Thinness and Mortality

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Abstract: The relationship of thinness to mortality was examined in White adult members of the Kaiser Permanente Medical Care Program who had at least three multiphasic health checkups between 1964 and 1972, with mortality follow-up through 1980. A detailed comparison was performed of the mortality patterns of "thin" (decile 1 of Quetelet's index) and "average" weight (deciles 4 and 5) cohort members who were age 40–79 years and free of illness at the beginning of follow-up. Thin male (relative risk 1.6, 95 per cent confidence limits 1.0, 2.6) and female (R.R. 2.1, 95 per cent C.L. 1.1, 3.9) current cigarette smokers were at increased risk of mortality compared with average weight smokers. Unmeasured differences between thin and average weight smokers with respect to quantity of cigarettes smoked may have contributed to the apparent association of thinness with mortality in smokers. Thinness was not associated with increased mortality in never smokers and ex-smokers (R.R. 1.0 in men and women). As association of long-term weight loss with mortality was present in thin and average weight men and in thin women. (*Am J Public Health* 1987; 77:317–322.)

Introduction

The detrimental effects of obesity on health have been well documented.[1] In recent years, major studies have raised questions about whether relative thinness, as measured by body mass index (Quetelet's index) or relative weight (e.g., Metropolitan Relative Weight), is associated with adverse health effects.[2–5] Specifically, these studies have demonstrated increased mortality rates in the thin relative to people of average weight.

We studied the relation of body build to mortality in White adult members of the Kaiser Permanente Medical Care Program to examine the relation of thinness to mortality.

Methods

Study subjects were the 34,481 White adult members of the Kaiser Permanente Medical Care Program who underwent at least three multiphasic health checkups in either the Oakland or San Francisco facilities between 1964 and 1972. We specified a requirement of three multiphasic examinations so that we could examine changes in weight, and the study was limited to Whites because of small numbers in other racial groups. Subjects were between the ages of 20 and 79 at the time of third multiphasic health checkup, which served as the starting point for mortality follow-up. The average time interval between the initial and third examination was 44 months.

The men and women were separately classified by sex-specific decile of Quetelet's index at the second follow-up examination. Weight and height measurements were taken with the subject partially clothed, pockets empty, and shoes off. For detailed analysis, decile 1, containing the thinnest persons, was chosen for comparison against combined deciles 4 and 5, containing persons of more modal weight with substantially lower mortality. We shall refer to this latter group as being of average weight.

Mortality was ascertained through 1980 by computer-matching the members of the study cohort with the Health Plan membership roster as of 1981, and extracting a list of subjects who were no longer members. From the list we accepted as confirmed deaths those ascertained in a previously completed longitudinal study of smoking habits and mortality.[6] Mortality status of the remaining study subjects who were no longer members was ascertained by computer-matching with the California death file, using the CAMLIS computer matching program.[7] We checked our records of all decedents detected by the computer record to make sure that they were our study subjects.

Causes of death, as listed on the death certificate, were coded according to the International Classification of Diseases, Adapted (ICDA), Eighth Revision, by state vital statistics personnel. A random sample of 100 of the death certificates was reviewed by one of us (SS), and there was 97 per cent agreement between our coding and the state coding.

We ascertained whether an illness contributing to death was already present in decedents when they were weighed at the beginning of follow-up. One of us (SS) reviewed selected multiphasic examination data, blinded to weight status, to determine whether any condition mentioned on the death certificate had been present. If these data left any doubt, the medical chart was also reviewed.

Mortality rates were adjusted for age and sex by the direct method, with the entire study group used as the standard population. Person years of follow-up for each study subject were categorized by the age at the onset of follow-up and were not recategorized as age increased. Length of follow-up was similar in thin and average weight people. The multivariate analyses presented employed the proportional hazards model of Cox performed with the computer program of the Statistical Analysis System.[8] Taylor series estimates of the variance of the relative risk were used to compute confidence intervals.[9]

Results

General

Men and women in the lowest and highest deciles of body mass index (Quetelet's index) had higher age-adjusted mortality rates from all causes than men and women of intermediate body mass index (Figure 1). In all deciles, the mortality rates for men were higher than those for women. The weights associated with each decile are tabulated in the Appendix with the current Metropolitan Insurance Company weights included for comparison.

The total age-adjusted mortality rate was 65 per cent higher in thin women (decile 1) than in women of average weight (deciles 4 and 5), while thin men had a 45 per cent higher mortality rate than men of average weight. Because of the low mortality rate of the 20–39 year old age group, which contained about 20 per cent of the population and only about 2 per cent of the deaths, the remaining analyses were restricted to subjects age 40–79 years.

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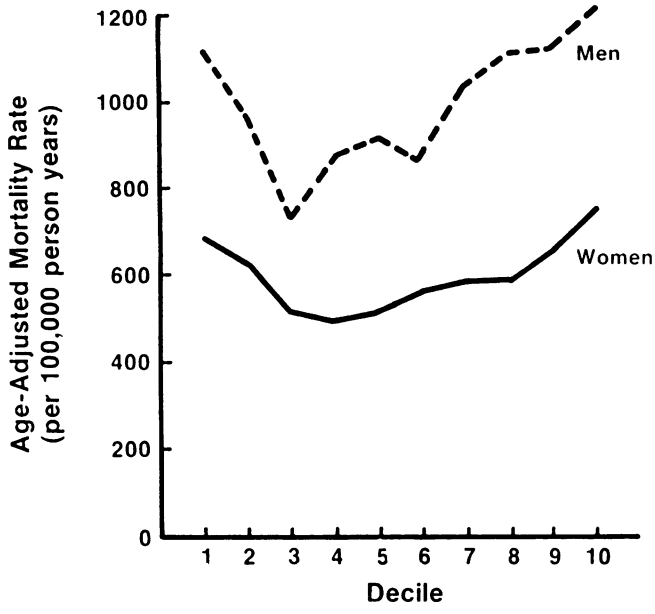

FIGURE 1—Age-adjusted Mortality Rate by Decile of Quetelet's Index in White Men and Women

Illness

In thin and average weight people who subsequently died, we defined illness to be the presence at the beginning of follow-up of a disease that appeared on the death certificate as an underlying or contributing cause of death. A higher proportion of the thin men and women than those of average weight who subsequently died were ill at the beginning of follow-up (40 versus 32 per cent for men; 29 vs 18 per cent for women). This relation was true for men and women in all age groups.

To reduce the effect of pre-existing illness on the mortality rates of thin and average weight people, we developed a measure of illness of the entire study cohort and performed our analyses only on "well" people, i.e., people who were not ill at the start of follow-up as defined by this measure. This measure of illness was based on computerized historical and laboratory data from the multiphasic health checkup. A person was classified as ill if any of the following items was present at that time: self-reported history of cancer, stroke, heart attack (including angina), diabetes, colon or bowel disease, frequent depression, recent involuntary 10 pound weight loss, or current limited or disabled work status; use of heart medicine; laboratory findings of urine protein or electrocardiographic evidence of myocardial infarction. The age-sex distribution of our resulting "well" population is shown in Table 1.

Mortality in Well Thin and Average Weight People (Table 2)

Well thin men and women in each age decile up through age 69 had higher total mortality rates than well men and women of average weight. Thin men between the ages of 70 to 79 had nearly the same mortality rate as men of average weight, while thin women in this age group had a somewhat lower mortality rate than women of average weight. The number of men and women in the 70–79 age group was relative small. The overall age-adjusted mortality rate for ages 40–79 was 49 per cent higher in thin women than in women of average weight, and 27 per cent higher in thin men than in men of average weight.

TABLE 1—Age Distribution of "Well" Thin and Average Weight Men and Women (mean length of follow-up in years)

	Age Groups				
Sex/Weight	40–49	50–59	60–69	70–79	Total
Males					
Thin	242	215	97	23	577
	(11.2)	(11.2)	(10.3)	(9.6)	(11.0)
Average	641	565	278	64	1,548
	(11.0)	(11.2)	(10.9)	(10.3)	(11.0)
Females					
Thin	276	202	98	17	593
	(11.3)	(11.5)	(10.8)	(11.0)	(11.3)
Average	697	606	339	79	1,721
	(11.4)	(11.3)	(11.2)	(10.2)	(11.3)

Most of the excess mortality in thin women was accounted for by cancer deaths (relative risk [RR] 2.1, 95 per cent confidence limits [CL] 1.3–3.5). Thin women also had higher rates of mortality from respiratory diseases; accidents, violence, and suicide; and other causes of death, although the numbers of deaths in each of these categories were small. Thin women had somewhat lower rates of mortality than women of average weight from coronary heart disease and other circulatory diseases.

Thin men had higher mortality rates than men of average weight from cancer; other circulatory diseases; respiratory disease; and accidents, violence, and suicide. Thin men had somewhat lower mortality rates than men of average weight from coronary heart disease and other causes of death.

Cigarette Smoking (Table 2)

There were substantially more current cigarette smokers among well thin men and women than among well men and women of average weight (34 vs 27 per cent for men; 37 vs 27 per cent for women). The mortality rates of thin and average weight never smokers and ex-smokers were very similar in men and women. The mortality rate of thin male current smokers was somewhat higher than that of average weight male current smokers (RR 1.3, 95 per cent CL 0.7–2.1) and the mortality rate of thin female current smokers was considerably higher than that of their average weight counterparts (RR 2.4, 95 per cent CL 1.2–4.6). Thus, cigarette smoking contributes importantly to the excess mortality of the thin, because of the higher prevalence of cigarette smoking in thin people than in those of average weight and because of the apparent interaction of thinness and cigarette smoking on mortality.

Long-term Weight Loss (Table 2)

The subject's weight at the beginning of follow-up was subtracted from the self-reported greatest adult weight to ascertain the weight loss from greatest adult weight. Greater weight loss was associated with higher mortality rates in both thin men and men of average weight. This finding also occurred in thin women but not in women of average weight; however, there was a serious potential source of bias in the data for women because we could not determine whether or not pregnancy weights were reported as maximum weights. Although mortality rates were similar for thin and average weight men for most of the weight loss range categories, thin men were more likely to have large long-term weight losses (38 per cent of thin men lost 7 kilograms or more vs 24 per cent of average weight men). Thin men and women who had lost relatively small amounts of weight from their greatest

TABLE 2—Mortality Rates (per 1,000 person years) and Relative Risks in "Well" Thin (Decile 1) and Average Weight (Deciles 4 and 5) White Men and Women, Ages 40–79, by Various Characteristics

Subgroup	Men			Women		
	Thin (#deaths)	Average Weight (#deaths)	Relative Risk Thin vs Average (95% CL)	Thin (#deaths)	Average weight (#deaths)	Relative Risk Thin vs Average (95% CL)
Age (years)						
40–49	2.6(7)	2.0(14)	1.3(0.5,3.2)	2.2(7)	1.6(13)	1.4(0.5,3.2)
50–59	8.3(20)	6.7(42)	1.3(0.7,2.1)	6.5(15)	3.1(21)	2.1(1.1,4.1)
60–69	21.0(21)	14.9(45)	1.4(0.8,2.6)	17.0(18)	9.0(34)	1.9(1.1,3.4)
70–79	31.8(7)	30.4(20)	1.0(0.5,2.4)	21.4(4)	29.9(24)	0.7(0.3,2.0)
40–79	10.3(55)	8.1(121)	1.3(0.9,1.8)	8.1(44)	5.4(92)	1.5(1.0,2.2)
Cause of Death						
Cancer	3.6(20)	2.3(36)	1.6(0.9,2.7)	4.5(26)	2.1(38)	2.1(1.3,3.5)
Coronary heart disease	2.8(16)	3.5(52)	0.8(0.5,1.4)	1.4(6)	1.6(26)	0.8(0.5,3.0)
Other circulatory disease	1.5(6)	0.8(12)	1.8(0.7,4.8)	0.7(4)	1.0(16)	0.7(0.2,2.1)
Accidents, violence, suicide	0.9(6)	0.6(9)	1.6(0.6,4.6)	0.9(5)	0.3(6)	2.8(0.8,9.4)
Respiratory disease	0.9(5)	0.1(1)	13.2(1.5,112.7)	0.3(1)	0.1(1)	5.8(0.4,92.4)
Other	0.5(2)	0.8(11)	0.6(0.1,2.9)	0.4(2)	0.3(5)	1.2(0.2,6.3)
Smoking Status						
Never	5.5(5)	6.3(31)	0.9(0.3,2.3)	5.1(13)	4.9(45)	1.0(0.6,1.9)
Ex-smoker	8.5(14)	7.7(34)	1.1(0.7,1.9)	5.9(3)	6.3(11)	0.9(0.2,3.6)
Current:	15.4(27)	12.3(47)	1.3(0.7,2.1)	15.2(23)	6.4(29)	2.4(1.2,4.6)
<1 pack	19.1(10)	8.8(12)	2.2(0.9,5.1)	16.4(8)	5.9(12)	2.8(0.8,9.9)
1–2 packs	12.6(14)	15.6(25)	0.8(0.4,1.7)	14.9(13)	7.2(13)	2.1(0.9,4.9)
>2 packs	7.1(3)	11.8(10)	0.6(0.2,2.2)	30.0(2)	10.7(4)	2.8(0.4,17.8)
Weight Loss from Most Weighted (kg)						
0–1.9	5.5(5)	6.5(25)	0.8(0.3,2.7)	2.9(3)	4.4(19)	0.7(0.2,2.4)
2–6.9	9.5(19)	6.9(47)	1.4(0.8,2.4)	7.0(13)	6.2(41)	1.1(0.6,2.2)
7–11.9	10.8(16)	11.8(27)	0.9(0.5,1.7)	9.6(18)	5.3(20)	1.8(1.0,3.4)
≥12	12.5(11)	13.6(17)	0.9(0.4,2.0)	9.8(9)	4.1(6)	2.4(0.8,6.7)
Weight Change from Initial Multiphasic Health Checkup (kg)						
≥2 loss	9.6(8)	7.3(28)	1.3(0.7,2.5)	7.9(8)	5.0(23)	1.6(0.8,3.3)
1.9-loss– 1.9 gain	10.6(31)	8.7(68)	1.2(0.8,1.9)	7.4(22)	5.2(53)	1.4(0.9,2.4)
≥2 gain	10.1(16)	7.5(25)	1.4(0.6,3.0)	11.7(14)	5.2(16)	2.3(0.9,5.6)
Interval from Third Multiphasic Health Checkup (years)						
<2	7.3(7)	1.8(5)	4.1(1.7,9.9)	2.1(2)	1.6(5)	1.3(0.2,6.6)
2–4.9	9.8(14)	4.5(19)	2.2(1.1,4.4)	3.3(5)	4.4(20)	0.7(0.3,2.0)
5–9.9	11.7(26)	11.1(65)	1.1(0.7,1.7)	12.4(27)	6.5(45)	1.9(1.2,3.1)
≥10	11.7(8)	14.4(32)	0.8(0.4,1.8)	11.6(10)	8.8(22)	1.3(0.6,2.8)

N = ———.

weights (less than 2 kilograms for men and less than 7 kilograms for women) had mortality rates similar to those of men and women of average weight who experienced weight losses of a small magnitude. This finding, and the finding of a low mortality rate in the small group of people whose self-reported greatest weight was in decile 1, that is, people who had always been thin, suggested that those people with a lifelong history of thinness had low mortality.

Objective Weight Change (Table 2)

We also obtained an objective measure of weight change by calculating the difference between the weights at the initial and third multiphasic examination (average three and two-thirds years apart). Thin men and women had higher mortality rates than men and women of average weight over all ranges of weight change: there was no suggestion of a deleterious effect of weight loss during this interval on mortality.

Follow-up Time (Table 2)

The mortality rates were disproportionately high in thin men compared with men of average weight during the first five years of follow-up, but were not disproportionate in subsequent years. In women, the mortality rates in thin and average weight women during the first five years of follow-up were low and not disproportionate, with excess risk of mortality in thin women occurring in later years. Thus, the increased mortality rate associated with thinness in men was the result of excessive mortality during the early follow-up period.

Multivariate Analysis

Because our findings suggested that thinness was associated with an increased risk of mortality only in current cigarette smokers, we performed separate multivariate analyses of current smokers using the Cox proportional hazards model, and of non-smokers and ex-smokers grouped together. Variables were included that we felt were potential confounders of the relation of thinness to mortality. Table 3 shows the results of the multivariate analysis for current smokers, with the quantity of cigarettes entered as a continuous variable using the three quantities available in our data base (less than one pack per day, one to two packs per day,

TABLE 3—Multivariate Analysis of Total Mortality Risk in "Well" Current Cigarette Smokers, Ages 40–79

Variable	Cox Proportional Hazards Model	
	Relative risk (95% CL)	
	Male	Female
Thinness (decile 1 vs. 4–5)	1.6(1.0,2.6)	2.1(1.1,3.9)
Age (per decade)	2.0(1.4,2.7)	2.7(1.8,4.0)
Smoking (per quantity unit)	1.3(0.9,1.9)	1.4(0.9,2.4)
Alcohol		
Nondrinkers vs 1–2 drinks/day	2.4(1.2,4.6)	1.1(0.5,2.5)
≥3 drinks/day vs 1–2 drinks/day	1.3(0.7,2.2)	0.7(0.2,1.9)
Education		
Elementary school vs > high school	0.7(0.3,1.5)	1.5(0.4,5.9)
Post high school vs. > high school	0.7(0.4,1.2)	2.4(0.9,6.1)
Blood Pressure		
High vs normal	2.1(1.0,4.6)	2.5(1.0,5.9)
Borderline vs normal	1.3(0.8,2.3)	1.4(0.6,2.9)

N = 578 males, 70 deaths; 613 females, 43 deaths.

TABLE 4—Mortality Rates (per 1,000 person years) and Relative Risks in "Well" Thin (Decile 1) and Average Weight (Deciles 4 and 5) Current Cigarette Smokers, Ages 40–79 by Cause of Death

Cause of death	Men			Women		
	Thin	Average Weight	RR	Thin	Average Weight	RR
Cancer	6.6(11)	2.9(14)	2.3	5.1(11)	3.1(15)	1.7
Coronary Heart Disease	4.2(8)	6.3(21)	0.7	3.3(3)	1.6(5)	2.1
Other circulatory	0 (0)	1.5(5)	0	0.7(2)	0.6(3)	1.3
Respiratory	2.5(4)	0	—	2.6(1)	0(0)	—
Accidents, violence, suicide	2.1(4)	1.1(4)	1.9	2.3(4)	0.7(4)	3.3
Other	0 (0)	0.6(3)	0	1.2(2)	0.4(2)	2.7

*All of the 95% confidence limits for these relative risks include 1.

and two or more packs per day). The RR of thinness for mortality relative to average weight was 1.6 (1.0, 2.6) in men, and 2.1 (1.1, 3.9) in women. The RR of thinness for mortality in non-smokers and ex-smokers was 1.0 in both men and women (95 per cent CL 0.6, 1.7 for men, 0.6, 1.9 for women) in a multivariate model which included the same variables except for cigarette quantity.

Mortality in Thin and Average Weight Current Smokers (Table 4).

Because of the findings of higher total mortality rates in well thin male and female cigarette smokers compared with smokers of average weight, we examined the mortality patterns of thin and average weight smokers by cause of death. The higher mortality rate of thin female smokers was distributed over all cause of death categories. The excess mortality in thin male smokers was distributed in the categories of cancer, respiratory disease, and deaths from accidents, violence and suicide. Thin male smokers had a somewhat lower mortality rate from cardiovascular disease than average weight smokers.

We examined cancer mortality further since the excess cancer mortality rate in thin male smokers relative to average weight male smokers more than accounted for the excess total mortality rate of the thin male smokers, and since cancer mortality accounted for half the deaths of thin and average weight female smokers. Cancers of the trachea, bronchus, and lung (ICDA code 162) accounted for 14 (56 per cent) of the cancer deaths in men, and 10 (38 per cent) of the cancer deaths in women. The RR of death from cancer of these sites was 2.5 in thin male smokers and 3.5 in thin female smokers relative to smokers of average weight. There were an inadequate number of deaths at other sites to make any meaningful comparisons.

Discussion

The findings from this study suggest that there is an interaction between thinness and cigarette smoking resulting in a higher mortality rate in thin current cigarette smokers compared with their average weight counterparts. There is no evidence of an increased risk of mortality in thin non-smokers or ex-smokers.

In men, the excess risk of mortality of thin smokers was distributed predominantly over cancer and respiratory disease, with a tendency toward a protective effect of thinness on cardiovascular disease mortality. The disproportionately high mortality rate of thin men compared to men of average weight during the early years of follow-up suggests that some significant illnesses may have been present in thin men at the beginning of follow-up that were not ascertained by the illness measure. If so, illness may have confounded the relation of thinness to mortality.

In women, the excess risk of mortality of thin smokers was distributed over all the categories of cause of death we examined. In contrast to males, the mortality rate of thin women during the early years of follow-up was low.

We observed higher cancer mortality rates in thin male and female ex-smokers compared with their average weight counterparts. Among never smokers, there were no cancer deaths in thin men, but an increase in cancer mortality was present in thin women compared to average weight women among the relatively small number of cases. This latter finding contrasts with the finding of lower cancer mortality in thin non-smoking women in the much larger American Cancer Society study.[3]

An important potential source of bias in this study was the broad categories for quantity of cigarette smoking in our questionnaire. Based on a validation study of the response to questions about smoking status on the multiphasic questionnaire administered during the time period of the study, it is unlikely that study subjects were misclassified as never, ex-, or current smokers to any important extent.[10] However, it is possible that the categories of current smoking quantity (less than one pack per day, one to two packs per day, or two or more packs per day) were too broad. For example, if the mean number of cigarettes smoked by a thin smoker in the "less than one pack per day" category was 15 cigarettes per day while the mean number smoked by an average weight smoker was 10 cigarettes per day, then it would be reasonable to conclude that the higher mortality rate of thin "light" smokers was partially due to the fact that they smoked more. Such misclassification might explain at least part of the apparent increased risk of lung cancer in thin vs average weight smokers, since a dose response relationship of lung cancer to cigarette smoking is well established.

If the finding of an interactional effect between thinness and cigarette smoking on mortality is a real one, the following hypotheses could explain how it works:

- Thin smokers are at higher risk for the development of serious disease than smokers of average weight.
- Thin smokers have a lower survival rate from serious disease than smokers of average weight.

These hypotheses imply that cigarette smoking has a different biological effect on thin individuals than individuals of average weight. It has been shown that smoking increases energy expenditure, and that the degree of increased energy expenditure varies from one individual to another.[11] It would be reasonable to presume that thin smokers tend to be individuals who have relatively high degrees of increased energy expenditure from cigarette smoking. It may be that these metabolic changes are accompanied by other physiological changes that might result in increased susceptibility to disease, or decreased ability to survive serious disease.

Although the requirement of three health screening examinations distinguishes our study population from the general population, we have no reason to believe that this criterion for selection would affect the relationship of thinness to mortality. Table 4 shows that the mean Quetelet's index of the men in our Kaiser Permanente study was similar to the mean Quetelet's index of the Framingham Study men, and somewhat higher than the values for the Build Study and American Cancer Society study cohorts.[12] The Honolulu Heart Study cohort had considerably lower values of the mean Quetelet's index. The mean Quetelet's index of Kaiser Permanente women was lower than the value for Framingham women, and higher than the values for the Build Study and American Cancer Society cohorts.[11]

In our study, the upper limit of Quetelet's index in decile 1 (the "thin" group) was 14 per cent below the mean Quetelet's index in men, and 18 per cent below it in women. In the Build Study, increased mortality was seen in men and women who were 15 per cent or more below average weight while the American Cancer Society study revealed increased mortality in men and women who were 20 per cent or more below average body mass index.[2,3] The Framingham Study reported substantially higher mortality rates in smokers below the desirable Metropolitan weight compared with those of average or slightly above average the desirable Metropolitan weight.[4] No report was given of the mortality rate of below average weight nonsmokers in Framingham because of the small number of people in this group. The threshold level of "thinness" at which increased mortality was observed relative to a more average body mass index was therefore similar in the Kaiser Permanente study to that in other studies.

Cigarette smoking almost completely confounded the relation between thinness and mortality in the Framingham Study. More than 80 per cent of the less than average weight members of the Framingham cohort were cigarette smokers. In contrast, approximately 40 per cent of the thin men and women in our study were current cigarette smokers. Twenty-eight per cent of the thin men and 37 per cent of the thin women had never smoked. Because of the much lower prevalence of cigarette smoking in our cohort, we were able to control for its confounding effects. Thinness remained a risk factor for mortality in the Honolulu Heart Study when cigarette smoking was adjusted for in a multivariate analysis. In the American Cancer Society study, thin male and female never smokers (below 80 per cent of average weight index) had higher total mortality rates but lower cancer mortality rates than average weight never smokers. The potential confounding effects of smoking with weight were not evaluated in the Build Study. The observation that consumption of one to two alcoholic drinks per day was associated with more favorable mortality than nonconsumption of alcohol is consistent with findings of other studies.[13,14] There are other factors that may affect the relation between thinness and mortality, e.g., diet and physical activity, for which we did not have good data.

TABLE 5—Mean Quetelet's Index for Men and Women in Kaiser Permanente and Other Study Populations*

Age (years)	Study	Quetelet's Index (kg/m², S.D. in parentheses when available) Men	Women
20–29	Kaiser Permanente	25.2 (3.4)	22.7 (4.0)
30–39	Kaiser Permanente	25.6 (3.1)	23.6 (4.1)
	Build Study	25.0	22.7
	American Cancer Society	24.6	22.6
	Framingham	25.8 (3.7)	24.2 (4.3)
40–49	Kaiser Permanente	26.1 (3.2)	24.6 (4.4)
	Build Study	25.4	23.6
	American Cancer Society	24.9	23.5
	Framingham	26.1 (3.5)	25.7 (4.6)
	Honolulu Heart Study**	24.3	—
50–59	Kaiser Permanente	26.3 (3.2)	25.2 (4.4)
	Build Study	25.5	24.3
	American Cancer Society	24.9	24.4
	Framingham	26.3 (3.5)	27.5 (5.0)
	Honolulu Heart Study	23.9	—
60–69	Kaiser Permanente	26.1 (3.0)	25.2 (3.9)
	Honolulu Heart Study	23.3	—
70–79	Kaiser Permanente	25.8 (3.1)	24.7 (3.6)

*Table 5 adapted from Simopoulos.[12]

**The Honolulu Heart Study figures reported cover the ages 45–49. The Build Study, American Cancer Society Study, and Framingham Study population figures reported cover the ages 50–62.

Ill people were excluded from analysis by various criteria in all of these studies except the Honolulu Heart Study. As in our study, higher mortality rates were found in the Honolulu Heart Study in thin men who had lost substantial amounts of weight during their adult years. This finding in the Honolulu Heart Study was interpreted as suggesting that the excess mortality in thin middle-aged individuals was predominantly due to antecedent disease leading to weight loss. Since individuals with a wide variety of medical problems were eliminated from our study cohort, the findings of a gradient of increasing mortality rates with increasing long-term weight loss in thin and average weight men and in thin women suggest an alternative hypothesis. It may be that substantial weight loss over an extended period of time during adult life leads to increased susceptibility to serious illness over a wide range of weights, although a favorable effect on the mortality rates of overweight people who lose weight has been documented.

Our findings of an association between weight loss and mortality raise the question of whether the weight loss and its associated higher mortality in our study population was involuntary or due to dieting. Unfortunately, we do not have data on the reason for weight loss in these subjects. We recently conducted an informal survey of 267 persons taking multiphasic health checkups who indicated that they had lost 10 pounds or more in the previous six months. Seventy-one per cent said that they had been trying to lose weight. If this high percentage were also true of the subjects in our follow-up study, questions would have to be raised about the long-term safety of dieting. We cannot be sure, however, that the current high prevalence of dieting would have held true about 15 or 20 years ago.

In summary, thinness was associated with increased mortality in male and female cigarette smokers in this study, although our limited ability to control for quantity of cigarette smoking may have contributed to this association. An increased risk of mortality among thin persons was not present in never smokers or ex-smokers.

We conclude that being thin may cause an increased risk of mortality in cigarette smokers and that substantial weight loss may affect mortality adversely. Further study of the effects of weight change during adult life on health may help to clarify this issue.

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APPENDIX
Weight-Height Chart for Kaiser-Permanente Thinness Study Cohort

	Weight Ranges (lbs) Associated with Deciles of Quetelet's Index										1983 Metropolitan Height and Weight Tables*		
Height	Decile 1	Decile 2	Decile 3	Decile 4	Decile 5	Decile 6	Decile 7	Decile 8	Decile 9	Decile 10	Small Frame	Medium Frame	Large Frame
						MALES							
5'2"	<122	123–128	129–133	134–137	138–140	141–144	145–148	149–151	152–162	>162	128–134	131–141	138–150
5'4"	<130	131–137	138–141	142–145	146–149	150–153	154–158	159–161	162–172	>172	132–138	135–145	142–156
5'6"	<138	139–145	146–150	151–155	156–159	160–163	164–168	169–171	172–183	>183	136–142	139–151	146–164
5'8"	<147	148–154	155–160	161–164	165–169	170–173	174–178	179–181	182–195	>195	140–148	145–157	152–172
5'10"	<156	157–163	164–169	170–174	175–179	180–183	184–189	190–192	193–206	>206	144–154	151–163	158–180
6'0"	<165	166–173	174–179	180–184	185–189	190–194	195–200	201–203	204–218	>218	149–160	157–170	164–188
6'2"	<174	175–183	184–189	190–194	195–200	201–205	206–211	212–215	216–230	>230	155–168	164–178	172–197
6'4"	<183	184–193	194–199	200–205	206–210	211–216	217–223	224–227	228–243	>243	162–176	171–187	181–207
						FEMALES							
4'10"	<96	97–101	102–105	106–109	110–112	113–116	117–121	122–128	129–139	>139	102–111	109–121	118–131
5'0"	<103	104–108	109–112	113–116	117–120	121–125	126–130	131–137	138–149	>149	104–115	113–126	122–137
5'2"	<110	111–116	117–120	121–124	125–128	129–133	134–139	140–146	147–159	>159	108–121	118–132	128–143
5'4"	<117	118–123	124–128	129–132	133–137	138–142	143–148	149–156	157–169	>169	114–127	128–138	134–151
5'6"	<125	126–131	132–136	137–141	142–146	147–151	152–157	158–165	166–180	>180	120–133	130–144	140–159
5'8"	<132	133–139	140–144	145–149	150–155	156–160	161–167	168–176	177–191	>191	126–139	136–150	146–167
5'10"	<140	141–147	148–153	154–158	159–164	165–170	171–177	178–186	187–202	>202	132–145	142–156	152–173
6'0"	<149	150–156	157–162	163–167	168–173	174–179	180–187	188–197	198–214	>214	138–151	148–162	158–179

*Weight ranges associated with lowest mortality.