Clinical Nutrition 31 (2012) 435–447

Contents lists available at SciVerse ScienceDirect

Clinical Nutrition

journal homepage: http://www.elsevier.com/locate/clnu

Review

Body composition: Why, when and for who?☆

Ronan Thibault, Laurence Genton, Claude Pichard*

Nutrition Unit, Geneva University Hospital, Geneva, Switzerland

ARTICLE INFO

Article history:
Received 28 June 2011
Accepted 19 December 2011

Keywords:
Fat-free mass
Fat mass
Chronic diseases
Cancer
Sarcopenic obesity

SUMMARY

Body composition reflects nutritional intakes, losses and needs over time. Undernutrition, i.e. fat-free mass (FFM) loss, is associated with decreased survival, worse clinical outcome and quality of life, as well as increased therapy toxicity in cancer patients. In numerous clinical situations, such as sarcopenic obesity and chronic diseases, the measurement of body composition with available methods, such as dual-X ray absorptiometry, computerized tomography and bioelectrical impedance analysis, quantifies the loss of FFM, whereas body weight loss and body mass index only inconstantly reflect FFM loss. The measurement of body composition allows documenting the efficiency of nutrition support, tailoring the choice of disease-specific and nutritional therapies and evaluating their efficacy and putative toxicity. Easy-to-use body composition methods integrated to the routine of care allow sequential measurements for an initial nutritional assessment and objective patients follow-up. By allowing an earlier and objective management of undernutrition, body composition assessment could contribute to reduce undernutrition-induced morbidity, worsening of quality of life, and global health care costs by a timely nutrition intervention.

1. Introduction

Undernutrition features loss of variable intensity of fat-free mass (FFM), associated with loss of fat mass whose importance increases with the duration of undernutrition. Its prevalence among elderly subjects, patients with chronic diseases or during the course of the hospital stay is very high[1–4] and likely to increase during the next decade, since the negative impact of undernutrition on the clinical outcome is expected to increase. Indeed, the improvements in medical technology and therapy prolong survival, even in elderly sedentary subjects with pre-existing sarcopenia[5] or in patients with chronic diseases. As a consequence, the proportion of patients with low FFM will increase, leading to an impairment of their overall health, functional capacities and quality of life.[6,7] Indeed, FFM loss is unequivocally associated with decreased survival, negative clinical outcome, i.e. increased rate of infections, complications, hospitalizations, lengths of hospital stay and recovery,[2] and therapy toxicity in cancer patients,[8] which ultimately increase health care costs.[2] Therefore, the management of nutritionally at risk patients should integrate a nutritional strategy aiming at reducing the clinical and functional consequences of the disease and/or the hospital stay, in the setting of a cost-effective medico-economic approach.[9,10]

This review sustains the hypothesis that the measurement of FFM should be implemented on a regular basis in clinical practice, with the aim of optimizing the early detection, the management and the follow-up of undernutrition.

2. Why measuring body composition in clinical practice?

The main goal of body composition measurements in clinical practice is the evaluation of nutritional status by measuring FFM and fat mass (FM). The clinical assessment of nutritional status is recommended on a regular basis in hospitalized patients and nutritionally at risk outpatients.[11] In some chronic conditions, body mass index (BMI) and the percentage of weight loss do not provide any insight about the respective contributions of FFM and FM in the body mass changes. In chronic obstructive pulmonary disease (COPD), bioelectrical impedance analysis (BIA) is more sensitive than anthropometry, i.e. BMI, muscle arm circumference, skinfold thickness, and biological markers, i.e. transthyretin and albumin, to detect FFM loss.[12,13] BIA is also more sensitive at assessing body composition in intellectual and motor disabled children than the sum of four

☆ This review is adapted from the Wretlind Lecture given by Claude Pichard at the 2009 ESPEN Congress, Vienna, Austria.

* Corresponding author. Nutrition Unit, Geneva University Hospital, Rue Gabrielle-Perret-Gentil 4, 1211 Genève 14, Switzerland. Tel.: +41 22 3729349; fax: +41 22 3729363.

E-mail addresses: ronan.thibault@orange.fr (R. Thibault), claude.pichard@unige.ch (C. Pichard).

0261-5614/$ – see front matter © 2011 Elsevier Ltd and European Society for Clinical Nutrition and Metabolism. All rights reserved.
doi:10.1016/j.clnu.2011.12.011

skinfold-thicknesses.[14] Furthermore, BMI and the percentage of weight loss may not be linked to clinical outcome[3] on the contrary of non-invasive and easy-to-use methods of body composition measurement which are able to show the relation between mortality and FFM or fat mass (FM) losses (Table 1). Furthermore, in case of overweight or obesity, BMI does not allow identification of FFM loss. The increased prevalence of obesity in an aging population has lead to the recognition of a new nutritional entity, the "sarcopenic obesity".[24,26,27] Sarcopenic obesity is characterized by an increased FM and a reduced FFM with a normal or high body weight.[28] The emergence of this concept demonstrates the limits of sensitivity of standard clinical assessment of nutritional status based on body weight changes for the early detection of FFM loss.

Body composition reflects nutritional intakes, losses and expenses over time. Contrary to body weight and BMI, techniques for body composition measurement (Table 2) allow the measurement of tissue losses, by analyzing distinctly the two major body compartments: FFM and FM. Some techniques, such as BIA, allow the measurement of total body water. A graphical representation shows indicative values of body composition of a healthy 70 kg subject (Fig. 1). During acute and chronic diseases, body composition is impaired through time (Table 3). For example, by using *in vivo* neutron activation analysis, Hill suggested that a loss of approximately 24% of total body protein was measured before surgery in patients who underwent a major elective surgery.[33] During the two postoperative weeks, there was an additional loss of total body protein of 0.6 kg or 5% of total body protein, together with a loss of 0.7 kg of fat.[33] Similarly, about 150 g/day of total body protein are lost in intensive care unit (ICU) patients with sepsis despite of a nutrition support sufficient to result in a gain of total body fat.[33] Other *in vivo* neutron analysis studies from the Hill's group have also contributed for a better understanding of protein losses during critical illness.[34,35] Plank et al. have shown that, in patients with severe sepsis, the protein loss originates by 67% from skeletal muscle mass during the first 10 days and later on predominantly from viscera.[34] Also, patients with blunt trauma loose 70% of their protein mass as skeletal muscle mass during the first 15 days.[35] Currently, no method of body composition is validated in the ICU setting. However a routine assessment would allow the early detection of active cell mass (Fig. 1) loss, which could sign the increased muscle catabolism in the absence of intracellular water changes. A US prospective study, conducted in 33 ICU medical and surgical ventilated ICU patients, has shown a tight correlation between active cell mass measured daily by BIA and energy and protein intakes.[36] In that study, energy (30 kcal/kg actual body weight/d) and protein intakes (1.5 g/kg/d) could stabilize the active cell mass. Thus, the follow-up of FFM by BIA could help optimizing nutritional intakes when indirect calorimetry cannot be performed. The measurement of active cell mass by BIA could be useful for the assessment of nutritional status in the ICU,[36] but such an approach still needs to be validated.

The interest of body composition assessment in the clinical practice is further illustrated by two clinical situations. The recovery after an acute illness is associated with weight gain, which does not necessarily mean an increase in FFM. A case report has shown that weight gain 6 months after ICU discharge is mostly related to an increase in FM (+7 kg) while FFM only increased by 2 kg; dual-energy x-ray absorptiometry (DEXA) and air displacement plethysmography were used to measure FM and FFM.[37] Similarly to weight changes, BMI alone does not measure accurately FFM at hospital admission. Patients could have the same BMI than sex- and age-matched controls but a decreased FFM measured by BIA (Fig. 2).[38] These examples illustrate that body composition assessment allows a *quantitative* assessment of body weight variations, and a more accurate identification of FFM loss than BMI.

Table 1
Studies showing the relation between mortality and fat-free mass (FFM) or fat mass (FM) losses determined by non-invasive and easy-to-use method of body composition measurement.

Ref.	Conditions	Design	Patients (n)	Follow-up	Body composition method	FFM or FM thresholds[a]
15	COPD	Prospective, observational	412	5 years	BIA	FFMI <16 (men) FFMI <15 (women)
16	COPD	Prospective, observational	86	6 years	BIA	FFMI<16.6
17	COPD	Prospective, population-based cohort	1898	7 years	BIA	FFMI 10th percentiles: <17.05 (men) <14.6 (women)
18	COPD & acute respiratory failure	Retrospective	51	3 years	BIA	Active cell mass (ACM) ≤40.6% BW
19	Chronic respiratory insufficiency/ Lung transplant candidates	Prospective, observational	78	–	Creatinine height index	ND
20	Chronic heart failure	Prospective, observational	1025	1785 days (median)	BIA	ND
21	Renal insufficiency and hemodialysis	Prospective, observational	149	13.5 months (mean)	BIA	FM<15% (phase angle<6°)
22	Hemodialysis with BMI>18.5	Prospective, observational	70,028	5 years	24 h urinary creatinine excretion	≤0.55 g/24 h
23	Amyotrophic lateral sclerosis	Prospective, observational	92	–	BIA	Each 2 kg of FM increase
24	Cancer with sarcopenic obesity	Prospective, observational	250	4 years	3rd lumbar computerized tomodensitometry	Appendicular skeletal muscle index : <7·26 kg/m^2 (men) < 5·45 kg/m^2 (women)
25	Nursing home elderly residents	Retrospective	82	1 year	24 h urinary creatinine excretion (Forbes formula)	ND

BIA, bioelectrical impedance analysis; BMI, body mass index; COPD, chronic obstructive pulmonary disease; FFMI, fat-free mass index (=fat-free mass (kg)/taille (m)^2); ND, undetermined; Ref., reference.
[a] Threshold of FFM or FM associated with increased mortality.