ORIGINAL PAPER

Nagoya J. Med. Sci. **70**. 89 ~ 96, 2008

DEVELOPMENT AND VALIDITY OF THE JAPANESE VERSION OF BODY SHAPE SILHOUETTE: RELATIONSHIP BETWEEN SELF-RATING SILHOUETTE AND MEASURED BODY MASS INDEX

KEN NAGASAKA, KOJI TAMAKOSHI, KUNIHIRO MATSUSHITA, HIDEAKI TOYOSHIMA and HIROSHI YATSUYA

Department of Public Health/Health Information Dynamics, Field of Social Life Science, Nagoya University Graduate School of Medicine, 65 Tsurumai-cho, Showa-ku, Nagoya 466-8550, Japan

ABSTRACT

We devised new body shape silhouettes to more accurately reflect Japanese body sizes. Our aim was to assess the association between measured body mass index (BMI) and body size through self-selection of nine figure scales. This study was comprised of 4808 men and 1093 women aged 35–71 years. Subjects were asked to identify the silhouettes that most accurately represent their current body size. BMI was calculated from measured height and weight based on annual health checkups. Spearman's correlation coefficients between silhouette ratings and BMI were 0.73 in men and 0.80 in women. Moreover, mean BMIs increased in value with increasing silhouette numbers in both genders (trend $p < 0.01$ for both). Simple linear regression models predicting BMI based on silhouette ratings showed a good fit, with silhouette self-selection statistically explaining 54.0% of BMI variance in men and 62.5% in women. Receiver operating curves showed that areas under the characteristics curves were higher than 0.8 for obesity and thinness in both genders. These findings suggest that our scale is a promising tool for examining body size and image among Japanese adults.

Key Words: Body shape silhouette, Validity, Body size, Body mass index, Japanese

INTRODUCTION

Standard body silhouettes were introduced by Stunkard *et al.*[1] as an easy-to-administer self-reported measure of body image. They can be useful as an adjunct to measured or self-reported height and weight in defining overweight and obesity in different settings; for example, in developing countries where clinical equipment such as scales and height gauges might not be readily available. They also show promise as a means of estimating body size in childhood or that of deceased individuals (e.g., parents). Recently, the disparity between actual and desired body size has been interpreted as a measure of body dissatisfaction,[2] which has been associated with weight-control efforts.[3,4]

Few studies have assessed the association between measured BMI and body silhouettes. The

Corresponding author: Koji Tamakoshi
Department of Public Health/Health Information Dynamics, Field of Social Life Science,
Nagoya University Graduate School of Medicine, 65 Tsurumai-cho, Showa-ku, Nagoya 466-8550, Japan
Phone: +81-52-744-2128, Fax: +81-52-744-2131, E-mail: tamako@med.nagoya-u.ac.jp

available literature, which refers mostly to BMI derived from self-reported height and weight, deals primarily with Caucasian populations.[5,6] The accuracy of self-reported height and weight has been investigated by some researchers; generally, height is overestimated and weight is underestimated, thus causing BMI to be underestimated.[7-9] Since it is known that there are differences in the way populations perceive their body size,[10-13] it would be unwise to apply these data to non-Caucasian populations. In addition, the silhouettes based on Caucasians would be not suitable for Japanese subjects, most of whom differ from them in body size.

Therefore, we modeled a new body shape instrument along with those already validated. The purpose of this study is to evaluate the correlation between self-rating body size and BMI derived from measured height and weight in adult Japanese men and women, which is the first step in understanding how body image perception impacts obesity-related health behaviors.

METHODS

Population

Our investigation was conducted as part of a cohort study on cardiovascular disease which started in 1997. The participants were public servants in a workplace in Aichi prefecture, Japan, who underwent an annual physical examination including measurements of height and weight. In 2005, 4808 men and 1093 women aged 35–71 years were requested to answer a self-administered questionnaire about body size. Current body size and both current height and weight were obtained from 4707 men and 964 women, all of whom gave their informed consent to the use of their personal information for analysis.

The study protocol was approved by the Ethics Review Committee of the Nagoya University School of Medicine, Nagoya, Japan.

Anthropometric data

Height and weight were measured when subjects were dressed in light indoor clothing and without footwear. Height was measured to the nearest 0.1 cm, and weight to the nearest 0.1 kg. BMI was calculated as weight in kg divided by height in m squared. Obesity was defined as BMI $\geq$ 25, and thinness as BMI < 18.5 according to the criteria recommended by the Japan Society for the Study of Obesity.[14]

Silhouettes of adult men and women figures were used for rating participants' self-selected body size. We modified Stunkard's widely recognized nine-figure scale to more faithfully represent the shape of Japanese subjects (Fig. 1). When Stunkard's silhouettes were used, some studies reported that mean BMI corresponding to silhouette 5, which is the median silhouette in 9, was higher than 25.[6,15] Since the proportion of obesity (BMI $\geq$ 25) in Japanese is low, Stunkard's silhouettes were a poor fit. Therefore we modeled a new body shape instrument comprised of thinner silhouettes than Stunkard's. Participants were shown an array of nine adult body sizes representing their gender and were asked to identify the figure that most accurately represented their own current body size; 'Which silhouette is closest to your usual appearance.' Each of the nine figures was rated from 1 to 9, with 1 representing the most slender figure and 9 the heaviest.

Statistical analysis

Separate analyses were made for each gender. Mean, median, standard deviations, and 95% confidence intervals were used to describe the general characteristics of the samples. One-way analysis of covariance with polynomial contrast in an SPSS statistical package (SPSS Inc.,

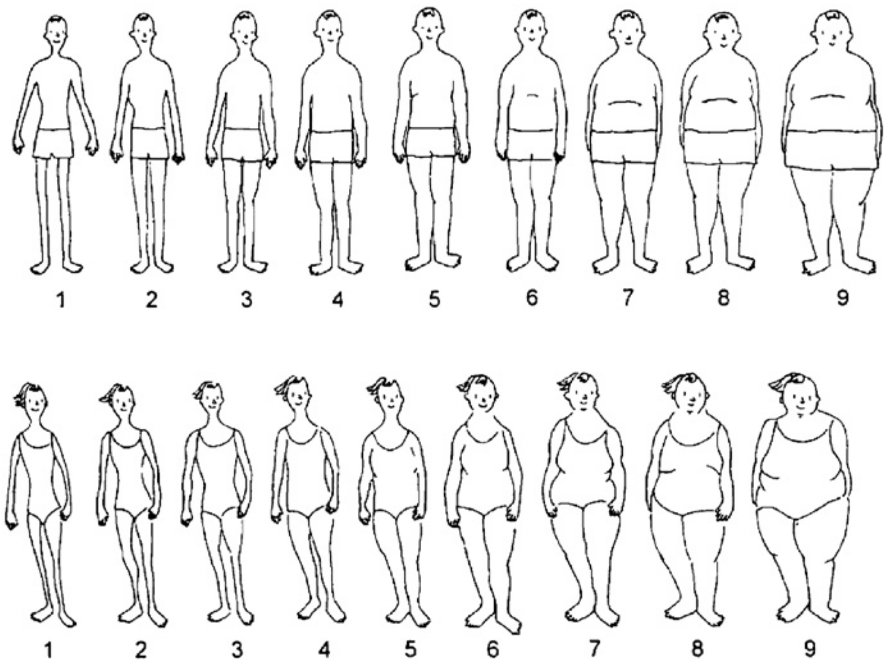

Fig. 1 Male and female body image instrument.

Chicago, IL) was used to evaluate statistical differences and trends in BMI across all 9 silhouette categories. Polynomial contrast subcommand estimated linear trends across all figure categories. Spearman correlations were calculated between silhouette ratings and BMIs. A simple linear regression analysis was used to estimate BMI values by assuming silhouette categories to be equally spaced ordinal variables. Receiver operating curves (ROC) were generated, and the area under the ROC (AUC) was used to determine how well the silhouettes perform in predicting obesity and thinness. All analyses were conducted using the SPSS statistical package for Windows Version 12.0; $p < 0.05$ was considered statistically significant.

RESULTS

The correlations between BMI and figure ratings were 0.73 for men and 0.80 for women (0.79 for both men and women in the <30-years age group, 0.73 for men and 0.80 for women in the 40 to 49-years age group, 0.72 for men and 0.78 for women in the 50 to 59-years age group, and 0.77 for men and 0.71 for women in the ≥60-years age group). Table 1 presents the general characteristics of the participants. The mean BMI values for men and women were 23.3 (SD = 2.8) and 21.5 (SD = 2.9), respectively. With regard to the selected silhouettes, the median corresponded to silhouette 5 for both genders.

Table 2 presents the sample distributions by gender according to the self-selected silhouettes, and their corresponding BMI values (mean and 95% confidence intervals). Mean BMIs increased in value with increasing silhouette numbers in both genders (trend $p < 0.01$ for both). The model silhouette chosen by men was number 6, which corresponded to a mean BMI of 24.1, while the one chosen by women was number 4, which corresponded to a mean BMI of 20.2.

Simple linear regression equations were calculated for men and women. The statistical models for predicting BMI based on silhouette selection were statistically reliable in both genders ($p < 0.01$ for both). The results show that it is possible to predict BMI from silhouette self-selections. The equations obtained were:

for men: $y = 16.283 + 1.347x$

for women: $y = 13.888 + 1.654x$

where y is the BMI value and x is the silhouette number (from 1 to 9). The coefficient of determination r^2 indicates that 54.0% of the BMI variance in men and 62.5% in women are statistically explained by silhouette self-selection. The respective beta values for the silhouettes are higher in women than in men (1.654 vs. 1.347 BMI units per silhouette change). The differences between estimated and actual BMI were generally small (less than 0.5 kg/m^2) in

Table 1 Characteristics of the study population, by gender.

Variables	Mean	SD	Min.	Percentile 25	Percentile 50	Percentile 75	Max.
Men (n = 4707)							
Age (years)	48.6	7.2	35	43	50	55	71
Height (cm)	169.0	5.6	144.0	165.0	169.0	172.7	198.0
Weight (kg)	66.7	9.1	41.6	60.5	66.0	72.0	132.0
BMI	23.3	2.8	15.3	21.5	23.1	24.9	39.2
Silhouettes	–	–	1	4	5	6	9
Women (n = 964)							
Age (years)	46.9	7.5	35	40	47	53	64
Height (cm)	156.6	5.3	137.0	153.0	156.7	160.0	173.0
Weight (kg)	52.7	7.4	35.0	48.0	52.0	56.6	96.6
BMI	21.5	2.9	14.4	19.5	21.1	23.0	39.2
Silhouettes	–	–	1	4	5	5	9

Table 2 Number, Mean BMI and 95% confidence intervals of subjects according to silhouette.

Silhouettes	n	%	BMI Lower 95% CI	BMI Mean	BMI Upper 95% CI
Males					
1	57	1.2	17.6	18.1	18.5
2	192	4.1	19.3	19.6	19.8
3	423	9.0	20.3	20.5	20.6
4	683	14.5	21.6	21.7	21.8
5	1025	21.8	22.8	22.9	23.0
6	1455	30.9	24.0	24.1	24.2
7	682	14.5	25.7	25.9	26.0
8	161	3.4	27.6	28.0	28.4
9	29	0.6	29.9	31.2	32.5
Females					
1	8	0.8	15.6	16.5	17.4
2	46	4.8	17.8	18.1	18.5
3	143	14.8	19.0	19.2	19.4
4	273	28.3	20.0	20.2	20.3
5	257	26.7	21.7	21.8	22.0
6	153	15.9	23.5	23.9	24.2
7	64	6.6	25.2	25.9	26.6
8	17	1.8	26.4	28.4	30.5
9	3	0.3	22.1	32.3	42.5

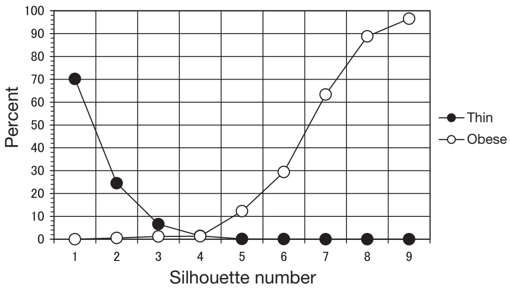

Fig. 2 Percent of Obese (BMI ≥ 25) and Thin (BMI < 18.5) Men by Silhouette.

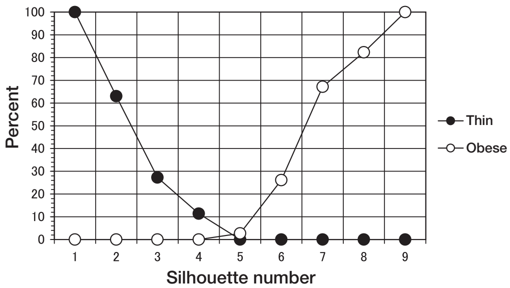

Fig. 3 Percent of Obese (BMI ≥ 25) and Thin (BMI < 18.5) Women by Silhouette.

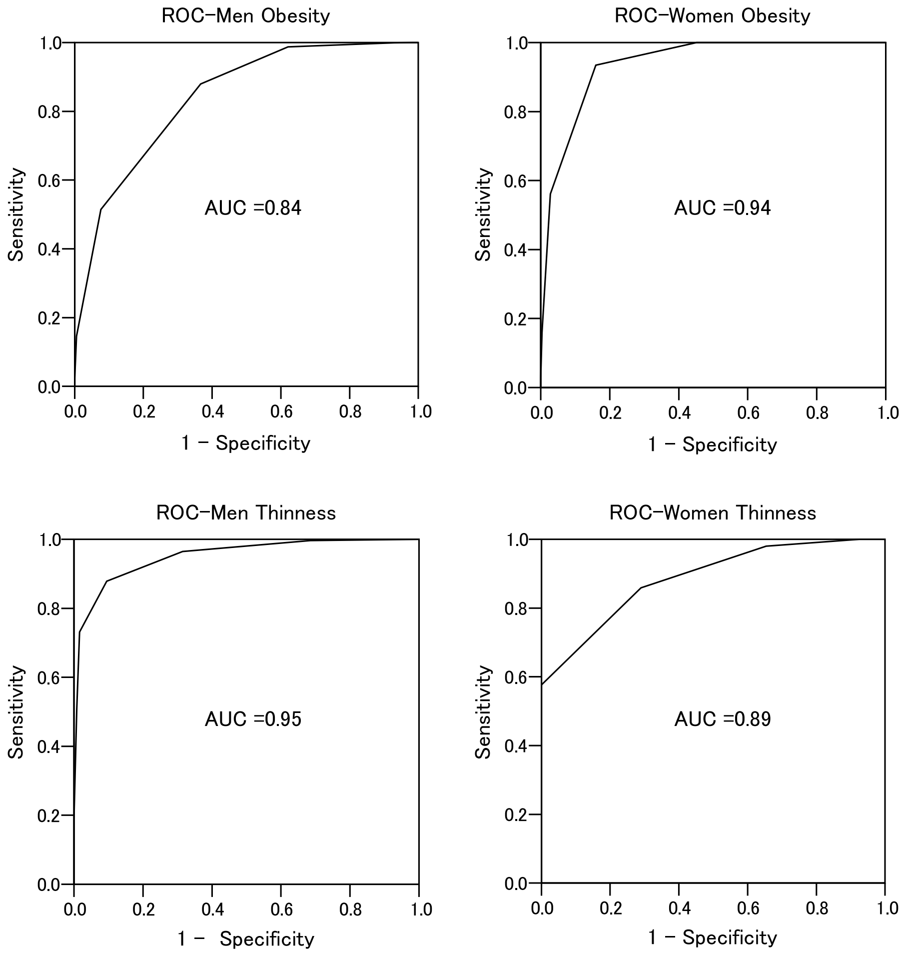

Fig. 4 Receiver operating curves for obesity and thinness in men and women.

both genders, except for number 9. Men who selected silhouette 9 had a mean BMI of 31.2 compared with 28.4, based on the regression model. The same finding was observed in women; while a mean BMI of 32.3 was calculated for those who selected silhouette 9, the BMI derived from the model was 28.8.

Figures 2 and 3 present the percentage of men and women, respectively, who are thin (solid) or obese (empty) in each silhouette category. These figures indicate that, with very few exceptions, both men and women who selected silhouette 8 or 9 as representative of their body size were indeed obese. In women, the accuracy at the lower end of the scale is clear. On the other hand, it is less clear in men, with about 70% of subjects who selected silhouette 1 actually meeting the criterion for thinness.

Figure 4 presents the ROC curves for obesity and thinness in both genders. The silhouettes perform quite well in correctly classifying individuals as obese [AUC (95% confidence interval) = 0.84 (0.83–0.85) and 0.94 (0.92–0.96) for men and women, respectively] or thin [AUC (95% confidence interval) = 0.95 (0.94–0.97) and 0.89 (0.86–0.91) for men and women, respectively].

DISCUSSION

We modeled the new body shape instrument to accurately reflect the body size of the Japanese population. The self-selected body silhouettes were significantly and positively associated with actual BMIs among men and women. The statistical models for predicting BMI based on silhouette selection also fit in both sexes. These findings indicate that self-rating body size using our instrument corresponds to the individual's BMI value. Furthermore, silhouettes showed a high rate of accuracy in identifying obese and thin individuals, as shown by the AUC values higher than 0.8.

Our data suggest that there are good correlations between silhouette ratings and BMIs (r = 0.73 for men and r = 0.80 for women), with higher correlations in women. When Stunkard's silhouettes were used, Fitzgibbon *et al.*[10] reported correlations of 0.69–0.77 in non-treatment-seeking community groups of Caucasians, African Americans, and Hispanics. Bulik *et al.*[6] found high correlations among Caucasians (r = 0.81 for men and r =0.73 for women) through polyserial correlations of the log of BMI and the silhouettes, while Kaufer-Horwitz *et al.*[15] also showed high correlations in Mexican subjects (r = 0.702 for men and r = 0.766 for women).

In our study, silhouette self-selection statistically explained 54.0% of the BMI variance in men and 62.5% in women. Using Stunkard's silhouettes, the Bulick *et al.*[6] coefficient of determination was similar to ours (53.3% in men and 65.6% in women), while that of Kaufer-Horwitz *et al.*[15] was slightly lower than ours (49.3% in men and 58.7% in women).

The accuracy of our body shape silhouettes for the identification of obesity and thinness was also high in both men and women, as shown by the AUC values in the ROC curves (higher than 0.8 overall). When Stunkard's silhouettes were used, Bulick *et al.*[6] reported that the AUC values for obese (BMI ≥30) were 0.88 for men and 0.93 for women, while those for thin (BMI < 20) were 0.88 and 0.87, respectively. Kaufer-Horwitz *et al.*[15] also showed a high degree of accuracy for detecting overweight (BMI ≥ 25) and obese (BMI ≥ 30) in both men (AUC = 0.85 for overweight and AUC = 0.84 for obese) and women (AUC = 0.89 for overweight and AUC = 0.86 for obese). These findings support the validity of our scales. However, in Japan, body shape silhouettes will not need to be used in diagnosing individuals as obese or thin since each measured height and weight is usually available.

In some respects, as mentioned above, our body shape instruments can stand comparison with Stunkard's silhouettes for Caucasians and have proven useful in detecting individual Japanese body shapes.

Our study has two primary strengths. First, it includes a large sample of 4707 Japanese men and 964 women. Second, we used measured rather than self-reported height and weight, since self-reported values are known to underestimate BMI in Japanese as well as Western subjects.[9)]

Several notable limitations of the current study need to be kept in mind when interpreting these data. First, our subjects were relatively homogeneous. We devised the new body shape instrument in consideration of the body size of the Japanese population. However, given that our subjects were public servants in a workplace, our data may not be representative of the Japanese population as a whole, since BMI and the perception of body size differ across socio-economic groups and between urban and rural populations.[16,17)] Further research needs to be done among other workplaces and communities in Japan. Second, we had a low percentage of subjects selecting silhouettes number 1 or 9 (1.8% for men and 1.1% for women), making it necessary to treat information regarding those two silhouettes with extra care. The discrepancy between the actual mean value of BMI and the value estimated by the regression model was large, especially among those subjects who selected silhouette 9. We mainly examined concurrent validity (the degree to which predictions made by a test are confirmed by corresponding measures). We also need to evaluate interrater reliability (consistency among independent ratings using the same test), and convergent validity (how strongly observer ratings of body size correlated with one another and with participants' ratings.). Finally, we also need to examine potential factors associated with the validity of our scale, including age, BMI, and so on.

Despite these limitations, the silhouette approach may prove valuable in providing health advice to individuals. A few previous studies have reported that body image discrepancy (BD: the difference between the actual and ideal body image) was a variable associated with weight-control efforts.[3,4)] White women who reported higher body dissatisfaction were less likely to be successful on a diet and exercise program than those with lower levels of BD.[3)] Additionally, black women with lower levels of BD were more apt to engage in healthful eating and exercise than those with higher levels.[4)] These findings suggest that overcoming body dissatisfaction may prevent obesity and related health risks.

In summary, we modeled a new body shape instrument for Japanese adults. Our self-selected body silhouettes were designed to correspond to the individual's BMIs, and our silhouette method identified obesity and thinness with a high degree of accuracy. However, the present study is only the first step in understanding how body image perception impacts obesity-related health behaviors. A subsequent assessment of the potential of our instrument as a health-education tool is needed.

ACKNOWLEDGEMENTS

The authors wish to express their sincere appreciation to the participants, and to the healthcare personnel of the local government office. We are grateful to Ms. Yoriko Matsushita for her technical assistance in drawing the body shape silhouettes. We also wish to thank Ms. Kuniko Takihi and Ms. Tomoko Kameyama for their valuable support. This work is supported in part by grants to Hideaki Toyoshima (17390185), Koji Tamakoshi (18590594), and Hiroshi Yatsuya (17790384) from the Japanese Ministry of Education, Culture, Sports, Science and Technology and the Japan Atherosclerosis Prevention Fund (JAPF).

REFERENCES

1) Stunkard A, Sørensen TI, Schulsinger F. Use of the Danish Adoption Register for the Study of Obesity and Thinness. In *Genetics of Neurological and Psychiatric Disorders*, edited by Kety SS, Rowland LP, Sidman RL, Matthysee SW. pp. 115–120, 1983, Raven Press, New York.
2) Fallon AE, Rozin P. Sex differences in perceptions of desirable body shape. *J Abnorm Psychol*, 1985; 94: 102–105.
3) Kiernan, M, King, A, Kraemer, H, Stefanick, M, Killen, J. Characteristics of successful and unsuccessful dieters: an application of signal detection. *Ann Behav Med*, 1998; 20: 1–6.
4) Flynn KJ, Fitzgibbon M. Body images and obesity risk among black females: a review of the literature. *Ann Behav Med*, 1998; 20: 13–24.
5) Madrigal-Fritsch H, de Irala-Estévez J, Martínez-González MA, Kearney J, Gibney M, Martínez-Hernández JA. The perception of body image as a qualitative approach to nutritional status. *Salud Publica Mex*, 1999 (in Spanish); 41: 479–486.
6) Bulik CM, Wade TD, Health AC, Martin NG, Stunkard AJ, Eaves LJ. Relating body mass index to figural stimuli: population-based normative data for Caucasians. *Int J Obes Relat Metab Disord*, 2001; 25:1517–1524.
7) Kuskowska-Wolk A, Bergström R, Boström G. Relationship between questionnaire data and medical records of height, weight and body mass index. *Int J Obes Relat Metab Disord*, 1992; 16: 1–9.
8) Hill A, Roberts J. Body mass index: a comparison between self-reported and measured height and weight. *J Public Health Med*, 1998; 20: 206–210.
9) Wada K, Tamakoshi K, Tsunekawa T, Otsuka R, Zhang H, Murata C, Nagasawa N, Matsushita K, Sugiura K, Yatsuya H, Toyoshima H. Validity of self-reported height and weight in a Japanese workplace population. *Int J Obes (Lond)*, 2005; 29: 1093–1099.
10) Fitzgibbon ML, Blackman LR, Avellone ME. The relationship between body image discrepancy and body mass index across ethnic groups. *Obes Res*, 2000; 8: 582–589.
11) Bhuiyan AR, Gustat J, Srinivasan SR, Berenson GS. Differences in body shape representations among young adults from a biracial (Black-White), semirural community: the Bogalusa Heart Study. *Am J Epidemiol*, 2003; 158: 792–797.
12) Altabe M. Ethnicity and body image: quantitative and qualitative analysis. *Int J Eat Disord*, 1998; 23: 153–159.
13) Miller KJ, Gleaves DH, Hirsch TG, Green BA, Snow AC, Corbett CC. Comparisons of body image dimensions by race/ethnicity and gender in a university population. *Int J Eat Disord*, 2000; 27: 310–316.
14) The Examination Committee of Criteria for'Obesity Disease'in Japan, Japan Society for the Study of Obesity. New Criteria for'Obesity Disease'in Japan. *Circ J*, 2002; 66: 987–992.
15) Kaufer-Horwitz M, Martínez J, Goti-Rodríguez LM, Avila-Rosas H. Association between measured BMI and self-perceived body size in Mexican adults. *Ann Hum Biol*, 2006; 33: 536–545.
16) Paeratakul S, White MA, Williamson DA, Ryan DH, Bray GA. Sex, race/ethnicity, socioeconomic status, and BMI in relation to self-perception of overweight. *Obes Res*, 2002; 10: 345–350.
17) Jackson RT, Rashed M, Saad-Eldin R. Rural urban differences in weight, body image, and dieting behavior among adolescent Egyptian schoolgirls. *Int J Food Sci Nutr*, 2003; 54: 1–11.