Body Mass Index and Mortality in Nonsmoking Older Adults: The Cardiovascular Health Study

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ABSTRACT

Objectives. This study assesses the relationship of body mass index to 5-year mortality in a cohort of 4317 nonsmoking men and women aged 65 to 100 years.

Methods. Logistic regression analyses were conducted to predict mortality as a function of baseline body mass index, adjusting for demographic, clinical, and laboratory covariates.

Results. There was an inverse relationship between body mass index and mortality; death rates were higher for those who weighed the least. Inclusion of covariates had trivial effects on these results. People who had lost 10% or more of their body weight since age 50 had a relatively high death rate. When that group was excluded, there was no remaining relationship between body mass index and mortality.

Conclusions. The association between higher body mass index and mortality often found in middle-aged populations was not observed in this large cohort of older adults. Overweight does not seem to be a risk factor for 5-year mortality in this age group. Rather, the risks associated with significant weight loss should be the primary concern. (*Am J Public Health*. 1998;88:623–629)

Introduction

Recent results from large prospective studies have raised public awareness of the dangers of being overweight in middle age.[1] There is, however, relatively little information on the relationship of weight to mortality for older adults (age 65+ years), even though issues of how to treat patients who are overweight or underweight are of great importance. Three large population-based studies have addressed this question,[2–4] finding higher mortality for people with a low body mass index (BMI) and mixed results for those with a high BMI. However, the available covariate data were limited, and the statistical methods and the results also differed somewhat, as discussed below. In this paper we assess the relationship of BMI to 5-year mortality in a large cohort of currently nonsmoking older adults for whom risk factors, subclinical disease, and morbidity are well characterized.

Methods

Data

The Cardiovascular Health Study is a population-based longitudinal study of 5201 adults 65 years of age and older, designed to identify factors related to the occurrence of coronary heart disease and stroke.[5] Subjects were recruited from a random sample of the Health Care Financing Administration Medicare eligibility lists in 4 US counties. Those eligible were aged 65 years or older at baseline, were not institutionalized, and were expected to remain in the area for the next 3 years. Persons who were wheelchair-bound or receiving hospice treatment, radiation therapy, or chemotherapy for cancer at baseline were excluded. Extensive baseline data were collected from all subjects, including a home interview and clinic examination. Data collection began in 1989, and 5-year vital status is known for all subjects.[6] Most of the subjects (95%) are White.

This paper examines the relationship between baseline BMI and 5-year all-cause mortality. BMI is defined as measured weight in kilograms divided by the square of measured height in meters. (Equivalently, BMI is weight in pounds divided by squared height in inches, then multiplied by 704.5.)

We chose baseline covariates that were prevalent in the elderly, were related to mortality in previous studies, and were likely to be related to BMI. Self-reported covariates include age, sex, smoking (never or former), history of cancer, fair or poor self-reported health status, 10-lb weight loss in the past year, and recalled weight at age 50. Clinical covariates include hypertension, diabetes, cardiovascular disease (prevalent heart disease, peripheral vascular disease, or cerebrovascular disease), maximum thickness of the internal carotid artery, depression (Center for Epidemiological Studies Depression Scale), forced expira-

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tory volume at 1 second, serum albumin, serum cholesterol, and serum creatinine. These measures are explained in more detail elsewhere.[7–11]

We excluded 593 current smokers and 291 people with missing information on the covariates, leaving 4317 subjects (including 539 who died during the 5-year follow-up) who are the main subjects of this analysis.

Analysis

All analyses were performed separately for men and women. We first examined the bivariate relationship of each covariate with mortality, controlling for age in a logistic regression model. We also examined relationships of covariates to BMI, using least squares regression to adjust for age.

Since all subjects were followed up for 5 years, we used 5-year mortality as the dependent variable. The results are presented as adjusted mortality rates, which were calculated from 2 logistic regression models, one controlling only for age and the other controlling for all of the covariates. We present both models because of the possibility of "overadjustment" (controlling inappropriately for factors that may have been affected by the person's weight). Adjusted mortality was calculated as observed mortality minus predicted mortality (from regression) plus the overall mortality (.083 for women or .177 for men). The mean of this variable, for a group of subjects, is the adjusted mortality for that group, which is shown in the tables. The standard errors for the adjusted rates are not shown, but are approximately the binomial standard error. Age-adjusted BMI was computed in a similar manner, using least squares regression. To lessen the effect of BMI outliers on the regression analyses, BMI was Winsorized,[12] with all values below the 5th percentile set to the 5th percentile and all values above the 95th percentile set to the 95th percentile.

For some analyses BMI was divided into 2-unit categories. The highest and lowest categories were widened to provide a minimum of 100 persons per category. We used logistic regression to test formally whether the relationship of mortality to BMI was linear or quadratic. We entered covariates first, then BMI, then BMI^2. To test whether the highest or lowest BMI categories had risks different from the others, we tested whether dummy variables for those BMI categories made significant improvements to the regressions.

To study the role of long-term weight loss, we performed some regressions excluding people who had lost more than 10% of their body weight since age 50. In addition, we divided subjects into 3 equal groups based on their BMI at baseline and used the same cutoffs for their BMI at age 50. We examined mortality cross-tabulated by BMI at age 50 and at baseline. We also conducted logistic regressions of baseline BMI vs mortality within the 3 BMI at age 50 subgroups.

To assess the comparability of the Cardiovascular Health Study sample to the US population, we compared the distribution of BMI at baseline with national data for ages 65 through 74 and compared the distribution of BMI at age 50 with national data for ages 45 through 55.[13]

TABLE 1—Age, Body Mass Index (BMI), and 5-Year Mortality in Nonsmoking Older Adults, by Sex: The Cardiovascular Health Study, 1996

	Women (n = 2410)	Men (n = 1907)	Total (n = 4317)
Age, y			
Mean	72.5	73.5	73.0
SD	5.4	5.7	5.6
Minimum	65.0	65.0	65.0
Maximum	95.0	100.0	100.0
BMI (kg/m^2)			
Mean	26.6	26.5	26.5
SD	5.0	3.7	4.5
Minimum	14.7	16.9	14.7
Maximum	53.2	62.8	62.8
Mean 5-y mortality, %	8.3	17.7	12.5
Survival after baseline, y			
1	19	42	61
1–2	40	53	93
2–3	38	78	116
3–4	45	70	115
4–5	59	95	154
>5	2209	1569	3778

Results

Table 1 shows descriptive statistics for age, BMI, and mortality, separately for men and women. The mean age was 73 years, and mean BMI was 26.5. The 5-year death rate was 12.5%, and it was higher for men (17.7%) than for women (8.3%). Only 61 of the 539 deaths occurred in the first year of follow-up.

Most of the covariates were significantly related to mortality after control for age, and many were also significantly associated with BMI. Although most covariate information is omitted here to conserve space, Table 2 presents detailed information about age and 2 measures of weight loss. Both 5-year mortality and mean BMI were significantly related to age.

Table 2 also shows that the age-adjusted death rate for people who reported an unintended loss of 10 lb or more in the year before baseline (16.2% for women and 33.0% for men) was much higher than the death rate for those who lost weight through diet or exercise or who maintained or gained weight. Some of the regression runs included a dummy variable for "short-term unintended weight loss" based on this variable.

The final variable shown in Table 2 is the difference between recalled weight at age 50 and measured weight at baseline (long-term weight change). The subjects who lost 10% or more of their weight had a relatively high death rate—15.9% for women and 30.3% for men. Their weight loss averaged 26 lb for women and 29 lb for men (not shown). They were significantly older than other subjects and were significantly more likely at baseline to have recent weight loss, cardiovascular disease, low cholesterol, and fair or poor health status. For women, weight loss was also associated with former smoking, hypertension, and depression. For men, weight loss was also associated with thicker carotid walls. Long-term weight loss was not included directly in the regressions because it is calculated from baseline BMI, which is the independent variable of interest. Instead, it was used to cross-classify persons in several analyses.

The mortality rate for different levels of baseline BMI is shown in the top half of Table 3. For example, 131 women had a BMI of 20 or lower; of these, 22 (16.8%) died within 5 years of baseline. After adjustment for age, the mortality rate

TABLE 2—Age-Adjusted Body Mass Index (BMI) and Mortality in Nonsmoking Older Adults, by Covariates and Sex: The Cardiovascular Health Study, 1996

	Women			Men		
	n	5-y Mortality, %	Mean BMI	*n*	5-y Mortality, %	Mean BMI
Age, y						
65–69	892	3.7	27.3	564	9.6	27.2
70–79	1235	8.0	26.4	1041	16.6	26.5
80+	283	24.4	25.2	302	36.8	25.0
Past-year weight change						
10 lb loss, unintended	157	16.2	25.6	138	33.0	26.0
10 lb loss, intended	132	5.0	27.0	91	16.4	27.3
No gain or loss	1882	7.4	26.2	1585	16.1	26.3
Weight gained	239	9.5	30.0	93	14.0	29.2
Weight change from age 50						
>10% loss	213	15.9	23.4	217	30.3	24.1
5%–10% loss	184	8.2	24.0	240	19.1	24.9
No gain or loss	709	7.4	24.7	776	13.9	25.8
5%–10% gain	411	6.1	26.3	303	15.0	27.6
>10% gain	804	7.9	29.7	314	16.7	29.7
Missing	89	4.3	28.2	57	20.2	27.4

Note. BMI (kg/m^2) and mortality are adjusted for age by regression. Mortality and BMI are significantly related to age ($P < .05$), past-year weight changes, and weight change from age 50 (adjusted for age, $P < .05$) with one exception: for men, past-year weight is not significantly related to BMI.

became 13.9%, and after adjustment for all other variables, the adjusted mortality was 14.9%. For women, the lowest BMI category had a significantly higher death rate than the other categories combined, adjusted for age and adjusted for the other covariates (P = .03 and .01, respectively). There was no other significant relationship between BMI and mortality.

A BMI of 20 or lower is equivalent to a 5 ft 5 in woman weighing 88 to 120 lb, which corresponds to the lowest 5% of women in the Cardiovascular Health Study and about the lowest 7% of women aged 65 through 74 nationally.[13] These women were significantly older (by 2.6 years) and had a significantly lower prevalence of hypertension, diabetes, and high cholesterol than other women (data not shown). They were significantly more likely to have had an unintended weight loss of 10 lb or more in the past year (18/131) and to have lost 10% or more of their weight since age 50 (56/131). Only 2 of the deaths occurred in the first year after baseline.

For men, the death rates were highest in the 3 lowest BMI categories, and there was a marginally significant negative linear relationship between BMI and mortality (P = .10, 2-tailed, when all variables were controlled). There was an apparent upturn in mortality for BMI greater than 32; however, there was not a significant quadratic relationship between BMI and mortality, and the mortality rate for men with a BMI greater than 32 was not significantly higher than the rate for men with a BMI between 24 and 32. The age-adjusted mortality rates are also shown in Figure 1 with 95% confidence intervals, some of which are rather large.

The bottom half of Table 3 shows mortality rates after people who had lost 10% or more of their weight after age 50 were removed from the analysis. The excess of deaths in the lowest BMI category, seen in the top half of the table, disappeared. There were no significant linear or quadratic associations between BMI and mortality.

To permit further exploration of long-term weight loss, Table 4 shows mean age-adjusted mortality (defined above) as a function of both recalled BMI at age 50 and BMI measured at baseline (age 65–100). Both BMI variables were categorized into tertiles of baseline BMI to preserve sample size. For example, there were 653 women who had low BMI (≤24.12) both at age 50 and at baseline. Their age-adjusted 5-year mortality rate was 7.8%. People who lost weight since age 50 are in the upper right section of the table, and those who gained are in the lower left section. Note that there are substantially more people in the "high" BMI category at baseline than at age 50, indicating a weight shift over time.

For women in the low or medium categories at age 50, and men in the low category, there was not a significant relationship between BMI at baseline and mortality. For women with a high BMI at age 50, and for men with a medium or high BMI at age 50, there was a significant negative relationship between baseline BMI and mortality, based on logistic regression with 2 dummy variables. Treating baseline BMI as a continuous variable gave similar results. For both men and women, the high mortality for those with low baseline BMI occurred primarily for people who had lost weight since age 50 (e.g., the 23 women who had a high BMI at age 50 but a low BMI at baseline had 25.4% mortality). People whose weight was stable or increased after age 50 showed no excess risk. Results (not shown) were similar after we controlled for all of the covariates.

Summary

We examined the relationship of baseline BMI to 5-year mortality in 4317 older adults. Women with a BMI of 20 or lower had higher mortality than others, and there was not a significant relationship of BMI and mortality for men. This was true with or without controlling for a large number of clinical covariates, including recent unintended weight loss. Weight loss between age 50 and baseline was associated with higher mortality. If those who lost weight since age 50 were excluded, there was no relationship between baseline BMI and mortality. BMI at age 50 was positively related to mortality.

In studies that did not control for any health or behavioral factors,[14] the relationship of weight to mortality has usually taken a J-shape that becomes flatter with age. Three population-based studies of older adults have used methods similar to ours. A study based on the National Health and

TABLE 3—5-Year Mortality in Nonsmoking Older Adults, by Baseline Body Mass Index (BMI) and Sex: The Cardiovascular Health Study, 1996

	Women				Men			
	n	5-y Mortality, %	Mortality Adjusted for Age, %	Mortality Adjusted for All Covariates,[a] %	*n*	5-y Mortality, %	Mortality Adjusted for Age, %	Mortality Adjusted for All Covariates,[a] %
All subjects								
BMI (kg/m²)								
≤20	131	16.8	13.9	14.9	...[b]	...	...	...
20–22	267	8.2	6.9	7.6	181	26.0	19.6	20.4
22–24	389	8.0	7.1	8.0	289	20.4	18.2	19.6
24–26	428	8.6	8.5	9.2	455	19.1	18.7	19.3
26–28	414	7.0	6.9	7.4	412	15.0	15.4	15.9
28–30	290	7.6	7.3	7.4	279	14.7	15.2	15.9
30–32	175	6.9	7.8	7.8	140	10.7	13.5	14.2
32–34	129	9.3	10.1	8.5	151	17.9	20.7	18.2
>34	187	7.5	9.1	7.6	...[b]	...	...	...
Only subjects with stable or increased weight since age 50								
BMI (kg/m²)								
≤20	75	8.0	7.4	9.8	...[b]	...	...	...
20–22	223	5.8	5.5	6.8	102	16.7	12.9	15.9
22–24	352	7.4	7.1	8.6	236	16.1	14.5	17.4
24–26	399	8.0	8.1	9.0	415	17.1	17.2	18.5
26–28	387	6.2	6.3	7.1	392	14.3	14.8	15.5
28–30	282	7.1	6.8	7.1	263	13.7	14.6	15.5
30–32	169	6.5	7.4	7.6	136	11.0	13.8	14.9
32–34	127	9.5	10.2	9.0	146	17.1	19.8	17.4
>34	183	7.1	8.7	7.2	...[b]	...	...	...

[a]The covariates are listed in the Methods section.
[b]This category was combined with adjacent category to increase sample size.

Nutrition Examination Survey Epidemiological Follow-Up Study (NHEFS)[2] followed 3339 people aged 65 to 74 for up to 20 years and included as covariates smoking, cholesterol, blood pressure, history of diabetes, cardiovascular disease, bronchitis, alcohol intake, and education. A study based on the Framingham cohort[3] followed 1723 nonsmoking persons aged 65 at baseline for an average of 9.5 years. Covariates included cholesterol, blood pressure, and blood glucose. The third study was based on the Established Populations for Epidemiologic Studies of the Elderly (EPESE) data set,[4] which included 6387 persons aged 70 and older, using as covariates self-reported smoking, number of chronic diseases (diabetes, coronary heart disease, stroke, hip fracture, cancer, angina), previous hospitalizations or nursing home admissions, and measures of disability, function, and mental status. Follow-up was 3 to 6 years. Our study, the Cardiovascular Health Study (CHS), included 4317 nonsmoking persons aged 65 to 100, followed for 5 years, with many clinical covariates. All four are population-based studies of older adults, but the covariates and length of follow-up differ. All addressed issues of low BMI, high BMI, and change in BMI. The key findings are summarized below, with the studies referred to by the source of their data.

Low BMI

The studies defined low BMI differently, but all found significant excess mortality in the lowest BMI group, with and without control for covariates.

High BMI

In the highest BMI group, the Framingham study found significantly elevated mortality and NHEFS found marginally elevated risk, while EPESE and CHS found no significant risk. EPESE and CHS had shorter follow-ups than the other 2 studies, suggesting that studies with longer follow-up periods might yet find high BMI to be a risk factor. (This was the case for younger subjects in a different analysis of the Framingham data.[14]) However, CHS and EPESE also had the largest number of subjects and the most extensive set of covariates and so might be expected to have less bias and more power than the other studies.

Change in Weight

The 3 earlier studies reported on different aspects of long-term weight loss. All studies found that weight loss was associated with higher mortality, as has been seen in many other studies.[15] The Framingham study, EPESE, and CHS all found little relationship between BMI and mortality when subjects with long-term weight loss were excluded. One study of women based on the NHEFS data, however, found that among women without recent weight loss BMI was associated with higher mortality.[16] In the Framingham study, people who had a high BMI at both age 55 and age 65 had the highest mortality. In contrast, CHS found that those with a high BMI at both times had better survival than those with a high BMI at age 50 and a lower BMI at baseline. Both EPESE and CHS found that BMI at age 50 was positively associated with mortality. Our findings agree substantially with those in the literature.

Optimal Weight and Overweight

Recent studies have defined overweight for all ages as a BMI of 27.8 or more for men and 27.3 or more for women.[17] Andres et al., however, suggested that a BMI of 24 to 30 is the desirable range for people aged 60 to 69.[18] Our data show no excess risk for a BMI above 27 and would seem to support using higher desirable weights for older adults, if decreasing mortality is the only goal. However, it may be preferable to base desirable weights on other outcomes, such as disability or risk of disease.

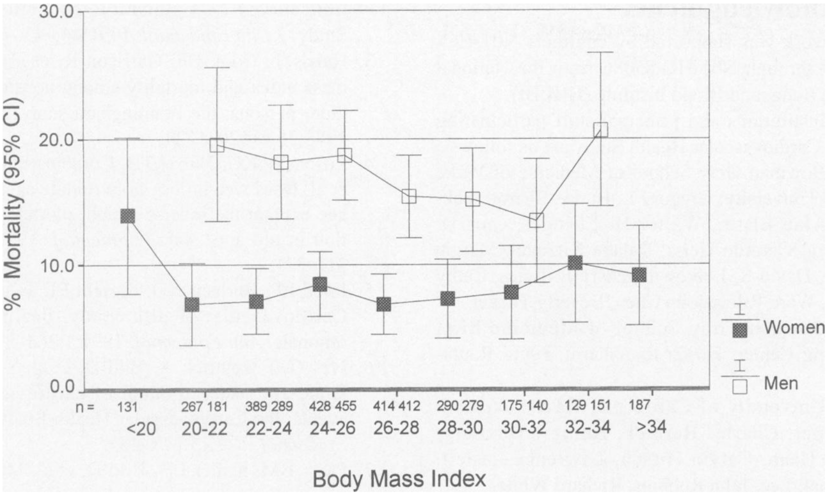

FIGURE 1—5-year mortality, adjusted for age, by body mass index and sex: The Cardiovascular Health Study, 1996.

Discussion

Our findings support those of earlier studies: that for older adults there is little relationship between BMI and mortality, except for those with a very low BMI, who have higher mortality than others.

The higher mortality found for people with the lowest BMI is often attributed to researchers' failure to control for smoking, weight loss, and preclinical disease.[19] In this study, however, low BMI was associated with mortality even after control for a wide variety of measures of baseline illness, including short-term unintended weight loss. High BMI showed no associations with mortality, despite the relationship of cardiovascular disease and other factors to both past and current weight.[20] The relatively low mortality found for older adults with a high BMI is sometimes attributed to researchers' controlling for covariates in the causal pathway.[19] Since the covariates had little effect on the findings, however, this does not seem to be an issue here.

TABLE 4—Age-Adjusted Mortality in Nonsmoking Older Adults, by Body Mass Index (BMI) at Baseline and at Age 50: The Cardiovascular Health Study, 1996

	BMI (kg/m^2) Category at Age 50							
	Low (≤24.12)		Medium[a] (24.12–27.96)		High[b] (>27.96)			
	Mortality		Mortality		Mortality		Total	
	No.	%	No.	%	No.	%	No.	%
Women								
Baseline BMI								
Low	653	7.8	111	6.7	23	25.4	787	8.1
Medium	347	7.3	362	7.0	70	16.7	779	8.0
High	77	8.8	357	6.8	321	10.2	755	8.4
Total	1077	7.7	830	6.9	414	12.1	2321	8.2
Men								
Baseline BMI								
Low	427	13.7	158	29.4	37	36.9	622	19.0
Medium	193	14.1	312	14.2	113	27.6	618	16.6
High	58	20.9	204	12.2	348	17.0	610	15.8
Total	678	14.4	674	17.1	498	20.9	1850	17.1

[a]Baseline BMI is significantly ($P \leq .05$) associated with age-adjusted mortality for men.
[b]Baseline BMI is significantly ($P \leq .05$) associated with age-adjusted mortality for both women and men.

Unlike other covariates, long-term weight loss had a profound effect on the results. Ironically, the covariate that mattered most could be considered the least reliable, since weight at age 50 was recalled 15 to 50 years after the fact. Others have found that remembered weight is highly correlated with measured weight, but that there is some regression toward the mean.[21,22] The role of long-term weight loss is not well understood. It may be a marker of important conditions for which we do not have appropriate clinical indicators. Alternatively, weight loss could have a direct causal effect on mortality. There is little evidence on this issue, because few large data sets can separate unintended from intended weight loss.[15]

The relationship between BMI and mortality for older adults is different from the relationship found in younger populations. For example, Manson et al.[1] recently found no excess risk for nonsmoking middle-aged women with a low BMI but significantly higher mortality for those with BMI above 27. There are several possible explanations for these differences. The first is a type of selection effect; middle-aged individuals whose health is sensitive to their weight, perhaps because of genetic or environmental factors, are less likely to survive into old age. This would result in less susceptibility among older people (survivors) to the health problems of high or low weight. The shortage in the Cardiovascular Health Study population of individuals with very high or very low BMI at age 50, compared with national data on all individuals alive at age 50, supports this explanation.

It is also possible that, in old age, the protective aspects of obesity may outweigh the negative effects. Obesity provides a nutritional reserve to the individual in times of stress, such as illness or trauma, and individuals with a higher BMI are more likely to survive acute illness.[23–25] Obesity is also a protector against acute injury from traumatic events such as falls. There are lower rates of osteoporosis in heavier individuals, probably as a result of fatty tissue synthesis of estrogens and greater weight-bearing-related bone formation.[26,27] If risks and benefits of obesity average out within individuals, there is no reason to counsel heavy older adults about their weight. It is likely, however, that weight loss would be beneficial for some persons (e.g., heavy older persons with hypertension or diabetes) and not for others. Identification of factors that confer increased or decreased risk among persons who lose weight would enable weight counseling approaches to be tailored to the individual.

Another reason for differences between older and younger adults is that the nature of the disease and treatment processes that affect the middle-aged and older populations changes. The excess of chronic disease in the higher weight categories tends to decrease as lighter weight people eventually contract these diseases.[14] The total disease burden increases as the population ages, which leads to different interactions with the health care system, an increase in hospitalizations, and changes in patterns of medication use and lifestyle. The health hazards of being overweight in later life may be masked by other health risks associated with aging.[14]

There are limitations to the research reported here. The Cardiovascular Health Study contains an excellent set of clinical control variables, but important factors may have been omitted. The number of subjects and deaths is reasonably large, but it did not permit us to perform detailed subgroup analyses. Analyses based on longer follow-up may provide different results. The study protocol excluded some of the sickest people, and we found fewer of the very thinnest men than would be expected from national statistics, suggesting that the results may not apply to the sickest or thinnest older adults. The relationship of BMI to morbidity, as opposed to mortality, also requires further study.

The interesting finding that weight at age 50 is more predictive of mortality than weight at baseline suffers from the fact that the Cardiovascular Health Study population is not a representative sample of all Americans alive at age 50, since it includes only people who survived to old age. Table 3 does not necessarily provide evidence in favor of having a low BMI at age 50. In addition, since we cannot separate out unintended long-term weight loss from intended long-term weight loss, the findings should not necessarily be taken to recommend against weight loss after age 50.

Despite the limitations of this research, we conclude that low BMI is a risk factor for 5-year mortality in older adults. However, for those who have not lost substantial weight since age 50, weight does not seem to be an important concern, perhaps because the benefits and detriments of higher weight balance out. Our findings suggest that obesity in older adults may not be a significant clinical target for reducing mortality, and that a preferred public health emphasis for this age group would be to increase awareness that substantial weight loss after age 50 and unintended weight loss are potential indicators for poor prognosis. □

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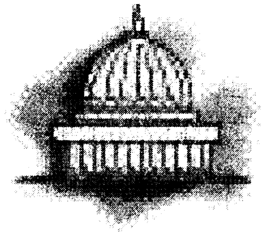
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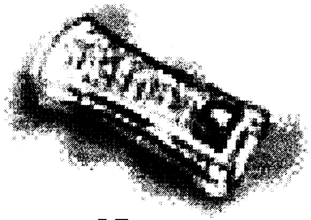
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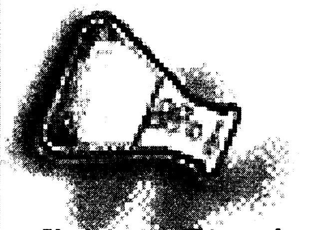
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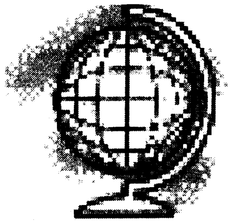
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