Body Mass Index and Mortality in a Very Large Cohort: Is It Really Healthier to Be Overweight?

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ABSTRACT

Context: Controversy persists about optimal body weight. Many experts define "normal" (healthy) body mass index (BMI) as 18.5 to 24.9 kg/m^2, 25 to 29.9 kg/m^2 as overweight, and 30 kg/m^2 or greater as obese. Obesity is subdivided into 30 to 34.9 kg/m^2 (Grade 1), 35 to 39.9 kg/m^2 (Grade 2), and 40 kg/m^2 and above (Grade 3). Studies consistently show higher mortality for underweight and Grade 2 or 3 obesity, but results conflict for the overweight category and Grade 1 obesity.

Objective: To study 30-year risk of death related to baseline BMI.

Design: Retrospective cohort study in a multiracial population of 273,843 persons using logistic regression with 7 covariates (sex, age, race-ethnicity, education, marital status, smoking, alcohol intake).

Main Outcome Measures: Mortality risk by baseline BMI.

Results: With average follow-up exceeding 30 years, there were 103,218 deaths: 41,215 attributed to cardiovascular causes and 62,003 to noncardiovascular causes. Odds ratios (and 95% confidence intervals) for all deaths in BMI categories, with a BMI of 18.5 to 24.9 kg/m^2 as the referent, were BMI below 18.5 kg/m^2 = 1.1 (1.0-2.0), BMI 25 to 29 kg/m^2 = 1.1 (1.1-1.2), BMI 30 to 34 kg/m^2 = 1.5 (1.4-1.5), BMI 35 to 39 kg/m^2 = 2.1 (1.9-2.3), and BMI 40 kg/m^2 or higher = 2.7 (2.4-3.0). Disparities existed regarding age, race/ethnicity, cause of death, and interval to death.

Conclusion: Compared with persons with BMI defined as normal, persons who were underweight, overweight, and obese were at increased risk of death over 30 years.

INTRODUCTION

Despite substantial published literature, there is controversy about the optimal level of body weight and how to best study this important subject.[1-5] A relation of weight to health was first noted more than a century ago.[6] Interest was stimulated in the 1940s by life insurance company data[7] showing increased mortality among persons with body weight 20% or more above "desirable" weights, adjusted for height and body frame. Such persons were charged increased premiums. Desirable weights were defined as the then-current means for each sex at 25 years of age; 20% above these corresponded to a body mass index (BMI) of 27.8 kg/m^2 in men and 27.3 kg/m^2 in women. These values became the definition of obesity offered by a 1987 National Institutes of Health (NIH) consensus panel. In the late 1990s the World Health Organization (WHO)[8] and an NIH panel[9] recommended categorization of BMI as follows: 25 to 29.9 kg/m^2 as preobesity or overweight, and 30 kg/m^2 or greater as obese, with the latter subdivided into 30 to 34.9 kg/m^2 (Grade 1 obesity), 35 to 39.9 kg/m^2 (Grade 2 obesity) and 40 kg/m^2 or greater (Grade 3 obesity). Pleas for standardization of definitions arose.[10]

The WHO and NIH categories of BMI remain in widespread use and are familiar to clinicians and the public. Early cohort studies of risks associated with higher BMI often used below 25.0 kg/m^2 as the referent in categorical models. However, it became clear that overall BMI-related mortality risk is J-shaped, with very lean (underweight) persons also at increased risk.[4,5,11,12] The increased risk at low BMIs has been thought possibly related to reverse causality, that is, early illness in some of these persons,[13] but this is unproved. An early Kaiser Permanente analysis[11] suggested that increased risk of underweight persons might be concentrated in smokers. The J-shaped relationship has led some experts to feel that "normal" (healthy) BMI should be defined as 18.5 to 24.9 kg/m^2 and that this should be the standard referent in analytic models.

Studies have consistently shown higher mortality for obese persons, but data are conflicting regarding the overweight category.[1-5] A 2013 report[4] showed lower mortality for overweight and Grade 1 obese persons, which received widespread attention in the lay press. Some press reports offered a sarcastic view of medical admonitions about the dangers of being overweight or obese.[14,15] Some of the disparity between reports may be due to study population differences in age, race, fitness, and sex as well as disparities caused by differences in BMI categorization groups.[4]

Although BMI clearly is not an ideal measure of actual adiposity,[4,5] it has been a widely available and much-used marker. Results with its use correlate well with other markers of obesity, such as waist circumference and waist-to-hip ratio.[2] The increased risk for obese persons has been clearest for cardiovascular (CV) diseases,[1,4,16-18] but increased risks for other conditions have been reported, including liver disease,[19] kidney disease,[20] diabetes mellitus,[21] and some types of cancer.[22-24]

Arguably, the obesity epidemic may be leveling off,[25] but it remains a major public and individual health concern. Weight control is one of the most frequent issues that health practitioners need to consider

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when giving medical counsel to patients. Recently reported disparities plus the natural skepticism of many have created confusion among health care practitioners and patients about the optimal level of BMI. Several of our previous studies showed increased risk of mortality from various causes among overweight persons. Therefore, we hypothesized that more detailed study of BMI and total mortality would show this. We believe that the data presented here about mortality risk in a large comprehensive health plan, including stratification by sex and race/ethnicity, will be very helpful to both the public and practitioners.

METHODS

Subjects

The institutional review board of the Northern California Kaiser Permanente Medical Care Program approved the study protocols. We performed a retrospective cohort study of 273,843 free-living persons who provided detailed racial classification and underwent health examinations offered by the Kaiser Foundation Heath Plan of Northern California. Voluntarily taken as a health appraisal, the examination included health measurements, such as height and weight, and questionnaire queries about sociodemographic status, habits, and medical history.[26] Except for extremes of income, the examinees are thought to represent a cross-section of the population in the area. Detailed racial classification was available for 2 time intervals: 1964 to 1973 and 1978 to 1985. For persons with multiple examinations, baseline data from the first examination in either 1964 to 1973 or 1978 to 1985 were used for all subjects. Mean age at baseline examination was 37.3 years for women and 39.2 years for men.

Mortality Ascertainment

We followed subjects through December 2012 using an automated matching system[27] to ascertain death in California that did not require continued Health Plan membership. We accepted primary International Classification of Diseases, Ninth Revision (ICD-9) death certificate codes, converting from International Classification of Diseases, Eighth Revision codes when necessary. Presumption of complete follow-up yielded a calculated 8.21 million person-years of follow-up, but estimates[27] suggest a sensitivity of 89% for the method used. We studied total mortality (n = 103,218) in all persons and models stratified by sex, race/ethnicity, age, and smoking. We also studied 3 interval-to-death end points: deaths within 10 years (n = 12,750), deaths at 10 to 19 years (n = 23,873), and deaths after 20 years (n = 66,595). Finally, we studied deaths due to CV causes (ICD-9 codes

Table 1. Body mass index (BMI) category distributions of subjects by race/ethnicity

BMI category, kg/m²	Both sexes, no. (column %) [row %]	Men, no. (column %) [row %]	Women, no. (column %) [row %]
All persons	273,843 (100.0) [100.0]	123,361 (100.0) [45.1]	150,482 (100.0) [55.0]
< 18.5	8463 (3.1) [100.0]	1460 (1.2) [17.3]	7003 (4.7) [82.7]
18.5-24.9	148,624 (54.3) [100.0]	57,515 (46.6) [38.7]	91,109 (60.5) [61.3]
25-29.9	74,633 (27.3) [100.0]	45,980 (37.3) [61.6]	28,653 (19.0) [38.4]
30-34.9	17,323 (6.3) [100.0]	8445 (6.8) [48.8]	8878 (5.9) [51.2]
35-39.9	4,388 (1.6) [100.0]	1319 (1.1) [30.1]	3069 (2.0) [69.9]
≥ 40	1919 (0.7) [100.0]	372 (0.3) [19.4]	1547 (1.0) [80.6]
< 25	157,087 (57.4) [100.0]	58,975 (47.8) [37.5]	98,112 (65.2) [62.5]
≥ 30	23,630 (8.6) [100.0]	10,136 (8.2) [42.9]	13,494 (9.0) [57.1]
Whites	188,929 (100.0) [100.0]	87,378 (100.0) [46.2]	101,551 (100.0) [53.8]
< 18.5	5142 (2.7) [100.0]	849 (0.1) [16.5]	4293 (4.2) [83.5]
18.5-24.9	104,750 (55.4) [100.0]	40,224 (46.0) [38.4]	64,526 (63.5) [61.6]
25-29.9	51,729 (27.4) [100.0]	33,566 (38.4) [64.9]	18,163 (17.9) [35.1]
30-34.9	10,402 (5.5) [100.0]	5479 (6.3) [52.7]	4923 (4.8) [47.3]
35-39.9	2343 (1.2) [100.0]	812 (0.9) [34.7]	1531 (1.5) [65.3]
≥ 40	910 (0.5) [100.0]	223 (0.3) [24.5]	687 (0.7) [75.5]
< 25	109,892 (58.2) [100.0]	41,073 (47.0) [37.4]	68,819 (67.8) [62.6]
≥ 30	13,655 (7.2) [100.0]	6514 (7.5) [47.7]	7141 (7.0) [52.3]
Blacks	50,573 (100.0) [100.0]	20,462 (100.0) [40.5]	30,111 (100.0) [59.5]
< 18.5	1521 (3.0) [100.0]	248 (1.2) [16.3]	1273 (4.2) [83.7]
18.5-24.9	23,496 (46.5) [100.0]	8836 (43.2) [37.6]	14,660 (48.7) [62.4]
25-29.9	15,273 (30.2) [100.0]	7741 (37.8) [50.7]	7532 (25.0) [49.3]
30-34.9	5421 (10.7) [100.0]	2197 (10.7) [40.5]	3224 (10.7) [59.5]
35-39.9	1678 (3.3) [100.0]	388 (1.9) [23.1]	1290 (4.3) [76.9]
≥ 40	883 (1.8) [100.0]	121 (0.6) [13.7]	762 (2.5) [86.3]
< 25	25,017 (49.5) [100.0]	9084 (44.4) [36.3]	15,933 (52.9) [63.7]
≥ 30	7982 (15.8) [100.0]	2706 (13.2) [33.9]	5276 (17.5) [66.1]
Asians	20,685 (100.0) [100.0]	9462 (100.0) [45.7]	11,223 (100.0) [54.3]
< 18.5	1435 (6.9) [100.0]	310 (3.3) [21.6]	1125 (10.0) [78.4]
18.5-24.9	13,472 (65.1) [100.0]	5878 (62.1) [43.6]	7594 (67.7) [56.4]
25-29.9	3544 (17.1) [100.0]	2265 (23.9) [63.9]	1279 (11.4) [36.1]
30-34.9	395 (1.9) [100.0]	201 (2.1) [50.9]	194 (1.7) [49.1]
35-39.9	54 (0.3) [100.0]	22 (0.2) [40.7]	32 (0.3) [59.3]
≥ 40	16 (0.1) [100.0]	6 (0.1) [37.5]	10 (0.1) [62.5]
< 25	14,907 (72.1) [100.0]	6188 (65.4) [41.5]	8719 (77.7) [58.5]
≥ 30	465 (2.3) [100.0]	229 (2.4) [49.2]	236 (2.1) [50.8]
Others	13,656 (100.0) [100.0]	6059 (100.0) [44.4]	7597 (100.0) [55.6]
< 18.5	365 (2.7) [100.0]	53 (0.9) [14.5]	312 (4.1) [85.5]
18.5-24.9	6906 (50.6) [100.0]	2577 (42.5) [37.3]	4329 (57.0) [62.7]
25-29.9	4087 (29.9) [100.0]	2408 (39.7) [58.9]	1679 (22.1) [41.1]
30-34.9	1105 (8.1) [100.0]	568 (9.4) [51.4]	537 (7.1) [48.6]
35-39.9	313 (2.3) [100.0]	97 (1.6) [31.0]	216 (2.8) [69.0]
≥ 40	110 (0.8) [100.0]	22 (0.4) [20.0]	88 (1.2) [80.0]
< 25	7271 (53.2) [100.0]	2630 (43.4) [36.2]	4641 (61.1) [63.8]
≥ 30	1528 (11.2) [100.0]	687 (11.3) [45.0]	841 (11.1) [55.0]

390-459, n = 41,215), non-CV causes (all codes except 390-453, n = 62,003), and the largest specific CV and non-CV diagnoses: coronary disease (codes 410-414, n = 20,094), and cancer (codes 140-209, n = 28,013), respectively.

Analytic Methods

We used age-adjusted logistic regression with 7 covariates. They were as follows:

1. sex
2. race/ethnicity: a model comparing blacks, Asians (to indicate Asian Americans), and other races/ethnicities ("others") with whites as the referent, and another model comparing blacks, Chinese, Japanese, Filipinos, South Asians, other Asians, and other races/ethnicities with whites as the referent
3. education: no college (referent), some college, college graduate
4. marital status: now married (referent), never married, formerly married
5. cigarette smoking: never (referent), ex-smoker, less than 1 pack per day, 1 or more packs per day
6. alcohol drinking: none (referent), fewer than 3 drinks per day, 3 or more drinks per day
7. BMI: for all outcomes, 2 models of BMI categories
   a. BMI below 25 kg/m^2 was the referent, 25 to 29.9 kg/m^2 was overweight, and 30 kg/m^2 or higher was obese
   b. BMI 18.5 to 24.9 kg/m^2 was the referent, BMI below 18.5 kg/m^2 was underweight, 30 to 34.9 kg/m^2 was Grade 1 obesity, 35 to 39.9 kg/m^2 was Grade 2 obesity, and 40 kg/m^2 or greater was Grade 3 obesity.

All covariate data were obtained from computer-stored information collected at the baseline examination. Analyses were performed using SAS statistical software Version 9.3 (SAS Institute, Cary, NC).

In this article, we present results as odds ratios (ORs), 95% confidence intervals (CIs), and associated p values. The term *significant* is used to refer to estimates with a p value < 0.05. We realize that, with multiple comparisons, many would require a stricter definition. Thus, consistency in multiple strata will also be used as an indicator of validity of associations.

RESULTS

Demographics

We studied 273,843 subjects, of which 45.1% (rounded) were men and 55.0% were women. The racial composition was 69.0% white, 18.5% black, and 7.6% Asian. The remaining 4.9% were mixed race or other. The largest Asian group was Chinese (3.5% of the total); others were Japanese (1.1%), Filipino, (2.1%), South Asian (0.4%), and other Asian (0.5%).

Distributions of Body Mass Index Categories by Sex and Race

Mean BMI was higher in men (25.2 kg/m^2) than in women (23.9 kg/m^2), but women were about 10% more likely than men to be obese (BMI ≥ 30 kg/m^2), almost entirely because of an excess of obesity in black women (Table 1). Obesity was substantially less prevalent in Asians of both sexes. Among whites and Asians, men were twice as likely as women to be overweight (BMI = 25-29 kg/m^2), whereas black men were 50% more likely than black women to be overweight. Women were almost 4 times more likely than men to be underweight (BMI < 18.5 kg/m^2). The proportion of underweight persons was greatest in Asians, the only racial group with more underweight than obese persons.

The BMI category distributions for the specific Asian ethnic groups varied slightly (Table 2). Proportions of obese persons ranged from 1.5% of Chinese to 3.2% of Filipinos, and proportions of underweight persons ranged from 5.0% of Filipinos to 8.1% of Chinese. The mean BMIs were also lower among Asians (whites = 24.5 kg/m^2, blacks = 25.6 kg/m^2, and Asians = 22.6 kg/m^2). All Asian ethnic groups had lower mean BMIs than whites or blacks did, ranging from 22.3 kg/m^2 in Chinese to 23.3 kg/m^2 in Filipinos.

Mortality in All Persons

The J-curve association of BMI to total mortality is evident in Table 3 and Figure 1A. Compared with persons whose BMI ranged from 18.5 to 24.9 kg/m^2, underweight men were 32% more likely to die and underweight women were 9% more likely to die. Overweight men were 10% more likely to die and men with Grade 1 obesity were 45% more likely to die. Overweight women were 22% more likely to die, and women with Grade 1 obesity were 56% more likely to die. The footnote data in Table 3 show that the increased risk estimates for the overweight and Grade 1 obese groups were virtually identical in models with referents of less than 25 kg/m^2 and 18.5 to 24.9 kg/m^2. In both sexes there were progressively larger increases in mortality risk for persons with Grades 2 and 3 obesity. The associations were slightly stronger for men than for women at the extremes of underweight and marked obesity.

Racial-Ethnic Differences in Body Mass Index Mortality Risks

The increased risk of death was similar for overweight and obese whites and blacks (Figure 1B). For example, the ORs (95% CIs) for overweight and Grade 1 obese whites were 1.13 (1.09-1.16) and 1.47 (1.40-1.56), respectively. The corresponding ORs for blacks were 1.14 (1.08-1.21) and 1.46 (1.35-1.58), all with p < 0.001. However, overweight and obese Asians were at substantially higher risk (Figure 1B), with ORs of 1.43 (1.29-1.59) for overweight Asians and 2.51 (1.93-2.56) for Grade 1 obese Asians (both p < 0.001). Underweight Asians had no increased risk (OR = 0.95 [0.78-1.16]); underweight whites had an OR of 1.16 (1.06-1.27, p < 0.01), and underweight blacks had an OR of 1.09 (0.92-1.29).

There was no increased mortality risk among underweight persons in any Asian sex-ethnicity group (Chinese, Japanese, Filipino, South Asian), with nonsignificant ORs slightly below 1.0 for most groups (data not shown). Overweight persons in the specific Asian ethnic groups had the following ORs for total mortality: Chinese = 1.41 (1.21-1.65, p < 0.001), Japanese = 1.37 (1.05-1.80, p = 0.02), Filipinos = 1.71 (1.43-2.05, p < 0.001), South Asian = 1.19 (0.73-1.94, p = 0.5). Obese Asians of each ethnic group had substantially increased mortality risk, but with wide CIs in several subgroups because of small numbers.

Age Differences in Body Mass Index Mortality Risks

The increased mortality risk of overweight and obese persons lessened substantially with increasing baseline age

(Figure 1C). For baseline age categories of younger than 40, 40 to 49, 50 to 59, and 60 or more years, the ORs for overweight persons were, respectively, 1.34 (1.29-1.38), 1.22 (1.10-1.28), 1.07 (1.01-1.14), and 1.06 (0.96-1.15). The ORs for Grade 1 obese persons for the 4 age categories were 1.98 (1.86-2.11), 1.54 (1.43-1.67), 1.22 (1.11-1.35), and 1.17 (1.01-1.35).

Table 2. Body mass index (BMI) category distributions of subjects by Asian ethnicity

BMI category, kg/m²	Both sexes, no. (column %) [row %]	Men, no. (column %) [row %]	Women, no. (column %) [row %]
Chinese	9519 (100.0) [100.0]	4553 (100.0) [47.8]	4966 (100.0) [52.2]
< 18.5	768 (8.1) [100.0]	191 (4.2) [24.9]	577 (11.6) [75.1]
18.5-24.9	6433 (67.6) [100.0]	3011 (66.1) [46.8]	3422 (68.9) [53.2]
25-29.9	1299 (13.7) [100.0]	893 (19.6) [68.7]	406 (8.2) [31.3]
30-34.9	128 (1.3) [100.0]	72 (1.6) [56.3]	56 (1.1) [43.8]
35-39.9	11 (0.1) [100.0]	4 (0.1) [36.4]	7 (0.1) [63.6]
≥ 40	4 (0.0) [100.0]	3 (0.1) [75.0]	1 (0.0) [25.0]
< 25	7201 (75.7) [100.0]	3202 (70.3) [44.5]	3999 (80.5) [55.5]
≥ 30	143 (1.5) [100.0]	79 (1.7) [55.2]	64 (1.3) [44.8]
Japanese	2999 (100.0) [100.0]	1214 (100.0) [40.5]	1785 (100.0) [59.5]
< 18.5	197 (6.6) [100.0]	21 (1.7) [10.7]	176 (9.9) [89.3]
18.5-24.9	2029 (67.7) [100.0]	745 (61.4) [36.7]	1284 (71.9) [63.3]
25-29.9	501 (16.7) [100.0]	332 (27.4) [66.3]	169 (9.5) [33.7]
30-34.9	57 (1.9) [100.0]	32 (2.6) [56.1]	25 (1.4) [43.9]
35-39.9	11 (0.4) [100.0]	6 (0.5) [54.5]	5 (0.3) [45.5]
≥ 40	2 (0.1) [100.0]	—	2 (0.1) [100.0]
< 25	2226 (74.2) [100.0]	766 (63.1) [34.4]	1460 (81.8) [65.6]
≥ 30	70 (2.3) [100.0]	38 (3.1) [54.3]	32 (1.8) [45.7]
Filipinos	5808 (100.0) [100.0]	2469 (100.0) [42.5]	3339 (100.0) [57.5]
< 18.5	291 (5.0) [100.0]	48 (1.9) [16.5]	243 (7.3) [83.5]
18.5-24.9	3542 (61.0) [100.0]	1381 (55.9) [39.0]	2161 (64.7) [61.0]
25-29.9	1279 (22.0) [100.0]	735 (29.8) [57.5]	544 (16.3) [42.5]
30-34.9	153 (2.6) [100.0]	71 (2.9) [46.4]	82 (2.5) [53.6]
35-39.9	26 (0.5) [100.0]	9 (0.4) [34.6]	17 (0.5) [65.4]
≥ 40	5 (0.1) [100.0]	2 (0.1) [40.0]	3 (0.1) [60.0]
< 25	3833 (66.0) [100.0]	1429 (57.9) [37.3]	2404 (72.0) [62.7]
≥ 30	184 (3.2) [100.0]	82 (3.3) [44.6]	102 (3.1) [55.4]
South Asians	1117 (100.0) [100.0]	668 (100.0) [59.8]	449 (100.0) [40.2]
< 18.5	80 (7.2) [100.0]	32 (4.8) [40.0]	48 (10.7) [60.0]
18.5-24.9	685 (61.3) [100.0]	401 (60.0) [58.5]	284 (63.3) [41.5]
25-29.9	241 (21.6) [100.0]	169 (25.3) [70.1]	72 (16.0) [29.9]
30-34.9	26 (2.3) [100.0]	10 (1.5) [38.5]	16 (3.6) [61.5]
35-39.9	—	—	—
≥ 40	—	—	—
< 25	765 (68.5) [100.0]	433 (64.8) [56.6]	332 (73.9) [43.4]
≥ 30	26 (2.3) [100.0]	10 (1.5) [38.5]	16 (3.6) [61.5]
Other Asians	1242 (100.0) [100.0]	558 (100.0) [44.9]	684 (100.0) [55.1]
< 18.5	99 (8.0) [100.0]	18 (3.2) [18.2]	81 (11.8) [81.8]
18.5-24.9	783 (63.0) [100.0]	340 (60.9) [43.4]	443 (64.8) [56.6]
25-29.9	224 (18.0) [100.0]	136 (24.4) [60.7]	88 (12.8) [39.3]
30-34.9	31 (2.5) [100.0]	16 (2.9) [51.6]	15 (2.2) [48.4]
35-39.9	6 (0.5) [100.0]	3 (0.5) [50.0]	3 (0.4) [50.0]
≥ 40	5 (0.4) [100.0]	1 (0.2) [20.0]	4 (0.6) [80.0]
< 25	882 (71.0) [100.0]	358 (64.2) [40.6]	524 (76.6) [59.4]
≥ 30	42 (3.4) [100.0]	20 (3.6) [47.6]	22 (3.2) [52.4]

— = no cases.

Body Mass Index Mortality Risk in Smoking Strata

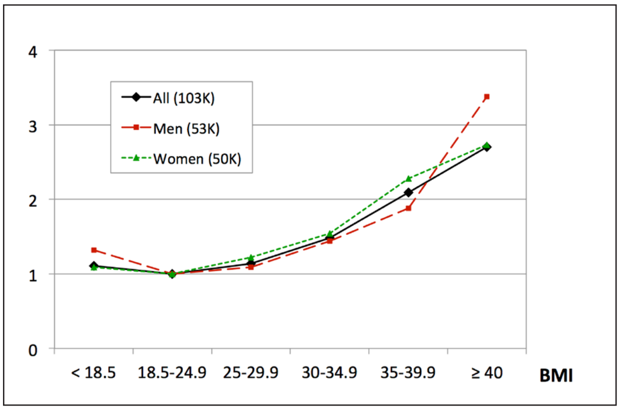
The increased mortality risk of overweight and obese persons was strongest in never smokers (Figure 1D). Increased risk in underweight persons was strongest in ex-smokers (Figure 1D), with OR = 1.31 (1.06-1.67, p = 0.02); this was present in both men (OR 1.66, p = 0.05) and women (OR 1.27, p = 0.07). For overweight persons the increased OR of death was significant in all smoking categories (data not shown).

Interval to Death Models

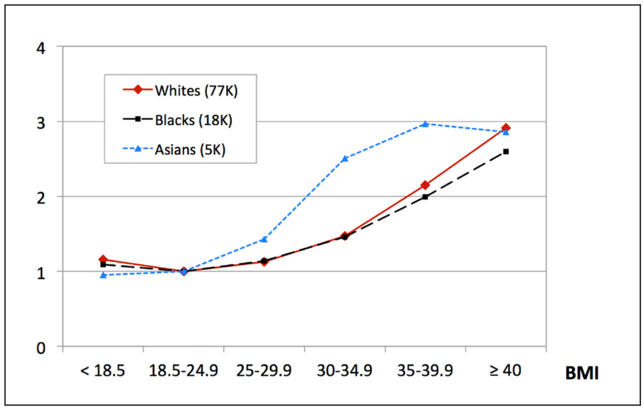
Data from separate models for 3 follow-up time intervals are presented in Figure 1E. Overweight persons had a slightly decreased risk of dying within 10 years of baseline (OR = 0.95 [0.91-0.99]; p = 0.01), but at 10 to 19 years their risk was slightly increased (OR = 1.05 [1.01-1.08], p = 0.009) and at 20 years or longer their increased risk was more substantial: OR = 1.18 (1.15-1.22, p < 0.001). The Grade 1 obese group had no reduced risk in any timeframe (Figure 1F). Underweight persons had substantially increased risk within 10 years (OR = 1.69 [1.48-1.93], p < 0.001) with some modulation at 10 to 19 years (OR = 1.29 [1.22-1.36], p < 0.001), and no increased risk at more than 20 years (OR = 1.00).

Deaths by Cardiovascular and Noncardiovascular Causes

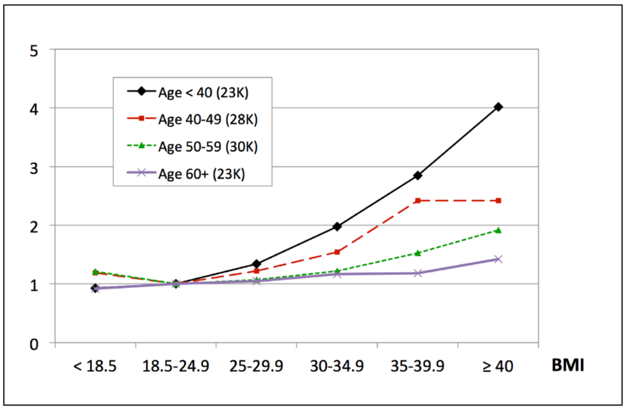
As shown in Figure 1F for non-CV deaths, the OR for overweight persons was 1.03 (1.01-1.06, p = 0.02) and for CV deaths it was 1.37 (1.33-1.42, p < 0.001). For Grade 1 obese persons, these ORs were 1.23 and 1.99, respectively (both p < 0.0001). The CV/non-CV disparity increased progressively with increasing obesity. For underweight persons, risk was increased for non-CV death (OR 1.18 [1.09-1.27], p < 0.001) but decreased for CV death (OR = 0.84 ([0.74-0.95], p = 0.01). Cancer deaths made up 45.2% of non-CV deaths, and coronary disease comprised 48.8% of CV deaths. For cancer deaths, the ORs for overweight and Grade 1 obese persons were 1.09 (1.05-1.13) and 1.15 (1.08-1.25), respectively (both p < 0.001). For coronary disease deaths, these ORs were 1.43 (1.37-1.50)



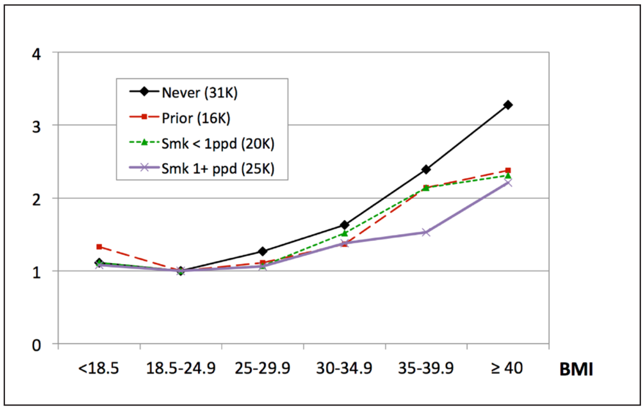
A. Total deaths OR for all persons, men, and women.
ORs for women (49,693 deaths) are on broken green line, for men (53,525 deaths) on broken red line, and for all persons (103,218 deaths) on solid black line.



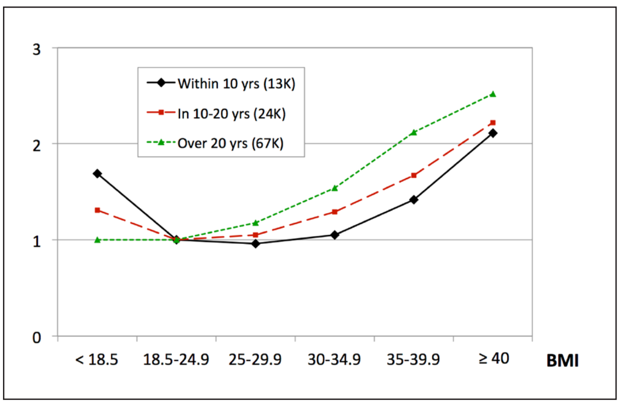
B. Total deaths OR by race/ethnicity.
ORs for whites (76,805 deaths) are on solid red line, for blacks (17,898 deaths) on broken black line, and for Asians (4995 deaths) on broken blue line.



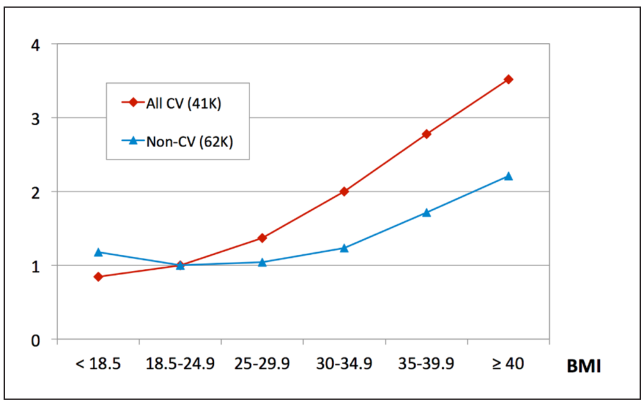
C. Total deaths OR by age groups.
ORs for persons aged below 40 years at baseline (22,530 deaths) are on solid black line, 40 to 49 years at baseline (27,902 deaths) on broken red line, 50 to 59 years at baseline (30,096 deaths) on broken green line, and 60 years or older at baseline (22,690 deaths) on solid lavender line.



D. Total deaths OR by smoking status.
ORs for never smokers (31,325 deaths) are on solid black line, for ex-smokers (16,037 deaths) on broken red line, for under 1 pack per day smokers (19,793 deaths) on broken green line, and for 1 or more packs per day smokers (24,888) on solid lavender line.



E. Total deaths OR by time to death groups.
ORs for 12,750 persons who died within 10 years are on solid black line, for 23,873 persons who died in 10 to 20 years on broken red line, and for 66,595 persons who died after 20 years on broken green line.



F. All CV and non-CV deaths by BMI.
ORs for persons who died of noncardiovascular (non-CV; 62,003) causes on solid blue line and for persons who died of CV (41,215) causes on solid red line.

Figure 1. Adjusted odds ratios (ORs) for deaths through 2012 according to body mass index (BMI, kg/m^2) ascertained from 1964 to 1985 (BMI referent = 18.5-24.9 kg/m^2). Number of deaths in rounded thousands (K) are in parentheses. Analysis was by logistic regression models with age, sex, race, education, smoking (Smk), and alcohol.
CV = cardiovascular

and 2.16 (1.98-2.28), both with p < 0.001. For underweight persons, the risks for cancer and coronary deaths were 1.12 (1.01-1.23, p = 0.03) and 0.62 (0.51-0.76, p < 0.001), respectively.

DISCUSSION

Total Mortality in Overweight and Obese Persons

Increased 30-year mortality was shown in overweight or Grade 1 obese persons across multiple strata in our study population; this consistency supports the validity of our findings. Although stratified analyses show disparities in the magnitude of increased risk, none show reduction of total 30-year mortality risk among overweight or Grade 1 obese persons. Only for deaths within 10 years was there a slightly reduced mortality for overweight persons. The greatest increase in risk in overweight and Grade 1 obese subjects was at 20 years or more, but our use of baseline BMI only does not allow us to assess the role of BMI changes in this outcome.

Estimates of increased death risk for overweight or slightly obese persons were quite similar in models that used as the referent less than 25 kg/m^2 or 18.5 to 24 kg/m^2. Thus, differences in risk estimates related to use of these referents is, in our opinion, an unlikely explanation for disparate findings in published studies. The magnitude of the increased risk among Grade 1 obese persons is substantial (approximately 50%), with even larger increased risk in Grades 2 and 3 obesity (approximately doubled and tripled).

As previously reported,[28] increased risk of overweight and obese persons diminished in our data with increasing age. Although probably mostly an artifact of the increasing dominance of age itself and age-related factors, it has been suggested[13] that this might be related to selection of healthy, relatively low-risk persons in population study cohorts. This is a possible factor in our study because the subjects voluntarily took the health examination and persons with known chronic illnesses were presumably underrepresented. Another factor could be selective survival of persons resistant to the metabolic consequences of obesity. This touches on the interesting phenomenon known as the "obesity paradox." This phenomenon refers to data indicating that obese persons with certain medical problems or procedures, including chronic renal failure, myocardial infarction, coronary artery bypass grafting, angioplasty, and heart failure, have a better prognosis than those of normal BMI.[29-32] Obesity carries increased risk of certain medical conditions, but in persons with these conditions obesity carries lower risk. Attempts to explain the paradox as a statistical artifact have so far not been conclusive. Unfortunately, our data do not cast light on this matter.

Table 3. Adjusted[a] odds ratios of total mortality according to body mass index (BMI) among 273,843 subjects

Group	Number of deaths	Odd ratios (95% confidence intervals) of BMI vs < 25 kg/m^2 as referent		Odds ratios (95% confidence intervals) of BMI vs 18.5-24.9 kg/m^2 as referent[b]				
		25-29.9 kg/m^2	≥ 30 kg/m^2	< 18.5 kg/m^2	25-29.9 kg/m^2	30-34.9 kg/m^2	35-39.9 kg/m^2	≥ 40 kg/m^2
All persons	103,218	1.14 (1.11-1.16)[c]	1.66 (1.60-1.73)[c]	1.11 (1.03-1.19)[d]	1.14 (1.11-1.17)[c]	1.49 (1.43-1.55)[c]	2.09 (1.93-2.26)[c]	2.70 (2.40-3.03)[c]
All men	53,525	1.09 (1.06-1.13)[c]	1.55 (1.46-1.64)[c]	1.32 (1.14-1.55)[d]	1.10 (1.06-1.13)[c]	1.45 (1.36-1.54)[c]	1.89 (1.64-2.18)[c]	3.34 (2.58-4.34)[c]
All women	49,693	1.22 (1.17-1.26)[c]	1.80 (1.71-1.90)[c]	1.09 (1.00-1.18)[e]	1.22 (1.18-1.27)[c]	1.56 (1.46-1.65)[c]	2.27 (2.06-2.50)[c]	2.73 (2.39-3.12)[c]

[a] Logistic regressions with age, sex, race-ethnicity, BMI, education, marital status, smoking, and alcohol intake.
[b] In another model, odds ratios (95% confidence intervals) for BMI 30-34 kg/m^2 vs < 25 kg/m^2 were as follows: all = 1.48 (1.42-1.55); men = 1.44 (1.36-1.53); and women = 1.55 (1.46-1.64).
[c] p < 0.001.
[d] p < 0.01.
[e] p < 0.05.

Table 4. Adjusted[a] odds ratios (95% confidence intervals) to risk of death for selected covariates

Factor (referent)	All	Men	Women
Age (per 10 years)	3.40 (3.36-3.43), p < 0.001	3.28 (3.23-3.33), p < 0.001	3.50 (3.45-3.55), p < 0.001
Male sex (female)	1.57 (1.54-1.61), p < 0.001	—	—
Black (white)	1.48 (1.43-1.52), p < 0.001	1.50 (1.44-1.56), p < 0.001	1.46 (1.40-1.51), p < 0.001
All Asians (white)	0.88 (0.84-0.92), p < 0.001	0.84 (0.79-0.89), p < 0.001	0.93 (0.87-0.99), p = 0.02
Chinese (white)	0.91 (0.86-0.97), p = 0.006	0.88 (0.81-0.96), p = 0.006	0.96 (0.88-1.05), p = 0.40
Japanese (white)	0.86 (0.78-0.95), p = 0.003	0.87 (0.75-1.00), p = 0.06	0.87 (0.76-1.00), p = 0.06
Filipino (white)	0.85 (0.78-0.92), p < 0.001	0.76 (0.67-0.85), p < 0.001	0.95 (0.85-1.07), p = 0.39
South Asian (white)	0.59 (0.48-0.72), p < 0.001	0.55 (0.43-0.70), p < 0.001	0.69 (0.47-1.01), p = 0.05
Alcohol ≤ 2 drinks per day (none)	0.97 (0.94-1.00), p = 0.03	0.98 (0.94-1.03), p = 0.49	0.96 (0.93-1.00), p = 0.08
Alcohol ≥ 3 drinks per day (none)	1.27 (1.22-1.33), p < 0.001	1.27 (1.19-1.35), p < 0.001	1.32 (1.23-1.42), p < 0.001
Ex-smoker (never)	1.08 (1.04-1.11), p < 0.001	1.09 (1.04-1.14), p < 0.001	1.08 (1.03-1.13), p = 0.002
Smoking < 1 pack per day (never)	1.38 (1.34-1.42), p < 0.001	1.39 (1.33-1.46), p < 0.001	1.38 (1.33-1.44), p < 0.001
Smoking ≥ 1 pack per day (never)	2.06 (2.00-2.13), p < 0.001	1.98 (1.90-2.07), p < 0.001	2.21 (2.11-2.31), p < 0.001
College graduate (no college)	0.65 (0.63-0.67), p < 0.001)	0.61 (0.58-0.63), p < 0.001)	0.72 (0.70-0.75), p < 0.001

[a] Logistic models with age, sex, smoking, alcohol, body mass index, and education.

Sex and Race Differences

It is noteworthy that the different distributions of BMI categories between men and women and between blacks and whites did not translate into disparate risks for overweight and Grade 1 obese persons. This contrasts with Asian/white comparisons. Our data also concur with reports[33-35] showing that, by the usual categorizations, Asians have lower proportions of overweight and obese persons and that these persons have greater increased death risk than do whites or blacks. Our data also agree with reports[33,34] that Asians have a greater proportion of underweight individuals and that underweight Asians have no increased mortality risk. These relationships were generally similar for the various Asian ethnicities. It has been suggested[34,36-38] that obesity in Asians be defined as BMI of 25 kg/m^2 or greater and overweight as BMI 23 to 24.9 kg/m^2. Our data support this concept and the conclusion in a recent review[34] that more data are needed in this area. We plan to pursue this area further.

Risk of Underweight Persons

The increased risk of underweight persons was concentrated in men, non-Asian race groups, the first 10 years of follow-up, ex-smokers, and persons dying of non-CV causes. Presumably, the concentration in early years represents to some extent early manifestations of ultimately lethal conditions and supports this previous suggestion.[39] These data show the importance of a long follow-up period in the study of BMI and mortality. The greater risk of underweight men compared with underweight women is likely to be an artifact of the smaller proportion of men with BMI under 18.5 $kg/m.^2$ The absence of increased risk among underweight Asians suggests the possible need for revision of both low and high BMI cut-points for this racial group. The high risk of underweight ex-smokers suggests that some ex-smokers are likely to have quit because of symptoms or other evidence of ill health.

Cardiovascular versus Noncardiovascular Causes of Death

As expected,[1,4,13,16] the increased risk of death among overweight and obese persons was more substantial among those dying of CV causes. Risk of death for CV causes was actually reduced among underweight persons. Deaths attributed to coronary disease and cancer comprised almost half of the CV and non-CV composites and made proportionate contributions to these associations. Prior reports[22-24] indicate substantial variability of obesity-associated risk among cancer types. We plan to pursue further investigation of BMI associations to specific death causes. For now, we point out that demographic disparities in causes of death could help explain disparate findings in various studies.

Covariate Relationships

There was increased death risk associated with increasing age, male sex, black race, smoking, and heavy drinking (Table 4). Higher educational attainment and Asian race were associated with lower risk (Table 4). These expected relationships help to confirm the validity of our analyses.

Limitations and Strengths

Our study had some limitations, including use of only a single baseline BMI measure, which precludes study of effect of both prior and subsequent weight changes, as well as a similar limitation to baseline measurement of covariates. Additionally, the study was limited to deaths in California, and it lacked controls for diet, exercise, and several other relevant traits. These confounder traits, rather than BMI, could be the operative factors responsible for increased mortality. Furthermore, there was a lack of study of intermediary factors between higher BMI and mortality, such as hypertension, blood lipid abnormalities, and, of special importance, diabetes. The absence of more specific data indicative of adiposity (eg, waist-hip ratio, body fat composition) limited our ability to explain sex and race disparities. Finally, it is possible that a health-conscious cohort was selected, which could bias the results.

Strengths include 1) the large size of a free-living and relatively stable study population, 2) exceptionally long follow-up, 3) excellent ascertainment of race/ethnicity, 4) presentation of data about specific Asian ethnic groups, and 5) availability of data enabling control for several important potential confounders, especially smoking.

Public Health Considerations

Because we present no data about changes in BMI, our findings do not directly support recommendations about weight loss to reduce mortality risk in overweight and obese persons. In this regard, the literature is conflicting. Much evidence suggests that weight reduction has a favorable effect on CV risk factors; yet several reports suggest no mortality benefit or even increased mortality in persons who lose weight, even deliberately.[40-42] A meta-analysis of randomized controlled trials showed that intentional weight loss in obese adults was associated with a 15% reduction in all-cause mortality.[43] These aggregate data do not apply to all persons. As in almost all health issues, advice about losing weight should be individualized.

CONCLUSION

We conclude that it is not healthier to be overweight. In this analysis in a large multiethnic population, persons with "normal" BMI had the lowest 30-year mortality. These data also support the proposition that there should be lower cutpoints for the definition of overweight and obese in Asians than in whites or blacks. ❖

Disclosure Statement

The author(s) have no conflicts of interest to disclose.

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