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Nutritional assessment: lean body mass depletion at hospital admission is associated with an increased length of stay[1–3]

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ABSTRACT

Background: Low fat-free mass may be an independent risk factor for malnutrition that results in an increased length of hospital stay (LOS).

Objectives: The objectives were to compare differences in fat-free mass and fat mass at hospital admission between patients and healthy control subjects and to determine the association between these differences and the LOS.

Design: Patients (525 men, 470 women) were prospectively recruited at hospital admission. Height-corrected fat-free mass and fat mass (fat-free-mass index or fat-mass index; in kg/m^2) were determined in patients at admission by bioelectrical impedance analysis and were compared with values for sex-, age-, and height-matched control subjects. Patients were classified as well-nourished, moderately depleted, or severely depleted on the basis of a Subjective Global Assessment questionnaire and a body mass index (in kg/m^2) $<$ or $>$ 20.

Results: Low fat-free mass was noted in 37% and 55.6% of patients hospitalized 1–2 d and $>$ 12 d, respectively. The odds ratios were significant for fat-free-mass index and were higher in patients with a LOS of $>$ 12 d [men (odds ratio: 5.6; 95% CI: 3.1, 10.4), women (4.4; 2.3, 8.7)] than in those with a LOS of 1–2 d [men (3.3; 2.2, 5.0), women (2.2; 1.6, 3.1)]. Severe nutritional depletion was significantly associated only with a LOS $>$ 12 d.

Conclusion: Fat-free mass and fat-free-mass index were significantly lower in patients than in control subjects. Because the fat-free-mass index is significantly associated with an increased LOS, provides nutritional assessment information that complements that from a Subjective Global Assessment questionnaire, and is a more sensitive determinant of the association of fat-free mass with LOS than is a weight loss $>$ 10% or a body mass index $<$ 20, it should be used to evaluate nutritional status. *Am J Clin Nutr* 2004;79: 613–8.

KEY WORDS Body composition, lean body mass, body fat, length of hospital stay, nutritional assessment, malnutrition

INTRODUCTION

Worldwide studies indicate that 30–50% of hospitalized patients show some degree of malnutrition (1), a condition that is associated with increased morbidity (2, 3). Complications of malnutrition increase the length of hospital stay (LOS), hospital costs, and ultimately the cost of patient rehabilitation (4).

There is no universally accepted index of nutritional status that predicts LOS and mortality. Weight loss has been shown to be highly predictive of hospital readmission (5, 6), whereas serum protein concentrations and lymphocyte counts are specific and sensitive indicators of postoperative complications (7). Albumin and hematocrit were shown to predict longer LOS and mortality (8). The Subjective Global Assessment (SGA) questionnaire for determining nutritional status is an accurate predictor of complications, such as infections and poor wound healing (9), and is associated with longer LOS in severely malnourished patients (10).

Patients with $\geq$ 2 abnormal nutritional markers (weight for height, percentage weight loss, arm muscle circumference, and serum albumin) had more serious complications than did patients with a normal nutritional status (11). Schols et al (12) showed that depletion of muscle mass, reflected by lean body mass or fat-free mass, could occur in patients who maintained their weight and that fat-free mass depletion contributed to impaired functional status. Thus, low fat-free mass may be an independent risk factor for longer LOS.

Kyle et al (13) found, with the SGA questionnaire, that fat-free mass is significantly lower in malnourished patients than in healthy control subjects and that fat mass is greater in chronically ill patients aged $>$ 55 y at hospital admission, despite lower body mass indexes (BMIs; in kg/m^2), than in age- and height-matched healthy adults (14). Furthermore, 33% of patients fell below the 10th percentile of fat-free mass compared with only 10% of the control subjects (15). Thus, body composition appears to be altered in patients and may provide useful nutritional assessment information in patients at the time of hospital admission (15). However, it is not known whether lower fat-free mass affects LOS, a point that is addressed in the current study.

One limitation of using fat-free mass to assess nutritional status is that fat-free mass and body fat vary with age and sex, and percentile ranks are population specific (16). This limitation can be overcome by normalizing fat-free mass and fat mass with the use of the fat-free-mass index and the fat-mass index (kg/m^2), which effectively standardize for height (17). Furthermore, the comparison of patients at hospital admission with age- and height-matched control subjects permits the determination of

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whether differences in fat-free mass and body fat exist between patients and healthy control subjects.

The purpose of this controlled population study ($n = 995$) was to determine whether differences in body composition, as assessed on the basis of the fat-free-mass index and the fat-mass index, exist between patients at hospital admission and age- and height-matched healthy control subjects and whether low fat-free-mass indexes and fat-mass indexes are associated with an increased LOS.

SUBJECTS AND METHODS

Patients

All adult patients admitted to the hospital admission center for medical or surgical reasons and subsequently hospitalized were eligible for inclusion. Every 10th patient who met the entry criteria was included in the study over a 3-mo period ($n = 995$). Two patients refused to participate. Exclusion criteria were edema, burns, peritoneal dialysis, hemodialysis, rehydration perfusion, and major cardiorespiratory resuscitation ($n = 61$). The age and sex distribution of patients included in the study did not differ significantly from those of the entire patient group seen in the hospital admission center during the inclusion period. Patients were evaluated in the hospital admission center, within 3 h after admission, by the same 2 coworkers from the Nutrition Unit. LOS data were obtained from the computerized patient hospital record after the patients were discharged. Forty-three of the 995 patients were excluded because LOS data could not be retrieved from the hospital administration records. The study protocol was approved by the Geneva University Hospital Ethics Committee, and informed consent was obtained from all subjects.

Control subjects

Healthy men ($n = 525$) and women ($n = 470$) were age- (± 2 y), sex-, and height-matched (± 2 cm) to serve as a control group from a Geneva University Hospital database ($n = 5635$ healthy adults aged 15–98 y). Control subjects were recruited from the greater Geneva area, the same area from which the patients came from (18).

Anthropometric measurements and bioelectrical impedance analysis

All measurements were performed at hospital admission. Body height was measured to the nearest 0.5 cm and body weight to the nearest 0.1 kg on a chair scale or a hoist with an attached weighing device for patients who were bedridden. The scales were cross-calibrated weekly.

Body composition was determined by bioelectrical impedance analysis (BIA) as previously described (19) with the use of a 50-kHz generator (RJL-101 analyzers; RJL Systems Inc, Clinton Township, MI) (20). Previous studies have established the validity of BIA (21, 22).

Fat-free mass was calculated by using a previously validated multiple regression BIA equation (22):

$$\text{Fat-free mass} = -4.104 + (0.518 \times \text{height}^2/\text{resistance}) + (0.231 \times \text{weight}) + (0.130 \times \text{reactance}) + (4.229 \times \text{sex}) \quad (1)$$

where men = 1 and women = 0. Cross-validation of BIA with dual-energy X-ray absorptiometry was excellent ($r = 0.986$, SEE = 1.72 kg, technical error = 1.74 kg). This same BIA equation had been further validated in elderly subjects (23) and patients (24).

The fat-free-mass index and fat-mass index were derived as fat-free mass and fat mass (kg), respectively, divided by height squared (m). Ranges of fat-free-mass index and fat-mass index were derived from polynomial regression equations for each of the BMI cutoffs (20, 25, and 30) from our healthy subjects ($n = 5635$) (25). These cutoffs correspond to World Health Organization categories for low weight (< 20), normal weight (20–24.9), overweight (25–30), and obese (> 30). The respective fat-free-mass index and fat-mass index categories are low, normal, high, and very high.

The fat-free-mass index was considered "low" if < 17.4 (men) and 15.0 (women), "normal" if 17.5–19.7 (men) and 15.1–16.6 (women), and "high" if > 19.8 (men) and 16.7 (women). The fat-mass index was considered "low" if < 2.4 (men) and 4.8 (women), "normal" if 2.5–5.1 (men) and 4.9–8.2 (women), "high" if 5.2–8.1 (men) and 8.3–11.7 (women), and "very high" if > 8.2 (men) and 11.8 (women).

Subjective Global Assessment questionnaire

The SGA was performed as previously described (9) with the use of a standardized questionnaire that incorporates the patient's history (weight loss, changes in dietary intake, gastrointestinal symptoms, and functional capacity) and results of a physical examination (muscle, subcutaneous fat, sacral and ankle edema, and ascites) and the clinician's overall judgment of the patient's status (normal, moderately, or severely malnourished).

Albumin

Blood samples were routinely drawn at admission, before initiation of the intravenous fluids. The cutoff value for low albumin [measured by immunonephelometry (26)] was set at < 35 g/L (normal range: 35–55 g/L).

Statistical analysis

The results are expressed as means ± SDs. The differences between age groups and LOS were analyzed by analysis of variance, with the use of STATVIEW 5.0 (SAS Institute Inc, Cary, NC). The multiple-comparisons procedure was by the Bonferroni method. Multiple regression analysis (trend test) was used to evaluate the association, adjusted for age, between LOS and fat-free mass, fat-free-mass index, and percentage fat mass and used nonhospitalized control subjects as references (categories: 0, LOS 1–2 d = 1, LOS 3–6 d = 2, LOS 7–11 d = 3, and LOS > 12 d = 4). Multiple logistic regressions, adjusted for age, were used to estimate odds ratios (ORs) for various categories of BMI and fat-free-mass index. ORs with 95% CIs describe the magnitude of effects for each level of the study variable compared with the reference category. All analyses were performed separately for men and women because of a significant sex interaction for body-composition measurements. Statistical significance was set at $P \leq 0.05$ for all tests.

RESULTS

The anthropometric and body-composition characteristics of the control subjects and patients are shown in **Table 1**. Patients

TABLE 1
Body-composition characteristics of healthy control subjects and patients by length of hospital stay (LOS)

	Control subjects	Patients				
		LOS 1–2 d	LOS 3–6 d	LOS 7–11 d	LOS > 12d	*P* for trend[1]
Men						
n	525	338	38	52	72	
Age (y)	49.3 ± 19.8[2]	46.8 ± 19.2	53.2 ± 22.2	51.2 ± 19.4	61.0 ± 18.6[3,4]	<0.0001
BMI (kg/m^2)	24.8 ± 2.9	24.4 ± 3.8	23.9 ± 3.3	23.9 ± 4.2	24.2 ± 3.9	0.001
Fat-free mass (kg)	58.5 ± 6.5	55.6 ± 7.4[3]	54.7 ± 8.3[3]	54.2 ± 7.2[3]	52.5 ± 7.4[3,4]	<0.0001
Fat-free-mass index (kg/m^2)	19.5 ± 1.6	18.5 ± 1.9[3]	18.5 ± 1.8[3]	18.2 ± 2.3[1]	18.0 ± 2.1[3]	<0.0001
Fat-mass index (kg/m^2)	5.4 ± 1.9	5.9 ± 2.5[3]	5.4 ± 2.3	5.7 ± 2.4	6.2 ± 2.5[3]	0.075
Women						
n	470	319	33	39	61	
Age (y)	55.6 ± 23.3	52.0 ± 24.1	59.8 ± 20.1	65.6 ± 19.8[4]	70.2 ± 17.7[3,4]	<0.0001
BMI (kg/m^2)	23.7 ± 3.9	23.4 ± 4.2	23.2 ± 4.7	24.3 ± 5.5	23.1 ± 5.1	0.0598
Fat-free mass (kg)	41.2 ± 4.8	39.5 ± 5.7[3]	36.9 ± 5.5[3]	38.3 ± 7.4[3]	35.9 ± 5.6[3,4]	<0.0001
Fat-free-mass index (kg/m^2)	16.0 ± 1.6	15.2 ± 1.7[3]	14.7 ± 2.0[3]	15.0 ± 2.4[3]	14.5 ± 2.2[3,4]	<0.0001
Fat-mass index (kg/m^2)	7.7 ± 2.9	8.2 ± 3	8.5 ± 3.2	9.3 ± 3.6[3]	8.6 ± 3.2	0.032

[1] Trend test (included control subjects *see* Subjects and Methods); adjusted for age.
[2] $\bar{x}$ ± SD (all such values).
[3] Significantly different from control subjects, $P \leq 0.05$ (post hoc Bonferroni test after one-factor ANOVA).
[4] Significantly different from LOS 1–2 d, $P \leq 0.05$ (post hoc Bonferroni test after one-factor ANOVA).

hospitalized ≥ 7 d were significantly older than patients hospitalized ≤ 6 d (Table 1). The BMI was not significantly different between the control subjects and patients regardless of LOS. Sixty-nine percent of patients were hospitalized for 1–2 d, 17% for 3–11 d, and 14.0% for > 12 d. Twenty-one (2%) patients died during hospitalization; 0.9% of the deceased were hospitalized for 1–2 d, 5.8% for 3–11 d, and 52.4% for > 12 d. Patient admission, categorized as a LOS of 1–2 or ≥ 3 d, is shown in **Table 2** according to the hospital services received.

Fat-free mass, fat-free-mass index, and fat-mass index

In contrast to BMI (Table 1), mean fat-free mass and fat-free-mass index were significantly lower in the patients than in the healthy control subjects and were also lower in patients hospitalized > 12 d than in patients hospitalized 1–2 d. Low fat-free mass and fat-free-mass index (trend test $P < 0.0001$) was associated with greater LOS. In addition, low fat-free-mass index was noted in 37% of patients hospitalized 1–2 d, and this increased to 55.6% of patients hospitalized > 12 d (**Figure 1**). Fewer patients than healthy control subjects had a normal or high fat-free-mass index for all LOS categories. The prevalence of low fat-free-mass index (**Table 3**) and severe depletion assessed by SGA questionnaire (**Table 4**) was higher in women than in men (fat-free-mass index: 53.0 versus 31.6%; SGA questionnaire 27.0 versus 20.7%, respectively).

The fat-mass index was significantly higher in men hospitalized 1–2 d and > 12 d than in male control subjects (Table 1) and significantly higher in female patients hospitalized 1–2 d and > 7 d than in female control subjects. Higher fat-mass index was associated with greater LOS in women (trend test, $P < 0.03$) but not in men. These results show that the patients had lower fat-free mass and higher body fat than did the control subjects.

TABLE 2
Number (percentage) of patients admitted for various hospital services by length of hospital stay (LOS)

Hospital service	LOS 1–2 d	LOS ≥3 d	Total
		n (%)	
Cardiovascular	43 (4.5)	44 (4.6)	87 (9.1)
Dermatology	38 (4.0)	6 (0.6)	44 (4.6)
Endocrinology	10 (1.0)	9 (0.9)	18 (1.9)
Ear, nose, and throat	44 (4.6)	10 (1.0)	53 (5.6)
Gastrointestinal	18 (1.9)	14 (1.5)	32 (3.4)
Nephrology and urology	27 (2.8)	10 (1.0)	36 (3.8)
Neurology	48 (5.0)	20 (2.1)	68 (7.1)
Miscellaneous	112 (11.8)	24 (2.5)	136 (14.3)
Psychiatry	57 (6.0)	20 (2.1)	77 (8.1)
Pulmonary disease	54 (5.7)	19 (2.0)	73 (7.7)
Rheumatology	26 (2.7)	29 (3.0)	54 (5.7)
Trauma			
Major	8 (0.8)	92 (9.7)	100 (10.5)
Minor	173 (18.2)	0 (—)	173 (18.2)
Total	657 (69.0)	295 (31.0)	952 (100.0)

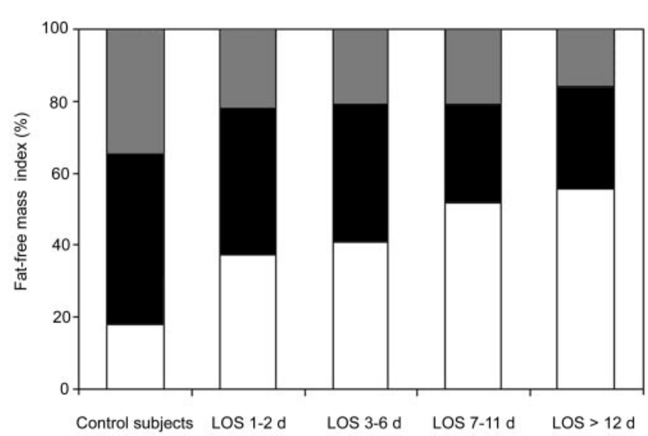

FIGURE 1. Prevalence of low (□), normal (■), and high (▨) fat-free-mass index in control subjects and patients hospitalized for 1–2, 3–6, 7–11, and > 12 d. The prevalence of low fat-free-mass index progressively increased with an increased length of hospital stay (LOS) and was highest in patients with the longest LOS (55% compared with 18% in control subjects). Chi-square test = 158.5, df = 9, $P < 0.001$.

TABLE 3
Odds ratios (OR) and 95% CIs for length of hospital stay (LOS) by fat-free-mass index at hospital admission in men and women[1]

	Low fat-free-mass index	Normal fat-free-mass index	OR (95% CI)[2]
	n (%)	*n (%)*	
Men[3]			
Control subjects	50 (16.1)	261 (83.9)	1
Patients (n = 393)			
LOS 1–2 d	93 (37.7)	154 (62.3)	3.3 (2.2, 5.0)[4]
LOS 3–6 d	9 (32.1)	19 (67.9)	2.3 (1.0, 5.5)
LOS 7–11 d	22 (52.4)	20 (47.6)	5.9 (3.0, 11.6)[4]
LOS >12 d	31 (55.4)	25 (44.6)	5.6 (3.1, 10.4)[4]
Women[5]			
Control subjects	129 (38.1)	210 (61.9)	1
Patients (n = 380)			
LOS 1–2 d	151 (56.8)	115 (43.2)	2.2 (1.6, 3.1)[4]
LOS 3–6 d	20 (71.4)	8 (28.6)	3.8 (1.6, 8.9)[4]
LOS 7–11 d	25 (83.3)	5 (16.7)	7.1 (2.6, 19.0)[4]
LOS >12 d	43 (76.8)	13 (23.2)	4.4 (2.3, 8.7)[4]

[1] There was a significant interaction for sex. *See* Subjects and Methods for definition of normal and low fat-free-mass index.
[2] Adjusted for age.
[3] Chi-square test = 62.9, df = 4, $P < 0.001$.
[4] $P < 0.001$.
[5] Chi-square test = 58.4, df = 4, $P < 0.001$.

Risk factors for a low and high fat-free-mass index

Patients were more likely than were the control subjects to have a low fat-free-mass index (Figure 1, Table 3) and were less likely to have a high fat-free-mass index (Figure 1). Nutritional variables indicating risk of malnutrition (poor food intake, recent weight loss, nutritional depletion by SGA questionnaire, and low fat-mass index) were associated with a low fat-free-mass index. Poor food intake before hospital admission was associated with an increased risk of a low fat-free-mass index (OR: 4.3; 95% CI: 3.1, 6.0). Moderately (OR: 2.7; 95% CI: 1.9, 3.9) and severely (OR: 10.5; 95% CI: 6.7, 16.5) depleted patients by SGA questionnaire were significantly more likely to have a low fat-free-mass index (OR: 0.6; 95% CI: 0.4, 0.8) and were less likely to have a high fat-free-mass index (OR: 0.3; 95% CI: 0.2, 0.7). A BMI of 25–29.9 decreased (OR: 0.1; 95% CI: 0.1, 0.2) and a BMI < 20 increased the risk of having a low fat-free-mass index (OR: 25.9; 95% CI: 12.7, 52.9), whereas a BMI > 25 increased the risk of having a high fat-free-mass index (OR: 8.5; 95% CI: 5.2, 14.2). Similarly a low fat-mass index increased (OR: 3.6; 95% CI: 1.9, 6.7) and a high fat-mass index decreased (OR: 0.3; 95% CI: 0.2, 0.4) the risk of a low fat-free-mass index. A high fat-mass index was associated with a high fat-free-mass index (OR: 1.9; 95% CI: 1.2, 3.0). A recent weight loss of ≥ 5% was associated with an increased risk of having a low fat-free-mass index (OR: 3.7; 95% CI: 2.5, 5.5). Serum albumin was associated with a low fat-free-mass index in men (OR: 2.1; 95% CI: 1.1, 3.9), but not in women.

TABLE 4
Prevalance of severely depleted, moderately depleted, and well-nourished patients by Subjective Global Assessment and odds ratios (OR) and 95% CIs for length of hospital stay (LOS) for severely depleted compared with well-nourished patients at hospital admission[1]

LOS category	Severely depleted	Moderately depleted	Well nourished	OR (95% CI)[2]
	n (%)	*n (%)*	*n (%)*	
1–2 d	132 (20.1)	248 (37.7)	277 (42.2)	1
3–6 d	16 (22.5)	30 (42.3)	25 (35.2)	0.8 (0.4, 1.7)
7–11 d	25 (27.5)	36 (39.6)	30 (33.0)	1.2 (0.7, 2.3)
>12 d	49 (36.8)	54 (40.6)	30 (22.6)	2.0 (1.2, 3.5)[3]

[1] n = 952. Chi-square test = 26.9, df = 6, $P < 0.001$. There was no significant interaction for sex.
[2] Adjusted for age.
[3] $P < 0.05$.

Length of hospital stay

LOS was 4.3 ± 7.2 d in patients with a normal or high fat-free-mass index and was 8.7 ± 21.0 d in patients with a low fat-free-mass index (Mann Whitney U test: $P < 0.0001$). Similarly, LOS was longer in severely malnourished patients by SGA questionnaire (10.8 ± 26.3 d) than in moderately depleted (5.4 ± 8.2 d) or well-nourished (3.9 ± 7.8 d) patients (Kruskal-Wallis test: $P < 0.0001$).

A low fat-free-mass index, adjusted for age, was significantly associated with LOS (Table 3), and the OR was greatest in patients with the longest LOS, which suggested that a low fat-free-mass index is a risk factor for a longer LOS. On the other hand, severe depletion by SGA questionnaire was significantly associated only with a LOS > 12 d (Table 4). A high fat-free-mass index, low and high fat-mass indexes, and albumin were not significantly associated with LOS. A weight loss of > 10% was significantly associated with a LOS > 12 d in men and women (OR: 2.6; 95% CI: 1.4, 4.4). A BMI < 20 was significantly associated with a LOS > 12 d in women (OR: 2.3; 95% CI: 1.2, 4.6) and with all LOS categories in men: 1–2 d [OR: 5.0; 95% CI: 2.5, 10.2], 3–6 d [OR: 9.2; 95% CI: 3.0, 27.8], 7–11 d [OR: 12.6; 95% CI: 4.9, 32.2], and > 12 d [OR: 8.2; 95% CI: 3.2, 21.1]. Serum albumin correlated with LOS (r = 0.15, P = 0.001), but was not associated with LOS.

DISCUSSION

This was the first study to show a significant association between low lean body mass as identified by fat-free-mass index at hospital admission and LOS. Our study also showed that a low fat-free-mass index that resulted in a longer LOS was already present at the time of hospital admission. We suggest that a low fat-free-mass index is an indicator of malnutrition and should be measured to evaluate nutritional status.

Correlation between malnutrition and length of hospital stay

A low fat-free mass was noted in 37% of patients hospitalized 1–2 d, and this increased to 55.6% of patients hospitalized > 12 d (Figure 1). Kyle et al (15) previously reported a higher prevalence of fat-free mass below the 10th percentile in patients (33%) than in control subjects (10%) in the same population. However, we did not anticipate that 37% of patients hospitalized for 1–2 d would be classified as having a low fat-free-mass index. The high prevalence of a low fat-free-mass index at hospital admission in patients hospitalized for short periods of time (1–2 d) in the current study further confirmed the high frequency of malnutrition and reinforced the argument that nutritional status should be evaluated at hospital admission.

Malnutrition was previously shown to increase LOS (27–29) and to be associated with higher rates of major and minor complications (30) and medical consultations (31), higher mortality (27), and higher hospital costs (28, 32). Thus, malnutrition is associated with poor outcome. Our study extends these findings by showing that a low fat-free-mass index was associated with being a patient (compared with a healthy control subjects), poor food intake before hospitalization, moderate or severe nutritional depletion by SGA questionnaire, and low serum albumin in men but not in women. Thus, these risk factors led to nutritional consequences, ie, low protein reserves. Neither a low nor a high fat-mass index was associated with increased LOS, at least at the rates of obesity reported in this study.

Nutritional status, as defined by a low fat-free-mass index, was significantly associated with a longer LOS in men and women, except for borderline significance in men hospitalized 3–6 d (Table 3). On the other hand, severe depletion by SGA was significantly associated only with a LOS $>$ 12 d (Table 4). Moderate depletion by SGA was not associated with increased LOS. Although a low BMI was associated with an increased LOS in men and women with a LOS $\geq$ 12 d, BMI was an inadequate variable because only 17% of patients were identified at risk because of a BMI $<$ 20 compared with 41.4% of patients having a low fat-free-mass index and 62% being classified as moderately or severely depleted by SGA questionnaire (Table 3 and 4). Clearly, BMI underestimated the incidence of malnutrition, and the assessment by SGA questionnaire suggested a higher risk than that determined by a low fat-free-mass index. We suggest that because recent weight loss, BMI, and SGA are imprecise indicators of fat-free mass depletion, they are less-specific predictors of LOS than is the fat-free-mass index. Because of the cross-sectional nature of this association study, a causal relation between a low fat-free-mass index and LOS cannot be determined. LOS is influenced by many factors, including age, diagnosis, severity of disease and treatment, and nutritional status. Further research is necessary to determine the influence of these factors on nutritional status and LOS.

The most severely ill subjects, who may have been more malnourished than the subjects included, were excluded because the validity of BIA is questionable in subjects with an abnormal hydration status. Thus, the association between a low fat-free-mass index and LOS might have been greater if all patients had been evaluated by BIA. Mortality in the patients was low (2%) because patients who were hydroelectrically unstable (eg, major resuscitation and burns) at the time of admission could not be measured by BIA and were therefore excluded.

Sex differences noted in the association between LOS and BMI may indicate differences in nutritional risk between men and women. Men had a lower prevalence of low fat-free-mass index than did women (Table 3), but the OR for a low BMI ($<$ 20) in men were significant for all LOS categories. Despite a higher prevalence of a low fat-free-mass index in women, the OR for low BMI was significant only for a LOS $>$ 12 d. It is possible that women with a BMI range of 18.5–20.0 are less at nutritional risk than are men. Further research is necessary to clarify these sex differences in LOS.

Optimized nutritional assessment at hospital admission

Nutritional assessment variables vary in their ability to discriminate between patients who are malnourished and patients who are at risk of becoming malnourished. In our study, the subjects with a low fat-free-mass index had insufficient nutrient intakes or an increased metabolic demand of sufficient duration to lead to physical consequences, including low fat-free mass reserves. The SGA questionnaire, on the other hand, identified both those patients who were depleted and those who were at risk of becoming depleted. Although body-composition measurements do not appear to replace nutritional assessment by SGA questionnaire, they extend the evaluation process beyond weight and BMI, which are inadequate to determine fat-free mass depletion. For example, a patient with muscle atrophy and elevated adipose tissue may be categorized as having a normal nutritional status on the basis of BMI but would be considered to be undernourished on the basis of a low fat-free-mass index. In fact, we found fewer patients (15%), hospitalized 1–2 d, who were identified as "at nutritional risk" because of a low BMI ($<$ 20) than because of a low fat-free-mass index (37%) (Table 3) or because of being moderately or severely depleted on the basis of the SGA questionnaire (57.8%) (Table 4). Thus, malnutrition is frequently present in patients at hospital admission and is better detected by fat-free-mass index or by SGA questionnaire than by BMI.

Screening tools, such as body-composition measurements and the SGA questionnaire, are valuable for determining which patients need further nutrition evaluation. The benefit of body-composition measurement at hospital admission, but also in physicians' offices, is that it is a rapid and cost-effective method for determining which patients are at nutritional risk because of low fat-free-mass index reserves. The high prevalence of malnutrition at hospital admission also suggests that effective nutritional screening must be implemented to detect and treat nutritional problems before they become severe or aggravated and result in an increase in LOS and overall treatment costs (33).

Limitations of the study

We had insufficient information on why patients were malnourished and therefore could not distinguish between malnourishment secondary to inadequate intake and increased needs or losses. Few patients with cancer ($<$ 6%) were included in this study, because cancer patients admitted for repeated treatment (eg, with chemotherapy) bypass the admission center and are admitted directly to the oncology ward and were therefore not included in this study.

LOS in the current study was measured retrospectively and, hence, potentially includes hospital days of patients who could be discharged but who were still hospitalized because they were awaiting transfer to intermediate-care facilities. This does not appear to be sufficient to invalidate our results, because the necessity for intermediate care may indicate frailty for which malnutrition would be a risk factor. No nutrition intervention data were collected during hospitalization, because the aim of the study was to evaluate nutritional status at hospital admission and not to evaluate nutrition intervention during hospitalization.

BIA has been validated extensively as an instrument for measuring body composition, but it is sensitive to hydration abnormalities. Even though we excluded hydroelectrically unstable patients, we could not rule out the possibility that some of the patients may have had mild nonvisible overhydration, which would have resulted in the overestimation of fat-free mass and, thus, in the underestimation of the prevalence of malnutrition.

Conclusions

The mean fat-free mass and fat-free-mass index were significantly lower in the patients than in the healthy control subjects.

A low fat-free mass at hospital admission is significantly associated with a longer LOS. Because the fat-free-mass index provides nutritional assessment information in patients in addition to that derived from an SGA and is more sensitive in determining an association with LOS than is a weight loss > 10% or a BMI < 20, it should be measured to evaluate nutritional status.

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