Comparison of different nutritional assessments and body-composition measurements in detecting malnutrition among gynecologic cancer patients

Brenda Laky, Monika Janda, Geoffrey Cleghorn, and Andreas Obermair

ABSTRACT

Background: Few studies have assessed global nutritional assessment tools and body-composition measurements in gynecologic cancer patients.

Objective: We aimed to assess the convergent validity of different nutritional tools such as the scored Patient-Generated Subjective Global Assessment (PG-SGA), serum albumin, skinfold-thickness measurements, and total-body potassium (TBK) and body density measurements to identify gynecologic cancer patients at risk of malnutrition.

Design: We assessed the nutritional status of 194 patients with suspected or proven gynecologic cancer according to the SGA and the scored PG-SGA, and skinfold-thickness ($n = 145$), TBK ($n = 51$), and body density measurements ($n = 42$) before primary treatment.

Results: According to the SGA and the scored PG-SGA global rating, 24% of gynecologic cancer patients were classified as malnourished. The prevalence of malnutrition was highest in ovarian (67%) and lowest in endometrial (6%) cancer patients. The ability of the PG-SGA score ($P < 0.001$) and albumin ($P < 0.001$), triceps skinfold-thickness ($P = 0.041$), and TBK ($P = 0.005$) measurements to predict the SGA was significantly better than chance. TBK significantly correlated with measurements associated with protein depletion, including age ($P < 0.001$), arm muscle area ($P < 0.001$), fat-free mass ($P < 0.001$), and the PG-SGA score ($P = 0.009$). Multiple regression analysis showed that, together, the PG-SGA score and arm muscle area adjusted for age accounted for 66% of total TBK variance.

Conclusions: The PG-SGA is significantly associated with subjective and objective parameters and is a widely recognized, clinically relevant method of evaluating nutritional status. It therefore seems most appropriate for identifying malnourishment in gynecologic cancer patients. Am J Clin Nutr 2008;87:1678–85.

INTRODUCTION

Malnutrition frequently co-exists in patients with chronic diseases and may itself be associated with adverse outcomes (1–4). It has been suggested that up to 20% of patients with cancer die of the effects of malnutrition rather than of the malignancy itself (5). The prevalence of malnutrition in cancer patients varies by tumor type and disease stage. Among patients with gynecologic cancer, ≈20% are malnourished, according to the scored patient-generated subjective global assessment (PG-SGA) at diagnosis (6). For example, patients with ovarian malignancies were 19 times as likely to present with a poor nutritional status before treatment than were patients with benign conditions (6).

The nutritional status of patients with gynecologic cancer has been evaluated mainly by using, either alone or in combination, various objective anthropometric [eg, weight loss, body mass index, triceps skinfold (TSF) thickness, and arm circumference], biochemical (eg, serum albumin, prealbumin, total protein, transferrin, hemoglobin, and vitamins), and immunologic (skin sensitivity tests) measurements (7–12).

To date, few studies have used subjective assessment tools such as the subjective global assessment (SGA) and the scored PG-SGA in gynecologic oncology (6, 13). A further development of the SGA (14) is the oncology-specific PG-SGA (15) and the scored PG-SGA (16). The scored PG-SGA has a high sensitivity and specificity in predicting the results of the more commonly used, reliable, and validated SGA (17, 18). Although there is no consensus gold standard in gynecologic oncology patients, the current guidelines of the American Society for Parenteral and Enteral Nutrition and the European Society for Clinical Nutrition and Metabolism recommend the SGA as an assessment tool of nutritional status (19, 20). The PG-SGA and the scored PG-SGA have also been validated (15, 17) and compared with other nutritional tools, including objective techniques (6, 18, 21). The Oncology Nutrition Dietetic Practice Group of the American Dietetic Association has accepted the scored PG-SGA as the standard for nutrition assessment for cancer patients (22).

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Other studies in cancer patients pointed toward a potential benefit of using body-composition measures such as total-body potassium (TBK) (23–26). TBK reflects body cell mass (BCM) and hence metabolically active tissue, which is altered in patients with poor nutritional status and chronic wasting diseases (27). Other common body-composition methods such total body water analysis are confounded by fluid imbalances, whereas TBK could be valuable in ovarian cancer patients with ascites (26, 28, 29). However, we are unaware of any studies evaluating body composition by using TBK in patients with gynecologic malignancies.

Previous findings are inconsistent with regard to the most appropriate measure of malnutrition in patients with gynecologic malignancies. Therefore, the purpose of the present study was to assess the convergent validity of various nutritional tools such as the scored PG-SGA, serum albumin, skinfold-thickness measurements, TBK, and body density measurements to identify gynecologic cancer patients who are also at risk of malnutrition.

SUBJECTS AND METHODS

Patients

All women with presumed or proven primary gynecologic cancer from the gynecologic oncology clinic at The Royal Brisbane and Women’s Hospital (RBWH, Brisbane, Australia) were screened for eligibility. Women with recurrent cancer, women who had received treatment for other cancers within the past 5 y, women with psychological or cognitive impairments (eg, schizophrenia or dementia), and non-English-speaking women were ineligible. Women with suspicious ovarian masses in whom final histopathologic results postoperatively showed a benign tumor served as controls. Patients were categorized according to their cancer sites: 1) ovarian cancer category, including primary peritoneal cancer and fallopian tube cancer; 2) endometrial cancer; 3) other cancers, including cancer of the cervix, vulva, and pseudomyxoma peritonei; and 4) tumors of low malignant potential. Between March 2004 and December 2006, 234 patients met the inclusion criteria. Twenty-six patients declined to participate, 8 patients were excluded for missing data, and 6 patients participated, 8 patients were excluded for missing data, and 6 patients had their treatment elsewhere and were therefore not included in the study. Data on age, weight, body mass index (BMI; in kg/m²), and body height were measured to the nearest 0.1 kg and 0.001 m, respectively by using a digital scale (model 770; SECA Corp, Hamburg, Germany) and a wall-mounted stadiometer (model 222; SECA Corp, respectively). BMI also was measured.

All patients (n = 194) who agreed to take part in the study completed the SGA and the scored PG-SGA and were asked to participate in further in-depth measurements of nutritional status. A health professional, trained and experienced in using the scored PG-SGA, assessed the nutritional status of all patients according to the guidelines (16). Overall, 51 patients underwent TBK counting and 42 patients underwent body density measurements; these measurements were performed in the body-composition laboratory at the Royal Children’s Hospital. Skinfold-thickness measurements were performed by the same experienced researcher on 145 patients at the outpatient department at the RBWH. Preoperative serum albumin concentrations were available for 179 patients.

All assessments were carried out either at the patient’s initial visit at the RBWH outpatient clinic or at the RBWH preadmission clinic, typically 1–5 wk before primary treatment was initiated. The median waiting time for ovarian and cervical cancer patients was 2 wk; patients with endometrial cancer or benign diseases waited 5 wk.

Written informed consent was obtained from 194 patients. The RBWH Hospital Human Research Ethics Committee (Protocol Number 2004/007) and the University of Queensland Medical Research Ethics Committee (Brisbane, Australia; Project Number 2006000533) approved the present nutritional study.

Nutritional assessment

The SGA uses information obtained by clinical history (ie, weight loss, changes in dietary intake, gastrointestinal symptoms, and functional capacity) and physical examination (ie, loss of subcutaneous fat, muscle wasting, and edema or ascites) to classify a patient’s nutritional status as either well-nourished or moderately or severely malnourished (14). A further development of the SGA is the PG-SGA (15), which has been specifically developed for patients with cancer, and the validated scored PG-SGA (16) followed the PG-SGA. The scored PG-SGA consists of a medical history component, which provides information about weight change, dietary intake, gastrointestinal symptoms (eg, nausea, vomiting, and diarrhea that have persisted for 2 wk), and changes in functional capacity. Loss of subcutaneous fat, muscle wasting, edema and ascites are considered in the physical examination. On the basis of the global assessment, the patient is classified as category A (well-nourished), category B (moderately or possibly malnourished), or category C (severely malnourished). In addition to the global ratings, the scored PG-SGA incorporates a numerical score called the PG-SGA score (16). For the PG-SGA score, all point values for each section (eg, patient’s history and physical examination) of the PG-SGA are summed. Typical PG-SGA scores in the range of 0 to 35 have been reported in patients with gastrointestinal, head, or neck cancer (30). Whereas the range differs somewhat between patients with different cancer types, higher scores reflect a greater risk of malnutrition. The PG-SGA score also provides cutoff scores for appropriate nutritional triage and intervention to improve symptom management—eg, a score of ≥9 indicates a critical need for nutritional intervention (16).

Body-composition and anthropometric measurements

Anthropometric measurements

While the subject was wearing light clothes, body weight and body height were measured to the nearest 0.1 kg and 0.001 m, respectively, by using a digital scale (model 770; SECA Corp, Hamburg, Germany) and a wall-mounted stadiometer (model 222; SECA Corp, respectively). BMI also was measured.

Serum albumin

Blood samples were routinely drawn at the preadmission clinic before the commencement of initial treatment. They were examined in the hospital’s clinical chemistry laboratory.

Skinsfold-thickness measurement

A measuring tape was used to take skinfold-thickness measurements to the nearest 0.1 cm at the midpoint of the upper left nondominant arm, between the acromion process and the tip of the olecranon. Skinfold-thickness measurements provide an estimate of the size of the subcutaneous fat depot. All skinfold-thickness measurements were also performed with a precision...
calorimeter (Harpenden, John Bull; British Indicators Ltd, St Albans, United Kingdom) by the same experienced health professional. The TSF thickness was measured to the nearest 0.2 mm. Readings were made in triplicate, and the results were averaged. Body-composition indexes of fat-free mass (FFM) and body fat were calculated from the midupper arm circumference and skinfold-thickness measurements. Midupper arm muscle area (AMA) and sex-corrected midupper AMA (cAMA) provided an index of body muscle mass and hence protein nutritional status. This was calculated by using the following equations [31 (equation 1 only), 32]:

\[
\text{AMA (cm}^2) = \frac{\text{AC (in cm)} - 3.142 \times \text{TSF thickness (in cm)}^2}{4} \times 3.142
\]

(1)

\[
\text{AMA = AMA (cm}^2) - 6.5 \, \text{(female)}
\]

(2)

and

Corrected arm fat area (in cm²)

\[
= \frac{\text{AC (in cm²)/4} \times 3.142}{4} - \text{AMA (cm}^2)
\]

(3)

where AC = arm circumference.

Total-body potassium

Almost all (98%) of the body’s potassium is located within the BCM, which consists of the nonfat cellular portion of tissues, such as skeletal muscle, viscera, organs, blood, and brain, and which can be altered by nutritional status, physical activity level, and disease states (27, 33). TBK counting has been used as a BCM marker since the 1960s (27, 34). The whole-body counter detects the 1.46-MeV γ-ray emitted by the naturally occurring isotope \(^{40}\text{K}\). This isotope represents a fixed proportion of naturally occurring potassium and is detected in a low-background-shield whole-body counter (Accuscan; Canberra Industries, Meriden, CT). There is a known constant ratio between \(^{40}\text{K}\) and TBK; therefore, the mass of the TBK can be calculated. The subject was required to lie still on a bed that moves under the detector. The \(^{40}\text{K}\) signal was recorded twice (for 18 min each time), corrected for background, and converted to a TBK in grams and calculated TBKm in mmol by multiplying TBK (g) by 1000/39. The technical error for repeated measurements of phantoms in our laboratory is 2.3% (35). BCM was calculated according to the equation of Cohn et al (36):

\[
\text{BCM(kg)} = \text{TBK(mmol)} \times 0.0092
\]

(4)

In addition, measured TBK was compared with expected normal values from healthy females by using the following predictor equations (26):

\[
\text{TBK}_p(\text{mmol}) = (14.76 \times \text{weight in kg}) + (22.07 \times \text{height in cm}) - (9.05 \times \text{age in y}) - 1669
\]

(5)

and

\[
\text{TBK}^\% \text{ predicted} = \frac{\text{TBK}_m(\text{mmol})}{\text{TBK}_p(\text{mmol})} \times 100
\]

(6)

where TBK\(_m\) = measured TBK, and TBK\(_p\) = predicted TBK.

Body density measurement

Air-displacement plethysmography was used to measure body density. This method is based on the same whole-body measurement principle as underwater weighing. The instrument used in our laboratory is called the BodPod (Life Measurement, Inc, Concord, CA). The BodPod itself is a dual-chambered, fiberglass plethysmograph that determines body volume by measuring changes in pressure within a closed chamber. The front, or test, chamber has a seat that forms a common wall (diaphragm) separating it from the rear, or reference, chamber. The door to the front chamber is closed and sealed during the brief data collection period (2 periods of 1 min each). Detailed descriptions of the principles, procedures, and calibration details for the use of the BodPod can be found elsewhere (37, 38). The BodPod measured the subject’s mass and the volume of air displaced by the person’s body while he or she sat inside the chamber wearing underwear or a swimsuit and a swimming cap. From these measurements, whole-body density was determined. With these data, FFM and fat mass (FM) were calculated.

Statistical analysis

All data were analyzed with the use of SPSS software (version 14.0; SPSS Inc, Chicago, IL). Descriptive statistics were used to present patients’ characteristics. All data except the PG-SGA score were normally distributed. Because of the small number of severely malnourished patients (n = 3), the moderately and severely malnourished categories were collapsed for further analysis, and that category is referred to hereon as “malnourished.” Independent t tests were used to examine differences in means for normally distributed continuous variables (age, weight, BMI, serum albumin, skinfold-thickness measurements, TBK, and body density measurements), and the Kruskal-Wallis test was performed to compare differences in PG-SGA scores between well-nourished and malnourished patients grouped by the SGA.

Receiver operating characteristic (ROC) analysis was performed to examine the concordance between nutritional parameters (PG-SGA score, serum albumin, TSF thickness, and TBK) and the SGA. The ROC area under the curve (AUC) represents the probability that patients found to be malnourished by the SGA will have a higher PG-SGA score and a lower albumin, TSF thickness, and TBK than will patients found to be well-nourished. Negative values for the PG-SGA score were used to create a concise plot. A ROC AUC of 1.0 would suggest that nutritional parameters are perfectly discriminating, whereas a ROC AUC of 0.5 would suggest that those parameters are no better than chance at discriminating between well-nourished and malnourished patients. The true-positive rate (sensitivity) was plotted against the false-positive rate (1 specificity) across the values of the nutritional parameters, with the 45° line representing the ROC AUC of 0.5.

In clinical practice, TBK measurements are too involved and time-consuming for cancer patients, and relatively few hospitals are equipped with the costly device. However, TBK is a useful...
RESULTS

Subject and clinical characteristics

A total of 60 (31%) patients were diagnosed with benign conditions, 14 (7%) patients had ovarian tumors of low malignant potential, and 120 (74%) patients were diagnosed with a histologically proven gynecologic malignancy. Detailed baseline characteristics of the study participants are shown in Table 1.

Comparison of clinical variables between well-nourished and malnourished patients

When patients were grouped according to their SGA rating, the highest prevalence of malnutrition (67%) was detected among ovarian cancer patients. Malnourished gynecologic cancer patients were significantly older and had significantly lower values of weight and BMI, had higher PG-SGA scores, and had lower serum albumin, TSF thickness, cAMA, arm fat area, and TBK measurements than did well-nourished patients, according to the SGA. In contrast, FFM and FM did not differ significantly between the well-nourished and malnourished patients (Table 2).

Relation between the SGA and clinical variables

Simple linear regression analyses between TBK and age, weight, BMI, PG-SGA score, albumin, TSF thickness, cAMA, arm fat area, FFM, and FM are shown in Table 3. TBK was correlated significantly with age, weight, PG-SGA scores, cAMA, and FFM, and it showed a trend toward an association with albumin. There was no significant correlation between TBK and BMI, TSF thickness, arm fat area, or FM. As expected, the results indicate that parameters that are associated with protein depletion but not those associated with fat were related to TBK.

The results of the definitive multiple linear regression model are also shown in Table 3. All clinically relevant variables, such as age, weight, PG-SGA scores, albumin, and cAMA, were entered stepwise into the model. No significant interactions were detected. The final model included age, PG-SGA scores, and cAMA, which explained 66% of the total variation of TBK.

DISCUSSION

The present study showed that the PG-SGA score, serum albumin, TSF thickness, and TBK were accurate at predicting the SGA global rating and therefore were useful in discriminating malnourished from well-nourished patients. Furthermore, we found strong correlations between TBK and measurements associated with protein depletion (including age, cAMA, and FFM) and with the scored PG-SGA. The cAMA together with the PG-SGA score, when adjusted for age, was able to predict 66% of the total variance in TBK.
It was previously established that advanced age and disease stage are associated with impaired survival and greater risk of death among patients with ovarian cancer (39, 40). Our study showed that elderly women with more advanced ovarian cancer are significantly more likely to be malnourished than are elderly women with other types of gynecologic cancer. In addition, our data confirmed a study by Kyle et al (41), which found that age was significantly correlated with TBK.

At present, body weight or weight loss is widely used, either alone or in combination with other assessment tools. A previous study by our group found that weight loss alone was not an accurate indicator of malnutrition among women with gynecologic cancer, and thus weight loss was not considered in the present study (6). Although the mean BMI of the malnourished women was significantly lower than that of the well-nourished women, the mean BMI of malnourished patients still was 27.4, which, according to the World Health Organization (42), is considered to represent overweight. The accumulation of ascites and the occurrence of large tumors in gynecologic cancer patients may contribute to their weight and mask weight loss. Previous studies in cancer patient groups also highlighted the limitations of using BMI as the sole measure of nutritional status (18, 43). Thus, our results suggest that BMI and weight fail to detect malnutrition among gynecologic cancer patients when used alone as nutritional variables.

To our knowledge, this study is the first to measure body fat with an air-displacement plethysmography (BodPod) method in patients with gynecologic cancer. Despite our finding that neither FFM nor FM was significantly lower in malnourished than in well-nourished women, malnourished women tended toward a lower FFM. A possible reason for the nonidentification of malnourished patients via body density measurements may be that many of the women were obese before disease development. Furthermore, we detected a strong correlation between FFM and TBK, which indicates protein depletion. However, the feasibility of body density measurements in the clinical setting is limited, because of the limited availability of the machine in hospitals and because of the limited compliance of very ill patients.

Body-compartment analyses using dual-energy X-ray absorptiometry in cancer patients showed that lean tissue was preferentially lost from arm tissue (44). This is in agreement with the present study’s findings and the findings of others (32, 45) that cAMA is significantly higher in well-nourished than in malnourished patients. However, despite the high correlation with TBK, further research is required to establish what constitutes a clinically important change in cAMA.

Previous studies showed that cancer patients who report recent weight loss have an altered body composition according to TBK counting, whereas those who report stable weight do not (23, 27, 51).
Considering the present results, the average proportion of predicted TBK for malnourished women was \( \approx 12\% \) lower than that for the well-nourished group. A study by McMillan et al (25) showed similar results, such as low BCM among male cancer patients exhibiting weight loss. They also reported a significant correlation between albumin and percentage of predicted TBK, which is also in concordance with our results. In contrast, no correlation between TBK and albumin could be found in the present study. This finding may be due to the fact that TBK is directly proportional to BCM, which is the active tissue, found in muscle as well as in viscera, whereas albumin is mainly a marker of visceral protein, or it may be due to the fact that somatic protein is depleted earlier than visceral protein. However, TBK counting seems to be a reliable body-composition method of detecting protein depletion even in patients with fluid imbalances. Several studies in cirrhosis patients reported normal intracellular potassium concentrations, irrespective of the presence of ascites (48–50). Although TBK was able to discriminate malnourished from well-nourished gynecologic cancer patients, and although it is a reliably objective tool for detecting protein depletion, its wider use in a clinical setting may be prevented by the scarcity of the expensive machine in hospitals, the limited compliance of very sick patients—especially ovarian cancer patients—and the time intensity of the method.

The present study showed that a low serum albumin concentration is associated with a greater risk of malnutrition among gynecologic cancer patients. In contrast to those results, a study by Covinsky et al (51) reported a much lower ROC AUC (0.58 compared with 0.92 in the present study) for albumin as a predictor of the SGA. However, their study was conducted by using a sample of hospitalized older people, a cohort that may not be concordant with the study population in the present study. Other possible reasons for controversial results with respect to serum albumin as a direct nutritional marker may be factors that affect serum albumin, such as inflammation, trauma (including surgery), hypothyroidism, alcohol abuse, and malignancy itself. In contrast to previous studies (52, 53), the current study was not able to detect correlations between serum albumin and TBK in detecting protein depletion. Nonetheless, the study population of both of the previous studies did not include patients with chronic illnesses (52, 53). However, as previously reported, low serum albumin is a powerful predictor of surgically related morbidity (8, 54, 55) and thus is of great value in the clinical setting and remains an important part of the general evaluation of gynecologic cancer patients.

The PG-SGA score not only was able to discriminate between the SGA categories, but it also correlated well with TBK. However, the PG-SGA score has some limitations: whereas it was correlated with TBK, which indicates that the PG-SGA score may suggest depletion in BCM, it is definitely not precise enough, compared with TBK, to detect the difference between FFM and FM. Despite this limitation, we suggest that the scored PG-SGA is the most appropriate and clinically feasible tool for detecting malnutrition among gynecologic cancer patients.
A principal limitation of our study was that we compared all nutritional variables with the SGA, which is widely recommended, especially for cancer patients, but which is not clearly regarded as the gold standard by which to measure malnutrition. This comparison is not clear-cut, because the scored PG-SGA has been derived from the SGA, and both tools include subjective measurements that have been performed by the same investigator. Another potential limitation of the present study was that not all study participants agreed to take part in body-composition measurements. Participation depended on patients’ willingness to undergo a 60-min body-composition examination, and, clearly, patients with a high level of disability were less likely to agree to this component of research. Furthermore, the results obtained were obtained in a heterogenic group of gynecologic cancer patients with a comparatively low prevalence of severe malnutrition. Despite these limitations, the major strengths of this study were the high participation rate of women with gynecologic cancer and the early nutritional assessment, in which measurements were taken before treatment was initiated, which allowed early intervention for malnourished patients in the future.

In summary, our findings suggest that, compared with other clinical variables, the scored PG-SGA is an accurate and simple nutritional assessment tool that is suitable for clinical practice and that has the added advantage of providing triage suggestions for nutritional counseling. It is easier and quicker to perform than the TBK and is less biased by a patient’s BMI and ascites status than are other body-composition measurements, such as air-displacement plethysmography, in gynecologic cancer patients. Future investigations are needed to assess whether the scored PG-SGA can predict which patients are at risk of adverse clinical outcomes and how well it serves in monitoring nutritional interventions, especially for malnourished ovarian cancer patients.

The authors’ responsibilities were as follows—AO: initiated the study; BL: collected data; AO, BL, and MJ: data analysis; AO and GC: project supervision; AO, BL, and MJ: writing the manuscript; and all authors: revision of the manuscript. None of the authors had a personal or financial conflict of interest.

REFERENCES


## Table 3

Results of simple and multiple linear regression analysis with total-body potassium (TBK, in mmol) as the dependent variable.

<table>
<thead>
<tr>
<th>Subjects</th>
<th>Simple linear regression</th>
<th>Multiple linear regression&lt;br&gt;Unstandardized coefficient B</th>
<th>SE</th>
<th>Standardized coefficient β</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (y)</td>
<td>51</td>
<td>$-0.678^4$</td>
<td>0.459</td>
<td>&lt; 0.001</td>
<td>$-18.688$</td>
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<tr>
<td>Weight (kg)</td>
<td>51</td>
<td>0.340</td>
<td>0.115</td>
<td>0.015</td>
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<tr>
<td>BMI (kg/m²)</td>
<td>51</td>
<td>0.149</td>
<td>0.022</td>
<td>0.298</td>
<td></td>
</tr>
<tr>
<td>PG-SGA score</td>
<td>51</td>
<td>$-0.258^5$</td>
<td>0.130</td>
<td>0.009</td>
<td></td>
</tr>
<tr>
<td>Albumin (g/L)</td>
<td>45</td>
<td>0.291</td>
<td>0.084</td>
<td>0.053</td>
<td></td>
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<tr>
<td>Triceps skinfold thickness (mm)&lt;sup&gt;6&lt;/sup&gt;</td>
<td>51</td>
<td>0.101</td>
<td>0.010</td>
<td>0.482</td>
<td></td>
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<tr>
<td>Arm muscle area (cm²)&lt;sup&gt;6&lt;/sup&gt;</td>
<td>51</td>
<td>0.505</td>
<td>0.255</td>
<td>&lt; 0.001</td>
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<tr>
<td>Arm fat area (cm²)&lt;sup&gt;6&lt;/sup&gt;</td>
<td>51</td>
<td>0.194</td>
<td>0.037</td>
<td>0.174</td>
<td></td>
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<tr>
<td>Fat-free mass (kg)&lt;sup&gt;6&lt;/sup&gt;</td>
<td>39</td>
<td>0.688</td>
<td>0.473</td>
<td>&lt; 0.001</td>
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<tr>
<td>Fat mass (kg)&lt;sup&gt;6&lt;/sup&gt;</td>
<td>39</td>
<td>$-0.226$</td>
<td>0.051</td>
<td>0.167</td>
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<tr>
<td>Constant</td>
<td>2795.924</td>
<td>280.189</td>
<td>&lt; 0.001</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<sup>1</sup> PG-SGA, patient-generated subjective global assessment (16).
<sup>2</sup> All variables except fat-free mass (because of a small sample size) that were found to be marginally and significantly associated ($P < 0.10$) in the simple linear regression analysis were stepwise included in the multiple linear regression analysis. The final model included the PG-SGA score and arm muscle area as independent variables, and it was adjusted for age.
<sup>3</sup> Total $R^2 = 0.662$.
<sup>4</sup> Pearson correlation coefficient (all such values).
<sup>5</sup> Spearman’s rank correlation coefficient.
<sup>6</sup> Derived from skinfold-thickness measurements.
<sup>7</sup> Derived from body density measurements.


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