Precision of Recumbent Anthropometry

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ABSTRACT In some studies recumbent anthropometric measures are more appropriate than standing measures. There is little published information, however, on the precision of recumbent measures. To estimate the interobserver precision of recumbent anthropometry, 22 men and 29 women volunteers 35–64 years of age were each measured on the same day by four trained nurses previously inexperienced in anthropometry. Fourteen recumbent measurements were taken, including abdominal sagittal diameter measured with a new type of caliper. The nurses also measured standing waist and hip girths. Various indicators of interobserver precision were estimated including the intraclass correlation coefficient (ICC). The ICC ranged from 98.5% for calf girth to 56.2% for the suprailiac skinfold in men, while it ranged from 95.8% for upper arm girth to 67.0% for the suprailiac skinfold in women. The abdominal sagittal diameter measurement had very high precision as estimated by the ICC in both men and women, 95.8% and 96.3%, respectively. Recumbent waist girth was, on average, only 0.3 cm larger than standing girth. In contrast, recumbent hip girth was 3.8 cm smaller than standing girth. These findings suggest that studies using recumbent anthropometry can achieve levels of precision similar to those obtained with standing anthropometry. For both sexes, however, the suprailiac skinfold appears to have much lower precision in the recumbent than in the standing position. In addition, prevalence estimates of abdominal obesity derived from the ratio of waist-to-hip girths will be higher in studies using recumbent anthropometry than in studies using standing anthropometry.

Clinical and epidemiologic studies have established that the distribution of body fat is a strong correlate of cardiovascular risk factors and disease in adults (Larsson, 1991). In many studies, fat distribution is ascertained from a variety of anthropometric dimensions, including both girths and skinfold thicknesses. These measurements are ordinarily taken when study participants are in a standing position (Lohman et al., 1988). This is appropriate when the participants are in good health and can remain standing for the time required to take the measurements; however, standing anthropometry may not be feasible in some studies, especially those involving acutely ill or elderly subjects (Chumlea et al., 1985). Anthropometric dimensions are also used clinically to ascertain the nutritional status of hospitalized patients and patients with orthopedic or neurologic impediments that limit their ability to sit or stand upright during anthropometric assessment (Jensen et al., 1981). In such populations, recumbent anthropometry is more appropriate than standing measurement. However, information on the reliability of recumbent anthropometric dimensions is scant.

The reliability of a measurement has two components: precision and dependability (Mueller and Martorell, 1988). Precision or repeatability in a very short time span is decreased by measurement errors arising from imperfections in the measuring instru-
ments and in the technique of the measurer. Dependability is decreased by longer-term physiologic variation that affects the magnitude of the dimension. Precision, however, is likely the most important determinant of reliability for many anthropometric dimensions (Mueller and Martorell, 1988; Marks et al., 1989).

The purpose of this study was to estimate the interobserver precision of 14 recumbent anthropometric dimensions taken by trained but previously inexperienced research nurses. The dimensions included the abdominal sagittal diameter (Sjostrom, 1991) which was measured by a new caliper for which precision has not previously been reported. In addition, this study assessed the comparability of standing and recumbent waist and hip girths, two of the most commonly used indicators of abdominal obesity.

SUBJECTS AND METHODS

The data were collected as part of a training exercise for nurse anthropometrists in a case control study of ischemic heart disease and body fat distribution. The nurses first received an 8 hour didactic and practical training session conducted by one of the authors (C.M.W.) who is an experienced anthropometrist. After the training session was completed, four nurses took part in the reliability study. The experienced anthropometry trainer (C.M.W.) observed but did not participate in the reliability study.

Fifty-one volunteer participants (22 men, 29 women), 35–64 years of age, were recruited. Mean heights and weights were 1.78 m (range: 1.71–1.88 m) and 86.6 kg (63.6–118.2 kg) in men, and 1.64 m (1.50–1.79 m) and 68.0 kg (45.9–102.3 kg) in women. Each participant wore only undergarments and a hospital gown, and the entire measurement session took approximately 90 minutes. The four nurses repeated the same set of measurements on every participant in a round-robin fashion on the same day. Nurses were not permitted to observe each other, review measures obtained, or discuss subject measurements until after all of the nurses had completed the battery for that subject. Skin markings were erased between examinations by each nurse. The measurements were performed following standard procedures (Lohman et al., 1988) modified for the recumbent position.

Recumbent measurements were collected for one diameter (abdominal), six circumferences (waist, hip, mid-thigh, lower thigh, calf, and upper arm), and seven skinfolds (mid-abdominal, anterior thigh, suprailiac, forearm, medial calf, subscapular, and triceps). Waist and hip circumferences were also measured when the participants were standing.

Measurement protocol

Standing measurements. With the participant standing, the nurse first visually determined the narrowest point between the lower ribs and the iliac crest, placed the tape around the waist at this point in a horizontal plane, and recorded standing waist circumference from the front of the participant. Standing hip circumference was measured with the tape in a horizontal plane around the point of visually determined maximum protuberance of the buttocks. The participant was then asked to lay supine on a standard hospital bed.

Recumbent measurements. With the participant supine, eight anatomic landmarks were marked with a cosmetic pencil in the following order: mid-upper arm (right arm marked at midpoint between acromiale and olecranon on the posterior aspect of the triceps muscle); mid-forearm (right arm marked over the radius with palm upward and midway between lateral epicondyle and styloid process); iliac crest (right iliac crest in the mid-axillary line); natural waist (midpoint between the lower ribs and the iliac crests, bilaterally); mid-abdomen (midpoint between the lower ribs and the iliac crests, bilaterally); mid-abdomen (midpoint between the iliac crests); paraumbilicus (4 cm to the right of the midpoint of the umbilicus); anterior mid-thigh (right thigh at the midpoint between lateral inguinal fold and mid-patella); anterior lower thigh (right thigh 4 cm above the superior margin of the patella).

Diameter. Abdominal sagittal diameter was measured by a sliding caliper designed by one of the authors (H.S.K.) and herein designated as an “abdometer.” The abdometer consists of a broad, flat, fixed arm which is slipped beneath the back of the recumbent subject; a parallel sliding arm which is lowered to touch the front of the patient’s abdomen; a vertical shaft with a fixed scale (cm) from which readings are taken directly, and two spirit levels for ensuring verticality of the shaft (Fig. 1).
The participant was asked to briefly raise the hips from the bed while the abdometer’s fixed arm was inserted underneath the small of the back at the level of the iliac crests. The upper arm of the abdometer was placed over the mid-abdomen mark and brought to within 2.5 cm above the abdominal surface. This location is understood to closely approximate the level of the L4-L5 interspace. The participant was asked to inhale and exhale gently and the arm of the abdometer was brought down to touch the mid-abdomen mark without compression. The diameter was recorded to the nearest 0.1 cm. After removal of the abdometer the entire measurement process was repeated at least once. If the first two values differed by more than 1.0 cm then the measurement was repeated two more times, and all four replicates were reported.

Mid-arm circumference. This was taken at the marked midpoint with the right elbow extended just away from the trunk, the palm facing the thigh, and the arm relaxed and resting on the bed surface.

Waist circumference. This was taken with the tape in a horizontal plane over both waist marks. The participant was asked to inhale and exhale, and the tape was brought close without compressing the skin.

Mid-thigh circumference. This was taken with legs straight and feet relaxed and rotated outward 60°. The tape was drawn vertically around the thigh, with the zero end just below the mid-thigh mark.

Lower thigh circumference. This was taken by moving the tape down the thigh to the lower thigh mark.

Calf circumference. This was taken on the right calf with the right foot flat on the bed and the knee flexed 90°. The tape was placed around the calf and moved up or down in a plane perpendicular to the long axis of the calf to locate the maximum circumference.

Skinfolds. Skinfolds were taken with Holtain calipers after a count of “one-thousand-one, one-thousand-two” and recorded to the nearest 0.2 mm. If the first two measurements differed by more than 2.0 mm, four replicates were taken. If any skinfold exceeded the 44.0 mm capacity of the calipers, the value “44.4” was recorded.

Medial calf skinfolds. This was taken with right knee flexed 90° and the sole of the foot on the bed surface.

Subscapular skinfold. This was taken with the participant lying on the left side and the right arm relaxed along the entire length of the body. The scapula was palpated along its vertebral border to identify the inferior angle. A diagonal fold 1 cm medial to the angle of the right scapula was raised and the skinfold taken.

Triceps skinfold. This was taken with the participant still on the left side, and the re-
laxed right arm extended along the length of the body with the right palm against the lateral right thigh keeping parallel to the body axis. A fold was raised in the long axis, and the measurement was taken at the mid-arm mark.

**Suprailiac skinfold.** This was taken with the participant still on the side. The skinfold was taken at the suprailiac mark on a fold parallel to the inguinal crease.

**Forearm skinfold.** This was taken after return to the supine position at the mark, right arm along right side palm facing up.

**Abdominal skinfolds.** Horizontal fold taken after the participant relaxed the abdomen and breathed normally at the paraumbilical mark.

**Anterior thigh skinfold.** This was taken at the mid-thigh mark, right thigh relaxed.

### Statistical analysis

The mean of each nurse’s replicate measurements was used as the participant’s value for all estimates of variance components and precision in the analysis. Four indicators of interobserver precision were estimated for each of the anthropometric measures for men and women separately: mean of absolute within-subject differences among nurses (MAD), technical error of measurement (TER), coefficient of variation (CV), and intraclass correlation coefficient (ICC). TER, CV, and ICC were computed using variance components from a two-way analysis of variance, random effects model. Because some of the measurements were missing for a small number of subjects, the analysis of variance was corrected for the unbalanced design (SAS, 1989).

TER is the square root of the within-subject variance (VARW) contributed by the nurses’ measurement errors and the errors due to any interaction between nurses and subjects during measurement. If one assumes normality of within-subject measurement errors, then a given subject’s true value will be within ± twice the TER 95% of the time (assuming interaction is negligible compared to measurement error) (Malina et al., 1973). This interval is the 95% measurement interval (95% MI). CV is computed by dividing the TER by the overall mean value of the measurement, and represents the proportion of the mean value that is represented by measurement error. ICC is the ratio of between-subject variance (VARB) to the sum of the between- and within-subject variances (Bartko, 1966). ICC represents the proportion of total variation in a measurement that is due to true biologic variation among subjects and not due to observer imprecision. Because men and women have distinct patterns of body fat distribution, which may affect measurement precision in the recumbent position, sex-specific estimates of precision are presented. Differences between the sexes in MAD were tested statistically using the nonparametric Wilcoxon rank sum test, because absolute differences are not normally distributed (Gordon and Bradtmiller, 1992).

Visual evidence that precision varied with the size of the measurements was first examined by plotting MAD against the measurements themselves. Size effects on precision were estimated using linear regression with intrasubject MAD as the dependent variable and the intrasubject mean measurement as the independent variable. The sexes were combined for these analyses.

Although standing and recumbent circumferences are technically not the same dimensions, researchers working in populations which require recumbent measurement may still wish to compare their measurements to those obtained in other populations assessed in standing mode. Hence, agreement between the recumbent and standing measurement modes for waist and hip girths was also examined. For these analyses the mean of the four nurses’ measurements was used to represent each subject’s value. The Pearson product-moment correlation between the two modes of measurement was calculated, a paired t-test of the mean differences was computed, and the differences (recumbent-standing) against the mean (recumbent + standing/2) (Bland and Altman, 1986) were plotted. In addition, the differences were regressed on the means of the measurements. The regression models were tested by the method of Bradley and Blackwood (1989) which is a simultaneous F-test of the hypothesis that the intercept and slope coefficients are both zero. Rejection of the Bradley-Blackwood Test (BBT) indicates that the magnitude of measurement bias depends on the size of the measurement, and also that the variance of one mode of measurement is significantly different from the other. The sexes were combined for these analyses. The statistical assumptions for the regression models were examined using standard procedures (Draper and Smith, 1981).
## RESULTS

Among men, precision of girths and abdominal diameter was generally better than that of skinfolds (Table 1). Standing girths were slightly less precise than the corresponding recumbent girths as indicated by both the CVs and ICCs. Standing hip girth had the lowest precision of the girths (CV = 5.9%; ICC = 68.0%), while calf girth had the highest precision of any measurement (CV = 1.8%; ICC = 95.8%). Abdominal diameter also had high precision (CV = 2.5%; ICC = 95.8%). Of the skinfold thicknesses, the suprailiac site had the poorest precision (CV = 52.0%; ICC = 67.0%), while the abdominal had the best CV (11.0%) and the subscapular skinfold had the highest ICC (89.1%).

The MAD was statistically different between men and women for two dimensions, calf girth ($P = 0.0062$) and medial calf skinfold ($P = 0.0479$). In both cases, the MAD for men was less than that for women.

Among men, 6.8% of all skinfold measurements exceeded the capacity of the calipers (coded "44.4"), and ranged between 0.0% for forearm and medial calf skinfold to 25.3% for abdominal skinfold. After excluding the out-of-range values, the ICC for abdominal skinfold decreased 5.0 percentage points, while the ICC for anterior thigh and suprailiac skinfold increased 6.3 and 3.5 percentage points, respectively. Although only 2.3% of the triceps skinfold values were out-of-range, the exclusion of these values increased the ICC 18.4 percentage points. This occurred because two subjects were coded out-of-range by two different nurses, and the remaining nurses recorded much lower measurements for the two subjects. For subscapular skinfold the ICC was nearly the same after exclusion of out-of-range values.

Among women, 10.5% of all skinfold measurements exceeded the capacity of the calipers, and ranged between 0.0% for forearm

### TABLE 1. Estimates of interobserver precision for anthropometric dimensions taken by four nurses on 22 men aged 35-64 years

<table>
<thead>
<tr>
<th>Measurement</th>
<th>Measurement no.</th>
<th>Mean</th>
<th>MAD</th>
<th>TER</th>
<th>95% MI</th>
<th>CV%</th>
<th>VARB</th>
<th>VARW</th>
<th>ICC</th>
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<tr>
<td>Girths (cm)</td>
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<td></td>
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<tr>
<td>Waist</td>
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<td>96.4</td>
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<td>4.2</td>
<td>8.3</td>
<td>4.3</td>
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<td>87</td>
<td>103.8</td>
<td>2.1</td>
<td>6.1</td>
<td>12.2</td>
<td>5.9</td>
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<td>37.34</td>
<td>68.0</td>
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<td></td>
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<td></td>
</tr>
<tr>
<td>Waist</td>
<td>87</td>
<td>95.0</td>
<td>1.8</td>
<td>3.9</td>
<td>7.8</td>
<td>4.1</td>
<td>118.91</td>
<td>15.20</td>
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<tr>
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<td>1.7</td>
<td>3.4</td>
<td>6.8</td>
<td>3.4</td>
<td>76.90</td>
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<td>1.4</td>
<td>2.8</td>
<td>2.5</td>
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<td>1.93</td>
<td>93.4</td>
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<td>Lower thigh</td>
<td>87</td>
<td>41.4</td>
<td>0.6</td>
<td>0.9</td>
<td>1.8</td>
<td>2.2</td>
<td>17.07</td>
<td>0.80</td>
<td>95.5</td>
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<td>Calf</td>
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<td>38.2</td>
<td>0.3</td>
<td>0.5</td>
<td>0.9</td>
<td>1.2</td>
<td>14.47</td>
<td>0.22</td>
<td>98.5</td>
</tr>
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<td>Upper arm</td>
<td>87</td>
<td>33.2</td>
<td>0.5</td>
<td>0.7</td>
<td>1.4</td>
<td>2.1</td>
<td>11.60</td>
<td>0.51</td>
<td>95.8</td>
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<td>Diameter (cm)</td>
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<td></td>
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<tr>
<td>Abdominal</td>
<td>87</td>
<td>23.1</td>
<td>0.4</td>
<td>0.6</td>
<td>1.1</td>
<td>2.5</td>
<td>7.3</td>
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<tr>
<td>Abdominal</td>
<td>83</td>
<td>32.9</td>
<td>2.6</td>
<td>4.4</td>
<td>8.7</td>
<td>13.2</td>
<td>73.11</td>
<td>18.86</td>
<td>79.3</td>
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<td>Suprailiac</td>
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<td>20.1</td>
<td>4.1</td>
<td>6.4</td>
<td>12.9</td>
<td>32.1</td>
<td>53.42</td>
<td>41.45</td>
<td>56.2</td>
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<td>Anterior thigh</td>
<td></td>
<td>87</td>
<td>16.9</td>
<td>2.0</td>
<td>3.8</td>
<td>7.5</td>
<td>22.4</td>
<td>14.24</td>
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<td>87</td>
<td>7.8</td>
<td>0.7</td>
<td>1.3</td>
<td>2.6</td>
<td>16.8</td>
<td>7.36</td>
<td>1.71</td>
<td>81.1</td>
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<td>10.6</td>
<td>1.2</td>
<td>1.9</td>
<td>3.9</td>
<td>15.5</td>
<td>18.98</td>
<td>3.83</td>
<td>83.2</td>
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<tr>
<td>Subscapular</td>
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<td>20.6</td>
<td>1.8</td>
<td>2.9</td>
<td>5.8</td>
<td>14.2</td>
<td>68.69</td>
<td>8.92</td>
<td>88.9</td>
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<tr>
<td>Triceps</td>
<td>87</td>
<td>15.6</td>
<td>2.3</td>
<td>4.7</td>
<td>9.3</td>
<td>29.9</td>
<td>38.84</td>
<td>21.69</td>
<td>64.1</td>
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</table>

1Definitions for the precision indicators are given in the Subjects and Methods section. MAD, mean absolute deviation; TER, technical error of measurement; 95% MI, 95% measurement interval; CV%, coefficient of variation (%); VARB, between-subject variance; VARW, within-subject variance; ICC, intraclass correlation coefficient.
skinfold to 31.3% for abdominal skinfold. The exclusion of out-of-range values reduced the ICC for anterior thigh, suprailliac, and abdominal skinfold 7.0, 6.0, and 4.3 percentage points, respectively, and raised the ICC for medial calf skinfold by 6.0 percentage points. For triceps and subscapular skinfold, the ICCs remained nearly the same after exclusion of out-of-range values.

Precision of three dimensions showed a modest decrease with increasing size of the measurement. For each unit increase in the measurement, W increased by 0.06 cm for lower thigh girth \( (P = 0.0334) \), 0.12 mm for forearm skinfold \( (P = 0.0008) \), and 0.07 mm for medial calf skinfold \( (P = 0.0431) \). No other measurement showed a statistically significant effect of size on precision.

Waist girths taken in recumbent and standing positions were highly correlated \( (r = 0.97) \). For the average participant, recumbent waist girth was only 0.3 cm larger than standing waist girth (statistically insignificant difference: paired \( t = 0.78, P = 0.4373 \)). A plot of differences against means suggested that there was no systematic bias, nor trend in bias resulting from mode of measurement (Fig. 2). This was confirmed by the BBT for paired measurements which was insignificant \( (F_{2,45} = 0.91, P > 0.25) \).

Recumbent and standing hip girths were also highly correlated \( (r = 0.94) \), but the mean of the differences indicated that recumbent hip girth was 3.8 cm less than standing hip girth (statistically significant difference: paired-\( t = -8.7, P < 0.0001 \)). Figure 2 shows that, except for one participant, recumbent girth consistently underestimated standing girth. The BBT was statistically significant \( (F_{2,49} = 42.0, P < 0.0001) \), and the slope coefficient for mean hip girth from the BBT regression model was negative \( (-0.1 \text{ cm}) \), indicating that the variance of recumbent hip girth was significantly less than the variance of standing hip girth. The negative slope coefficient also indicates that the underestimation bias due to recumbency increased by 0.1 cm with each 1.0 cm increase in mean hip girth.

DISCUSSION

In this study of male and female volunteers, 35–64 years of age, who were measured by four research nurses, interobserver precision of measurements of recumbent body girths was generally higher than that of the recumbent skinfolds. Recumbent and standing waist girths were highly concordant, but hip girths taken in the recumbent position were significantly smaller than those taken in the standing position. In gen-
Fig. 2. Scatter plots of the differences against the means of the recumbent and standing measurements for the waist and hip girths.
eral, however, recumbent waist and hip girths were somewhat more precisely measured than standing girths. There was little evidence that the precision of recumbent anthropometry differed systematically between the sexes.

Chumlea et al. (1985) reported precision for three measurements taken in the recumbent position for 257 ambulatory White men and women aged 65–104 years. The results were reported for both sexes combined. For upper arm girth, MAD (0.4 cm), TER (0.4 cm), CV (1.4%), and ICC (98.8%) were very similar to that found in this study. For the triceps and subscapular skinfolds, however, the precision was markedly higher than that achieved in our study (triceps skinfold: MAD = 1.4 cm, TER = 1.5 cm, CV = 8.9%, and ICC = 95.4%; subscapular skinfold: MAD = 1.9 cm, TER = 1.9 cm, CV = 8.0%, and ICC = 94.4%). Higher precision may have been achieved by Chumlea et al. (1985) because they employed experienced anthropometrists, while our study utilized recently trained nurses who were previously inexperienced in anthropometry. Because of the many potential sources of error, skinfolds are generally viewed in anthropometry as among the most difficult to measure precisely (Harrison et al., 1988; Bray et al., 1978; Mueller and Malina, 1987).

Because the literature on precision of recumbent anthropometry is quite limited, interobserver precision estimates of our recumbent measurements were compared to those reported for measures taken in the standing position. The precision of standing thigh girth (Callaway et al., 1988) and thigh skinfold (Harrison et al., 1988) has been reported in terms of their correlation and standard error of measurement; thus they were not comparable to the indicators computed in our study. Estimates of precision for the forearm skinfold are not available (Harrison et al., 1988).

TER has been reported for standing waist and hip girths only, and only for adolescent and elderly subjects. TER ranged between 0.48 cm–1.56 cm for waist girth, and was reported to be 1.38 cm for hip girth (Callaway et al., 1988). These estimates are substantially smaller than the TER for both standing and recumbent waist and hip girths estimated in this study, which may again reflect the inexperience of nurse-anthropometrists, or the smaller measurement range encountered in samples of adolescents and the elderly.

Chumlea et al. (1990) reported interobserver precision for standing anthropometry for both sexes combined in the Hispanic Health and Nutrition Examination Survey (HHANES) as follows: calf girth MAD = 0.34 cm, TER = 0.52, ICC = 97.9% and upper arm girth MAD = 1.05 cm, TER = 1.33, ICC = 94.4%. Estimates of precision for these two girths measured in the recumbent position are very similar.

Chumlea et al. (1990) also reported precision estimates for four skinfolds in the HHANES as follows: suprailiac MAD = 4.54 cm, TER = 3.90, ICC = 89.7%; mid-calf MAD = 3.84 cm, TER = 3.92, ICC = 85.2%; subscapular MAD = 3.47 cm, TER = 3.30, ICC = 92.7; triceps MAD = 2.65 cm, TER = 2.59, ICC = 94.5%. Precision of recumbent suprailiac and triceps skinfolds in this study was substantially below that estimated by Chumlea et al. (1990). However, precision of recumbent medial calf and subscapular skinfolds was similar to that of Chumlea et al.

We could find no published studies that compared recumbent with standing waist and hip girths. Chumlea et al. (1985) have compared standing upper arm girth, and triceps and subscapular skinfolds to the respective recumbent measurements using linear regression. They reported strong concordance between standing and recumbent measures, with R²s ranging between 88% for the subscapular skinfold to 96% for upper arm circumference; there was also no evidence of any statistically significant under- or overestimation. Our findings suggest that recumbent and standing measures of waist girth are also highly comparable. For hip girth, however, the recumbent measure is consistently smaller than the standing measure. Hence, estimation of the prevalence of abdominal obesity determined by the waist-hip girth ratio may be higher in studies that measure hip girth in the recumbent position than in the standing position.

Precision decreased slightly with increased size of lower thigh girth and medial calf and forearm skinfolds. Although it is believed that the thicker the skinfold the lower the measurement precision (Harrison et al., 1988), the quantitative effects of size on precision are rarely presented. We were unable to identify any other study that reported size effects on precision for recumbent anthropometric measurements. In a study of standing anthropometry, Marks et al. (1989) found precision decreased as
triceps and subscapular skinfold thicknesses increased. Results for other skinfolds were not reported.

This study also found that precision of the abdominal sagittal diameter, as measured by a new type of caliper, was very high in both men and women, and was superior to the precision of the waist and hip girths. This improvement in precision may increase the power of future epidemiologic or clinical studies that examine the association between abdominal obesity and chronic disease. Abdominal sagittal diameter is apparently highly correlated with visceral adipose tissue volume estimated by computed tomography (Sjostrom, 1991); visceral adipose tissue volume may be specifically associated with hyperinsulinemia (Kissebah, 1991) and dyslipidemia (Bjorntorp, 1990). In addition, a recent prospective study reported that all cause and coronary heart disease mortality rates were significantly higher in men in the upper tertile of sagittal diameter compared to those in the lower tertile (Seidell et al., 1992).

In summary, precision of recumbent anthropometry for the assessment of body fat distribution is generally comparable to that achieved for standing anthropometry. Recumbent measurement of the suprailiac skinfold, however, appears to be substantially less precise than when measured in the standing position. Recumbent waist girth is very similar to standing waist girth, but hip girth measured in the recumbent position is significantly smaller than when measured in the standing position.

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LITERATURE CITED


