Estimation of thigh muscle cross-sectional area by dual-energy X-ray absorptiometry in frail elderly patients

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ABSTRACT

Background: Thigh muscle mass and cross-sectional area (CSA) are useful indexes of sarcopenia and the response to treatment in older patients. Current criterion methods are computed tomography (CT) and magnetic resonance imaging.

Objective: The objective was to compare thigh muscle mass estimated by dual-energy X-ray absorptiometry (DXA), a less expensive and more accessible method, with thigh muscle CSA determined by CT in a group of elderly patients recovering from hip fracture.

Design: Midthigh muscle CSA (in cm²) was assessed from a 1-mm CT slice and midthigh muscle mass (g) from a 1.3-cm DXA slice in 30 patients (24 women) aged 81 ± 8 y during 12 mo of follow-up. Fat-to-lean soft tissue ratios were calculated with each technique to permit direct comparison of a variable in the same units.

Results: Baseline midthigh muscle CSA was highly correlated with midthigh muscle mass (r = 0.86, P < 0.001) such that DXA predicted CT-determined CSA with an SEE of 10 cm² (an error of ≈12% of the mean CSA value). CT- and DXA-determined ratios of midthigh fat to lean mass were similarly related (intraclass correlation coefficient = 0.87, P < 0.001). When data were expressed as the changes from baseline to follow-up, CT and DXA changes were weakly correlated (intraclass correlation coefficient = 0.51, P = 0.019).

Conclusions: Assessment of sarcopenia by DXA midthigh slice is a potential low-radiation, accessible alternative to CT scanning of older patients. The errors inherent in this technique indicate, however, that it should be applied to groups of patients rather than to individuals or to evaluate the response to interventions.


KEY WORDS Sarcopenia, midthigh muscle mass, dual-energy X-ray absorptiometry, hip fracture, frail elders

INTRODUCTION

Sarcopenia, the age-related loss of skeletal muscle mass (SMM), is associated with physiologic, metabolic, and functional impairment (1, 2). Decreased muscle mass and quality may be related to osteoporotic fractures (3), and sarcopenia is understood to be an important factor in the development of frailty and loss of independence in the elderly (4).

Because poor function of the large upper leg muscle groups can be especially significant to the loss of mobility (5, 6), assessment of thigh muscle mass and composition has emerged as an important clinical and research measurement for elderly groups. The criterion method for monitoring thigh muscle mass is a midthigh computed tomography (CT) slice, which permits estimation of muscle cross-sectional area (CSA) (7). However, this technique requires considerable expertise to perform, involves radiation exposure, and is relatively costly, as is magnetic resonance imaging (8).

Dual-energy X-ray absorptiometry (DXA) offers a relatively low-cost alternative method of body-composition assessment that involves minimal radiation exposure and is becoming increasingly common in clinical and research applications. Because a whole-body DXA scan is able to divide the body into bone, fat, and lean compartments, the lean or fat-free soft tissue in the limbs calculated by the DXA software closely approximates limb SMM (9, 10). This DXA technique has been validated for application in elderly subjects (11). Furthermore, because the DXA software permits specific regional analyses, it is possible to estimate midthigh SMM, and this approach has been reported to be of acceptable accuracy in several studies (12–14). There is scarce information, however, on the application of DXA in the...
assessments of thigh muscle mass in frail elderly patients, in whom it assumes arguably the greatest clinical relevance.

The aim of this study was, therefore, to compare mid-thigh muscle mass estimated by DXA with CT-determined mid-thigh muscle CSA in a group of elderly patients recovering from hip fracture. We hypothesized that there would be strong agreement between the DXA and CT techniques, as indicated by an intra-class correlation coefficient (ICC) of ≥0.8.

SUBJECTS AND METHODS

Subjects

The eligible participants of this 12-mo prospective study were community-dwelling elderly persons aged ≥60 y who were hospitalized for surgical repair of fractured neck of femur due to minimal trauma. The overall aim of the study was to investigate the role of sarcopenia and undernutrition in recovery from hip fracture in this population.

A tracking system was established to capture admissions to the casualty departments of Sydney’s Royal North Shore Hospital (RNSH), Royal Prince Alfred Hospital, and St George Hospital because of fractures of femur, hip or pelvic pain, or falls. Patients residing in a nursing home at the time of fracture, terminally ill, or severely demented, unable to consent to participation in the research protocol, or non-English speaking were excluded. Eligible patients were contacted =1 wk after their admission and were invited to give informed consent to participate in the study.

Enrolled subjects were assessed within 2 wk of consent and at 4 and 12 mo after fracture in the domains of body composition (total body muscle, fat, and water), nutritional status, muscle function, gait and balance, neuropsychological function, social situation, burden of disease, and extent of disability.

All participants had field measures in each of these domains. In addition, a subset of participants at the RNSH underwent measures of regional muscle mass, CSA, and bone mineral density (Figure 1). These RNSH participants formed the sample for the present study, which compared DXA and CT measures of thigh muscle composition. The protocols were administered in accordance with the guidelines of the Ethics Committees of the Area Health Services for the 3 hospital sites involved and The University of Sydney.

FIGURE 1. Subject recruitment and assessment schedule. Of the total cohort of 193 patients, a subset of patients underwent additional body-composition assessment including computed tomography (CT) and dual-energy X-ray absorptiometry (DXA).

Body-composition measurements

DXA

Hip (femoral neck, trochanter, and Ward’s triangle) bone mineral content and bone mineral density, total body and regional bone mineral content, fat mass, and fat-free soft tissue mass (FFST) were measured with a Norland XR36 DXA (Norland Corporation, Fort Atkinson, WI), as described previously (11, 15). The whole-body scans used a scan speed of 130 mm/s, and all scans were analyzed with version 3.9.4 software. The instrument was calibrated daily with the manufacturer’s spine and soft tissue phantoms. The fat and lean phantoms use 77 combinations of acrylic and aluminum, and the software assumes a weighted linear fat distribution model that permits extrapolation of the fat content of bone-containing pixels (16, 17).

A 1.3-cm thick mid-thigh slice through the nonfractured leg was manually inserted on the DXA scan at the mid-point of the lower margin of the femoral condyles and the upper margin of the greater trochanter (Figure 2A). DXA-derived mid-thigh SMM (in g) was estimated as the FFST value calculated for the mid-thigh region with the DXA software, which also provided the fat content (in g) for this region. The same researcher analyzed all scans. The precision of the mid-thigh FFST and fat measurements, based on 5 separate scans of each of 2 subjects and expressed as a CV, was 3.5% and 4.7%, respectively. The error attributable to manual positioning of the mid-thigh region, assessed from repeat analyses of the scans of 10 subjects, was 1.7% for FFST and 2.0% for fat. A ratio of mid-thigh fat to lean tissue (15) was calculated by dividing the fat mass by the muscle (FFST) mass.

CT

CT scans of the thigh for soft tissue measurements were performed with a GE High Speed CTI Scanner (General Electric, Milwaukee, WI) (4). A 1-mm slice scan of the nonfractured leg was taken at the mid-thigh, measured as the mid-point from the inguinal crease to the proximal pole of the patella, with settings as follows: kV = 100, mAs = 170, and scanning time = 1 s; the displayed field of view varied depending on subject size (Figure 2B). For repeat scans, the scanner was set to take a cross-section at the exact distances, angles, and displayed field of views noted in the initial scan. All CT images were analyzed according to...
absorption on a computer (Macintosh G4; Apple, Sunnyvale, CA) by a blind assessor using Image software (version 1.62; National Institutes of Health, Bethesda, MD) modified for quantification of cross-sectional areas of muscle, bone, and fat to the nearest 0.01 cm². Editing of some scans was required to remove scan bed pixels and contralateral thigh pixels touching the scan of interest. Some images required editing of artifacts arising from the hip prosthesis in situ on the opposite side to the scan. These artifacts caused some parts of the muscle perimeter to extend into the subcutaneous fat and other parts to run too deeply. Editing therefore involved smoothing out the muscle perimeter. Thigh muscle attenuation was calculated using a template set up in Excel (Microsoft) based on the average density for thigh pixels in a specific absorption range (range: 10–113) chosen to best discriminate muscle from fat and bone.

Muscle volume was calculated as muscle CSA multiplied by scan thickness (0.1 cm). This volume was then multiplied by 1.055, the density (in g/cc) of skeletal muscle tissue determined in cadaveric human leg muscle samples (18), to estimate muscle mass in grams. Similarly, fat volume was calculated as fat CSA multiplied by scan thickness and then multiplied by 0.923, the density (in g/cc) of adipose tissue (7, 12). The fat-to-lean tissue ratio was then calculated by dividing the fat mass by the muscle mass.

Anthropometric measures

Body weight was recorded on a digital scale (TBF-521 Body Fat Monitor/Scale; Tanita, Arlington Heights, IL) while the subjects were wearing light indoor clothing. Standing and knee height were measured with a portable stadiometer, calibrated with a steel calibration measuring stick of known length. Knee height was used to predict height in subjects who could not stand, calculated in cm as h eight = 36.272 + 2.373 × knee height (19). Body mass index (BMI) was calculated by dividing the subject’s body weight in kilograms by the square of their height in meters.

Bioelectrical impedance analysis

Whole-body SMM (20), fat-free mass (FFM) (21), and fat mass were estimated by bioelectrical impedance analysis (BIA) with an RJL Systems BIA-Quantum Machine (RJL Systems Inc, Clinton, MI).

Strength and other measures

Maximum right and left isometric knee extension strength was measured as peak force (in kg) on a digital force gauge fixed to a stand (Chatillon Dynamometer CSD200; Ametek TCI Division, Largo, FL). Habitual gait velocity (22) was recorded over 2 m with an Ultra-timer (Raymar, Henley on Thames, Oxfordshire, United Kingdom).

Part C (Activities of Daily Living; ADL) of the first National Health and Nutrition Examination Survey (NHANES I) (23) was used to assess both basic and instrumental ADL as well as mobility and activity just before fracture. The Mini-nutritional Assessment (MNA) (24) was used to provide a global index of risk of malnutrition with the use of a combination of health status, anthropometric, psychological, and dietary intake questions and measurements at the time of assessment.

Standard venipuncture technique was used to obtain serum samples. The bromcresol green method (Thermo Trace, Noble Park, Victoria, Australia) was used for albumin analysis (25), which had a CV of 1.65% for day-to-day variability. The 25-hydroxyvitamin D assay (26, 27) was performed by using a chemiluminescence system on the Nichols Advantage Analyzer (Nichols Institute Diagnostics, San Clemente, CA), with a between-run CV of 7.1% and a within-run CV of 4.8%.

Statistical analysis

Data were visually and statistically inspected for normality and are presented as means ± SDs or medians and ranges as applicable. The ICC (one-factor, random effect) was used to evaluate the extent of agreement between DXA and CT measures. Because the ICC is essentially the ratio of between-subject variance to total variance, the concordance between measures increases as this correlation coefficient approaches 1.0. Power analysis indicated that a sample size of 22 subjects would provide 80% power, at a level of P = 0.05, to reject the null hypothesis of an ICC ≤ 0.5 (ie, weak concordance) when the actual ICC is 0.8 (ie, strong concordance) (28). Pearson’s correlation and regression analysis, Student’s paired t tests, and the method of Bland and Altman (29) were used to further compare the 2 methods of midthigh SMM estimation. Differences between patient groups were determined by Student’s t tests, Mann-Whitney U tests, and chi-square tests, as appropriate. Statistical analyses were carried out with SPSS for WINDOWS release 14.0 (SPSS Inc, Chicago, IL) and Microsoft EXCEL (version 9.0; Microsoft Inc, Redmond, WA) with the level of significance set at P < 0.05.

RESULTS

Characteristics of patient groups

Thirty patients (24 female) aged 81 ± 8 y underwent both DXA and CT scans at one of the initial measurement points (baseline or 4 mo) in the study. Of these 30 patients, 25 completed both DXA and CT measurements at baseline and an additional 5 patients completed both measurements at the 4-mo time point. The characteristics of these 30 patients are compared with the remainder of the study cohort (n = 163) in Table 1. No significant differences were found between the 30 patients and the remainder of the study cohort in age, sex distribution, muscle mass and strength, nutritional status, and performance measures. Notably, they were mildly to moderately disabled on the basis of the NHANES questionnaire, and the majority had indexes of global (MNA) or biochemical (albumin and vitamin D) deficiency. Most (85%) of the patients were sarcopenic (2), and only ≈50% of their midthigh soft tissue was muscle, compared with values of 65–70% observed in healthy younger subjects aged 25–50 y (13).

CT muscle area compared with DXA muscle mass

The initial values (at baseline or 4 mo) of these 30 patients were pooled to evaluate the ability of the DXA method to predict CT midthigh muscle CSA. The relation between CT-determined midthigh muscle CSA and DXA-derived midthigh SMM is shown in Figure 3. The 2 measures were significantly and positively correlated, such that the DXA technique predicted CT-derived CSA with an SEE of 10.0 cm². This SEE represents an error of ≈12% of the mean CT-derived CSA value.

CT compared with the DXA fat-to-lean ratio

The relation between CT- and DXA-derived midthigh fat-to-lean ratio for the 30 patients is shown in Figure 4. Because the
TABLE 1
Comparison of baseline characteristics of the group of patients who underwent dual-energy X-ray absorptiometry (DXA) and computed tomography (CT) scans (DXA group) and the remainder of the patients (non-DXA group)\(^1\)

<table>
<thead>
<tr>
<th>Variables</th>
<th>DXA group ((n = 30))</th>
<th>Non-DXA group ((n = 163))</th>
<th>(P^{2})</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sex (% females)</td>
<td>80.0</td>
<td>69.9</td>
<td>0.26</td>
</tr>
<tr>
<td>Age (y)</td>
<td>81.1 ± 7.9(^4)</td>
<td>80.5 ± 8.5</td>
<td>0.72</td>
</tr>
<tr>
<td>BMI (kg/m(^2))</td>
<td>23.1 (16.0–40.9)(^6)</td>
<td>22.8 (14.5–40.5)</td>
<td>0.90</td>
</tr>
<tr>
<td>Habitual gait velocity (m/s)</td>
<td>0.35 ± 0.18</td>
<td>0.29 ± 0.15</td>
<td>0.09</td>
</tr>
<tr>
<td>Maximum isometric knee extension strength on nonfractured side (kg)</td>
<td>6.6 (2.2–21.2)</td>
<td>8.6 (1.4–21.0)</td>
<td>0.09</td>
</tr>
<tr>
<td>NHANES Functional Status Survey Disability Score (0–3)</td>
<td>0.90 ± 0.82</td>
<td>0.97 ± 0.76</td>
<td>0.67</td>
</tr>
<tr>
<td>Total number of chronic diseases</td>
<td>2 ± 1</td>
<td>3 ± 2</td>
<td>0.06</td>
</tr>
<tr>
<td>Albumin (g/L)</td>
<td>40.3 ± 3.4</td>
<td>39.2 ± 3.4</td>
<td>0.12</td>
</tr>
<tr>
<td>Vitamin D status (%)</td>
<td></td>
<td></td>
<td>0.89</td>
</tr>
<tr>
<td>Normal, &gt; 50 nmol/L</td>
<td>41.4</td>
<td>45.8</td>
<td></td>
</tr>
<tr>
<td>Mild deficiency, &gt;25–50 nmol/L</td>
<td>41.4</td>
<td>39.8</td>
<td></td>
</tr>
<tr>
<td>Moderate deficiency, 12.5–25 nmol/L</td>
<td>17.2</td>
<td>14.4</td>
<td></td>
</tr>
<tr>
<td>MNA status (%)</td>
<td></td>
<td></td>
<td>0.37</td>
</tr>
<tr>
<td>Well nourished, ≥24.0</td>
<td>30.0</td>
<td>43.6</td>
<td></td>
</tr>
<tr>
<td>Undernutrition, &lt;17</td>
<td>60.0</td>
<td>46.4</td>
<td></td>
</tr>
<tr>
<td>Percentage body fat by BIA (%)(^5)</td>
<td>35.5 ± 8.6</td>
<td>30.7 ± 10.1</td>
<td>0.02</td>
</tr>
<tr>
<td>Fat-free mass by BIA (kg)(^6)</td>
<td>37.1 ± 8.2</td>
<td>40.2 ± 10.7</td>
<td>0.16</td>
</tr>
<tr>
<td>Skeletal muscle mass by BIA (kg)(^7)</td>
<td>16.1 ± 4.8</td>
<td>18.1 ± 6.3</td>
<td>0.11</td>
</tr>
<tr>
<td>Sarcopenia (%)(^8)</td>
<td>85.2</td>
<td>72.7</td>
<td>0.18</td>
</tr>
<tr>
<td>CT fat-to-lean ratio(^9)</td>
<td>0.95 ± 0.50</td>
<td>NA</td>
<td>NA</td>
</tr>
</tbody>
</table>

\(^1\) MNA, Mini-nutritional Assessment; NHANES, National Health and Nutrition Examination Survey; BIA, bioelectrical impedance analysis; NA, not applicable.

\(^2\) \(P\) value for the difference between groups \(t\) test for continuous normally distributed data, Mann-Whitney \(U\) test for continuous nonnormally distributed data, and chi-square test for categorical data.

\(^3\) Median; range in parentheses (all such values).

\(^4\) Fat mass = body weight in kg − fat-free mass (FFM).

\(^5\) Percentage body fat = body density (g/cm\(^3\)) × 100.

\(^6\) FFM = \(-4.03 + 0.734 \times \) (height in cm\(^2\)/resistance in ohms) + 0.116 (body weight in kg) + 0.096 (reactance in ohms) + 0.984 (sex: male = 1; female = 0).

\(^7\) SMM = 0.401 (height in cm\(^2\)/resistance in ohms) + 3.825 (sex: male = 1; female = 0) + age in years \((-0.071) + 5.102\).

\(^8\) Defined as a relative skeletal muscle index (RSMI) of < 5.45 kg/m\(^2\) for females and < 7.26 kg/m\(^2\) for males (see reference 2), where RSMI = 0.75(BIA-determined SMM)/(height\(^3\)), with height in meters.

\(^9\) CT fat-to-lean ratio = midthigh fat mass/midthigh muscle mass.

2 methods were expressed in the same units, the ICC was calculated: the value of 0.87 \((P < 0.001; 95\% CI: 0.75, 0.94)\) indicates that 87% of the variance is explained by between-subject differences, and only 13% is attributable to between-method differences. This, therefore, indicates strong agreement between the 2 techniques \((28)\). Regression analysis showed that the DXA value predicted the CT-derived ratio with an SEE of 0.24 \((P = 0.90)\). Regression analysis showed that the DXA value predicted the CT change with an SEE of 13.8 percentage change \((P = 0.90)\). The 95% confidence limits for the slope \((P = 0.001; 95\% CI: 0.75, 0.94)\) indicates that 51% of the variance was explained by between-subject differences and 49% was attributable to between-method differences. Hence, there was relatively weak agreement between the 2 techniques \((28)\) in assessing change in muscle mass.

**DISCUSSION**

Assessment of muscle mass and strength is of considerable clinical importance in the context of an aging population and an increasing awareness of the far-reaching consequences of sarcopenia. Although DXA has been used extensively to estimate total-body SMM in adults and has been validated for this application in older subjects \((11)\), few studies have reported the use of this technology in the assessment of thigh muscle mass \((30)\).

To our knowledge, this is the first validation study of the application of DXA in the assessment of midthigh muscle mass in frail elderly patients. Because the characteristics of the subset of patients in this validation study did not differ markedly from those of the remainder of the study cohort, the findings should be applicable to frail elderly patients of similar age and functional status.
The baseline data from this sample of 30 elderly men and women recovering from hip fracture demonstrate that DXA can predict CT-derived midthigh muscle CSA with reasonable accuracy in such patients. Others have reported similar accuracy when comparing DXA- with CT-derived data in healthy subjects. Visser et al (12), using fan-beam DXA (Hologic QDR) and a 10-mm CT slice, reported data indicating that DXA could predict CT-derived midthigh SMM with an SE of 5–6% in healthy men and women aged 70–79 y. Because the patients in the current study were relatively frail elders recovering from recent major surgery, it is likely that perturbations in their metabolic and hydration status affected the accuracy of the DXA measurement (31). Under these circumstances, the SE of 12% for predicting midthigh muscle CSA indicates that the DXA midthigh slice technique should be a useful tool in assessing sarcopenia in the frail elderly.

Fat-to-lean ratios were calculated to allow direct comparison of CT and DXA measures of thigh soft tissue composition. The strong level of agreement in fat-to-lean ratio values between the 2 methods that we obtained (Figures 4 and 5) may have been affected by use of the muscle density value of 1.055 g/cc for calculating CT-derived muscle mass. Although this density value was determined in cadaveric samples from older people (age 79 ± 9 y at time of death) (18), the CT muscle attenuation data for our subjects (data not shown) indicate that a lower muscle density value, consistent with lipid infiltration of muscle fibers (32), is likely to be more appropriate for this frail cohort. Application of a lower value would decrease the CT-derived muscle mass values and correspondingly increase the CT-derived fat-to-lean ratio values. In addition, DXA is likely to overestimate muscle tissue when compared with CT, due in part to the inclusion of skin and other nonmuscle tissue in the FFST measurement by DXA, whereas skin and fat between muscle groups is specifically excluded in the CT analysis technique we used (12, 33).

FIGURE 3. Computed tomography (CT)–determined midthigh muscle cross-sectional area (CSA) compared with dual-energy X-ray (DXA)–derived midthigh muscle mass: data from 30 patients obtained at baseline or 4 mo. Correlation and regression analysis showed a significant positive correlation between the 2 variables, such that the DXA measure predicted the CT-derived midthigh CSA with an SEE of 10 cm².

FIGURE 4. Midthigh fat-to-lean tissue ratios (F:L) obtained from computed tomography (CT) and dual-energy X-ray absorptiometry (DXA) measurements in 30 patients. Note that this ratio is dimensionless. The intraclass correlation coefficient (ICC) indicates a strong concordance between the CT and DXA techniques. Regression analysis showed that the DXA measure predicted the CT midthigh ratio with an SEE of 0.24. The solid line represents the regression line, and the dotted line represents identity.

FIGURE 5. Bland-Altman analysis of midthigh fat-to-lean ratios (F:L): the difference between the computed tomography (CT) and dual-energy X-ray absorptiometry (DXA) values is plotted against the mean of these values. The solid line represents the average difference between the methods (the bias); the dotted lines represent the 95% CIs (limits of agreement) for the bias. There was no significant correlation between the differences and the mean values.

FIGURE 6. Percentage change over 8–12 mo (change from initial value expressed as a percentage of the initial value) in computed tomography (CT)–derived midthigh muscle cross-sectional area compared with dual-energy X-ray absorptiometry–derived midthigh muscle mass in 15 patients. The intraclass correlation coefficient (ICC) value indicates weak concordance between the CT and DXA techniques. Regression analysis showed that the change derived by DXA predicted the change derived by CT with an SEE of 13.8%.
Despite these limitations, the level of agreement between the 2 techniques for this fat-to-lean variable, as shown by the ICC and Bland-Altman analyses, provides further evidence of reasonable accuracy of the DXA midtigh measurement.

Analysis of the longitudinal changes in thigh muscle composition throughout the 12 mo of recovery from hip fracture indicates, however, that the DXA technique lacks acceptable accuracy in assessing longitudinal changes in thigh muscle mass in individuals. It is interesting to note that Tylavsky et al (33) noted similar correlations between CT- and DXA-derived midtigh SMM changes \( (r = 0.55–0.6) \) during weight change over \( \approx 12 \) wk in 37 adults. Compounded errors inherent in combining serial measurements to calculate change (33), together with alterations in nutritional (34) and hydration (31) status, as discussed above, can be expected to contribute to a substantially weaker correlation in change data compared with cross-sectional data. It should be noted that the utilization of the now available multislice CT technique may have improved the accuracy of the CT method because this has been reported to more adequately represent thigh muscle mass than the single-slice approach (35). In addition, the utilization of a higher scan resolution may improve DXA accuracy, and this warrants further investigation.

In conclusion, the assessment of muscle mass and composition by DXA-derived midtigh slice has been shown to be reasonably accurate in comparison with a single-slice CT technique in this sample of frail elderly patients. Given the relatively high cost of CT and magnetic resonance imaging, the higher radiation exposure of CT relative to DXA, and the increasing availability and ease of use of DXA instrumentation, the DXA method should be considered for the assessment of sarcopenia in frail elders. The errors inherent in this technique indicate, however, that it should currently be applied to studying groups of patients rather than individuals and that it should be used cautiously in longitudinal studies.

We thank the staff of the Royal North Shore, Royal Prince Alfred, St George, and Balmain Hospitals orthopedic wards for their assistance with recruitment and initial assessment of the subjects; the staff of the hospitals’ emergency departments for providing data for the tracking system; and the technicians at the Departments of Radiology, Endocrinology and Nuclear Medicine, RNSH, for conducting the body-composition scans.

The authors’ responsibilities were as follows—MAFS, RDH, TPF, THD, ADD, THG, BJA, NAS, PIS, and MWT: designed and planned the study; MAFS, RDH, TPF, THD, ADD, THG, BJA, NAS, PIS, and MWT: recruited subjects; RDH: supervised recruitment of subjects; MAFS, RDH, TPF, THD, ADD, THG, BJA, NAS, PIS, and MWT: performed body-composition measurements at RNSH and interpreted the data; TMS, JNG, NAS, TPF, and PIS: supervised recruitment of subjects; RDH: supervised recruitment and initial assessment of the subjects; the staff of the hospitals’ orthopedic wards for their assistance with measurement in relation to lower extremity performance in men and women aged 70 to 79: the health, aging, and body composition study. J Am Geriatr Soc 2002;50:897–904.


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