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Accuracy of self-reported anthropometric measures — Findings from the Finnish Twin Study

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Abstract

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A competing interest statement
Dr. Kaprio reports grants from Academy of Finland, during the conduct of the study. Dr. Sipilä reports grants from The Finnish Foundation for Alcohol Studies outside the submitted work. All other authors have no conflicts of interest to disclose.

Ethical statement
We have read and have abided by the statement of ethical standards for manuscripts submitted to the Obesity Research & Clinical Practice. We ensure that this work has been carried out in accordance with the Code of Ethics of the World Medical Association (Declaration of Helsinki) for experiments involving humans, and informed consent was obtained from all subjects.
The study protocol was approved by the institutional ethics board of the Hospital District of Helsinki and Uusimaa, Finland and the Institutional Review Board of Augusta University.

CRediT authorship contribution statement
J. Tuomela: Conceptualization, Data curation, Formal analysis, Methodology, Software, Validation, Visualization, Writing - original draft, Writing - review & editing. **J. Kaprio:** Conceptualization, Data curation, Formal analysis, Funding acquisition, Investigation, Methodology, Project administration, Resources, Software, Supervision, Validation, Writing - original draft, Writing - review & editing. **P.N. Sipilä:** Conceptualization, Investigation, Methodology, Validation, Visualization, Writing - review & editing. **K. Silventoinen:** Conceptualization, Methodology, Writing - review & editing. **X. Wang:** Conceptualization, Funding acquisition, Methodology, Writing - review & editing. **M. Ollikainen:** Conceptualization, Funding acquisition, Investigation, Methodology, Project administration, Resources, Writing - review & editing. **M. Piirtola:** Conceptualization, Data curation, Formal analysis, Methodology, Software, Supervision, Validation, Visualization, Writing - original draft, Writing - review & editing.

Appendix A. Supplementary data
Supplementary material related to this article can be found, in the online version, at doi:https://doi.org/10.1016/j.orcp.2019.10.006.

Objective: To determine the accuracy of self-reported height, weight, body mass index (BMI) and waist circumference (WC) compared to the measured values, and to assess the similarity between self-reported and measured values within dizygotic (DZ) and monozygotic (MZ) twin pairs.

Methods: The data on self-reported and measured height, weight and WC values as well as measured hip circumference (HC) were collected from 444 twin individuals (53–67 years old, 60% women). Accuracies between self-reported and measured values were assessed by Pearson's correlation coefficients, Cohen's kappa coefficients and Bland-Altman 95% limits of agreement. Intra-class correlation was used in within-pair analyses.

Results: The correlations between self-reported and measured values were high for all variables (r = 0.86–0.98), although the agreement assessed by Bland-Altman 95% limits had relatively wide variation. The degree of overestimating height was similar in both sexes, whereas women tended to underestimate and men overestimate their weight. Cohen's kappa coefficients between self-reported and measured BMI categories were high: 0.71 in men and 0.70 in women. Further, the mean self-reported WC was less than the mean measured WC (difference in men 2.5 cm and women 2.6 cm). The within-pair correlations indicated a tendency of MZ co-twins to report anthropometric measures more similarly than DZ co-twins.

Conclusions: Self-reported anthropometric measures are reasonably accurate indicators for obesity in large cohort studies. However, the possibility of more similar reporting among MZ pairs should be taken into account in twin studies exploring the heritability of different phenotypes.

Keywords

Accuracy; Anthropometric measure; Body mass index; Twin study; Waist circumference; Hip circumference

Introduction

Obesity is a major risk factor for several non-communicable diseases [1]. It is commonly measured by body mass index (BMI, kg/m^2) and waist circumference (WC) [2,3]. However, measures of hip circumference (HC) and waist-to-hip ratio (WHR) also provide important additional information on fat distribution [4].

The most accurate methods to estimate body composition [5] are not cost-efficient in large cohort studies. Since measurements conducted by professionals are expensive and time-consuming, large population-based studies commonly use self-reported values [6,7]. However, when using self-reported values, the validity and sources of measurement errors should be considered. Therefore, self-reported values should be validated by using a standardised measurement protocol in a random sample of participants [8].

Typical self-reported anthropometric measures are height and weight, used for calculating BMI. A systematic review stated that weight is generally underestimated and height overestimated [9], resulting in underestimation of average BMI and obesity prevalence [8,10,11]. Overestimation of height and weight has been reported to increase with age [12], but a decrease in underestimating weight with age has also been reported in women [13].

Both BMI and WC are used as proxies of body fat, and the advantage of using BMI over WC is the smaller measurement error in BMI [14,15]. On the other hand, high WC has been shown to independently predict obesity-related diseases even when BMI is normal [16,17]. However, the greater the WC, the greater the underestimation of BMI [18]. Because self-reported WC could be either an underestimate [19] or overestimate [20], pictorial instructions for self-measurement of WC are recommended to obtain more accurate values [19,20]. Further, both BMI and WC should be assessed to better identify those at high risk for adiposity-related diseases [21].

Among the many reasons for differences between self-reported and measured values are characteristics of the individuals being measured, such as body image, social desirability, and familial factors, including genetics [22,23]. The comparison of monozygotic (MZ) and dizygotic (DZ) twin pairs allows the assessment of both shared environmental factors (e.g., parents' socioeconomic status) and genetic factors. This approach has rarely been used [24] in validation studies of anthropometric measures. An Australian twin study ascribed 36% of the misreporting in height in women to genetic effects [23].

This study aims to evaluate the accuracy of self-reported height, weight, BMI and WC compared to measurements conducted by healthcare professionals among twins sampled from the Finnish Older Twin Cohort. In addition, measured HC and WHR values are reported. Main focus of interest was whether the patterns of reporting values, measured values and reporting errors differed between MZ and DZ twin pairs.

Material and methods

Study participants

Study participants (N = 444, 60% women, 53–67 years old) were adult twins drawn from the population-based Finnish Older Twin Cohort [25,26]. They were selected from the original survey conducted between October 2011 and June 2012 using mailed questionnaires and targeting twins born between 1945 and 1957 (n = 8410; 72% response rate).

The data for the present analyses were originally collected to study the epigenetics of blood pressure [27]. For this reason, based on the questionnaire data in 2011, all twin pairs discordant for their history of measured high blood pressure values, a history of physician-diagnosed hypertension, or use of antihypertensive medications were identified and contacted. The data also included a smaller number of pairs concordant for the presence or absence of hypertension or a history of high blood pressure. The selection and characteristics of the sample are described elsewhere [27]. In total, 1170 participants were contacted, of whom 445 were invited and participated in the clinical measurements. The study was conducted in accordance with the Declaration of Helsinki and included a written informed consent from all participants. The study protocol was approved by the institutional ethics board of the Hospital District of Helsinki and Uusimaa, Finland (ID 154/13/03/00/11) and the Institutional Review Board of Augusta University.

In this study, one participant was dropped out because of an unrealistic self-reported height (+30 cm) compared to the previous surveys of the cohort. In total, the data included 220 same-sex twin pairs: 125 MZ pairs and 93 DZ pairs. Two pairs with unknown zygosity were excluded from the pairwise analyses.

Data collection

Self-reported data were collected by a mailed questionnaire during 2011–2012. No instructions or guidance for the actual measurement for height and weight were given. The participants were asked “How tall are you?” and “How much do you weigh?”, with open fields for height to the nearest centimeter and weight to the nearest kilogram. For the WC measurement, participants received a detailed pictorial instruction and a tape measure (Supplementary Figure 1), which had also been included in previous data collections of this twin cohort [25,26].

Height, weight and WC were measured by four healthcare professionals during the years 2012–2014 as part of the clinical assessment. Participants arrived to the clinical measurements between 8:00 and 10:00 am, most (89%) at 9 a.m., and were measured after providing a written informed consent. Siblings within a twin pair were invited to clinical measurements on the same day. The healthcare professionals followed a standardised examination protocol with standardised equipment, and measures were recorded to one decimal accuracy. The participants were wearing light clothing (0.5 kg was deducted from the weight) and no shoes during height and weight measurements. WC was measured on bare skin, between the lowest rib and the iliac crest (Supplementary Figure 1). HC was only available as a measured value, taken from the widest point of the pelvis. WHR was calculated as WC (cm) divided by HC (cm). BMI was calculated based on both self-reported and measured height and weight. BMI values were categorised into three categories (18.5–24.9 kg/m^2 as “normal”, 25–29.9 kg/m^2 as “overweight” and ≥30 kg/m^2 as “obese”) [2]. Three individuals categorised as underweight (BMI < 18.5 kg/m^2) based on self-reported values and five individuals based on measured values were incorporated into the BMI “normal” category since all had BMIs between 18.0–18.4 kg/m^2.

Statistical methods

We estimated the accuracy of self-reported values by assessing the relationship and agreement between self-reported and measured values of height, weight, BMI and WC. Pearson’s correlation coefficients with 95% confidence intervals (CI) were used in calculating the strength of relationships between the self-reported and measured values. The Bland-Altman method [28] was used to assess agreement between the self-reported and clinical measures. Within-person differences (self-reported – measured value) in measures versus within-person means in measures with 95% CIs were generated to examine the variability of the difference between the self-reported and measured values.

Further, we used a within-pair correlation with 95% CIs to analyse whether the within-pair correlation coefficients differed between MZ and DZ twin pairs. First, within-pair correlations of unadjusted values of height, weight, BMI, WC, and HC and WHR were calculated. Within-pair correlations of self-reported values were compared to within-pair correlations of measured values, separately for MZ and DZ pairs. The exceptions were HC and WHR, which were available as measured values only. Then, within-pair intraclass correlations were calculated from the differences between self-reported and measured values separately for all MZ and DZ pairs. The Stata procedure Cortesti, created by HM Caci (http://fmwww.bc.edu/RePEc/bocode/c), was used in analysing the equality of correlation coefficients between MZ and DZ pairs within sex.

Self-reported BMI proportions were cross-tabulated by measured BMI categories. Cohen's kappa coefficient was used to evaluate the significance of agreement between BMI categories. Bland-Altman limits of agreement were calculated from unadjusted self-reported and unadjusted measured height, weight, BMI and WC between the different BMI categories and sexes. All analyses were stratified by sex.

For sensitivity analyses, the effect of participants' age (53–67 years) and time difference between the self-reported (based on date of return of the questionnaire) and measured values (i.e. study date) (mean 2.01 [Standard deviation (SD) 0.77] years) in weight, height and WC were analysed with linear regression. Paired t-test was used in analysing the time difference within each twin pair (all, DZ and MZ pairs). A likelihood-ratio (LR) test showed no interactions between sex and time differences (p-values ≥0.39) or between sex and age (p-values range 0.06–0.60) in any of the self-reported and measured differences. Sex-adjusted linear regression was used in analysing the effect of age and time difference for the differences between self-reported and measured values. However, given that the participants' age range was narrow, the age-adjusted results were similar to those using unadjusted values (data not shown). Further, the difference in time between the self-reported and measured values was not associated with the difference between the respective values (p-values: 0.10–0.43). In all pairs, the mean within-pair difference in time between the self-reported and measured values was on average 16 days, with the corresponding difference within DZ pairs being 13 days and within MZ pairs 18 days. This variation was due to differences in time of return of the questionnaire, and for some pairs in attending the clinical study. In regression analyses, a robust estimator was used to take the non-independence of observations within twin pairs into account [29].

Stata SE version 14.2 (StataCorp, College Station, TX, USA) was used in all statistical analyses. All reported p-values are two-sided and those less than 0.05 were considered statistically significant.

Results

Characteristics of the self-reported and measured values are presented in Table 1. The mean time difference between the self-reports and the measures was 2.01 years (SD 0.77 years). On average, both male and female participants overestimated their height to be 1.2 cm greater than their measured height. The estimation error related to weight differed by sex: compared to measured weight, self-reported weight was, on average, 1.5 kg less in women and 1.3 kg more in men. The mean of self-reported BMI was 0.8 kg/m^2 less in men and 0.9 kg/m^2 less in women than their mean measured BMI values. Further, the self-reported WC was, on average, 2.6 cm (2.5 cm for men and 2.6 cm for women) less than the mean measured WC.

Pearson's correlation coefficients and Bland-Altman limits of agreement between the self-reported and measured values are shown in Table 2. Overall, the correlations were high (r = 0.86–0.98) for all variables. The limits of agreement between the self-reported and measured values are given in Table 2 (see also Supplementary Figure 2). Both correlation coefficients and limits of agreement behaved similarly in both sexes.

Based on linear regression analyses, older age was associated with larger differences between reported and measured height. This indicates that older people reported being taller than their measured height with an average of 0.12 cm (95% CI 0.07–0.17) per each additional year, regardless of sex. Among women, older age also increased the underestimation of weight by an average of 0.16 kg per year (95% CI 0.05–0.26). Age did not affect the difference in reported BMI or WC with respect to measured values.

In the pairwise analyses, all within-pair correlations of both self-reported and measured values tended to be higher in MZ pairs than in DZ pairs (Supplementary Table 1). When comparing the pairwise correlations of differences between self-reported and measured values in MZ and DZ pairs, the correlation coefficients in differences in height and in BMI were significantly higher in MZ female pairs than in DZ female pairs (Table 3). In male pairs, no such differences were seen.

Participant proportions based on their BMI categories by self-reported and measured BMI categories are presented in Table 4. Among all participants, 76% of those whose self-reported BMI was normal were also categorised as normal by their measured BMI, 82% of those with self-reported overweight were also categorised as overweight by the measured values, and 92% of participants with a self-reported BMI in the obese category were categorised as obese by the measured values. These proportions were similar in both sexes (kappa 0.71 [95% CI 0.61–0.81] in men; 0.70 [95% CI 0.60–0.80] in women).

Bland-Altman limits of agreement between self-reported and measured height, weight, BMI and WC by measured BMI categories and sex are presented in Table 5. Comparison between different BMI categories revealed that the limits of agreement in BMI and WC were wider in the obese category than in the overweight and normal categories. Moreover, in the overweight category, the limits of agreement were wider in weight, BMI and WC than in the normal category, though the difference between these categories was smaller than the difference between either of these categories and the obese category. The limits of agreement in weight tended to be wider in women compared to men in every BMI category, but the limits of agreement were widest in the obese category.

Discussion

This study examined the accuracy of self-reported height, weight, BMI and WC compared to measured estimates. Our results indicate that self-reported values are accurate enough to beused in large cohort studies. In our study, overweight and obese persons misreported their weight, BMI and WC more than participants with normal weight. However, BMI categorization was more accurate in obese individuals compared to normal weight individuals. Women misreported their weight more often compared to men in every BMI category. Our novel results include comparisons between MZ and DZ twin pairs in regards to the within-pair similarity in reporting. As expected, MZ co-twins tended to report their anthropometric values more similarly compared to DZ co-twins. However, these reporting differences were statistically significant only in height and BMI in female pairs.

Height

Participants reported their height, on average, 1.2 cm higher than their measured height, but the correlation coefficients between self-reported and measured height were high (r = 0.96 in men, r = 0.95 in women). We found that older age increased height overestimation in both sexes, which is in line with previously reported findings [10,11]. It is likely that the overestimation of height in older adults occurs because it may have been years to decades since a person's height was actually measured, and height tends to decrease with age [30]. Total reporting error in self-reported height likely arises from the possible measurement errors in the measures of height as well as reporting a previous height without actually measuring it. We recommend that while collecting self-reported values on height, the time when height was last measured should also be recorded.

The twin design enables analysing both shared environment and genetic components in reporting anthropometric values. When comparing differences in self-reported and measured height within twin pairs, more similar values were observed among the MZ pairs than among the DZ pairs in women but not in men, as also reported in another study including twin pairs [23]. This is mainly because height is a highly heritable trait [31].

Weight

Our results are consistent with previous findings suggesting that self-reported weight is an underestimation of the true body weight [10], especially in those with overweight or obesity [12]. In addition, older age increased the underestimation of weight among women in our study. This finding was also reported in a recent prospective cohort study from the US [12]. The increasing underestimation of weight with older age among women in our study might arise at least partly from the same reason as height: that participants did not actually measure their weight but reported the weight they remembered from the last time their weight was measured. In general, people tend to misreport their weight based on how they see themselves and due to social desirability [22]. Notably, the time difference (mean 2.0 years, range 0.5–4.1 years) between self-reported and measured weight did not play a major role in our study. A one-year time difference between measured and self-reported weight in persons aged 40–79 years was also not found to be significant in a prospective cohort study from the US [12]. Interestingly, there were no statistically significant differences between self-reported and measured weight between MZ and DZ twin pairs for either sex in our study, indicating that measurement error in weight is independent of genetic factors.

Body mass index

Though self-reported BMI is often an underestimation of the measured BMI [10], the comparison between self-reported and measured BMI by BMI categories showed that most participants were categorised into the same categories. If categories differed, participants tended to end up in a leaner category when self-reported values were used. This result is in line with previous studies indicating that BMI calculated from self-reported height and weight might lead to underestimation of obesity at the population level [9,11]. This might result in a biased estimate of the association of obesity with morbidity and related costs [9]. Further, an increase of the proportion of overweight individuals in a population has been shown to associate with increase of the proportion of individuals underestimating their body weight [32]. In our study, participants in the obese category either overestimated or underestimated their weight, BMI and WC more than participants in the overweight and normal weight categories. Misreporting was present especially among obese women, however, misreporting differed between sexes in every BMI category. A higher correlation in difference between self-reported and measured BMI was noticed among female MZ twin pairs compared with DZ pairs, suggesting genetic influence on reporting BMI value.

Waist circumference

Self-reported WC is recommended to be used in large-scale population and epidemiological studies when the actual measurements are not available [20]. Study participants tend to measure their WC with reasonable accuracy, but self-reported WC may be inappropriate for monitoring changes in situations where small changes are of clinical importance at the individual level [19]. Our results support these previous findings; although self-reported and measured WC values correlated well in this large sample, Bland-Altman limits of agreement for WC were wide. In the pairwise analyses, within-pair correlation between the differences in self-reported versus measured values for WC tended to be higher in MZ pairs than in DZ pairs. However, the difference in correlations was not statistically significant. This suggests that measurement errors in WC were not explained by familial factors, including genetics.

Within-pair correlations of actual values

In general, the differences between self-reported and measured within-pair correlations were small. Interestingly, within-pair correlations of weight and WC in MZ male pairs showed a tendency towards higher correlations between self-reported than between measured values. In a previous study of Danish twins (comprising healthy MZ and same-sex DZ twin pairs), within-pair correlations (intra-class correlations) of actual HC were 0.79 in MZ male pairs, 0.73 in MZ female pairs, 0.51 in DZ male pairs, and 0.51 in DZ female pairs [33]. In our study, within-pair intra-class correlations of HC were lower, ranging from 0.16 to 0.59. A possible explanation for the overall low within-pair correlations of actual values (not the difference between self-reported and measured values) is related to different inclusion criteria for these two studies. The participants of the Danish study were much younger on average, and the heritability of many anthropometric traits decreases with age [33]. Our sample of twin pairs was enriched for discordance in blood pressure. Therefore, the twin pairs may resemble each other less than expected for the anthropometric risk factors related to hypertension such as high BMI, WC and HC. Whether there are genetic or shared environmental components in under- or overestimating anthropometric measures merits further studies.

Strengths and limitations

This study has several strengths. The sample size of 444 adults including both women and men is large enough to enable generalisation of the results, at least to older middleaged populations. Although this study was not originally designed for anthropometric measurement validation purposes, study protocol was appropriately piloted, standardised, and pictorial instructions were also provided for measuring WC. Statistical methods covered both relatedness and agreement between the self-reported and measured values. A twin pair design also enabled us to examine to what extent shared environment, mainly in childhood, and genetics play a role in reporting anthropometric values.

A major limitation of this study is the time interval between the self-reports of anthropometric values (the time when the questionnaire was returned) and the clinical visit when all anthropometric values were measured. Some individual changes between the self-report and actual measurement in weight and WC have likely happened. However, the time interval did not systematically influence the differences between any of the self-reported and measured values (all p-values >0.05). In addition, it has been shown in a sample similar to our cohort that increase in fat and weight gain while ageing decrease after the age of 60 years, especially in women [34]. Despite possible true changes in weight, height and WC during the time gap between self-reports and clinical examinations, our analyses showed that most participants were categorised into the same BMI category in both self-reported and clinical measurements. Further, our novel results are in within pair analyses. Notably, questionnaires were mailed to both siblings within a pair simultaneously, and the co-twins were invited to the clinical measurements on the same day. Of the pairs, 75% (n = 165 pairs) were measured on the same day, and of the remaining 55 pairs, 80% of the siblings were studied within 2 weeks from each other. The mean within-pair time difference between the self-reported and measured values was on average 16 days for all pairs and 18 days for MZ pairs and 13 days in DZ pairs. Notably, weight fluctuation is normal in humans, and daily and day-to-day weight can fluctuate up to one kilo even with no changes in calorie intake or activity level [35]. In our clinical measurements, all participants were measured after an overnight fast between 8:00 and 10:00 am (89% between 9:00 and 9:30). Therefore, we consider that our individual-based analyses regarding BMI categories, HC and WHR as well as all within pair analyses are valid. Another limitation is the sample selection. Participants in this study were twin pairs mainly discordant for hypertension-related factors. This might have led to a greater awareness of commonly known risk factors of hypertension, such as obesity and central adiposity, and thus more frequent measures of weight. Whether or not it had an influence on self-reporting to a presumably more truthful direction compared to the general population is unknown.

Conclusions

This study shows that self-reported height, weight, BMI and WC are accurate enough to be used as indicators of obesity in large cohort studies, and that self-reported values are also accurate enough among those with risk factors for cardiovascular diseases. Identification of obese participants at the population level can be achieved with self-reports with tolerable accuracy, because participants are mainly categorised as normal weight, overweight and obese by their BMI, with similar accuracy for both self-reported and measured height and weight. However, internal validation of the self-reported values in all large cohorts is recommended since using self-reported BMI might cause an underestimation of obesity.

In addition, when precise individual values and changes in time are of interest, actual measurements conducted by trained professionals are warranted.

Our findings provide new evidence that besides social desirability to misreport anthropometric values, familial (possibly genetic) factors can also influence the reporting of anthropometric values. In twin studies exploring the heritability of different phenotypes related to anthropometric measures, the possibility of more similar values in MZ twin pairs should be considered as a potential source of bias resulting in the overestimation of heritability.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Table 1

Means, standard deviations and ranges of self-reported and measured values and their differences.[a]

Measurement	All (n = 444)		Men n = 180		Women (n = 264)	
	Mean (SD)	Range	Mean (SD)	Range	Mean (SD)	Range
Age, when self-report (yrs)	60.2 (3.7)	53.3–67.2	60.1 (3.6)	53.7–66.5	60.3 (3.8)	53.3–67.2
Age, when measured (yrs)	62.2 (3.9)	54.6–69.7	62.0 (3.9)	54.6–69.7	62.3 (3.9)	54.8–69.6
Time difference[b] (yrs)	2.0 (0.8)	0.5–4.1	1.9 (0.8)	0.5–4.1	2.1 (0.7)	0.8–3.5
Height, self-reported (cm)	169.0 (9.5)	147–196	177.9 (6.7)	162–196	163.0 (5.4)	147–176
Height, measured (cm)	167.8 (9.7)	143.9–194.5	176.8 (7.0)	158.8–194.5	161.7 (5.6)	143.9–174.1
Difference	1.2 (1.8)	−9.5–7.8	1.1 (1.9)	−9.5–6.1	1.2 (1.8)	−4.7–7.8
Weight, self-reported (kg)[c]	75.8 (15.8)	42–130	87.0 (13.9)	57–130	68.2 (12.2)	42–104
Weight, measured (kg)	77.3 (16.6)	41.6–132.0	88.3 (14.5)	58.4–132.0	69.8 (13.5)	41.6–117.1
Difference	−1.4 (3.8)	−19.1–16.2	−1.3 (3.5)	−13.8–9.9	−1.5 (3.9)	−19.1–16.2
Waist circumference, self-reported (cm)[c]	91.8 (13.1)	62–135	99.5 (11.0)	75–135	86.5 (11.7)	62–124
Waist circumference, measured (cm)	94.4 (14.5)	56.0–140.0	102.1 (12.5)	74.0–140.0	89.2 (13.5)	56.0–132.5
Difference	−2.6 (6.2)	−27.0–15.0	−2.5 (6.1)	−23.0–15.0	−2.7 (6.3)	−27.0–12.0
BMI, from self-reports (kg/m^2)	26.4 (4.3)	18.1–43.2	27.4 (3.8)	18.8–39.5	25.7 (4.5)	18.1–43.1
BMI, from measures (kg/m^2)	27.3 (4.9)	18.1–46.1	28.2 (4.2)	19.5–43.3	26.7 (5.2)	18.1–46.1
Difference	−0.9 (1.5)	−9.7–4.9	−0.8 (1.3)	−6.2–3.0	−1.0 (1.7)	−9.7–4.9
Hip, measured (cm)	101.8 (9.4)	69.5–135.0	102.6 (7.7)	83.0–132.0	101.2 (10.4)	69.5–135.0
Waist-to-hip ratio, from measures	0.9 (0.1)	0.7–1.2	1.0 (0.1)	0.8–1.2	0.9 (0.1)	0.7–1.1

BMI = body mass index, WC = waist circumference.

[a] All values are unadjusted values. Difference = self-reported value − measured value.

[b] Time difference from self-report to measurement.

[c] Self-reported weight value was missing for one woman, and self-reported waist value was missing for one man and one woman.

Table 2

Pearson's correlation coefficients with 95% confidence intervals (CI) and Bland-Altman limits of agreement between self-reported and measured height, weight, body mass index (BMI), and waist circumference (WC) values.

Anthropometric measurement	Correlation coefficient (95% Confidence Intervals [CI])			Bland-Altman limits of agreement		
	All (n = 444)	Men (n = 180)	Women (n = 264)	All (n = 444)	Men (n = 180)	Women (n = 264)
Height (cm)	0.98 (0.98, 0.99)	0.96 (0.95, 0.97)	0.95 (0.94, 0.96)	−2.437–4.769	−2.627–4.785	−2.308–4.759
Weight (kg) [a]	0.97 (0.97, 0.98)	0.97 (0.96, 0.98)	0.96 (0.95, 0.97)	−8.928–6.080	−8.273–5.695	−9.364–6.332
BMI (kg/m^2)	0.95 (0.94, 0.96)	0.95 (0.94, 0.96)	0.95 (0.94, 0.96)	−3.954–2.154	−3.414–1.869	−4.287–2.314
WC (cm)[a]	0.90 (0.89, 0.92)	0.87 (0.83, 0.90)	0.86 (0.86, 0.91)	−14.981–9.836	−14.654–9.752	−15.221–9.911

BMI = body mass index; WC = waist circumference; 95 % CI = 95% confidence intervals.

[a]Weight value was missing in one person (n = 443; one woman [n = 263]), and waist value was missing in two persons (n = 442; one man [n = 179] and one woman [n = 263]).

Table 3

Within-pair correlation coefficients with 95% confidence intervals (CI) of differences between self-reported and measured height, weight, body mass index (BMI) and waist circumference (WC) in all twin pairs and by zygosity and sex.

Differences between self-reported and measured variable[a]	ALL pairs			MEN pairs				WOMEN pairs			
	All (n = 220)	MZ (n = 125)	DZ (n = 93)	All (n = 89)	MZ (n = 49)	DZ (n = 39)		All (n = 131)	MZ (n = 76)	DZ (n = 54)	
	r (95% CI)	r (95% CI)	r (95% CI)	r (95% CI)	r (95% CI)	r (95% CI)	p-value[c]	r (95% CI)	r (95% CI)	r (95% CI)	p-value[c]
Height (cm)	0.32 (0.19, 0.43)	0.42 (0.27, 0.56)	0.16 (−0.04, 0.36)	0.29 (0.09, 0.47)	0.29 (0.01, 0.53)	0.28 (−0.04, 0.55)	0.961	0.35 (0.19, 0.49)	0.55 (0.37, 0.69)	0.09 (−0.19, 0.35)	0.004
Weight (kg)[b]	0.23[b] (0.10, 0.36)	0.26 (0.09, 0.42)	0.21[b] (0.01, 0.40)	0.15 (−0.06, 0.35)	0.06 (−0.22, 0.34)	0.29 (−0.03, 0.56)	0.284	0.28[b] (0.11, 0.43)	0.39 (0.18, 0.56)	0.17[b] (−0.10, 0.42)	0.191
BMI (kg/m^2)	0.30[b] (0.17, 0.42)	0.40 (0.24, 0.54)	0.19[b] (−0.01, 0.38)	0.22 (0.01, 0.41)	0.16 (−0.13, 0.42)	0.37 (0.06, 0.61)	0.459	0.33[b] (0.17, 0.48)	0.52 (0.34, 0.67)	0.12[b] (−0.16, 0.38)	0.013
WC (cm)[b]	0.39[b] (0.27, 0.50)	0.34[b] (0.17, 0.49)	0.43 (0.25, 0.58)	0.42[b] (0.23, 0.58)	0.42[b] (0.15, 0.63)	0.44 (0.14, 0.66)	0.913	0.37[b] (0.21, 0.51)	0.30[b] (0.08, 0.50)	0.43 (0.18, 0.63)	0.411

MZ = monozygotic; DZ = dizygotic; r = correlation coefficient; BMI = body mass index; WC = waist circumference; 95 % CI = 95% confidence intervals.

Note: Zygosity was unknown in one male pair and in one female pair.

[a] Difference variable (self-reported value − measured value) of twin 1 correlated to difference variable (self-reported value − measured value) of twin 2.

[b] Missing values: Weight in one DZ woman, BMI in one DZ woman, and waist in one MZ man and one MZ woman.

[c] P-values for differences in correlation coefficients between MZ and DZ pairs within sex.

Table 4

Proportions (%) of participants in categories of measured body mass index (BMI, kg/m^2) by categories of self-reported BMI by sex.

Self-reported BMI (kg/m^2)	Measured BMI (kg/m2)								
	ALL (n = 443)			Men (n = 180)			Women (n = 263)		
	Normal (BMI 18.5–24.9)%	Overweight (BMI 25–29.9) %	Obese (BMI ≥30)%	Normal (BMI 18.5–24.9)%	Overweight (BMI 25–29.9) %	Obese (BMI ≥ 30)%	Normal (BMI 18.5–24.9)%	Overweight (BMI 25–29.9) %	Obese (BMI ≥ 30)%
Normal (BMI 18.5–24.9)	76.4	23.6	0	76.1	23.9	0	76.5	23.5	0
Overweight (25–29.9)	3.8	81.7	14.5	5.3	80.9	13.8	2.2	82.6	15.2
Obese (BMI ≥ 30)	0	7.6	92.4	0	7.5	92.5	0	7.7	92.3

[a] Weight value was missing in one person (n = 443; one woman [n = 263]), and waist value was missing in two persons (n = 442; one man [n = 179] and one woman [n = 263]).

Table 5

Bland-Altman Limits of agreement between self-reported height, weight, BMI and WC by measured BMI categories and sex.

Anthropometric measurement	Normal (BMI 18.5–24.9 kg/m^2)			Overweight (BMI 25–29.9kg/m^2)			Obese (BMI ≥30kg/m^2)		
	All (n = 178)	Men (n = 46)	Women (n = 132)	All (n = 186)	Men (n = 94)	Women (n = 92)	All (n = 79)	Men (n = 40)	Women (n = 39)
Height (cm)	−2.095–4.307	−2.134–3.778	−2.064–4.475	−2.897–5.203	−2.902–5.343	−2.908–5.077	−2.048–4.661	−2.407–4.497	−1.633–4.781
Weight (kg)	−6.914–4.958	−6.647–5.138	−7.021–4.909	−7.834–4.796	−7.703–4.668	−7.999–4.958	−14.043–9.638	−10.888–8.158	−16.799–10.676
BMI (kg/m^2)	−3.167–1.817	−2.666–1.729	−3.326–1.831	−3.539–1.692	−3.241–1.477	−3.829–1.899	−5.960–3.260	−4.413–2.683	−7.204–3.508
WC (cm)	−13.068–9.247	−12.726–9.983	−13.205–9.008	−14.962–9.567	−14.246–9.395	−15.727–9.769	−18.538–11.235	−17.568–9.999	−19.609–12.573

BMI = body mass index (calculated from the measured height and weight values); WC = waist circumference.