Anthropometric estimates of muscle and fat mass in relation to cardiac and cancer mortality in men: the Paris Prospective Study[1–4]

Jean-Michel Oppert, Marie-Aline Charles, Nadine Thibult, Bernard Guy-Grand, Eveline Eschwège, and Pierre Ducimetière

ABSTRACT

Background: The associations of different components of body mass with disease outcomes are not well defined.

Objective: We investigated the effects of body composition on risk of death from cardiac causes and cancer in adult men.

Design: Middle-aged men (n = 7608) in the Paris Prospective Study were followed up for 15 y. At study entry, the following measurements were obtained: sagittal diameter, sum of midarm and midthigh circumferences, sum of 3 trunk skinfold thicknesses (estimate of trunk subcutaneous fat), and sum of 3 extremity skinfold thicknesses (estimate of extremity subcutaneous fat). To assess their relative contributions to cardiac and cancer mortality, we used multivariate Cox models in which the sagittal diameter adjusted for trunk skinfold thicknesses was used as an estimate of intraabdominal fat and the sum of midarm and midthigh circumferences adjusted for extremity skinfold thicknesses was used as an estimate of muscle mass.

Results: In multivariate analyses in both smokers and nonsmokers, the sagittal diameter was the only significant predictor of cardiac death. The sum of midarm and midthigh circumferences was negatively associated and sagittal diameter was positively associated with cancer death, whereas extremity skinfold thicknesses exhibited a U-shape relation. Exclusion of subjects who died from cancer in the first 5 y of follow-up did not change these results.

Conclusions: Intraabdominal fat appears to be the main body compartment involved in risk of cardiac death, whereas increased risk of cancer death is associated with lower muscle mass and lower subcutaneous fat, independent of smoking and after the exclusion of early mortality. Increased central fat distribution may confer additional risk of death from cancer. *Am J Clin Nutr* 2002;75:1107–13.

KEY WORDS Body composition, fat distribution, body fat, muscle mass, mortality, cardiovascular disease, cardiac death, heart disease, cancer, prospective study

INTRODUCTION

It is well accepted that being overweight has a negative effect on longevity. The current trend in which the prevalence of obesity is rising worldwide has been recognized as an important public health issue (1). According to a large number of studies, the relation of weight-for-height indexes such as body mass index (BMI) with all-cause mortality appears to be U-shaped (2). However, controversy continues in this area because the association of low BMI with increased mortality risk may be confounded by smoking and unknown preexisting disease that results in low body weight (3–6).

Scientists seeking to better understand the relation between weight and mortality are increasingly recognizing the relevance of both the composition of body mass (ie, fat and lean components) and the anatomical distribution of body fat (7, 8). Recent data from the Gothenburg Study show that in elderly Swedish men followed for 22 y, total mortality rose in a linear manner as body fat increased and fat-free mass (measured with total potassium) decreased (9). Few studies have investigated the contribution of muscle mass, a major component of lean body mass, to specific causes of death (10, 11).

Much evidence indicates that having more fat on the trunk, and especially within the trunk, as opposed to the extremities is associated with increased risk of several chronic diseases and their mortality, independent of the overall amount of body fat (12–14). These chronic diseases include type 2 diabetes and cardiovascular disease. In this area of research, simple anthropometric indexes such as ratios of waist-to-hip circumference or iliac-to-thigh circumference have been used extensively over the years (15, 16). It was noted that higher values for such circumference ratios might reflect relative muscle atrophy in the gluteal or thigh area as much as they might reflect increased fat deposition on the trunk (13). In a previous report from the Paris Prospective Study, higher mortality from all causes and from cancer in middle-aged men after 15–20 y of follow-up was associated with lower BMIs and higher iliac-to-thigh ratios, taking into account blood pressure, serum cholesterol concentration, and smoking (17). This combination of low BMI and high iliac-to-thigh ratio

[1] From the Nutrition Department, Hôtel-Dieu Hospital, Paris (J-MO and BG-G), and the Institut National de la Santé et de la Recherche Médicale U 258, Hôpital Paul Brousse, Villejuif, France (M-AC, NT, EE, and PD).

[2] J-MO and M-AC contributed equally to this work.

[3] Presented in abstract form (preliminary data) at the Annual Meeting of the North American Association for the Study of Obesity (NAASO), Charleston, SC, 14–18 November 1999.

[4] Address reprint requests to M-A Charles, INSERM U 258, Hôpital Paul Brousse, 16 avenue Paul Vaillant-Couturier, 94807 Villejuif, France. E-mail: charles@vjf.inserm.fr.

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could be a marker for a body-build pattern characterized by high intraabdominal fat and low muscle mass; this pattern would be particularly deleterious to health (7, 13).

The aim of this study was to provide further insight into the differential effects of body mass compartments on disease outcomes. We used data from the Paris Prospective Study I to examine the associations of anthropometric estimates of muscle mass and various body fat components with cardiac and cancer mortality in middle-aged men.

SUBJECTS AND METHODS

Subjects

The population and methods used in the Paris Prospective Study I were described previously in detail (18). Briefly, the subjects were 7746 native-born Frenchmen, employed as policemen by the Paris Civil Service and aged 43–55 y at the time of the initial examination (1967–1972). The screening visit included questionnaires about medical history and lifestyle (particularly smoking), a clinical examination, an electrocardiogram, and a set of anthropometric measurements obtained under standardized conditions. We excluded subjects with overt cardiovascular disease ($n = 67$) and those with missing anthropometric data ($n = 62$). The study was conducted in accord with the Helsinki Declaration.

Measurement of body mass compartments

All subjects were examined in light underwear and without shoes, while standing with their arms lying along the body, and in apnea fixed at midrespiratory phase. Anthropometric measurements taken at the initial examination and used in the present study were obtained with the following methods. Height was measured with a wall-mounted stadiometer and recorded to the nearest cm. Sagittal diameter, which is the maximal anteroposterior diameter of the abdomen in the sagittal plane (19), was measured with a sliding caliper at the lower rib margin and recorded to the nearest cm. Circumferences were measured with an inelastic tape measure. Midarm circumference was measured on the left arm midway between the tip of the acromion and the tip of olecranon and was recorded to the nearest 5 cm. Midthigh circumference was measured on the left thigh midway between the lateral inguinal fold and midpatella and was recorded to the nearest 5 mm. Skinfold thicknesses were measured with a Harpenden skinfold caliper (British Indicators Ltd, London) and recorded to the nearest 0.1 mm at the following sites: subscapular, axillary, subumbilical, biceps, triceps, and anterior thigh. All anthropometric data were recorded by the same 3 technicians who had been specially trained for the study.

The sum of the subscapular, axillary, and subumbilical skinfold thicknesses was used as an indicator of trunk subcutaneous fat. The sum of the biceps, triceps, and anterior thigh skinfold thicknesses was used as an indicator of extremity subcutaneous fat. The sagittal diameter adjusted for the sum of trunk skinfold thicknesses was used as an indicator of intraabdominal fat, and the sum of midarm and midthigh circumferences adjusted for extremity skinfold thicknesses was used as an indicator of muscle mass.

Ascertainment of mortality

The inquiry about vital statistics was made through official sources to ascertain the dates when study participants died. The causes of death, coded by using the *International Classification of Diseases*, revisions 8 and 9 (20, 21), were obtained whenever possible from treating physicians, hospital records, or families up to 1988. From 1989 onward and for those subjects with missing data on causes of death in the earlier period, the cause of death recorded on the death certificate was obtained through the national center for information on medical causes of death. Deaths of cardiac origin were defined by codes 410.0–414.9 (myocardial infarction), 795.0 (sudden death), and 782.0–782.9, 427.0, 427.1, and 519.1 (heart failure). Cancer deaths were defined by codes 140–209. All-cause mortality included deaths resulting from cardiac disease, cancer, or other causes. Nine subjects were excluded from the analyses because we could not obtain information on their vital status at any time during follow-up. Therefore, the present study includes data from 7608 subjects. For 342 (4.5%) of these subjects, mortality status could not be traced after the first 5 y of clinical follow-up, and therefore we limited their person-time to the years during which their status could be traced. The cause of death was missing or undefined for 38 subjects (0.5%); however, these subjects were included in analyses related to all-cause mortality.

Statistical analyses

To study the associations of 15-y cardiac, cancer, and all-cause mortality with each anthropometric variable at study entry, univariate analyses were performed by using the actuarial method and log-rank test. The same analyses were performed with the residuals of a linear regression of sagittal diameter on trunk skinfold thicknesses, and of the sum of midarm and midthigh circumferences on extremity skinfold thicknesses, to estimate the relation of intraabdominal fat and muscle mass, respectively, with mortality. Interrelations between anthropometric variables were assessed by using Pearson's product-moment correlation coefficients. Multivariate analyses including all anthropometric variables were performed with Cox models, separately in smokers and nonsmokers, controlling for age, height, and, in smokers, number of cigarettes per day. Anthropometric variables were entered into the models as continuous variables. Because some anthropometric variables displayed nonlinear relations with mortality, second-order polynomial terms were systematically tested and retained in the final models when significant ($P < 0.05$). The SAS statistical package, version 6.12 (SAS Institute Inc, Cary, NC) was used for all analyses.

RESULTS

Descriptive data obtained from the subjects at the initial examination are shown in **Table 1**. Sixty-three percent of the subjects were current smokers; the median number of cigarettes smoked per day was 15 (interquartile range: 10–20). After 15 y of follow-up, 1008 subjects (13.2%) had died. Cancer accounted for 401 (39.8%) of the deaths and cardiac causes accounted for 203 (20.1%) of the deaths.

The 15-y death rates from cardiac causes, cancer, and all causes are shown in **Table 2**. Death rates, as percentages, are shown separately for the quartiles of each anthropometric variable (cutoffs for each of the anthropometric variables are shown in Table 1). BMI was positively associated with the cardiac death rate and exhibited an inverted J-shaped relation with the cancer death rate and a U-shape relation with death from all causes; all of these relations were significant. The sum of midarm plus midthigh circumferences was significantly associated with death from cancer and

TABLE 1
Description of subjects in the Paris Prospective Study I at the initial examination[1]

	Value
Age (y)	49 (47–50)
Height (cm)	173 (171–177)
BMI (kg/m^2)	25.7 (23.7–27.8)
Midarm + midthigh circumferences (cm)[2]	82.0 (78.0–86.0)
Sagittal diameter (cm)	22 (20–24)
Trunk skinfold thicknesses (mm)[3]	78 (57–98)
Extremity skinfold thicknesses (mm)[4]	30 (24–37)

[1] Median; interquartile range in parentheses. n = 7608.
[2] Sum of midarm and midthigh circumferences.
[3] Sum of subscapular, axillary, and subumbilical skinfold thicknesses.
[4] Sum of biceps, triceps, and anterior thigh skinfold thicknesses.

from all causes, following inverted J-shaped curves for both. Sagittal diameter showed significant positive associations with cardiac death and death from all causes. Extremity skinfold thicknesses showed a significant negative association with cancer death. Relations with cardiac death and death from all causes were both U-shaped, but only the latter was significant. Trunk skinfold thicknesses showed a pattern of relations with death rates that was similar to the pattern found for BMI; relations with deaths from cancer and all causes were significant.

For each anthropometric measurement, the relation with all-cause mortality was a combination of the relations with cardiac and cancer mortality, the 2 main causes of death in this population. For example, the U-shaped relation of BMI with death from all causes appeared to combine the positive association of BMI with cardiac deaths and the negative association of BMI with cancer deaths.

The relations between 15-y death rates and the quartiles of intraabdominal fat and muscle mass are shown in **Figures 1** and **2**, respectively. Higher intraabdominal fat was significantly associated with higher all-cause, cardiac, and cancer mortality. Higher muscle mass was significantly associated with lower all-cause and cancer mortality, whereas the relation with cardiac mortality was not significant.

All of the anthropometric variables were significantly intercorrelated, as shown in **Table 3**. Multivariate analyses were then performed, with all variables entered into the models. Because smoking is associated with both cancer and ischemic heart disease, and is also associated with altered body composition (3), Cox regressions were performed separately for current smokers and current nonsmokers (**Table 4**). These regressions were adjusted for age, height, and, in smokers, number of cigarettes smoked/d. When these multivariate models were used, sagittal diameter was the only significant predictor of cardiac death in both smokers and nonsmokers (Table 4). The adjusted relative risks for cardiac death in relation to an increase of 1 SD (3.1 cm) in sagittal diameter were 1.54 (95% CI: 1.29, 1.85) and 1.59 (95% CI: 1.04, 2.43) in smokers and nonsmokers, respectively.

Sagittal diameter, the sum of midarm plus midthigh circumferences and its squared term, and extremity skinfold thicknesses and its squared term were all significant predictors of cancer death in both smokers and nonsmokers (**Table 5**). Therefore, all subjects were pooled in the same analysis with adjustment for the number of cigarettes smoked/d. To illustrate the specific contribution to cancer death of each of these 3 variables (sagittal diameter, sum of midarm plus midthigh circumference, and extremity skinfold thicknesses), the predicted 15-y death rates were calculated according to selected percentiles of the distribution of each

TABLE 2
Fifteen-year death rates from all causes, cardiac causes, and cancer by quartiles (Q) of selected anthropometric variables[1]

	Death rates				
	Q1	Q2	Q3	Q4	P[2]
Height					
All causes	14.1	14.3	13.5	13.2	<0.7
Cardiac	2.5	3.4	2.9	2.8	<0.4
Cancer	5.0	6.3	5.9	5.7	<0.5
BMI					
All causes	16.5	12.0	11.5	15.2	<0.001
Cardiac	1.9	2.8	3.1	3.9	<0.005
Cancer	8.9	5.3	4.1	4.9	<0.001
Midarm + midthigh circumferences					
All causes	18.5	11.9	11.8	13.1	<0.001
Cardiac	2.4	2.4	3.6	3.2	<0.10
Cancer	9.7	5.2	3.8	4.5	<0.001
Sagittal diameter					
All causes	11.6	12.7	13.6	17.7	<0.001
Cardiac	1.7	1.9	2.9	5.4	<0.001
Cancer	5.9	6.1	5.1	6.1	<0.53
Trunk skinfold thicknesses					
All causes	15.5	13.7	11.8	14.2	<0.01
Cardiac	2.1	3.0	3.0	3.6	<0.09
Cancer	8.3	5.7	4.5	4.6	<0.001
Extremity skinfold thicknesses					
All causes	18.7	12.4	10.9	13.1	<0.001
Cardiac	3.0	2.7	2.4	3.7	<0.12
Cancer	9.5	4.5	4.5	4.5	<0.001

[1] *See* Table 1 for the corresponding cutoffs for each quartile.
[2] Log-rank tests.

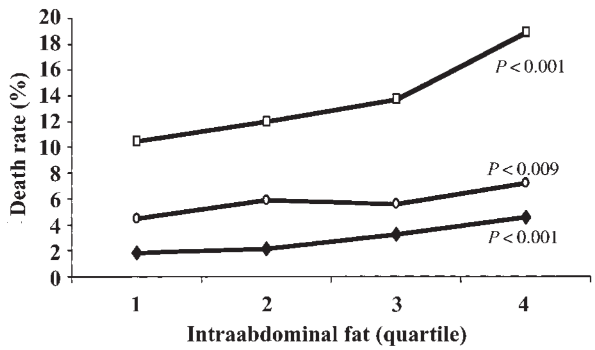

FIGURE 1. Relations between intraabdominal fat (in quartiles) and death from all causes (□), cardiac causes (◆), and cancer (○) in middle-aged men (n = 7608) during 15 y of follow-up in the Paris Prospective Study I. Intraabdominal fat was estimated from the sagittal diameter, adjusted by linear regression for the sum of trunk skinfold thicknesses.

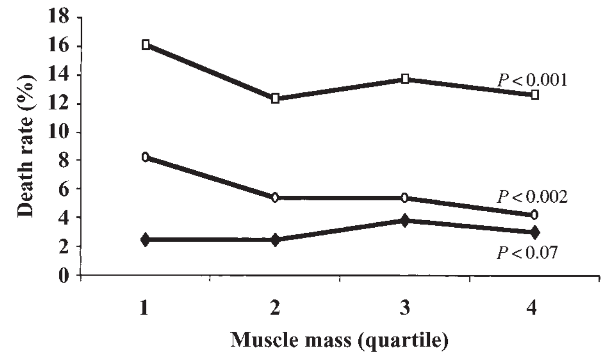

FIGURE 2. Relations between muscle mass (in quartiles) and death from all causes (□), cardiac causes (◆), and cancer (○) in middle-aged men (n = 7608) during 15 y of follow-up in the Paris Prospective Study I. Muscle mass was estimated from the sum of midarm and midthigh circumferences adjusted by linear regression for extremity skinfold thicknesses.

variable, with other variables in the model held constant at their mean value. The results are shown in **Figure 3** for subjects who smoked 1–10 cigarettes/d. The predictive value of the sagittal diameter depended on the variables in the model; it was significant only when skinfold thicknesses were in the model. Inclusion of the sum of midarm plus midthigh circumferences further enhanced its predictive power (data not shown). Exclusion of subjects who died from cancer in the first 5 y of follow-up (67 cases) did not change the results (data not shown).

DISCUSSION

In this study, we used multivariate analyses to assess the differential associations of major body mass compartments, derived from anthropometry, with cardiac, cancer, and all-cause mortality risks in middle-aged men followed for 15 y. These multivariate models allowed us to estimate the independent effects of 3 components of body fat (intraabdominal, trunk subcutaneous, and extremity subcutaneous) and of the muscular component of lean body mass. Intraabdominal fat (sagittal diameter adjusted for trunk subcutaneous fat) was found to be a marker for increased risk of cardiac death and cancer death in both smokers and nonsmokers. Low muscle mass (sum of midarm plus midthigh circumferences adjusted for extremity subcutaneous fat) and low extremity subcutaneous fat were predictive of cancer death. This association was not explained by smoking and remained significant when we excluded deaths from cancer during the first 5 y of follow-up.

The link between abdominal fat accumulation and increased cardiovascular morbidity and mortality is well documented. In men, this association was shown in prospective studies that used a variety of anthropometric indicators contrasting upper-body and lower-body fat, such as waist-to-hip ratio (22, 23), iliac-to-thigh circumference ratio (24, 25), waist circumference alone (23), and skinfold-thickness measurements (26, 27). To our knowledge, relations between sagittal diameter and increased mortality risk were reported in only one previous prospective study (28). In this study, the Baltimore Longitudinal Study on Aging, the sagittal diameter was positively associated with all-cause and coronary heart disease mortality in male participants <55 y old who were followed up for an average of 20.1 y (28); these findings are in agreement with the present study. In addition, in 2 case-control studies, the ratio of the sagittal diameter to the midthigh circumference was shown to be more strongly associated with ischemic heart disease in both sexes (29) and with sudden coronary death in men (30) than were other indicators of abdominal fat accumulation, such as waist circumference or waist-to-hip ratio. We have therefore confirmed that the sagittal diameter should be considered, at least in men, as a marker of cardiovascular risk.

It is generally believed that intraabdominal (or visceral) fat represents the critical adipose depot in relation to cardiovascular risk (12–14). Because of technical complexity, costs, radiation exposure, and availability, the precise quantification of abdominal visceral fat with imaging techniques (computed tomography or magnetic resonance imaging) is usually not feasible for large cohort studies. In the one published prospective study, Fujimoto et al (31) reported that intraabdominal fat measured with computed tomography, but not abdominal subcutaneous fat, was associated with the 10-y incidence of coronary heart disease in Japanese

TABLE 3
Correlations between anthropometric variables[1]

	Arm + thigh circumferences	Sagittal diameter	Trunk skinfold thicknesses	Extremity skinfold thicknesses
Height	0.16	0.10	0.04	0.07
BMI	0.78	0.60	0.58	0.72
Midarm + midthigh circumferences		0.58	0.65	0.60
Sagittal diameter			0.56	0.41
Trunk skinfold thicknesses				0.64

[1] n = 7608. Values are Pearson's product-moment correlation coefficients. $P < 0.002$ for all.

TABLE 4
Potential predictors of cardiac death in smokers and nonsmokers in the Paris Prospective Study I[1]

	Smokers (n = 4641)		Nonsmokers (n = 2769)	
	β	P	β	P
Age (y)	0.030	0.50	0.068	0.45
No. of cigarettes smoked				
(10–19/d)	0.236	0.20		
(≥20/d)	0.365	0.14		
Height (cm)	0.008	0.63	−0.062	0.10
Midarm + midthigh circumferences (cm)	−0.002	0.33	−0.000	0.99
Sagittal diameter (cm)	0.140	<0.001	0.149	0.04
Trunk skinfold thicknesses (mm)	−0.004	0.35	0.003	0.74
Extremity skinfold thicknesses (mm)	−0.009	0.41	−0.000	0.99

[1] Multivariate Cox regression model in which all anthropometric variables were entered as continuous variables.

American men. Several studies suggested that the sagittal diameter is highly correlated with visceral adipose tissue volume as measured by computed tomography or magnetic resonance imaging (16, 19). In 2 studies, the prediction of the amount of visceral fat from abdominal diameters was improved after adjustment for abdominal subcutaneous fat thickness (32, 33). In our analyses, the sagittal diameter, whether adjusted for trunk subcutaneous fat or not, was highly predictive of cardiac death. In addition, our data show that the effect of the subcutaneous fat pattern contrasting trunk with extremity skinfold thicknesses, which was previously found predictive of cardiac death in the Paris Prospective Study (27, 34, 35), is overridden by the influence of intraabdominal fat. Altogether, our data, in agreement with previous studies, emphasize the importance of intraabdominal fat as a major body compartment involved in cardiovascular risk.

In the current study, the sum of midarm plus midthigh circumferences adjusted for extremity subcutaneous fat, which we used as an estimate of muscle mass, was not a significant predictor of cardiac mortality. This was an unexpected finding because higher muscle mass is generally associated with a higher amount of habitual physical activity or physical fitness, which are negatively associated with cardiovascular risk (36). Prospective data on the relations between muscle mass estimates and cardiovascular mortality are scarce. In agreement with our findings, midarm circumference was not significantly associated with coronary heart disease mortality in men in the US Railroad Study (11) and in the white men in the Charleston Heart Study (10). In the black men in the latter study, however, midarm circumference was found to be inversely related to coronary heart disease mortality (10).

Arm and thigh circumferences are the measurements used most frequently to estimate muscle mass (15). When arm or thigh circumference is adjusted for the adjacent skinfold thickness, this provides an estimate of extremity lean tissue mass, which includes muscle and bone. It is probable that interindividual differences in extremity lean tissue mass are mainly explained by variations in muscle mass. In a study by Martin et al (37), 6 male cadavers with a wide range of age and muscle mass values were examined. The correlation coefficients between total anatomical muscle mass and midarm and midthigh circumferences were 0.896 and 0.990, respectively, after correction for skinfold thicknesses. An issue that is receiving increasing attention is the role of intramuscular fat (adipose tissue infiltrating muscle groups) in relation to the metabolic complications seen in obesity and type 2 diabetes. A recent imaging study showed that in the thigh, intramuscular fat, and to a lesser degree subfascial fat, were correlated with insulin resistance whereas the larger compartment of subcutaneous fat was not (38). Thus, although we adjusted for subcutaneous fat in our analyses, we could not take into account the intramuscular fat component, which might be most relevant to cardiovascular risk.

In the present study, a low sum of midarm plus midthigh circumferences as well as low trunk and extremity skinfold thicknesses, but not a low sagittal diameter, contributed to increased all-cause and cancer mortality. Low arm circumference and low

TABLE 5
Potential predictors of cancer death in smokers and nonsmokers in the Paris Prospective Study I[1]

	Smokers (n = 4641)		Nonsmokers (n = 2769)	
	β	P	β	P
Age (y)	0.089	0.004	0.014	0.82
No. of cigarettes smoked				
(10–19/d)	0.825	<0.001		
(≥20/d)	1.143	<0.001		
Height (cm)	0.018	0.13	−0.019	0.62
Midarm + midthigh circumferences (cm)	−0.030	0.006	−0.052	0.03
Squared term[2]	1.49×10^{-5}	0.03	2.88×10^{-5}	0.05
Sagittal diameter (cm)	0.062	0.01	0.117	0.02
Trunk skinfold thicknesses (mm)	−0.002	0.63	0.006	0.31
Extremity skinfold thicknesses (mm)	−0.048	0.03	−0.093	0.02
Squared term[2]	6.65×10^{-4}	0.007	9.65×10^{-4}	0.008

[1] Multivariate Cox regression model in which all anthropometric variables were entered as continuous variables.
[2] Second-order polynomial terms were systematically tested and retained in the final model when significant ($P < 0.05$).

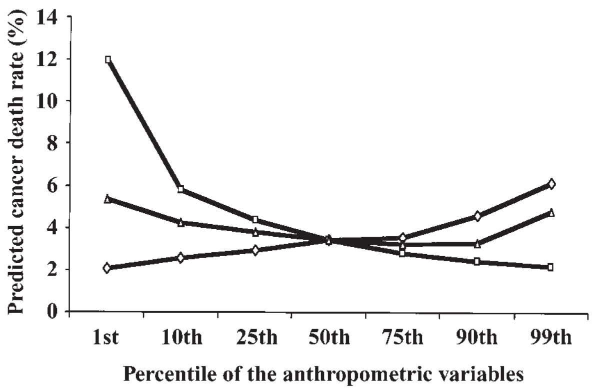

FIGURE 3. Predicted adjusted 15-y cancer death rates from a multivariate Cox model for selected percentiles of sagittal diameter (◇), sum of midarm plus midthigh circumferences (□), and sum of extremity skinfold thicknesses (△) in subjects who smoked 1–10 cigarettes/d. All the variables in the model, except for the one variable being evaluated, were held constant at their mean values. The values of the 1st, 10th, 25th, 50th, 75th, 90th, and 99th percentiles of the anthropometric variables were as follows: 15, 18, 20, 22, 24, 26, and 30 cm for sagittal diameter; 66, 74, 78, 82, 86, 90, and 98 cm for the sum of midarm plus midthigh circumferences; and 13, 20, 24, 30, 37, 44, and 62 mm for the sum of extremity skinfold thicknesses.

triceps skinfold thickness were associated with increased total mortality in elderly subjects (39). In a study of men aged 45–75 y who were followed up for 16 y, triceps skinfold thickness was negatively associated with cancer mortality in smokers and nonsmokers, independent of health status (40). In addition, a recent analysis of data from men born in 1913 in Gothenburg, Sweden, assessed body composition by measuring total body potassium and found that low fat-free mass was associated with increased all-cause mortality (9). Therefore, both low lean body mass and low subcutaneous fat mass appear to contribute to the high cancer mortality associated with a low BMI.

Our results were obtained in a cohort of employed policemen, independently of smoking status, and the results remained unchanged after exclusion of deaths in the first 5 y of follow-up. Therefore, it is not likely that these findings could be explained by the wasting of lean and fat tissue observed in the advanced phase of most chronic diseases. An alternative explanation could be that low muscle and subcutaneous fat masses are markers of adverse lifestyles, such as high alcohol intake, which are associated with all-cause and cancer mortality. Finally, low muscle and fat mass could themselves contribute to reduced immunocompetence and increased mortality risk (7). Subcutaneous fat represents 40–60% of total body fat and could be considered an energy buffer that protects against catabolic stresses and that is lacking when body weight is excessively low, as hypothesized (7).

In this study, accounting for subcutaneous fat in our multivariate model was necessary to uncover the positive relation between intraabdominal fat and cancer mortality risk. Up to their respective 90th percentiles, sagittal diameter increased whereas extremity skinfold thicknesses decreased in relation to cancer death rates (Figure 3). This suggests that cancer mortality risk is associated with a preferential localization of fat in the intraabdominal compartment. However, greater degrees of obesity, represented by both high intraabdominal and high subcutaneous fat masses, may carry a specific cancer risk thereby explaining the rise in the cancer mortality curve at the extremes of the BMI and subcutaneous fat distributions. Other studies in men found associations between indicators of abdominal obesity or fat distribution, such as waist circumference (6) or iliac-to-thigh ratio (17), and mortality from cancer, although negative results have also been reported (28).

In conclusion, data from the present study emphasize that the different components of body mass are related differently to health outcomes. From a clinical perspective, assessment of indicators of body mass compartments may contribute to a better evaluation of an individual's risk for the 2 major causes of premature death in industrialized countries, namely cardiovascular disease and cancer. It is anticipated that the application of more precise field techniques for estimating total and regional body composition will be of great benefit to future epidemiologic and clinical research on the risk of these prevalent chronic diseases.

The Paris Prospective Study I was performed by the Groupe d'Etude sur l'Epidémiologie de l'Athérosclérose (GREA), Paris, which was organized by the Institut National de la Santé et de la Recherche Médicale (INSERM) and the Direction de l'Action Sociale, de l'Enfance et de la Santé (DASES), Paris.

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