

ORIGINAL ARTICLE

Accuracy of self-reported height, weight and waist circumference in a Japanese sample

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Summary

Objective

Inconsistent results have been found in prior studies investigating the accuracy of self-reported waist circumference, and no study has investigated the validity of self-reported waist circumference among Japanese individuals. This study used the diagnostic standard of metabolic syndrome to assess the accuracy of individual's self-reported height, weight and waist circumference in a Japanese sample.

Methods

Study participants included 7,443 Japanese men and women aged 35–79 years. They participated in a cohort study's baseline survey between 2007 and 2011. Participants' height, weight and waist circumference were measured, and their body mass index was calculated. Self-reported values were collected through a questionnaire before the examination.

Results

Strong correlations between measured and self-reported values for height, weight and body mass index were detected. The correlation was lowest for waist circumference (men, 0.87; women, 0.73). Men significantly overestimated their waist circumference (mean difference, 0.8 cm), whereas women significantly underestimated theirs (mean difference, 5.1 cm). The sensitivity of self-reported waist circumference using the cut-off value of metabolic syndrome was 0.83 for men and 0.57 for women.

Conclusions

Due to systematic and random errors, the accuracy of self-reported waist circumference was low. Therefore, waist circumference should be measured without relying on self-reported values, particularly in the case of women.

Keywords: Accuracy, Metabolic syndrome, Self-reported, Waist circumference.

Introduction

Height, weight and waist circumference are anthropometric variables commonly used in epidemiological studies. Body mass index (BMI), calculated from weight and height, is used to classify underweight, normal and obese individuals in accordance with the Japan Society for Study of Obesity's specifications (1). Waist circumference is a marker of overall and central obesity (1).

For the evaluation of body size, direct and standardized measurement is more valid than self-reporting. However, self-reporting is also used in some cases. Thus, validation of self-reported body size is indispensable. If self-reporting measurements were accurate enough, they would be cost-effective. In contrast, if the self-reported accuracy is poor, then body size should be measured, because a valid estimation is required to analyse the effect of body size on some outcome in the future.

Previous studies have investigated the accuracy of self-reported height and weight (2–23), and according to several studies (2,4,6,9,10,15,19,21–23), a high correlation exists between measured and self-reported height, weight and BMI values. However, previous studies have also indicated that men overestimate their height (a range of 0.3 to 1.54 cm) (2–10) and that women underestimate their weight (a range of 0.53 to 3.56 kg) (2–11). Overall, this results in an underestimation of BMI (a range of 0.22 to 1.01 kg m⁻² in men and 0.43 to 1.31 kg m⁻² in women) (2–11). Furthermore, the accuracy of self-reported height and weight has been found to decrease with increasing age (3,5–8,10,12,19). Most studies investigating the accuracy of self-reported waist circumference have found waist circumference to be underestimated (13–17). However, among the general Japanese population, no study has examined the validity of self-reported waist circumference, although several studies examined for height, weight and BMI (21–23).

This study aimed to assess the accuracy of self-reported height, weight, BMI and waist circumference values in a Japanese sample by using the diagnostic standard of metabolic syndrome. We hypothesized that in the Japanese population, these self-reported values might not all be accurate and that the inaccuracies might be gender-dependent, indicating that one or more of these values should be measured by a clinician.

Methods

Study participants

The sample comprised 7,530 men and women aged 35–79 years who had attended the health check-up at Okazaki Public Health Center between 2007 and 2011 as a part of the Japan Multi-Institutional Collaborative Cohort Study (24). Each participant provided written informed consent after the study's purpose was thoroughly explained to them. Participants with incomplete data for either measured or self-reported height, weight and waist circumference values ($n = 86$) and outliers ($n = 1$) were excluded from the analysis. The remaining 7,443 participants (4,128 men and 3,315 women) were included. The Ethics Committee at Nagoya City University Graduate School of Medical Sciences approved the study protocol.

Anthropometric measurements

Standard protocols were used for the face-to-face measurement procedures for all anthropometric values, and trained staff conducted all measurements. Height and weight were measured without shoes using an automatic body fat scale (BF-220, TANITA, Tokyo, Japan). While

height was measured to the nearest 0.1 cm, weight was measured to the nearest 0.1 kg. Then, the standard formula, weight (kg) divided by height (m²), was used to calculate BMI. Using a measuring tape (KA-15, PROMART), waist circumference was measured to the nearest 0.1 cm at the umbilical line while the participant was standing. The tape measure was kept horizontal around the body. Measurements were taken only after normal exhalation and not when participants held their breath or contracted their abdominal muscles. When fat accumulation had pulled the umbilicus downwards, waist circumference was measured equidistant from the anterior superior iliac spine and the lower rib margin.

Self-reported height, weight and waist circumference values were collected through a questionnaire before the examination. In the questionnaire, each participant was asked for his/her height, weight and waist circumference with an accuracy of 1 cm and 1 kg. Because the goal was to evaluate the accuracy of reported values as a whole, whether the self-reported values were obtained by actual measurements, or whether the self-reported values were obtained by guess alone, was not distinguished. The self-reported height and weight were used to calculate self-reported BMI. Prior to screening, the study staff checked the questionnaire.

Statistical analysis

Self-reported values were subtracted from measured values to obtain differences for height, weight, BMI and waist circumference; a positive difference indicated under-reporting, whereas a negative difference indicated over-reporting.

Significant differences between measured and self-reported height, weight, BMI and waist circumference values were detected by using paired-sample *t*-tests. Furthermore, concordance between measured and self-reported height, weight, BMI and waist circumference values was evaluated by using Pearson's correlation coefficients. Agreement between measured and self-reported BMI, and waist circumference values were assessed by using the Bland–Altman method (25).

To evaluate the accuracy of these indices for obesity, the participants were divided into two groups according to their respective BMI and waist circumference values: obese (BMI ≥ 25 kg m⁻²) and non-obese (BMI < 25 kg m⁻²). For waist circumference for the obese and non-obese groups, respectively, the cut-off values were ≥ 90 and < 90 cm for men and ≥ 80 and < 80 cm for women. These were in accordance with the International Diabetes Federation standard for the Japanese people (26). These classifications were performed for both measured and self-reported values, and participants were divided into four

groups in a 2 × 2 setting. The participants were also divided into four groups in a 2 × 2 setting for metabolic syndrome diagnosis by using measured and self-reported waist circumference. The criteria suggested by the Japan Society for the Study of Obesity (BMI ≥ 25 kg m⁻² for obesity) were adopted because only 2.5% and 1.8% of male and female participants, respectively, had a BMI ≥ 30 kg m⁻², which defines obesity in the current WHO classification. Sensitivity and specificity were assessed to determine the accuracy of self-reported data by using the 2 × 2 tables. In each case, measured values were used as the gold standard.

Men and women were analysed separately. The SPSS statistical package for Windows version 23.0 was used for statistical analyses, and all tests were two-sided. The statistical significance was fixed at $p < 0.05$.

Results

Accuracy of self-reported height, weight and BMI

Table 1 indicates the mean values of both measured and self-reported height, weight, BMI and waist circumference, as well as the mean and range of differences between measured and self-reported values according to sex. Self-reported height, weight and BMI values were a mean of 0.31 cm, 0.41 kg and 0.06 kg m⁻² greater than measured values, respectively, for men. For women, the values were a mean of 0.06 cm, 0.40 kg and 0.15 kg m⁻² greater, respectively. Both men and women, across all age groups, overestimated self-reported weight and BMI. Strong correlations were observed between the measured and self-reported values for height, weight and BMI (Figure 1). Pearson's correlations for men and women,

respectively, were 0.98 and 0.98 for height, 0.99 and 0.99 for weight and 0.98 and 0.98 for BMI (Table 1).

Figure 2 depicts the frequency distributions of the differences between measured and self-reported values of BMI. In BMI for men and women, a high proportion of participants exhibited a difference close to 0, and the peaks of the distributions for men and women were almost in agreement.

Figure 3 shows Bland–Altman plots in which the differences between measured and self-reported values were plotted against the means of the measured and self-reported BMI. The 95% limits of agreement of BMI were -1.38 and 1.26 kg m⁻² for men and -1.46 and 1.16 kg m⁻² for women. As shown in this figure, the variability is relatively random, which indicates that the measured and self-reported BMI for men and women were in high agreement across all variables.

Accuracy of self-reported waist circumference

Table 1 shows that men significantly overestimated their waist circumference by a mean of 0.79 cm by paired-sample t -tests ($p < 0.001$). In contrast, women significantly underestimated their waist circumference by a mean of 5.10 cm ($p < 0.001$). For men, waist circumference was overestimated across all age groups. For women, waist circumference was underestimated across all age groups, and an approximate difference of 5 cm was observed between the measured and self-reported values across all age groups (data not shown). Pearson's correlations for men and women, respectively, were 0.87 and 0.73 for waist circumference, and the correlation value for waist circumference was the lowest compared with the correlation of height, weight and BMI (Table 1 and Figure 4).

Table 1 Measured and self-reported weight, height, BMI and waist circumference values among men and women

	Measured mean (SD)	Self-reported mean (SD)	Mean difference Mean (SD)	Range of difference Min; Max	Pearson's correlation coefficient
Men ($n = 4,128$)					
Weight (kg)	65.34 (9.83)	65.75 (9.68)	-0.41 (1.52)**	-13.10; 15.20	0.99
Height (cm)	166.48 (6.29)	166.79 (6.17)	-0.31 (1.31)**	-19.90; 10.40	0.98
BMI (kg m ⁻²)	23.54 (2.98)	23.60 (2.93)	-0.06 (0.66)**	-6.93; 5.81	0.98
Waist circumference (cm)	84.12 (8.04)	84.90 (7.83)	-0.79 (4.04)**	-21.50; 28.30	0.87
Women ($n = 3,315$)					
Weight (kg)	52.99 (7.88)	53.40 (7.76)	-0.40 (1.26)**	-21.00; 10.70	0.99
Height (cm)	154.41 (5.78)	154.47 (5.64)	-0.06 (1.25)*	-19.40; 22.50	0.98
BMI (kg m ⁻²)	22.23 (3.08)	22.38 (3.04)	-0.15 (0.65)**	-11.46; 4.78	0.98
Waist circumference (cm)	80.72 (8.70)	75.62 (9.84)	5.10 (6.91)**	-35.60; 33.40	0.73

BMI, body mass index (weight [kg] height [m]⁻²); SD, standard deviation.

*Mean difference was calculated as mean measured value - mean self-reported value.

* $p < 0.01$ (as determined by the paired t -test).

** $p < 0.001$ (as determined by the paired t -test).

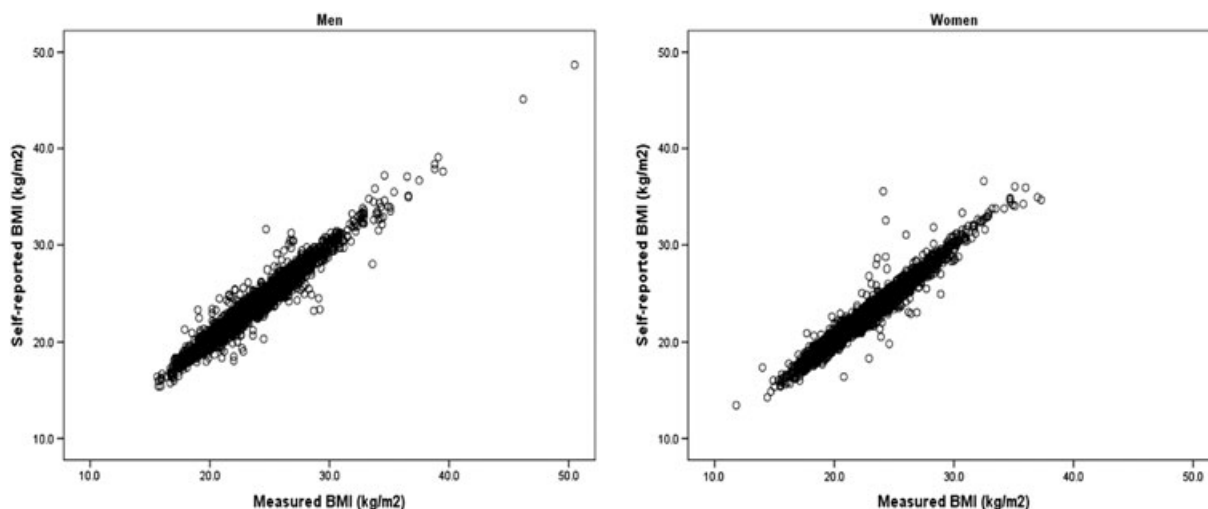


Figure 1 Scatter plots of measured and self-reported BMI values in men (*left panel*) and women (*right panel*). BMI, body mass index.

Figure 5 depicts the frequency distributions of the differences between the measured and self-reported values of waist circumference. The peaks of the distributions of waist circumference for men and women differed, unlike BMI. The distribution for women was skewed in the positive direction, and the differences varied widely compared with the values obtained for men.

Figure 6 shows that Bland–Altman plots indicating the difference between measured and self-reported values were against the means of the measured and self-reported waist circumference. The 95% limits of agreement for waist circumference were -8.87 cm and

7.30 cm for men and -8.71 and 18.92 cm for women. This figure indicates that the measured and self-reported waist circumferences for men had relatively high agreement across all variables. However, the measured and self-reported waist circumferences for women were in lower agreement, with a difference of 5.10 cm, due to a fixed bias.

Diagnostic accuracy of self-reported indices

Table 2 shows the diagnostic accuracy of self-reported indices. For the judgment of central obesity, the

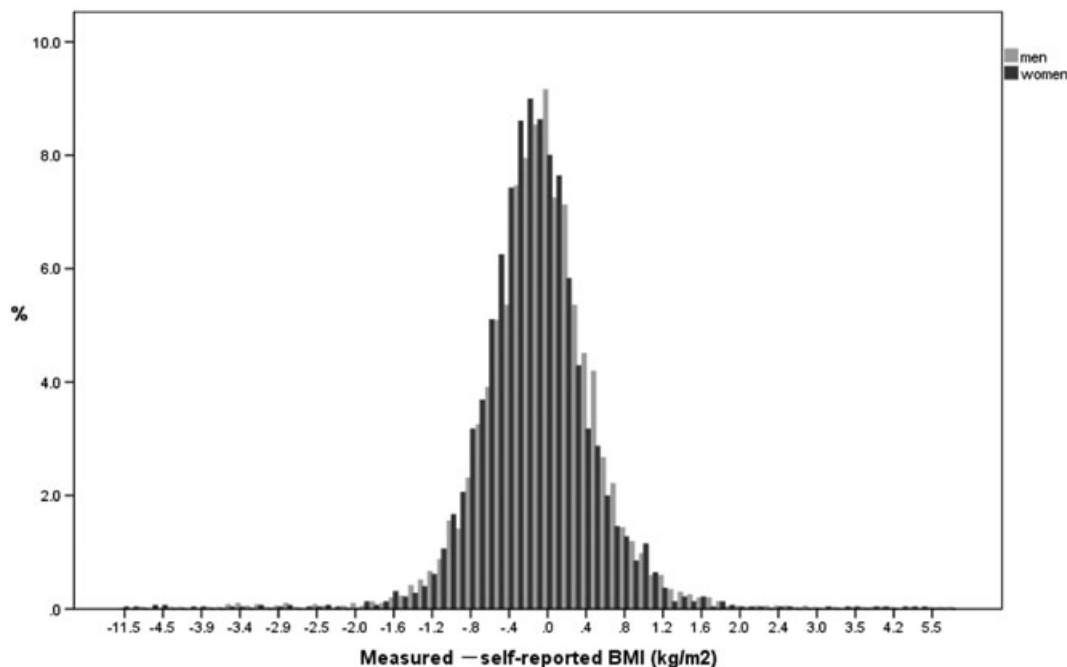


Figure 2 Percentage distribution of the differences between measured and self-reported BMI values in men and women. BMI, body mass index.

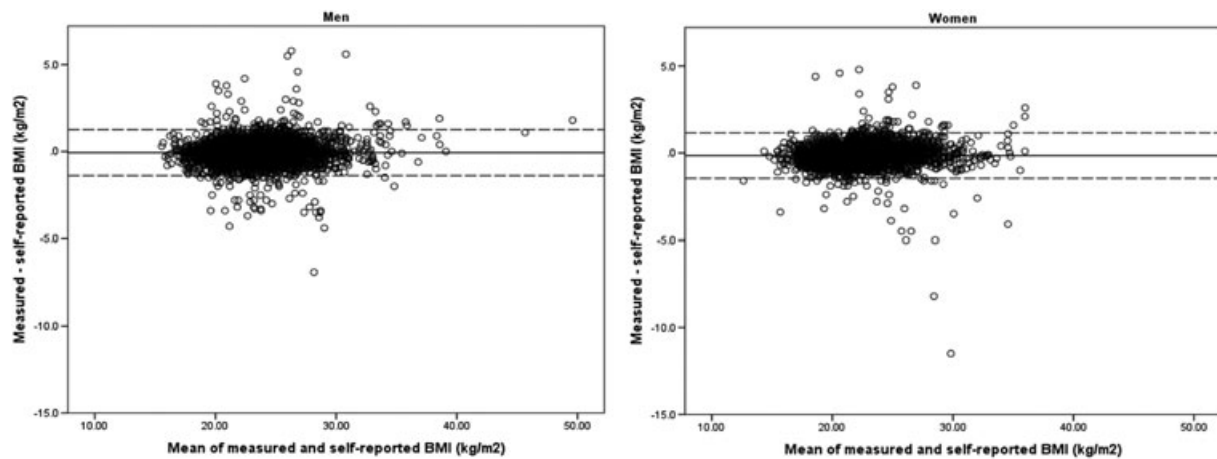


Figure 3 Bland–Altman plot of agreement between measured and self-reported BMI in men (*left panel*) and women (*right panel*). The horizontal lines represent the mean difference (*solid line*) and the 95% limits of agreement (*dotted lines*).

sensitivity and specificity were 0.83 and 0.90 for men and 0.57 and 0.92 for women, respectively. For the diagnosis of metabolic syndrome, the sensitivity and specificity were 0.84 and 0.96 for men and 0.68 and 0.99 for women, respectively.

Discussion

This study aimed to assess the accuracy of self-reported height, weight, BMI and waist circumference in a Japanese sample. In this study, high correlations between measured and self-reported height, weight and BMI were noted for both men and women. Particularly among women, the correlation was lower for waist circumference than for height, weight and BMI, thus indicating that the accuracy of self-reported waist circumference was

lower than the accuracy of self-reported height, weight and BMI.

In this study, the correlation of measured and self-reported values for height, weight and BMI were higher than 0.95 for both men and women. These findings are in good agreement with previous studies reporting >0.90 among men and women (2,4,6,10,19–22). Although both men and women overestimated height, weight and BMI, the differences between measured and self-reported values were close to 0, thus indicating a high degree of accuracy of self-reported height, weight and BMI. Therefore, these findings suggest that self-reported values can be used when collecting height and weight data. Christian et al. (27) reported that self-reported medical weights were significantly closer to measured weights than were self-reported personal weights for both women and men. In this study, the

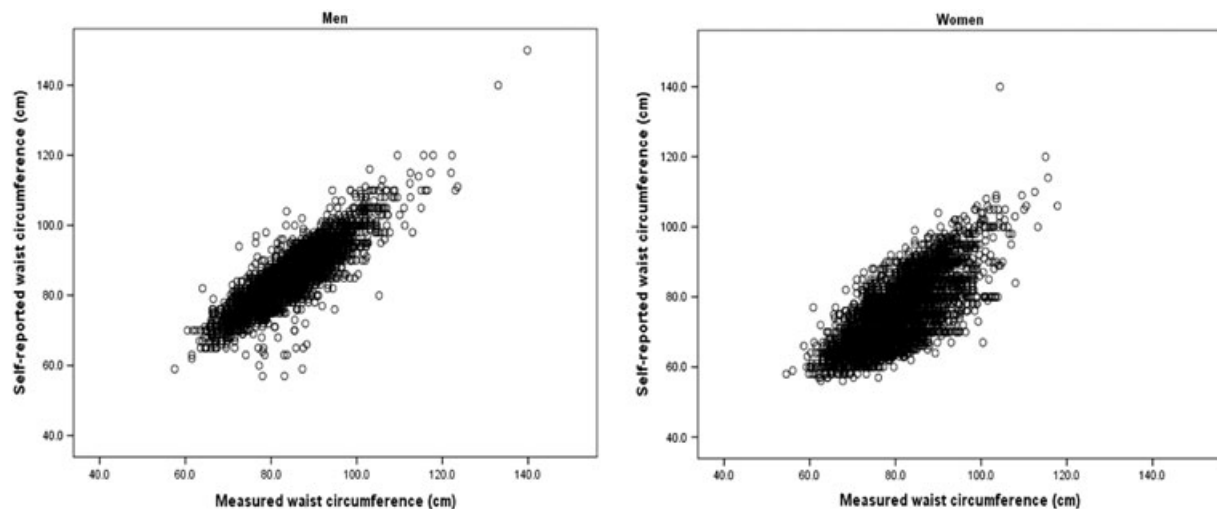


Figure 4 Scatter plots of measured and self-reported waist circumference values in men (*left panel*) and women (*right panel*).

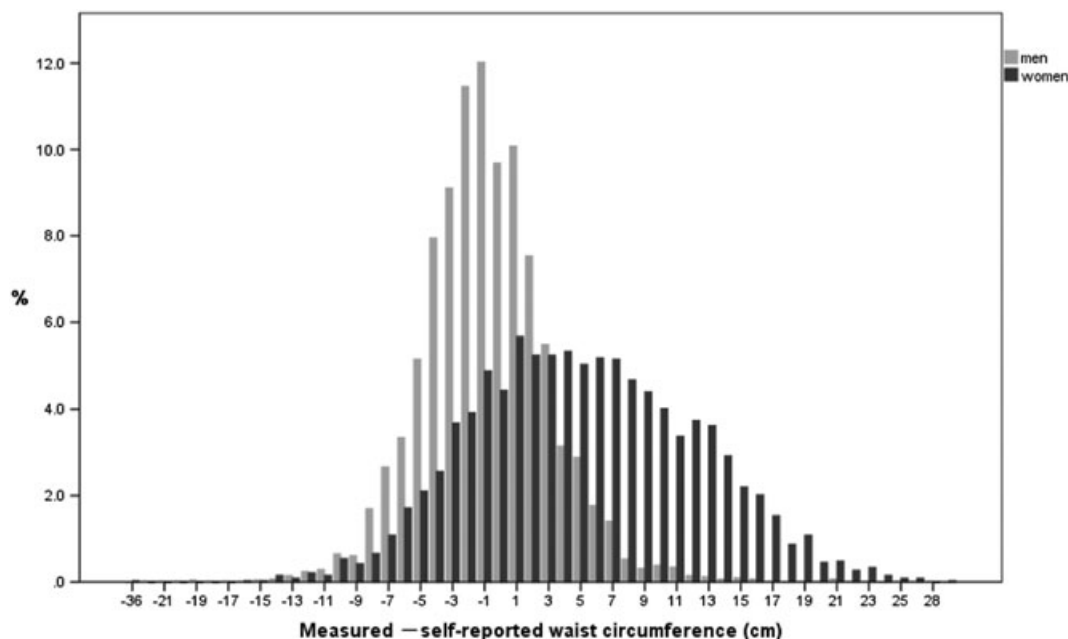


Figure 5 Percentage distribution of the differences between measured and self-reported waist circumference values in men and women.

accuracy of self-reported height, weight and BMI measured annually as part of the health check-up were high; in contrast, the accuracy of self-reported waist circumference, which is a more recently used measurement, was low. In the future, as the measurement of waist circumferences becomes more common, and if patient education improves, the accuracy of the self-reported value of the waist circumference may increase. However, in this case, women with frequent health check-up tend to have larger waist circumference and might generate confounding effect. To prevent the confounding, waist circumference should be measured directly.

The correlation of waist circumference in this study was 0.87 for men and 0.73 for women. In previous studies, correlations ranged from 0.80 to 0.92 for men (13,16,17) and from 0.78 to 0.88 for women (13,15–17). The correlation reported for women in this study was lower than that in previous studies. On average, waist circumference was overestimated by 0.8 cm for men and underestimated by 5.1 cm for women. This tendency was observed among all age groups of men and women. To the best of our knowledge, one previous study has reported the overestimation of waist circumference among adults (18). However, most previous studies reported an

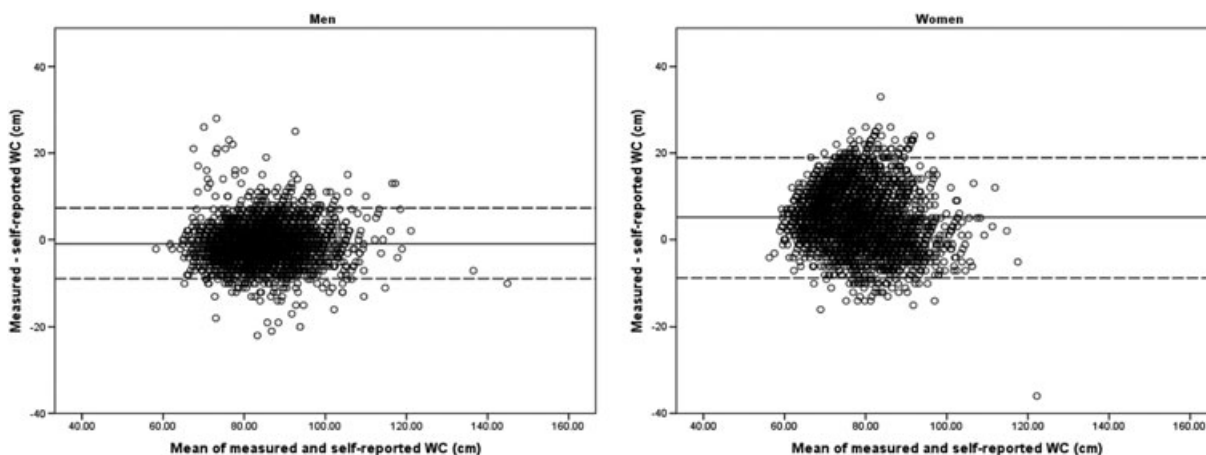


Figure 6 Bland–Altman plot of agreement between measured and self-reported waist circumference in men (*left panel*) and women (*right panel*). The horizontal lines represent the mean difference (*solid line*) and the 95% limits of agreement (*dotted lines*).

Table 2 Number and percentage of subjects diagnosed with metabolic syndrome based on the standard diagnostic criteria according to measured and self-reported values among men and women

Self-reported	Measured			
	Yes		No	
	<i>n</i>	Rate	<i>n</i>	Rate
Men (<i>n</i> = 4,128)				
Yes	true positive		false positive	
	428	0.84	153	0.04
No	false negative		true negative	
	81	0.16	3,466	0.96
Women (<i>n</i> = 3,315)				
Yes	true positive		false positive	
	364	0.68	24	0.01
No	false negative		true negative	
	172	0.32	2,755	0.99

Metabolic syndrome was indicated by a waist circumference of ≥ 90 cm in men and ≥ 80 cm in women accompanied by any two of the following four factors: triglycerides (≥ 150 mg dL⁻¹), HDL cholesterol (< 40 mg dL⁻¹), blood pressure (systolic BP ≥ 130 or diastolic BP ≥ 85 mmHg) and fasting plasma glucose (≥ 100 mg dL⁻¹).

underestimation of self-reported waist circumference in comparison with objectively measured waist circumference values (13–17).

The results of Pearson's coefficients of measured and self-reported height, weight and BMI were slightly higher than those given in other reports. This might be partly due to the educational status of the participants of the study. The screening programmes have been held every year, and most of the study subjects participated in the programme several times; participants might have remembered their height and weight. In contrast, because waist circumference is a much more recent measurement, there was no educational/recall effect, and this could partly explain the low coefficients.

Participants may use a thinner part of their abdomen than the umbilical line when measuring their abdominal circumference, which would explain why self-reported and measured values differed. Bigaard et al. (16) reported that the measured value of the umbilical line was 0.7 and 5.0 cm greater among men and women, respectively, than the slimmest part between the lower rib and the iliac crest. A difference in the recognition of the point from which 'waist circumference' is measured may partially explain the systematic error among women observed in the present study. Despite the standard measurement instructions outlined in the questionnaire, many women answered with the waist circumference that they use when choosing clothing size. In contrast, men overestimated their waist circumference by 0.8 cm, but there is no apparent reason for this. In addition, it was reported that

Chinese men underestimated their waist circumference by about 1.9 cm (20).

Among the errors observed among women in this study, the systematic error could be corrected by adding 5 cm to the values reported by each participant. Using this correction, the sensitivity increases to 74.6% and the specificity decreases slightly to 75.2%. However, the random error judged from the correlation coefficient could not be corrected by using this method. In fact, the correlation coefficient of measured waist circumference with self-reported waist circumference (0.73) is even lower than that with self-reported BMI (0.83). Therefore, self-reported waist circumference should not be used when assessing women, because it leads to inaccuracy. This knowledge will be helpful for researchers who plan to conduct prospective studies of waist circumference and health status.

Several limitations to this study must be acknowledged. First, the participants of the study did not represent the general Japanese population. They were undergoing a health check-up that forms a part of several participants' annual routine. The fact that the participants knew their measured height and weight may partly explain the extremely high correlation coefficients of height, weight and BMI. However, even these health-conscious participants failed to accurately report their waist circumference, particularly women. An even larger degree of error may occur among the general population. Second, rounding may be the cause of some of the bias related to them is reporting of anthropometric data. The questionnaire instructed participants to round down to the closest centimetre and kilogram, while for the measurement component, height and waist circumference and weight were measured to the nearest 0.1 cm and 0.1 kg, respectively. However, for waist circumference, the influence of rounding the numerical value would be small, particularly among women, because the systematic error is 5 cm.

Conclusions

In the present study, self-reported waist circumference among women was inaccurate due to both random and systematic errors. For accurate diagnosis of obesity and metabolic syndrome, waist circumference should be directly measured without consulting self-reported values gathered through a questionnaire, particularly for Japanese women.

Conflicts of interest statement

The authors report no conflicts of interest.

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