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# Anthropometric measurements and body silhouette of women: validity and perception.

B. Tehard<sup>1</sup>, M.J. van Liere<sup>1,2</sup>, C. Com Nougé<sup>3</sup>, F. Clavel-Chapelon<sup>1,\*</sup>.

<sup>1</sup> *Equipe E3N, INSERM U.521, Institut Gustave Roussy, 39, rue Camille Desmoulins 94805 Villejuif Cedex France.*

<sup>2</sup> *Department of Health Care and Disease Control. Royal Tropical Institute, Mauritskade 63, PO Box 95001, 1090 HA Amsterdam. The Netherlands.*

<sup>3</sup> *Université Paris VI, Département de Biostatistique et d'Epidémiologie, Institut Gustave Roussy.*

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## ABSTRACT

**Objective:** To examine the validity of self-reported values for current anthropometric measurements and factors related to misreporting.

**Design:** E3N, a prospective cohort study of cancer risk factors conducted in France, part of the European Prospective Investigation on Cancer. E3N comprises 100,000 women, born between 1925 and 1950, followed with self-administered questionnaires sent every 18 to 24 months starting in 1990.

**Subjects:** 152 women for the validation study of self-reported anthropometric measurements and 91,815 women selected to evaluate factors affecting misreporting of body silhouette.

**Statistical analysis:** Paired *t* tests, Pearson and Spearman correlations were applied to evaluate the validity of self-reported measures, and analysis of variance and logistic regression were used to assess the factors influencing misreporting silhouette.

**Results:** The correlation coefficients between self- and external measurements were very high. All but sitting height ( $r=0.56$ ) were more than 0.80, with weight and bust (nipples) measurements correlation coefficients attaining 0.94. The correlation between body mass index (BMI), measured by the technician and the self-reported silhouette, was 0.78. Small height was always associated with misclassification. Specific factors related to a more favorable perception of body silhouette were being overweight, small height, younger age and a lower level of education. These women were also more frequently unmarried, more physically active and had had a slender body shape during adolescence. Results denoting a less favorable perception of body shape were reversed.

**Conclusion/Applications:** Self-reported measurements (made with or without help) are valid measures in epidemiological studies. Body silhouettes are simple and useful indicators of body mass index. However they should be interpreted with caution in certain instances, especially for overweight subjects.

**Keywords:** weight, height, body mass index, body silhouettes, anthropometric measurements.

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Weight, height and body mass index (BMI) have been studied as risk factors for breast cancer. Some evidence suggests that a greater height and a weight gain in adults increase the risk of breast cancer. A large number of studies have consistently found a relationship between body mass (weight or BMI) and breast cancer risk although consistent findings were more frequently obtained from retrospective than from prospective data (1-3).

In epidemiological studies, and especially in large cohort studies, data are mostly collected through self-administered questionnaire. What we need to know is the accuracy of the self-reported values of the different anthropometric variables of the E3N cohort. The validity of data thus collected was demonstrated in validation studies (4-13) using technician measurements as the reference<sup>1</sup>(14). Several studies established the validity of long-term (as well as short-term) estimates of body weight. Stevens et al. (4) reported

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\* e-mail : [clavel@igr.fr](mailto:clavel@igr.fr)

<sup>1</sup> The choice of technician measurements as the reference is validated by Klipstein-Grobush et al (14) who analysed the reliability of repeated measurements taken either by one or by different technicians; they found a high level of accuracy and reliability of measurements.

correlations between self-reported and measured weight attaining  $r=0.98$  for current,  $r=0.94$  for 4-year and  $r=0.82$  for 28-year recall. Koprowski et al. (5) reported correlations ( $r=0.83$ ) between reported and actual BMI at menarche for young adult women. Some studies (6,7) showed that obese individuals underestimate their weight whereas slender individuals overestimated it. Casey et al. (8) reported correlations between recall of past weight and measured weight, ranging from  $r=0.87$  at 18 years to 0.95 at 40 years when 60-year-old participants of the study were questioned. Manson et al. (9) found a high correlation ( $r=0.96$ ) between weight measurements reported 6 to 12 months previously and current measurements.

Some studies have been published on the validity of other anthropometric parameters such as sitting height, bust, hip and waist measurements by comparing self-measurements and technician measurements. The correlation attained was 0.88 for the waist and 0.89 for the hip in Freudenheim and Darrow's study (10). Weaver et al. (11) found that the accuracy of self-reported measurements of waist, hip, chest and bust circumferences was high (Pearson correlation coefficients more than 0.93) as compared with the same measurements taken by a technician.

Recalling one's body corpulence or giving one's past weight and height is difficult and may generate numerous missing values (12). Body silhouettes such as those introduced by Sørensen et al. (13) allow subjects to be ranked and may avoid the problem of recalling an absolute value such as weight. It is therefore easier to have access to such information. Few studies have assessed the usefulness of these body silhouettes (15-19). Must et al. (16) found high correlations between body silhouettes and measured BMI for females (0.65 at 10 years of age, 0.75 at 15 years, 0.66 at 20 years and 0.75 for current age). Mueller et al. (19) found correlations over 0.92, comparing current body silhouettes to BMI. Thompson and Gray (17) and Gardner et al. (18) criticised the optimality of Sørensen's scale of silhouettes and Thompson and Gray (17) proposed another type of silhouette.

Factors related to misclassification of anthropometric measurements have been reported in the literature and most often concerned the objective of weight loss among dieters or people suffering with eating disorders, although some studies have published data on the general population (20-22).

The first objective of this study was to assess the validity of self-reported measurements of anthropometric characteristics and body silhouette (a simple measure that can be used as a surrogate for measured BMI). We therefore performed a validation study on a small sample of the E3N French cohort. The second objective, based on the whole cohort, was to test the relationship between the body silhouettes chosen by the women questioned and the BMI derived from the self-measured weight and height and to analyse factors related to misclassification of the self-reported body silhouettes.

## MATERIAL AND METHODS.

E3N is a prospective cohort study on cancer risk factors conducted in France and is part of the European Prospective Investigation on Cancer, (EPIC) (23). E3N includes 100,000 women, born between 1925 and 1950, living in France, and insured by a national health insurance plan (MGEN), that mostly covers teachers. The main objective of the study was to investigate relationships between diet and cancer and between hormonal treatments and cancer. The occurrence of cancer and of other diseases (cardiovascular diseases, diabetes and osteoporosis) is recorded prospectively. Participants were entered into the study between June 1990 and November 1991 when they replied to a baseline questionnaire, in which they had to indicate their current weight, height and body silhouettes (Figure). Follow-up questionnaires were sent every 18 to 24 months thereafter. All questionnaires were self-administered.

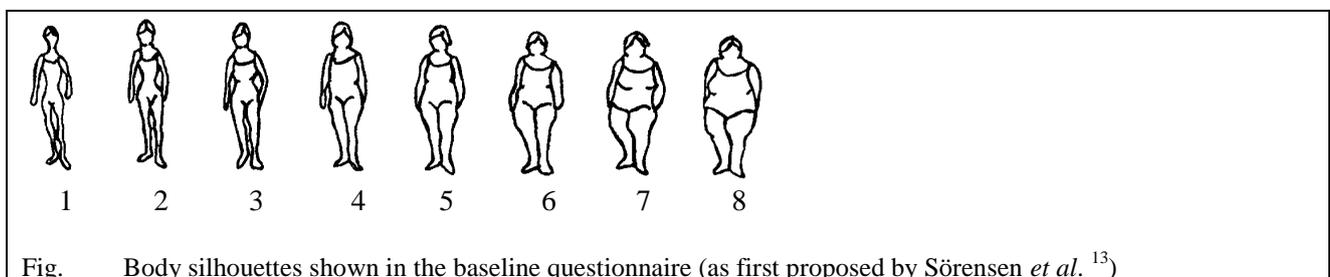


Fig. Body silhouettes shown in the baseline questionnaire (as first proposed by Sørensen *et al.* <sup>13</sup>)

First a validation study was done on a sample of the E3N cohort (186 subjects) who had volunteered to give blood for the biological sample bank. All the 186 women participants were from the Paris center of the E3N cohort as this was more convenient. The day before their appointment at the study center, women had to complete a self-administered questionnaire, reporting their weight, height, sitting height, hip, waist

and bust circumferences and body silhouette. All values were self-reported measurements that women completed with or without help (38% of our participants were assisted for measurements of their sitting height). A skilled technician took the same measurements, with standardised devices. Height and sitting height were measured with the SECA height gauge. Weight was measured with the SECA electronic scales, and all the anthropometric circumferences were measured with a tape measure. The technician also evaluated each woman's body silhouette. The 152 women (82%) who completed the questionnaire represent the validation study sample. Technician measurements were used as the "gold standard" to assess the validity of self-measurements made by study sample participants.

We then studied factors concerning reported silhouettes that differed from those expected, based on the 91,815 women in the E3N cohort who had answered the baseline questionnaire. We first had to determine what the expected, unbiased silhouette of each woman. We used the distribution of the silhouettes estimated by technicians in the validation sample of 152 women. Technicians had to choose between the 8 silhouettes of the scale. When they determined that a woman had to be classified between two adjacent silhouettes they chose the mean of the two silhouettes. No woman of the validation sample had a silhouette over 7, so we decided to create the category "over6". We sorted the 91,815 women of the cohort by increasing BMI, and obtained theoretical limits corresponding to each silhouette. We were thus able to obtain an expected silhouette for each woman that could be compared to the one indicated in the baseline questionnaire. Then we fitted the distribution of silhouettes given by technicians to the cohort and obtained an "expected" silhouette to each woman. We compared this "expected" silhouette to the one reported by the women at the baseline. For the 11,607 women chose two adjacent silhouettes, we allocated the mean between the chosen silhouettes. We classified a woman's self-reported silhouette as "realistic" when the difference between the two silhouettes was between -1 and 1. Others were declared "higher" if the expected silhouette was greater than the reported one, and "lower" in the other case.

### **Statistical analysis**

First, to validate our data set of anthropometric measurements, we used two statistics to compare measurements made by the 152 women with the ones made by the technicians: the Student's paired *t* test and Pearson correlation. The first statistic evaluated the likelihood of a constant bias of women self-measurements by comparing both means. The second statistic evaluated the linearity of the relationship between self-measurements and technicians' measurements (24). Body silhouettes were classified from 1 to 8 (from the thinnest to the heaviest). Pearson correlation coefficients were used to compare BMI and body silhouettes distributions and to compare the distribution of silhouettes chosen by technicians and by women.

On the whole cohort, the relationship between self-measured BMI and body silhouettes was analysed with an analysis of variance for multiple comparisons. We then computed odds-ratios (OR) of the frequency of the "higher" and of the "lower" women as compared with the "realistic" women for each of the indicators studied. Two logistic regressions using the same control group, were used to obtain adjusted OR estimates together with 95% confidence intervals. In both regressions, the reference was the "realistic" women who were compared with "higher" women and then to their "lower" counterparts. Terms for the educational level, year of birth, weight, height, marital status, body silhouette at menarche, physical activity level and dietary factors were included in the regressions. Statistical analysis were performed with SAS (Release 6.12; SAS Institute, Cary, NC).

### **RESULTS**

First we compared the validation sample to the whole cohort (results not presented). All 152 women in the validation study had volunteered to have a blood sample drawn for the biological sample bank in the Paris center. There was no difference observed in age. Their education had lasted longer and they had higher incomes ( $P < .001$ ). They were more frequently single ( $P < .02$ ).

#### **Validation study (152 subjects).**

No significant differences were observed between self-reported and technicians-measured mean values for weight, height and BMI (Table 1). Significant differences ( $P < .05$ ) were observed between self-reported and technician's mean values for sitting height, hip and bust (nipples) measurements. No difference exceeded 1.1 centimetre.

For all continuous variables (except for body silhouettes), the correlation coefficients between self-reported and technician measurements were between 0.56, for sitting height, and 0.94, for weight and bust (nipples). All the correlation coefficients statistically differed from zero. The correlation coefficients were

very high for weight, height and BMI (0.89, 0.94 and 0.92 respectively). The relations between self-reported and technician measurements were almost linear for these parameters.

The average body drawing was between image 3 and 4, for both the self- and technician evaluations, and the absolute difference between the two measurements was one drawing or less for 90% of the subjects. Correlation coefficients between body silhouette and BMI vary from 0.77 for self measurements to 0.87 for technicians' measurements; both differed significantly from zero. These correlations showed a real positive and linear trend between BMI and body silhouettes.

**Table 1. Relation between anthropometric parameters, as measured by subjects themselves and as measured by a skilled technician (N=152).**

Anthropometric measurements	N	Measurements by		P <sup>b</sup>	Correlation coefficient <sup>c</sup>
		Subject Mean ± Sd	Technician Mean ± Sd		
Weight (kg)	150	61.9 ± 10.4	61.7 ± 10.4	NS	0.94
Height (cm)	150	161.4 ± 6.4	161.0 ± 6.1	NS	0.89
Sitting Height (cm)	128	84.2 ± 11.5	85.3 ± 3.6	<.01	0.56
Hip Circumference (cm)	151	97.7 ± 9.8	98.7 ± 8.2	<.01	0.90
Waist Circumference (cm)	150	77.7 ± 10.6	77.1 ± 10.3	NS	0.79
Bust Circumference (base) (cm)	149	81.0 ± 7.2	81.5 ± 7.6	NS	0.83
Bust Circumference (nipples) (cm)	149	94.0 ± 8.2	93.4 ± 8.4	<.05	0.94
BMI <sup>d</sup>	149	23.81 ± 3.8	23.79 ± 3.8	NS	0.92
Silhouette	151	3.65 ± 1.1	3.46 ± 1.1	<.05	0.85

<sup>a</sup>SD= standard deviation

<sup>b</sup>p value: Student's t-test for paired samples: H<sub>0</sub>: means are equal.

<sup>c</sup>Pearson correlation coefficient: H<sub>0</sub>: the correlation coefficients are equal to zero. All correlations were significantly different from zero (p-value < 0.0001).

<sup>d</sup>BMI defined as weight (kg)/height (m<sup>2</sup>).

### Self-administered questionnaire (91,815 subjects).

The respective mean BMIs (calculation based on the whole cohort) of each expected silhouette from the thinnest to the largest were 16.4, 18.7, 21.3, 24.1, 26.0 and 30.3 and 37.4 for the category "over 6" (only mean for exact silhouette are shown). The value of each category was significantly different from that of other category ( $P < .0001$ ).

We studied the factors related to a woman's missperception of her own silhouette. Overall, 93.1% of women had a realistic perception of their silhouette (Table 2). Misclassification increased with increasing size of silhouette and small height. The logistic regression (Table 3) showed that women who considered their body silhouette favourably were heavier, shorter, younger and had a lower level of education than women with a more realistic perception of their body image. They were also more frequently unmarried, more physically active and had had a slender body silhouette during adolescence. Results denoting a "lower" perception of body silhouette were reversed.

**Table 2. Repartition of the misclassification of the observed silhouette, according to the "Expected" silhouette, for the women of the E3N cohort (n=91,815).**

"Expected" body silhouette	N	Lower		Realistic		Higher	
		N	%	N	%	N	%
1	632	24	3.8	608	96.2	0	0.0
1.5 <sup>b</sup>	1,259	98	7.8	1,161	96.2	0	0.0
2	6,991	67	1.0	6,867	98.2	57	0.8
2.5	8,405	182	2.2	7,899	94.0	324	3.8
3	34,509	532	1.5	33,677	97.6	300	0.9
3.5	9,733	432	4.4	9,014	92.6	287	3.0
4	15,024	210	1.4	14,545	96.8	269	1.8
4.5	1,049	17	1.6	890	84.8	142	13.6
5	5,925	18	0.3	5,255	88.7	652	11.0
5.5	3,233	27	0.8	2,033	62.9	1,173	36.3
6	4,419	11	0.3	3,518	79.6	890	20.1

<6	636	0	0.0	0	0.0	636	100
Total	91,815	1,618	1.8	85,467	93.1	4,730	5.1

<sup>a</sup>Expected body silhouette was found fitting the distribution of the silhouette estimated by technicians, on the validation sample, to the whole cohort sorted by increasing BMI.

<sup>b</sup>intermediate silhouettes in case of two adjacent choices.

Table 3. Factors associated with a pessimistic reported silhouette from that expected according to an external reference.

Factors	Realistic <sup>a</sup> % (n=85,467)	Lower % (n=1,618)	Adjusted-OR <sup>b</sup> (95% CI)	Higher % (n=4,730)	Adjusted-OR <sup>b</sup> (95% CI)
<b>Education level (years)</b>					
≤ 9	12.5	10.0	0.86 (0.72-1.03)	25.0	1.45 (1.33-1.58)
10-16	70.0	69.5	1.00	63.0	1.00
≥ 17	17.5	20.5	1.10 (0.97-1.25)	12.0	0.94 (0.85-1.03)
<b>Year of birth</b>					
After 1945	31.0	22.0	1.00	23.5	1.00
1941-45	25.0	26.0	1.46 (1.27-1.69)	23.5	0.98 (0.89-1.07)
1936-40	20.5	21.0	1.47 (1.27-1.72)	21.5	0.92 (0.83-1.01)
Before 1935	23.5	31.0	2.05 (1.77-2.36)	31.5	0.89 (0.81-0.97)
<b>Height (cm)</b>					
≤ 154	9.0	12.0	1.23 (1.03-1.46)	13.0	3.16 (2.82-3.54)
155-159]	23.0	28.0	1.29 (1.13-1.49)	23.0	1.61 (1.47-1.76)
160-164]	35.5	31.5	1.00	34.0	1.00
165-169]	23.0	20.5	1.11 (0.96-1.28)	20.0	0.57 (0.53-0.63)
≥ 170	9.5	8.0	1.23 (1.00-1.51)	10.0	0.42 (0.38-0.47)
<b>Weight (kg)</b>					
≤ 54	33.5	35.0	1.00	1.5	1.00
55-59]	26.0	31.0	1.09 (0.96-1.24)	6.5	1.09 (0.95-1.26)
60-64]	20.0	20.0	0.90 (0.78-1.05)	10.5	2.64 (2.32-3.01)
65-69]	11.0	9.0	0.69 (0.56-0.83)	19.5	9.67 (8.60-10.88)
≥70	9.5	5.0	0.37 (0.29-0.48)	52.0	32.95 (29.49-36.81)
<b>Ever married</b>					
Yes	79.0	75.5	1.00	75.5	1.00
No	21.0	24.5	1.08 (0.96-1.22)	24.5	1.20 (1.11-1.29)
<b>Physical Activity</b>					
Low	26.0	32.0	1.00	24.0	1.00
Moderate	25.0	26.5	0.84 (0.74-0.96)	23.5	1.15 (1.05-1.26)
Reasonable	24.0	22.5	0.73 (0.64-0.84)	23.0	1.15 (1.04-1.26)
High	25.0	19.0	0.60 (0.52-0.69)	29.5	1.29 (1.18-1.41)
<b>Body Silhouette at age 8<sup>c</sup></b>					
1	56.5	45.5	1.00	60.5	1.00
2	20.0	15.5	1.01 (0.87-1.16)	18.5	0.79 (0.72-0.85)
3	13.0	14.0	1.43 (1.22-1.66)	12.5	0.67 (0.61-0.74)
4	8.0	14.5	2.54 (2.18-2.95)	6.0	0.48 (0.42-0.54)
5	2.0	6.5	4.78 (3.86-5.91)	1.5	0.45 (0.35-0.58)
≥ 6	0.5	4.0	11.18 (8.51-14.69)	1.0	0.64 (0.45-0.93)

<sup>a</sup>Control group.

<sup>b</sup>Ratio of the probability of having estimated one's body silhouette "lower" or "higher."

<sup>c</sup>Silhouettes were coded in the upper category in case of two adjacent choices.

## DISCUSSION.

### Validation study.

The results of the validation study of self-reported anthropometric measurements were quite satisfactory although a potential limitation is a lack of statistical power due to the limited number of subjects included. Nevertheless, the differences observed between the two measurements (self-reported or taken by technicians) were small and the correlation coefficients ranged from 0.8 to 0.9 except for that concerning the sitting height. No significant difference was shown for height, weight, BMI, waist and bust (nipples) circumference. Self-reported measurements for these variables may thus be considered accurate and unbiased.

The relatively low correlation coefficient for sitting height was probably due to the fact that this fairly unusual measurement is not easy to obtain without help. Correlation coefficients for height and weight

were comparable to those reported in other studies (4,8,9,25-27) whereas paired differences for these parameters were smaller in our study (0.4 cm and 0.2 kg) compared to 1.6 cm and 1.1 kg in the study by Stewart et al. (25), and with 0.9 cm and 2.4 kg in the study by Palta et al. (26). Jacobson and DeBock (27) found no difference for height, but found significant differences for weight and BMI for women. Moreover we found high correlation coefficients for waist and hip measurements as well as for measurement of the bust (base and nipples). These are encouraging results because they are linked to the fat distribution for women and we know that this distribution is another potential anthropometric risk factor for cancer.

The relationship between body drawings and BMI is linear in shape, with differences between drawings representing about 2 or 3 units of BMI. The correlation coefficient between BMI and silhouette was similar to that of previous studies (13,16,19,28,29).

Mueller et al. (19) used Sørensen's silhouettes to compare estimates provided by two experts and one nonskilled observer. A lower correlation was observed in studies of men comparing to women, possibly because the silhouettes depicted typical female fat distribution patterns. This problem may also arise for women with an android body composition and who have an android hormonal profile that may be related to higher risk of breast cancer (30,31). Indeed, in our study, correlation between BMI and body silhouette was lower for women with a breast-to-hip ratio equal to or greater than one, than for women with a breast-to-hip ratio smaller than one ( $r=0.56$  vs  $0.73$ ).

Our study showed mean-BMI rounded values of 18, 20, 22, 24, 27 and 30 for the 7 category of self-reported silhouettes, based on data from more than 90,000 French women, ranging in age from 40 to 65 (mean age=49 years). These values are somewhat different from those reported in Mueller et al.'s study (19). The differences may be attributable to dissimilarities in interpretation due to age, gender and socio-educational or cultural references, as shown in some studies (6,20,21,32). Self-reported measurements in our study are likely to be more precise, however, because of the size of the study population and more accurate due to its homogeneity in terms of sex, age and educational level.

Gardner et al. (18), however, voiced methodological concerns about the use of silhouette figures to measure body images. These concerns are related to limited response options to one of a finite number and a limited range of silhouettes (the majority of subjects selected a very small range of silhouettes). The fact that women and technicians expressed the necessity to choose adjacent silhouettes when they were unable to fit to one of the 8 silhouettes support this point. However, silhouettes are used in epidemiological studies on cancer risk factors to rank subjects and to isolate outsiders, and Sørensen's silhouettes are the most used one. Gardner et al (18) also emphasised that changes in size between adjacent silhouettes are not proportional. One can legitimately argue that weight is not gained uniformly in the different body regions.

### **Self-administered questionnaire (91,815 subjects).**

The relatively low correlation coefficient obtained for the body silhouette in the results of the validation study prompted us to investigate which factors characterized a "higher" perception of a woman's body image. We found that correlation coefficients between self-reported and technician measurements were higher for almost all continuous variables (height, weight, BMI), than for categorical variables. We investigated this relationship to assess whether weaker correlations could be explained by the discrete nature of the variable, or by the fact that whereas height or weight are strictly unbiased measures, self-perception of one's silhouette is subjective and this can generate errors if women have a false self-perception (due to eating disorders, social status, social ideal of silhouettes, etc). The main problem for this investigation was undoubtedly finding a good correspondence between a given silhouette and the associated BMI, that would be adapted to a cohort of highly educated French women and that would be totally unbiased. Using the statistics calculated from the data of the validation study, we were able to perform an appropriate logistic regression analysis in which the explained variable (discrepancy in the perception of the body image between the subject and the observer) was constructed independently of the values of the variables included in the regression (in particular self-reported weight and height measurements).

The sample from which the expected body silhouette was constructed may be considered as unrepresentative of the population on which the logistic regression was done. The same analysis was also done on two other sets of data. One was composed of all the women who had volunteered to have a blood sample drawn in the Paris center ( $n=8,000$ ) and the other, of all blood donors ( $n=25,000$ ). The results (data not shown) were rigorously similar, except for the variable generation, which did not differ from unity, however.

Our study demonstrates that self-perception of the body silhouette was "higher" among women who were overweight. Interestingly, women who had experienced such weight problems during adolescence had a more realistic appreciation of their current body image.

Previous studies have demonstrated that heavy people underestimated their size to a greater degree than women of a normal weight (6,7,33-39). Chang and Christakis (34), Niedhammer et al. (38) and Rossouw et al. (39) found that misperception of weight was linked to age and level of education.

## APPLICATIONS/CONCLUSION

The results of our study indicate that responses to questions on anthropometric measurements provide information almost as accurate as if measurements had been done in a medical center. This represents an important gain of time and money concerning all cohort studies which base data collection on self-administered questionnaires. Body silhouettes are valuable proxy indicators for BMI, especially in situations where weight and height values cannot be obtained. However, self-assessments should be interpreted with caution in certain instances, especially for overweight subjects.

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