Table 1. Mortality and Stroke Rates by BMI Quintile\*  

<table>
<thead>
<tr>
<th>Quintile</th>
<th>Range of BMI</th>
<th>Events/Total Sample</th>
<th>Crude Rates per 1000</th>
<th>Adjusted Probability of Death in Rates per 1000$^{†}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>24.4 - 22.9</td>
<td>59785</td>
<td>75.2</td>
<td>71.1</td>
</tr>
<tr>
<td>2</td>
<td>24.5 - 23.5</td>
<td>43809</td>
<td>53.2</td>
<td>43.7</td>
</tr>
<tr>
<td>3</td>
<td>23.6 - 24.5</td>
<td>36787</td>
<td>45.7</td>
<td>41.9</td>
</tr>
<tr>
<td>4</td>
<td>24.6 - 25.5</td>
<td>40804</td>
<td>48.8</td>
<td>45.0</td>
</tr>
<tr>
<td>5</td>
<td>&gt; 25.5</td>
<td>37790</td>
<td>46.8</td>
<td>47.3</td>
</tr>
</tbody>
</table>

### Table 2. Baseline Characteristics by BMI Quintile\*  

<table>
<thead>
<tr>
<th>Quintile</th>
<th>Total Sample</th>
<th>History of Diabetes, %</th>
<th>History of Stroke, %</th>
<th>History of MI, %</th>
<th>Smoking, %</th>
<th>Age, y</th>
<th>SBP, mm Hg</th>
<th>DBP, mm Hg</th>
<th>Education, y</th>
<th>Serum Cholesterol Level, mmol/L (mg/dL)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>785</td>
<td>7.5$^{†}$</td>
<td>2.6$^{†}$</td>
<td>4.5</td>
<td>18.6$^{†}$</td>
<td>72.7</td>
<td>170.4</td>
<td>76.9</td>
<td>12.1</td>
<td>6.04 (233.7)</td>
</tr>
<tr>
<td>2</td>
<td>809</td>
<td>8.8</td>
<td>1.4</td>
<td>4.7</td>
<td>13.0</td>
<td>71.9</td>
<td>170.0</td>
<td>76.8</td>
<td>11.9</td>
<td>6.20 (239.7)</td>
</tr>
<tr>
<td>3</td>
<td>787</td>
<td>10.8</td>
<td>0.5</td>
<td>5.9</td>
<td>12.1</td>
<td>71.5</td>
<td>170.6</td>
<td>77.5</td>
<td>11.8</td>
<td>6.18 (239.2)</td>
</tr>
<tr>
<td>4</td>
<td>804</td>
<td>11.3</td>
<td>1.5</td>
<td>5.3</td>
<td>10.1</td>
<td>70.8</td>
<td>170.2</td>
<td>77.1</td>
<td>11.8</td>
<td>6.17 (238.7)</td>
</tr>
<tr>
<td>5</td>
<td>790</td>
<td>12.7</td>
<td>1.0</td>
<td>4.6</td>
<td>7.1$^{†}$</td>
<td>69.4</td>
<td>169.5</td>
<td>77.6</td>
<td>11.2$^{†}$</td>
<td>6.02 (232.8)</td>
</tr>
</tbody>
</table>

### Table 2. Baseline Characteristics by BMI Quintile\*  

<table>
<thead>
<tr>
<th>Quintile</th>
<th>Total Sample</th>
<th>History of Diabetes, %</th>
<th>History of Stroke, %</th>
<th>History of MI, %</th>
<th>Smoking, %</th>
<th>Age, y</th>
<th>SBP, mm Hg</th>
<th>DBP, mm Hg</th>
<th>Education, y</th>
<th>Serum Cholesterol Level, mmol/L (mg/dL)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>402</td>
<td>6.7</td>
<td>2.7$^{†}$</td>
<td>4.5</td>
<td>18.2$^{†}$</td>
<td>72.4</td>
<td>170.0</td>
<td>76.7</td>
<td>11.9</td>
<td>6.00 (232.2)</td>
</tr>
<tr>
<td>2</td>
<td>404</td>
<td>9.7</td>
<td>1.5$^{†}$</td>
<td>5.0</td>
<td>13.7</td>
<td>71.7</td>
<td>169.9</td>
<td>77.1</td>
<td>12.2</td>
<td>6.24 (241.5)</td>
</tr>
<tr>
<td>3</td>
<td>391</td>
<td>10.5</td>
<td>0.0</td>
<td>7.2</td>
<td>12.8</td>
<td>71.5</td>
<td>170.8</td>
<td>77.1</td>
<td>11.6</td>
<td>6.19 (239.5)</td>
</tr>
<tr>
<td>4</td>
<td>389</td>
<td>11.4</td>
<td>1.3$^{†}$</td>
<td>5.0</td>
<td>11.4</td>
<td>71.0</td>
<td>170.6</td>
<td>77.0</td>
<td>11.9</td>
<td>6.14 (237.5)</td>
</tr>
<tr>
<td>5</td>
<td>398</td>
<td>13.2</td>
<td>1.0</td>
<td>2.9$^{†}$</td>
<td>6.4$^{†}$</td>
<td>69.5$^{†}$</td>
<td>162.9</td>
<td>77.5</td>
<td>11.3</td>
<td>6.01 (232.5)</td>
</tr>
</tbody>
</table>

*Multiple comparisons were corrected by the Bonferroni procedure. BMI indicates body mass index; MI, myocardial infarction; SBP, systolic blood pressure; and DBP, diastolic blood pressure.

$^{†}$Significantly different from the middle quintile ($P < .05$).
For the active treatment group, Table 3 shows multivariate Cox regression coefficients and their SEs for death and stroke. The BMI quadratic term for both events was significant, with the point of lowest risk (nadir) for death occurring at a BMI of 27.7 and for stroke at a BMI of 29.3 (Figure 1). We repeated these analyses for never and for current and past smokers combined, with similar results, indicating a U shape in the treatment. The nadir for never smokers was 27.9 for death \( (P = .007) \) and 30.7 for stroke \( (P = .25) \), which was not significant; for current and past smokers, it was 29.1 for death \( (P = .05) \) and 30.7 for stroke \( (P = .06) \).

We also examined specific causes of the 215 deaths in this cohort (data not shown). The pattern of crude higher mortality in the lowest BMI quintile was true for deaths due to MI, stroke, infections, and indeterminate causes and sudden or rapid death (sudden death is within 1 hour, and rapid death is within 24 hours). There were 13 deaths due to indeterminate causes in the placebo group and 9 in the active treatment group. The number of deaths in each of these categories was too small to draw any statistical inferences; however, deaths due to coronary heart disease (CHD) and stroke in the active treatment group were lower in the lowest quintile of BMI (26.2/1000 compared with 38.4/1000 in the highest BMI quintile and 17.7/1000 in the middle quintile). In contrast, in the placebo group, while there was a markedly higher rate of deaths in the lowest BMI quintile (49.8/1000), there was not the expected increase in deaths due to CHD or stroke in the highest BMI quintile, which had a rate of 15.1 per 1000. An analysis of the 154 deaths due to cancer excluded from these analyses indicated that 25.3% occurred in the lowest, 21.4% in the middle, and 18.2% in the highest quintile of baseline BMI. The mean baseline BMI among the 4227 persons in the entire SHEP group who lived for the next 5 years was 27.6 (95% confidence interval, 27.4-27.7), while for those who had a subsequent stroke it was 25.7 (95% confidence interval, 23.5-28.0) and for those who had a subsequent MI it was 25.5 (95% confidence interval, 24.3-26.7) (data not shown).

![Figure 1](https://example.com/figure1.png)

**Figure 1.** Adjusted relative risk of death and fatal and nonfatal stroke within the active treatment group by body mass index (BMI) (calculated as weight in kilograms divided by the square of height in meters). The variables included educational level, history of diabetes, history of myocardial infarction, history of stroke, age, activity level, sex, race, smoking status, cholesterol level, BMI, BMI2, systolic blood pressure (SBP), and SBP (time dependent).

**Table 3.** Cox Regression Analyses’ Coefficients for Death and Stroke in the Active Treatment Group

<table>
<thead>
<tr>
<th>Variable</th>
<th>Death Coefficient</th>
<th>Death SE</th>
<th>Death P</th>
<th>Stroke Coefficient</th>
<th>Stroke SE</th>
<th>Stroke P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>0.0935</td>
<td>0.0174</td>
<td>&lt;.001</td>
<td>0.0466</td>
<td>0.0193</td>
<td>.02</td>
</tr>
<tr>
<td>Male sex</td>
<td>0.4826</td>
<td>0.2370</td>
<td>.04</td>
<td>-0.1391</td>
<td>0.2720</td>
<td>.61</td>
</tr>
<tr>
<td>Black race</td>
<td>0.0253</td>
<td>0.2719</td>
<td>.93</td>
<td>-0.1254</td>
<td>0.2969</td>
<td>.67</td>
</tr>
<tr>
<td>Education, y</td>
<td>-0.0092</td>
<td>0.0318</td>
<td>.77</td>
<td>0.0081</td>
<td>0.0355</td>
<td>.82</td>
</tr>
<tr>
<td>Activity level†</td>
<td>-0.2154</td>
<td>0.2356</td>
<td>.36</td>
<td>-0.0671</td>
<td>0.3097</td>
<td>.83</td>
</tr>
<tr>
<td>Smoking (current)</td>
<td>0.3988</td>
<td>0.2884</td>
<td>&lt;.001</td>
<td>0.5088</td>
<td>0.5666</td>
<td>.15</td>
</tr>
<tr>
<td>Cholesterol level</td>
<td>0.0049</td>
<td>0.0020</td>
<td>.01</td>
<td>-0.0018</td>
<td>0.0029</td>
<td>.54</td>
</tr>
<tr>
<td>History of diabetes</td>
<td>1.2771</td>
<td>0.2557</td>
<td>&lt;.001</td>
<td>1.1773</td>
<td>0.2919</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>History of MI</td>
<td>0.6243</td>
<td>0.3768</td>
<td>.10</td>
<td>-0.5004</td>
<td>0.7228</td>
<td>.49</td>
</tr>
<tr>
<td>History of stroke</td>
<td>-0.7272</td>
<td>1.0130</td>
<td>.47</td>
<td>0.5512</td>
<td>0.7285</td>
<td>.45</td>
</tr>
<tr>
<td>BMI</td>
<td>-0.3257</td>
<td>0.1229</td>
<td>.008</td>
<td>-0.2812</td>
<td>0.1482</td>
<td>.06</td>
</tr>
<tr>
<td>BMI²</td>
<td>0.0059</td>
<td>0.0020</td>
<td>.003</td>
<td>0.0048</td>
<td>0.0024</td>
<td>.05</td>
</tr>
<tr>
<td>SBP (time dependent)</td>
<td>-0.0590</td>
<td>0.0465</td>
<td>.20</td>
<td>-0.0292</td>
<td>0.0576</td>
<td>.61</td>
</tr>
<tr>
<td>SBP²</td>
<td>0.0002</td>
<td>0.0002</td>
<td>.18</td>
<td>0.0001</td>
<td>0.0002</td>
<td>.54</td>
</tr>
</tbody>
</table>

*MI indicates myocardial infarction; BMI, body mass index; and SBP, systolic blood pressure.
†Measured on a scale of 0 (able to do none of the listed daily activities without help) to 7 (able to do all the listed basic activities without outside help).
nonsmoking men and similar when done when those with a history of diabetes were excluded (data not shown).

As an example, in the treatment group at a BMI of 20, compared with the optimal BMI value, there is about a 72% excess risk of death for a woman and 36% for a man. Such a BMI value for a 173-cm-tall (5’8”) man corresponds to a weight of 60 kg (132 lbs); for a 163-cm-tall (5’4”) woman, 53 kg (117 lbs).

We have found, in a study of 4000 persons aged 60 years and older who were participants in a placebo-controlled clinical trial (SHEP), that there was an increased risk of death among lean, elderly patients with hypertension compared with those in the midrange of BMI due to all causes, stroke, CHD, and noncardiovascular causes. In the actively treated group, there was a marked U-shaped relation of BMI to death in men and women, and those who had a low BMI had a greater risk of death and stroke than those with more intermediate weights, with the lowest risk of death at a BMI of 27.7 and of stroke at a BMI of 29.3. The lowest risk of death for men was associated with a BMI of 25.8, for women, a BMI of 29.6. These results persisted after controlling for multiple covariates. There was a wide range of BMIs within which the probability of death or stroke was virtually the same, especially for an elderly man who is 173 cm tall (5’8”), the lowest risk was at a weight of 71.7 kg (158 lbs). For an elderly woman who is 163 cm tall (5’4”), the lowest risk was at a weight of 78 kg (172 lbs), with a statistically equivalent risk between 74 and 80 kg (165-178 lbs). For an elderly woman who is 163 cm tall (5’4”), the lowest risk was at a weight of 71.7 kg (158 lbs).

An analysis of the causes of death indicated that crude rates were higher for the lowest BMI quintile from cardiovascular and noncardiovascular causes, in the placebo and active treatment groups. It may be that elderly persons who are excessively thin are less able to withstand physiological insults in general. Low body weight in older persons may also be associated with poor nutritional status, which may contribute to disease.18

The findings reported herein, although based on data for persons with hypertension, sound a note of caution for weight loss recommendations for older persons who are only moderately overweight. Data from the National Health and Nutrition Examination Survey Epidemiologic Follow-up Study and the National Health Interview Survey of people aged 30 years and older found consistent U-shaped relations across all sex-race groups, with a steeply increasing relative risk of mortality at low BMI values and a broad range of BMI values in the middle of the distribution being associated with low relative mortality. The BMI associated with minimum mortality ranged from 25 to 28 for whites, depending on the cohort analyzed and on sex, and was higher for blacks, ranging from 27 to 30. A more recent analysis of those data from the same group,19 which modeled the relation between BMI and mortality compared with the minimum, found that the interval of BMI over which all-cause mortality did not increase by more than 20% was 9 BMI units wide. Hypertension, diabetes, and hypercholesterolemia were not controlled for in this analysis. The mean age in this cohort ranged from 48 years among men of both races to 54 years among black men, substantially younger than our cohort, whose mean age was older than 70 years.

An important study of the association of BMI to mortality among younger persons with hypertension (aged 30-69 years), in the Hypertension Detection and Follow-up Program, found a U-shaped relation to all-cause, cardiovascular, and noncardiovascular mortality in men and women.20 Persons with a BMI below 22 had higher adjusted 8-year death rates than those with a BMI in the median range of 26 to 29. Among men, smokers and nonsmokers had higher death rates at a low BMI; deaths related to lifestyle factors, such as smoking and alcohol intake, contributed to the excess risk, particularly among lean persons with hypertension.6 Our results are similar to those found in the younger nonhypertensive population samples, and in younger persons with hypertension, and extend the findings that there is a wide range of BMIs associated with similar risk to treated hypertensive elderly people.

Even studies2,10 that have been widely quoted as reporting a direct effect of high BMI on mortality have found that at a low BMI (<20) there is an excess risk of death, but these findings have not been emphasized and have largely been ignored in the popularly held belief that “thinner is better” regardless of age. A study in Germany20 of 6193 obese participants (BMI, >25) aged 18 to 75 years followed up for an average of 14 years indicated that moderate obesity (BMI, 25-32) was not associated with excess mortality. Similar to our findings, the impact of excess obesity (BMI, ≥32) was less pronounced in women than in men; gross obesity (BMI, ≥40) conferred a 3-fold excess risk in men and a 2-fold excess risk in women. The American Cancer Society’s Cancer Prevention Study21 of 62 116 nonsmoking men and 262 019 nonsmoking women reported that 12-year mortality increased with increasing BMI up to age 75 years, but the relative risk associated with a greater BMI declined with age. The curves of relative risk of deaths due to all causes and deaths due to cardiovascular disease for women aged 65 years and older are quite flat across a range of BMIs from 19 to more than 32. For younger men and women, relative risk increases after a BMI of 25 compared with the ref-

Figure 2. The adjusted relative risk of death within the treatment group by body mass index (BMI) (calculated as weight in kilograms divided by the square of height in meters). The variables included educational level, history of diabetes, history of myocardial infarction, history of stroke, age, activity level, race, smoking status, cholesterol level, BMI, BMI squared, systolic blood pressure (SBP), and SBP squared.
The Elderly, participants aged 65 years and older were fol-
lowered up prospectively for 10 years starting in 1981; the
defined BMI was stable in the years before our study or if
men who died during the follow-up period. Overweight, how-
significantly so for never smokers (P = .17 for trend); among
had a higher BMI at baseline than their counterparts who died
test BMI quintile, which had aberrantly low death rates in
was related to disability before death. However, BMI
in an average length of follow-up of 29 years. They found
those men younger than 65 years, however, risk increased
and among nonsmoking women analyzed separately, BMI was not re-
first quartile. Among women of all ages combined, and among
increasing relative risks of heart disease across increasing
line BMI was stable in the years before our study or if
in baseline characteristics that could be potential confound-
smokers there was still a J- or U-shaped relation of mortal-
with an average length of follow-up of 6.2 years, there was a trend
with an average follow-up of 6.2 years. There were people that
cancer or a death due to cancer at any time during the 5-year
6 months of follow-up. We repeated these analyses by excluding those who died or who had a history of stroke before 1 year, or who had diabetes, or who were never smok-
with increasing success rates of BMI when adjusted for age, but there
increased relative risk for mortality due to CHD in the
between BMI and death remained similar across a wide range
and among nonsmoking women analyzed separately, BMI was not re-
related to all-cause mortality when adjusted for age, but there
was not significantly so for never smokers (P = .06 for trend), but
in a cohort of 14,040 participants aged 45 to 64 years and free of CHD at base-
line BMI was comparable to the lowest quartile. Among women of all ages combined, and among
those men younger than 65 years, however, risk increased
successive quartiles of BMI compared with the lowest quartile. Among women of all ages combined, and among
nonsmoking women analyzed separately, BMI was not re-
related to all-cause mortality when adjusted for age, but there
was increased relative risk for mortality due to CHD in the
upper quartiles. The researchers did not present data for
older women separately. In the Epidemiologic Studies of
the different shape of the relation between BMI and death or stroke that we found in the treatment vs the control
group. In the treatment group, there was increased risk at a
low BMI, while in the control group there was not a signif-
ificant quadratic relation (an inverse linear trend in the
control group crude mortality rate was not significant when
smoking was controlled for). There is no U or J shape in
the control group because there is not the expected in-
crease in risk at the high BMI end and not because there is
a lower risk at a low BMI. In contrast, in the treatment

the different shape of the relation between BMI and death
remained similar across a wide range of BMIs (the curves are relatively flat). We cannot explain
the different shape of the relation between BMI and death or stroke that we found in the treatment vs the control

disease study found that the relation of increasing waist-hip
ratio with increasing CHD incidence was stronger for men
and women than the relation with BMI. In older people,
this may be an especially important factor, since there is
loss of lean body mass in older individuals and BMI may
not fully reflect the level of adiposity in these persons. We
did not have waist-hip measures available for analysis in
this cohort and so cannot say if there would be a different
relation between waist-hip ratio and mortality than what
we found with BMI. Thus, despite the fact that most stud-
ies indicate that there is little, if any, effect of BMI on mor-
tality in older women, until grossly high levels of obesity
are reached, the prevailing conclusions drawn from the re-
ports of these studies imply that the lower the relative
weight, the better for older women, and for younger ones.

We could not determine from our data set if the base-
line BMI was stable in the years before our study or if
there had been a weight gain or loss from a younger age.
However, we ran Cox proportional hazards models that
included BMI as a time-dependent covariate to adjust for
changes in BMI during the 5-year follow-up period. In
these analyses, we also found the quadratic term of BMI
to be statistically significant, indicating a J- or U-shaped
relation for death and stroke in the active treatment group.

It has been postulated that the effects of preexisting
illness may account for these U-shaped relations of weight
to mortality. We cannot rule that out completely; how-
ever, we have lessened that possibility by excluding from
our analysis cohort those persons who had a diagnosis of
cancer or a death due to cancer at any time during the 5-year
follow-up and those who had a stroke or MI or died before
6 months of follow-up. We repeated these analyses by excluding those who died or who had a history of stroke

In the treatment group, the lowest death risk was at a
BMI of 26 for men and 30 for women. However, the risk
of death and stroke remained similar across a wide range
of BMIs (the curves are relatively flat). We cannot explain
the different shape of the relation between BMI and death or stroke that we found in the treatment vs the control

time before 1 year, or who had diabetes, or who were never smok-
ers, with the same results in each case.

In conclusion, elderly persons with systolic hyper-
tension who are thin should be especially carefully moni-
tored for cardiovascular risk, nutritional status, and other
comorbidities, including depression, which is a risk fac-
tor for death and may itself be related to poor nutri-
tional status. Nevertheless, although these results sug-
gest that excessive leanness in elderly persons confers
increased risk, it should not be forgotten that excessive
overweight also confers increased risk, especially among
men; continued attention should be given to the well-
established relations between obesity and the known risk
factors for cardiovascular disease (hypertension, hyper-
cholesterolemia, and diabetes).

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