Associations between Smoking and Body Weight in the US Population: Analysis of NHANES II

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Abstract: Recent recommendations for increases in desirable body weights are based upon studies which did not consider the potential confounding effect of cigarette consumption on body weight. We investigated the relation between tobacco use and several anthropometric measurements in 12,103 men and women 19–74 years of age in the United States examined between 1976 and 1980 during the Second National Health and Nutrition Examination Survey (NHANES II). Cigarette smokers weighed less (mean ± standard error = 69.8 ± 0.2 kg) and were leaner (body mass index (weight (kg)/height (m)^2) = 24.6 ± 0.1) than nonsmokers (72.5 ± 0.2 kg and 25.7 ± 0.1, respectively), controlling for age and sex. Body leanness increased with the duration (but not intensity) of smoking. Ex-smokers were not heavier or fatter than nonsmokers, and these groups experienced similar weight gain after age 25 (approximately 6 kg in men, 9 kg in women), while current smokers gained substantially less weight (3.5 kg in men, 5.4 kg in women). Compared to nonsmokers, former and current smokers were also slightly taller. Most of these associations were evident in both sexes and all ages evaluated, and were not explained by differences in caloric intake, physical activity, illness, or socioeconomic status. Our findings suggest that the increased mortality observed among lean individuals in previous studies may have been due to smoking rather than leanness per se, and that as a result, currently accepted desirable body weights may be overestimated. (*Am J Public Health* 1987; 77:439–444.)

Introduction

Interest in the relation of various anthropometric measurements to human health has increased substantially in recent years. A large number of epidemiologic studies, including recent life insurance studies, have evidenced increased mortality (particularly cancer) among lean, underweight individuals compared to those of average weight.[1–5] This finding is paradoxical since most of the same studies demonstrated greater mortality for overweight and obese persons as well, and animal experiments have consistently shown morbidity and mortality to be positively related to body weight and fatness.[6–9] Nonetheless, the most recent Metropolitan Life Insurance Company weight-for-height ("ideal body weight") tables[10] reflect increases in weight associated with the lowest mortality compared to the earlier tables.[11] Additionally, some investigators have espoused the benefits of being overweight, based upon similar observations.[12] Considering the increasing prevalence of overweight and obesity in the United States and throughout parts of the world, the public health implications of such claims are far-reaching. Therefore, exclusion of other explanations for the observations is important.

Several studies have assessed the relation of body weight or body mass to various behavioral characteristics including tobacco use, and many of these investigations have demonstrated that lean individuals are more likely to be cigarette smokers than are the overweight or obese.[13–23] Consequently, the increased morbidity and mortality observed among underweight individuals may be due to smoking and not leanness per se. However, these studies were generally restricted to males, limited age ranges, narrow population samples, and/or assessment of body weight uncorrected for height, and only two studies evaluated caloric intake.[21,23] In addition, the heaviest smokers in these studies were not the leanest individuals, and, since the studies did not include information concerning smoking histories, no assessment was made of the effect of duration of smoking on body weight.

We investigated the association between smoking histories and body weight, several anthropometric measurements, and caloric intake in a large sample of men and women 19 to 74 years of age in the United States, to clarify some of the prior observations. Since the duration of smoking has important implications for chronic disease risk and mortality (particularly cancer),[24,25] and because previous studies have demonstrated greater excess incidence and mortality among leaner individuals in older age groups,[1,4,26] we evaluated the association between body weight and smoking duration, as well as smoking intensity.

Methods

Study Sample

This report examines cross-sectional data from the Second National Health and Nutrition Examination Survey (NHANES II). This survey, conducted by the National Center for Health Statistics (NCHS) between 1976–80 was designed to represent the US non-institutionalized, civilian population, 6 months to 74 years of age. Details of the sampling design and data collection procedures have been documented elsewhere.[27] The survey represents the most current information available concerning the health status of the US population which includes data obtained from interviews, as well as anthropometric, biochemical, and clinical measurements. The analyses reported here involve 12,103 adults, 19 years of age and older for whom complete information was available.

Smoking Data

Smoking data were self-reported by the subjects in response to the following questions: Have you smoked at least 100 cigarettes during your entire life?; Do you smoke cigarettes now?; On the average, how many cigarettes a day do you smoke?; How long has it been since you smoked cigarettes fairly regularly?; During the period when you were smoking the most, about how many cigarettes a day did you actually smoke?; About how old were you when you first started smoking cigarettes fairly regularly?; and, Do you smoke cigars or pipes now? Information concerning usual

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TABLE 1—Mean Values of Age- and Sex-adjusted Anthropometric Measurements and Caloric Intake among 12,103 US Men and Women by Smoking Status[a]

Smoking Category	Number	Height (cm)	Weight (kg)	Body Mass Index[b]	Triceps Skinfold (mm)	Subscapular Skinfold (mm)	Calories (kcal/day)
Nonsmokers	4959	168.0(0.1)	72.5(0.2)	25.7(0.1)	20.7(0.2)	20.8(0.3)	1964(26)
Cigars/pipes only	177	168.9(0.5)	74.3(1.1)	25.9(0.3)	20.7(0.9)	21.6(1.0)	1792(99)
Ex-smokers	2863	168.8(0.2)*	72.8(0.3)	25.5(0.1)	19.9(0.3)*	20.3(0.3)	1964(29)
Current smokers	4104	168.4(0.1)*	69.8(0.2)*	24.6(0.1)*	17.8(0.2)*	18.2(0.2)*	2020(17)
Total	12103	168.3(0.1)	71.6(0.1)	25.2(0.1)	19.5(0.2)	19.8(0.2)	1982(17)

[a]Numbers in parentheses represent the standard error of the mean.
[b]BMI = weight(kg)/height(m)^2.
*Value differs significantly ($p \leq 0.05$) from nonsmoking group.

brands or depth of inhalation was not queried. The following smoking categories were created for persons not smoking cigarettes at the time of the interview: nonsmokers (never smoked 100 cigarettes, and does not smoke cigars or pipes); cigar/pipe smokers (but never cigarettes); ex-smokers, including recent former smokers (quit smoking cigarettes during the year prior to interview), and longer-term former smokers (quit smoking cigarettes more than one year prior to interview). Current cigarette smokers were categorized according to three smoking measures:

- *intensity*, defined here as the usual number of cigarettes smoked daily at the time of interview (≤5, 6–10, 11–15, 16–20, 21–30, >30);
- *duration*, the number of years of smoking cigarettes, derived from age started smoking and age at examination (≤10, 11–20, 21–30, 31–40, 41–50, >50);
- *number of pack-years* of smoking, the product of current intensity (in packs) and duration (≤5, 5.1–10, 10.1–20, 21.1–30, 31.1–50, >50).

Ninety-three current cigarette smokers for whom the age at which they started smoking was unknown were excluded from the original age-eligible population of 12,196.

Anthropometric Measurements and Other Variables

Standing height (or stature), body weight, triceps and subscapular skinfold measurements were obtained in mobile examination centers through standardized procedures which have been described.[27] A body mass index (BMI) was calculated from these height (ht) and weight (wt) data (using the formula BMI = wt(kg)/ht(m)^2), to provide an index of weight controlled for height, which reflects body leanness and fatness better than weight alone. Based upon previous assessment of body mass indices within the NHANES I data set,[28] as well as our analysis of the NHANES II data,[29] an adjusted BMI (BMI = wt(kg)/ht(m)$^{1.5}$) was also used for women in order to minimize the correlation to height and maximize the correlation to weight over all ages and levels of fatness. Body weight at age 25 years reflects that self-reported at the time of interview. Excluded from analyses of weight change were 2,220 persons who were less than 25 years old at the time of examination or for whom weight at age 25 was not reported.

Caloric intake was determined by NCHS using standard food composition tables applied to the foods reported in each person's 24-hour dietary recall record. Participants were also asked to rate their level of recreational exercise (much, moderate, little or none), as well as other daily physical activity (very active, moderately active, quite inactive). Both types of activity, as well as an additive index of the two ranging from two to six, were used in some analyses of anthropometric variables and caloric intake to adjust for potential confounding by this factor.

Statistical Analyses

Analyses in this report were carried out using the statistical software package, SAS.[30] Regression analyses between anthropometric measures and smoking categories were conducted in which age and sex were included as covariates (gender was not included in the sex-specific analyses). In addition, as indicated in the text, some preliminary analyses of smoking duration included the number of cigarettes smoked daily as a covariate in the regression model. Similarly, indices of physical activity were included in other analyses of caloric intake or body fatness. Least-square means adjusted for the covariates in the model were tested for significant differences compared to the nonsmoking category. Adjusted means were produced with weighted data, making these results representative of the US population. The complex sample design of the NHANES II survey necessitated the use of special software. Standard errors of the adjusted means were calculated directly as weighted linear combinations of the beta weights, using the betas and their associated variance-covariance matrices from the program SURREGR,[31] according to the method developed by Feldstein.[32]

Results

Table 1 presents age- and sex-adjusted means for several anthropometric measurements and caloric intake according to smoking status for the entire study population. Approximately 41 per cent of this population were nonsmokers, 24 per cent were former smokers, and 34 per cent smoked cigarettes at the time of examination. Compared to nonsmokers, current cigarette smokers were taller, lighter, and leaner (as indicated by the body mass index and two skinfold thicknesses). Ex-smokers were taller than nonsmokers, and somewhat leaner, especially according to the triceps skinfold. No substantial differences were seen in caloric intake, although current smokers exhibited the highest intake. Adjustment for race or socioeconomic status did not alter these findings. Although not shown in the Table, using the lowest and highest deciles of relative body weight to define the leanest and most obese, respectively, the leanest individuals in our study, were twice as likely to be current cigarette smokers compared to the most obese group (49 per cent versus 24 per cent), and less likely to have never smoked (34 per cent versus 55 per cent).

A more detailed evaluation of the anthropometric measurements and caloric intake utilized three classification

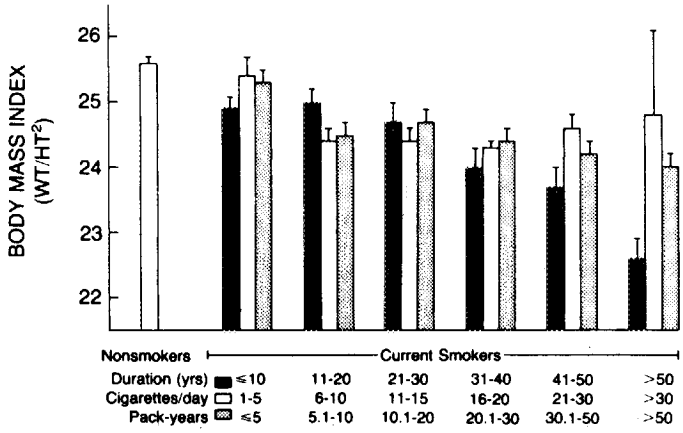

FIGURE 1—Age- and Sex-Adjusted Body Mass Index (mean ± S.E.) for Nonsmokers and Current Smokers According to Three Smoking Classification Schemes

schemes for current cigarette smokers. Results for the body mass index, wt(kg)/ht(m)^2, are presented in Figure 1. Every current smoking category exhibited a lower BMI (was leaner) compared to nonsmokers, although the relation between body mass and the three smoking measures differed. Moderate smokers (6–20 cigarettes daily) were leaner than either lighter smokers (1–5 cigarettes daily) or heavier smokers (>20 cigarettes daily). In contrast, except for a slightly lower body mass observed among persons smoking 1–10 years, body mass index decreased with increasing duration of smoking (whether or not adjustment was made for intensity of smoking). As one might expect, body mass index exhibited an association with total pack-years intermediate to that for either of its component variables. Based upon this compar-

TABLE 2—Mean Values of Age-adjusted Anthropometric Measurements and Caloric Intake by Sex and Smoking Category[a]

Smoking Category	Number	Height (cm)	Weight (kg)	Body Mass Index[b]	Triceps Skinfold (mm)	Subscapular Skinfold (mm)	Calories (kcal/day)
MALES							
Nonsmokers	1455	175.3(0.3)	79.3(0.4)	25.8(0.1)	13.9(0.2)	18.4(0.3)	2417(45)
Cigars/pipes only	171	176.0(0.5)	81.2(1.0)	26.1(0.3)	14.6(0.8)	19.8(0.9)	2311(105)
Ex-smokers							
≥1 year	1716	175.8(0.2)	80.0(0.5)	25.9(0.1)	13.8(0.3)	18.8(0.3)	2458(39)
<1 year	181	175.8(0.6)	78.4(1.0)	25.4(0.3)	13.0(0.7)	17.3(0.8)	2564(155)
Current smoker (# of years)							
1–10	509	175.1(0.3)	76.1(0.6)*	24.8(0.2)*	12.0(0.4)*	16.9(0.5)*	2462(73)
11–20	462	175.9(0.4)	77.9(0.8)	25.1(0.2)	12.3(0.4)	17.0(0.4)	2655(77)*
21–30	327	175.5(0.4)	76.9(0.9)	24.9(0.3)	11.8(0.5)*	16.3(0.7)*	2595(59)
31–40	332	175.0(0.4)	75.5(0.7)*	24.7(0.3)*	11.7(0.4)*	16.2(0.6)*	2493(62)
41–50	361	175.0(0.3)	74.8(1.0)*	24.4(0.3)*	12.2(0.5)*	16.0(0.5)*	2481(58)
>50	199	174.6(0.6)	71.9(1.1)*	23.3(0.4)*	11.5(0.6)*	15.3(0.1)*	2275(77)
TOTAL	5713	175.5(0.2)	78.3(0.2)	25.4(0.1)	13.1(0.1)	17.8(0.2)	2478(25)
FEMALES							
Nonsmokers	3504	161.4(0.2)	66.2(0.3)	32.3(0.1)	26.4(0.3)	22.7(0.4)	1510(18)
Cigars/pipes only	6	160.1(2.3)	64.7(5.0)	31.9(2.0)	24.0(4.8)	22.9(4.2)	935(194)*
Ex-smokers							
≥1 year	849	162.6(0.3)*	66.8(0.7)	32.2(0.3)	26.0(0.5)	21.9(0.6)	1551(24)
<1 year	117	162.0(0.5)	65.3(1.1)	31.7(0.5)	25.2(0.8)	21.6(0.9)	1582(77)
Current smoker (# of years)							
1–10	574	161.6(0.3)	65.0(0.8)	31.6(0.4)	23.8(0.5)*	20.9(0.5)*	1497(34)
11–20	443	162.6(0.3)*	65.1(0.8)	31.4(0.4)*	24.0(0.6)*	20.7(0.6)*	1603(39)*
21–30	345	161.9(0.5)	64.1(1.0)	31.1(0.5)*	23.2(0.7)*	19.1(0.9)*	1576(45)
31–40	302	162.7(0.5)*	61.5(1.2)*	29.6(0.5)*	20.7(0.8)*	17.0(0.1)*	1552(40)
41–50	219	162.4(0.4)*	61.3(1.4)*	29.5(0.7)*	20.4(0.8)*	17.5(1.1)*	1575(50)
>50	31	161.5(1.4)	59.1(2.0)*	28.8(1.1)*	20.5(1.8)*	17.5(1.8)*	1522(88)
TOTAL	6390	161.8(0.1)	65.6(0.3)	31.9(0.1)	25.2(0.3)	21.6(0.3)	1531(13)

[a]Numbers in parentheses represent the standard error of the mean.
[b]BMI = weight/height^2 for males; BMI = weight/height$^{1.5}$ for females.
*Value differs significantly ($p \leq 0.05$) from nonsmoking group.

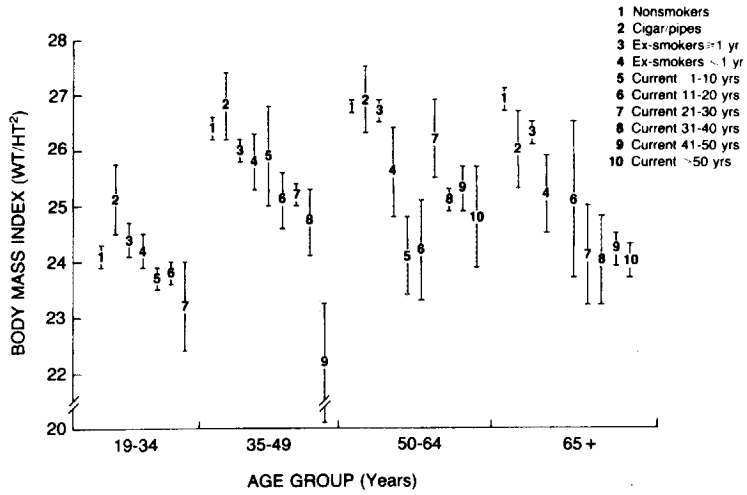

FIGURE 2—Age- and Sex-Adjusted Body Mass Index (mean ± S.E.) by Age Group and Smoking Category

ison of the three cigarette exposure measures, duration of use was chosen for subsequent analyses.

Table 2 illustrates that, overall, similar patterns exist for both men and women. Current cigarette users of either sex weighed less and were leaner than nonsmokers, and this association generally increased with increasing years of smoking. Compared to nonsmokers, caloric intake was higher in men and women for the 11–20 year duration current smoking group. With respect to weight and measures of fatness, recent ex-smokers of both sexes were more like current smokers than were long-term ex-smokers (who resembled nonsmokers). Adjustment for level of physical activity did not alter these findings with regard to either the anthropometric measurements or caloric intake.

The relation between BMI and smoking status for four age groups is shown in Figure 2. (Note that the first, second, and fourth age groups lack individuals in some of the smoking categories.) BMI increased with age up to approximately middle-age, after which it leveled off or decreased somewhat for most smoking categories. In each age group, recent ex-smokers were slightly leaner than long-term ex-smokers. Although small samples contribute to BMI variability, cigarette smokers were leaner than nonsmokers in the younger as well as older age groups (albeit, not statistically significant in the 19–34 year age group), and leanness increased with duration of smoking. It is of note that the leanness observed in 1–10 year smokers for the entire population (Figure 1) is evident primarily among 50–64 year olds, and was based upon 23 individuals who were much taller and weighed less than nonsmokers. This age group in general exhibited a more irregular BMI-smoking pattern. The difference in BMI between nonsmokers and all current smokers combined increased with age, from 0.5 in the 19–34 year old group, to 1.3, 1.5, and 2.8 in the three consecutive age groups, respectively.

Body weight changes after age 25 (adjusted for age and height), according to smoking status and sex, are shown in Table 3. With the exception of male current smokers of more than 50 years duration, all groups experienced weight gain. For each smoking category, women experienced greater weight gain (both absolute and relative to weight at age 25)

TABLE 3—Age- and Height-adjusted Weight Change Since Age 25 Years by Sex and Smoking Category[a]

	Males			Females		
Smoking Category	Number	Weight Change(kg)	% Change Since Age 25	Number	Weight Change(kg)	% Change Since Age 25
Nonsmokers	1047	5.8 (0.3)	8.5 (0.5)	2824	9.2 (0.2)	16.2 (0.3)
Cigars/pipes only	143	4.9 (0.8)	7.2 (1.1)	4	4.9 (2.6)	8.1 (4.7)
Ex-smokers						
≥1 year	1574	6.5 (0.3)	9.6 (0.4)	759	9.6 (0.6)	17.1 (0.9)
<1 year	139	5.6 (1.0)	8.0 (1.3)	83	9.3 (1.1)	16.9 (1.8)
Current smoker (# of years)						
1–10	171	4.1 (0.5)*	6.0 (0.8)*	243	5.9 (0.6)*	11.5 (0.9)*
11–20	442	4.7 (0.5)	7.3 (0.7)	430	8.2 (0.7)	15.3 (1.3)
21–30	319	4.3 (0.8)	6.4 (1.1)	330	7.9 (0.8)	14.4 (1.5)
31–40	320	2.9 (0.8)*	4.3 (1.0)*	287	4.7 (0.8)*	8.3 (1.5)*
41–50	349	1.4 (0.9)*	2.5 (1.3)*	207	3.7 (0.9)*	6.3 (1.5)*
>50	185	−0.6 (1.2)*	−0.3 (1.8)*	27	4.0 (2.6)	8.9 (5.3)
TOTAL	4689	5.1 (0.2)	7.6 (0.2)	5194	8.5 (0.2)	15.2 (0.3)

[a]Numbers in parentheses represent the standard error of the mean.
*Value differs significantly ($p \leq 0.05$) from nonsmoking group.

than did men; on average, approximately two-thirds more absolute weight, and twice as much relative weight. Cigar or pipe smokers, as well as ex-smokers, demonstrated no significantly greater weight gain compared to nonsmokers. Especially among men, current smokers evidenced the smallest weight gain, and weight gain generally decreased with increasing duration of smoking.

Discussion

The finding that cigarette smokers weigh less and are leaner than persons of the same sex and age who never smoked confirms that of several previous investigations.[13–23] While most of these same studies demonstrated greater weight or fatness among ex-smokers, in this population former smokers are similar to nonsmokers, corroborating three of the above studies.[13,15,17] These findings are complemented by the observation that compared to nonsmokers, current smokers gained less weight, and longer-term ex-smokers gained only slightly more weight, after age 25.[19,33,34] Current and former smokers are also taller than nonsmokers, a finding in conflict with most,[14,18–20,23] but not all,[15,33] studies. These associations between smoking status and body size are generally evident in both men and women, for all age groups studied, and are not explained by differences in caloric intake, physical activity, race, or socioeconomic status.

Most previous investigations of this relation evaluated only smoking intensity (or the number of cigarettes smoked daily) and body weight, and found increased average weight and obesity levels among the most intense smokers.[13,14,19,21] In general agreement with these reports, smokers of an intermediate number of cigarettes per day in our study weighed less and were leaner than either light (1–5 cigarettes) or heavy (≥20 cigarettes) smokers. While the absence of any difference in weight or level of fatness between nonsmokers and current smokers of 1–5 cigarettes daily is not surprising given the relatively low level of exposure this represents, increased weight among smokers of a pack or more daily is paradoxical. Although most investigators do not address this relationship, one group attempted to explain it in terms of differences in smoke inhalation between the smoking groups, or by viewing obesity as a cause of heavy smoking.[21] However, the latter hypothesis does not concur with our observation that even before they had started smoking, heavy smokers were not more obese at age 25 than nonsmokers.

In contrast to these findings concerning smoking intensity, a nearly linear diminution in body weight and fatness associated with increasing *duration* of cigarette consumption, having taken age into consideration, was demonstrated in this population. Although these findings are based upon cross-sectional, and not longitudinal data, they are suggestive of a cumulative effect, and offer a coherent and biologically plausible representation of the effect of smoking on body weight and fatness. This is supported by the observation of this study and other researchers that regular cigarette smokers gain less weight after the age of 25 than do nonsmokers.[33–35] Our findings concerning duration of smoking may clarify why heavier smokers are not as lean as other smokers, since, interestingly, the heavy smokers in our sample included proportionally fewer long-term smokers (>40 years duration, the group exhibiting the lowest body weight and level of fatness). It also explains the stronger association among older individuals, since only the older age groups would include substantial numbers of longer-term smokers.

Several mechanisms might account for these findings with respect to smoking and body size. With the possible exception of those smoking more than 50 years, caloric intake was not diminished among current cigarette smokers; rather it was somewhat increased. Thus, unless smokers systematically over-report food intake compared to nonsmokers (and we are unaware of data supporting this), reduced caloric intake is not the cause of underweight among smokers. Alternatively, current smokers may have greater energy requirements than do nonsmokers. Cigarette consumption is known to raise basal metabolism,[36] but no measure of this parameter is available in the NHANES II data. Caloric expenditure may also be increased through physical activity. Current smokers reported slightly higher levels of occupational and recreational physical activity than did ex-smokers and nonsmokers in this study, but adjustment for these differences did not materially affect our results with respect to calories or body weight. Increased gastrointestinal motility in smokers due to the effects of nicotine, which could result in loss of food calories, has been observed by some investigators.[37] An increased number of illnesses and hospitalizations among current and former smokers could, in theory, account for some increase in caloric expenditure or leanness among smokers. However, persons reporting one or more hospitalizations during the year prior to interview demonstrated reduced caloric intake and were no leaner than those reporting no hospitalizations, and adjustment for this factor did not alter our findings. Furthermore, leanness among the youngest smokers is not likely to have been due to smoking-induced chronic disease. Finally, the present study does not allow adequate evaluation of the hypothesis that individuals who become smokers are leaner to begin with, although at age 25 current smokers in our population were already leaner before they had started smoking than their nonsmoking age peers. Further research is necessary to elucidate the relative importance of these possible mechanisms.

Awareness of the interrelation between smoking and relative body weight is necessary for both clinical and public health practitioners attempting to modify either of the two characteristics in individuals; this is especially true for smoking cessation efforts. We have not found ex-smokers to be heavier or fatter than nonsmokers. Although persons in this population who continued smoking cigarettes experienced the smallest gain in weight after age 25, those who had quit smoking for up to one year gained no more weight than did nonsmokers. In addition, although weight gain after age 25 was somewhat greater among those who stopped smoking many years earlier compared to continuing smokers, the average difference between these groups was not large (approximately 3 kg for men and women), and was not much greater than the difference between nonsmokers and current smokers (2.2 kg in men, 2.5 kg in women). These results, based on a large sample of the US population and supported by previous studies,[33,34,38] should be encouraging to both practitioners and the public involved in cessation efforts and concerned about potential weight gain.

Based on these findings, the potential exists for tobacco use to strongly confound epidemiologic studies investigating the relation between absolute or relative body weight and cancer, as well as other diseases or causes of death. Evidence for such confounding is available from studies which assessed smoking status and demonstrated that leanness was a risk factor among cigarette smokers only.[2,3] In their study of an American Cancer Society survey, Lew and Garfinkel[2] showed that excess mortality from all causes (particularly smoking-related cancers) among those underweight was

restricted to smokers, while persons who never smoked exhibited a positive, linear relation between relative weight and mortality. Future investigations of the relation between anthropometry and morbidity or mortality should incorporate information regarding smoking histories (particularly duration of smoking) in order to avoid such confounding.

Another implication of these observations concerns desirable (or "ideal") body weights, which are usually derived from life insurance data analyses, and defined as the weight for age, sex, and frame size which yields the lowest overall mortality for the period and cohort. The most recent actuarial study[1] demonstrated greater mortality for underweight persons than did the earlier study,[39] and has revised upward the desirable body weights in order to reflect this apparent current mortality trend. However, since the actuarial analyses did not take smoking status into account when relating relative body weight to subsequent mortality, and the level of smoking-related mortality changed between those study periods,[40] their validity with respect to ideal body weight can be seriously questioned. The more likely possibility is that actual desirable body weights are lower than those currently recommended. Our findings suggest that it may not be leanness per se which has led to increased mortality, but rather smoking, especially long-term smoking, with associated leanness.

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