Identifying reliable predictors of protein-energy malnutrition in hospitalized frail older adults. A prospective longitudinal study

Gianfranco Sanson[a,*], Luca Bertocchi[a], Eugenia Dal Bo[a], Carmen Luisa Di Pasquale[b], Michela Zanetti[a,b]

[a] *School of Nursing, Dept. of Medical Science, University of Trieste, piazzale Valmaura 9, 34148, Trieste, Italy*
[b] *Nutrition Team, Trieste University Hospital, Strada di Fiume 447, 34149, Trieste, Italy*

ARTICLE INFO

Keywords:
CRP-albumin ratio
Elderly
Feeding self-care
Hospital malnutrition
MUAC
Older adults
Reduced food intake

ABSTRACT

Background: Decreased food intake is a risk factor for relevant complications (e.g. infections, pressure ulcers), longer hospital stays, higher readmission rates, greater health care costs and increased patient mortality, particularly in frail hospitalized older adults who are malnourished or at risk of malnutrition. Nurses are called to improve this criticality, starting from accurately identify patients for malnutrition at hospital admission and effectively monitoring their food intake.

Objectives: The primary aim was to identify reliable predictive indicators of reduced food intake at hospital admission. The secondary aims were to assess the adequacy of daily energy and protein intake and the impact of nutrient intake on patient outcomes.

Design: Prospective observational longitudinal study.

Setting: Internal Medicine Ward of an Academic Teaching University Hospital.

Participants: Acute older adults who were malnourished or at risk of malnutrition (Nutritional Risk Score-2002 ≥ 3, middle-upper arm circumference < 23.5 cm or impaired self-feeding ability) at admission.

Methods: The effective energy and protein intake was monitored during the first 5 days of hospital stay by a photographic method and compared to the daily energy and protein requirement calculated by specific equations. Data on anthropometry, inflammation/malnutrition laboratory data and body composition (phase angle calculated using bioelectrical impedance analysis) were collected.

Results: Eighty-one subjects (age 81.5 ± 11.5 years) were enrolled. Mean energy intake was 669.0 ± 573.9 kcal/day, and mean protein intake was 30.7 ± 25.8 g/day. Over 60% of patients ingested $\leq$50% of their calculated energy and protein requirements: these patients were older ($p = 0.026$), had a lower middle-upper arm circumference ($p = 0.022$) and total arm area ($p = 0.038$), a higher C-reactive protein/albumin ratio and Instant Nutritional Assessment score ($p < 0.01$), and experienced longer hospital stays ($p \leq 0.04$) and higher in-hospital and 30-day post-discharge mortality ($p < 0.001$). In the multivariate analysis, lower middle-upper arm circumference, higher C-reactive protein/albumin ratio, and impaired self-feeding at admission were independently associated with critically reduced energy and protein intake.

Conclusions: Middle-upper arm circumference, C-reactive protein/albumin ratio, and impaired self-feeding are easily obtainable indicators of impaired energy and protein intake and poor clinical outcomes. Such parameters should be adopted as screening criteria to assess the risk for critically reduced energy/protein intake in hospitalized older adults. These findings are relevant to improve clinical practice through the implementation of multidisciplinary strategies, given the adverse clinical outcomes related to hospital malnutrition.

What is already known about the topic?

- In acutely ill patients, reduced food intake strongly contributes to hospital-related malnutrition and its adverse clinical outcomes.
- Energy and protein intake should be consistently monitored in malnourished or at risk subjects, but such assessments are often imprecisely carried out or not at all.
- Evidence-based screening tools should be used to accurately identify

---

[*] Corresponding author at: School of Nursing, Dept. of Medical Science, University of Trieste, piazzale Valmaura 9, 34148, Trieste, Italy.
E-mail addresses: gsanson@units.it (G. Sanson), luca.berto89@gmail.com (L. Bertocchi), eugeniadalbo@gmail.com (E. Dal Bo), luisa.dipasquale@asuits.sanita.fvg.it (C.L. Di Pasquale), zanetti@units.it (M. Zanetti).

Accepted 6 March 2018

malnourished or at risk subjects, but no agreement exists in which parameters should be included in an 'ideal' tool in different patient populations.

What this paper adds

- An accurate monitoring of effective energy and protein intake permits to show that during the first 5 days of hospital stay malnourished or at risk patients consumed an amount of calories and proteins largely lower than their metabolic requirements.
- The reduced energy and protein intake marked a population of elderly individuals with higher length of hospital stay and increased in-hospital and 30-day mortality after discharge.
- A lower middle-upper arm circumference, a higher C-reactive protein/albumin ratio and the impaired ability to perform or complete self-feeding activities were all independently associated with reduced energy and protein intake during hospitalization.

1. Introduction

In acutely ill patients a disease-related malnutrition may occur, as a result of a catabolic state triggered by systemic inflammation secondary to a concomitant disease. The association of this condition with a negative energy balance impacts adversely on body composition, functional capacity and outcomes (Cederholm et al., 2017). Malnutrition has been associated with depression of the immune system, sarcopenia and increased incidence of complications (e.g. infections, pressure ulcers) in patients as well as with longer hospital stays, higher readmission rates, greater health care costs and increased hospital and long-term patient mortality (Agarwal et al., 2013; Barker et al., 2011; Hiesmayr et al., 2009; Souza et al., 2015). Reduced food intake in patients during hospital stays strongly contributes to hospital-related malnutrition and its adverse clinical outcomes (Cox Sullivan et al., 2016).

According to the World Health Organization, the term malnutrition refers to deficiencies ('undernutrition'), excesses or imbalances in a person's intake of energy and/or nutrients (World Health Organization, 2016). The association between reduced food intake and risk of malnutrition during hospitalization has been internationally clearly documented. For example, 40% of patients at risk for malnutrition eat less than half of the food offered; this percentage is double that of the rest of the hospitalized population (Agarwal et al., 2012; Hiesmayr et al., 2009). Hospital malnutrition is a particularly significant problem for vulnerable groups such as the older adults, who are at particular risk for low protein intakes because of higher incidence of chronic diseases, as well as for loss of independence in activities of daily living and worsening in oral health and presence of dysgeusia (Bauer et al., 2013; Eide et al., 2015a,b; Souza et al., 2015).

Notably, several factors contributing to malnutrition in acute settings have been identified as related to organisational factors (e.g. failure to recognise malnutrition; lack of nutritional screening or assessment; lack of nutritional training; confusion regarding nutritional responsibility; failure to record height, weight and nutritional intake; lack of staff to assist with feeding) (Amaral et al., 2010; Kubrak and Jensen, 2007; Mudge et al., 2011; Patel and Martin, 2008). Moreover, sometimes patients are reluctant to express their needs to the healthcare providers (Naithani et al., 2008). As a consequence, such problems often remain hidden.

Working in conjunction with physicians, dieticians and allied health staffing under an interdisciplinary perspective, nurses are in a pivotal position to improve this critical issue, having a duty of care to screen and monitor patients for malnutrition and having the opportunity to be the first to identify, as part of their holistic patient admission assessment, patients who need nutritional supports (Dudek and Dudek, 2013; Franklin, 2014; Sauer et al., 2016).

Unfortunately, nurses seldom consider the patient's nutritional aspects in an effective and comprehensive way due to different reasons, such as priority attributed to other activities, confusion regarding nurses' role in malnutrition screening, limited expertise in clinical judgement, lack of specific knowledge and skills (Franklin, 2014). Nutrition assessment is often based on 'clinical judgement' only, without using evidence-based tools (Raja et al., 2008). However, since up to 85% of hospital patients at risk of malnutrition are not identified in the absence of reliable screening program; the routine use of a simple screening procedure is thus recommended (Elia et al., 2005).

It should be noted that no agreement exists on which parameters should be included in an 'ideal' screening tool in order to accurately identify malnourished or at risk subjects in different patient populations (Hershkovich et al., 2017). As an example, inflammation/malnutrition laboratory data are not included in any nutritional screening tool. Finally, although the association between malnutrition and impaired mobility was clearly documented (Lahmann et al., 2015), most currently available nutritional screening tools for acute settings do not take into account functional aspects at all, whilst others consider only impaired mobility as a functional risk factor. Therefore, incidental or pre-existing factors that could potentially affect food intake during hospital stays may not be precisely assessed or documented at admission, particularly for vulnerable groups such as frail older adults in acute settings. Moreover, food intake may not be consistently monitored in these groups, further aggravating the burden of hospital malnutrition.

Patients at risk of reduced food intake during their hospital stay should be identified, and a precise early assessment of patients' nutrient intake should be performed in order to proceed with the appropriate nutritional support (Sullivan et al., 2016). Recent guidelines recommend to assess energy and protein intakes every 24–48 h (Bounoure et al., 2016). Regrettably, such assessments are often imprecisely carried out (e.g. only the percentage of a meal consumed by a patient is estimated) or not at all, resulting in inaccurate information on patient energy and protein intake. Consequently, several patients may not cover their basal metabolic requirements with oral nutrition, unbeknownst to the healthcare team (Sullivan et al., 2016).

Artificial (enteral or parenteral) nutrition should be initiated promptly (within 24–48 h of admission) in the hospitalized patients at high nutritional risk who are unable to maintain volitional oral intake (McClave et al., 2016). For patients at lower risk, nutritional support may be delayed: if after 5 days from hospital admission at least 75% energy and protein targets are not reached and it is evident that adequate oral nutrition will not be achievable within the next 48 h, artificial nutrition should be started (Bounoure et al., 2016; McClave et al., 2016). We speculate that earliest predictive indicators of risk for reduced food intake (e.g. impaired self-feeding), as well as evidence of actual food intake below 50% of energy/protein targets, could be considered in order to anticipate nutritional support.

Therefore, the primary aim of this study was to identify reliable indicators of reduced food intake during the first 5 days of their hospital stay in acute older adults who were malnourished or at risk of malnutrition at admission. The secondary aims were to accurately assess the adequacy of daily energy and protein intake and to analyse the causes of reduced nutrient intake. Finally, we explored the impact of nutrient intake on selected patient outcomes.

2. Materials and methods

2.1. Study design and setting

This was a prospective observational longitudinal study carried out in an Internal Medicine Unit of the Academic Teaching University Hospital of Trieste, Italy.

2.2. Eligibility and exclusion criteria

All older adults (> 65 years) consecutively admitted to the study unit from July 1st to October 31st, 2015, were assessed within 24 h following hospital admission in order to determine their potential inclusion in the study on the basis of whether they were currently malnourished or at risk of malnutrition. Patients were considered eligible if least one of the following criteria was present: Nutritional Risk Score (NRS 2002) ≥ 3 (Kondrup et al., 2003), middle-upper arm circumference (MUAC) < 23.5 cm (Stratton et al., 2004) or impaired ability to perform or to complete self-feeding activities resulting from distinct causes, whether resulting from cognitive, neurologic or musculoskeletal impairment or weakness/fatigue (Heardman and Kamitsuru, 2014; Kondrup et al., 2003). The exclusion criteria included lack of informed consent, artificial nutritional support at any time during the study and end-of-life care.

The study was approved by the Regional Bioethics Committee, based on a specific and detailed research project. Informed consent was obtained from each participating patient or from a person legally responsible for him or her. All healthcare providers (physicians, nurses, dieticians and nurse assistants) were aware of the current study and of each patient's intake assessment. The research was conducted according to the Declaration of Helsinki, and did not affect any nurses' or physicians' clinical decisions.

A minimum required sample size of 80 patients was calculated a priori based on a 10% difference between the energy intake of the studied population and the energy requirements of a similar at-risk population (1375 ± 500 kcal/day) (Perier et al., 2004). This sample size enabled a type-I probability error of 5% and a desired statistical power of 80%.

2.3. Data collection

Body height and MUAC were measured using a 2-m inextensible tape; measurements were rounded up or down to the nearest 0.1-cm mark. Body weight was measured to the nearest 0.1 kg on a chair or a lifter equipped with a weighing device, depending on the patient conditions. Care was taken to use always the same device for each patient during both the admission and the follow-up measurements. Body mass index (BMI, kg/m^2) was calculated by dividing the actual weight (kg) by squared height (m), whilst the total arm area (TAA, cm^2) was calculated by dividing the squared MUAC (cm^2) by 4π.

Demographic data and medical diagnoses at admission were collected from clinical documentation.

For each enrolled patient, the daily basal energy expenditure was estimated via the Harris-Benedict equation, and the daily energy requirement was calculated after correcting this equation for stress/activity factors (Nagano et al., 2015; Roza and Shizgal, 1984). The daily protein requirement was calculated as the product of the protein requirement index (g/kg) (Bounoure et al., 2016; Ferrie et al., 2013) by ideal body weight (McCarron and Devine, 1974).

Length of hospital stay (LOS) and in-hospital and 30-day post-discharge mortality were also documented.

2.4. Analytical determinations

Plasma complete blood count and serums creatinine and albumin were determined by standard laboratory techniques. C-reactive protein (CRP) was measured by ELISA.

Bioelectrical impedance analysis (BIA) can identify patients' malnutrition by assessing noninvasively whole-body cell membrane quality (Lukaski et al., 2017). Among BIA parameters, the phase angle (PhA) has been proposed as a screening tool to rapidly assess nutritional status (Jouinot et al., 2017). Studies have demonstrated that a low PhA is associated with mortality independently of age, sex, comorbidities and BMI (Bjornsdottir et al., 2013; Hickson et al., 2011; Nagano et al., 2015), wherein an improved nutritional state is associated with increased PhA (Mika et al., 2004). In the present study, a BIA-101 new edition device (Akern, Italy) was used for bioelectrical impedance analysis. Data were acquired in a standard mode (Lukaski et al., 1986); briefly, whilst the subject was lying in a supine position, four electrodes were placed respectively on the right hand, wrist, ankle and foot after cleaning the skin with 70% alcohol. PhA was calculated as the relationship between tissue resistance (R) and reactance (Xc). PhA was considered normal when ≥ 4.6° for female and ≥ 5.0° for male patients (Kyle et al., 2012).

2.5. Procedure

2.5.1. Baseline data

At hospital admission, all patients underwent a focused nursing assessment in order to determine the presence of inclusion criteria. For patients who were enrolled, data on lymphocyte count and serum levels of CRP, creatinine and albumin were collected following admission, and the Instant Nutritional Assessment (INA) (Seltzer et al., 1979) score and the CRP/albumin ratio (Fairclough et al., 2009) were also calculated. The INA score classifies a patient's nutritional state in one of four groups according to serum albumin level and blood lymphocyte count: group 1 (albumin ≥ 3.5 g/dl; lymphocytes ≥ 1.5 cells × 10^3/μL), group 2 (albumin ≥ 3.5 g/dl; lymphocytes < 1.5 cells × 10^3/μL), group 3 (albumin < 3.5 g/dl; blood lymphocytes ≥ 1.5 cells × 10^3/μL) and group 4 (albumin < 3.5 g/dl; lymphocytes < 1.5 cells × 10^3/μL); compared to different nutritional indices, this score showed to be the best single score to identify patients who are malnourished or at risk of malnutrition (Pablo et al., 2003). The CRP/albumin ratio, calculated by dividing plasma CRP by serum albumin, was previously described as a prognostic predictor of patients' nutritional and inflammatory status according to the following classification: no risk (< 0.4), low risk (0.4–1.2), moderate risk (1.2–2.0) and high risk (> 2.0) (Corrêa et al., 2002).

2.5.2. Effective energy and protein intake assessment

For enrolled patients, effective food intake was monitored during five consecutive days until reaching 15 consecutive meals (5 breakfasts, 5 lunches and 5 dinners) according to a photographic method. Briefly, digital pictures of the tray were taken when delivered to the patient and at the end of each meal. This method was shown to improve the calculation accuracy of both energy and protein intake and to have a much greater accuracy than other routine methods (Sullivan et al., 2016). All food items belonging to the provided meal were carefully included in the picture. Because of hospital policy, no extra food from home was allowed. In the case of incomplete food intake, the main reason according to a patient's explanation or a researcher's impression was recorded. The picture files were downloaded daily from the camera and stored in a dedicated folder on a personal computer after anonymising the files.

The specific nutritional content and energy composition of each provided meal was known. For the purpose of the study, the overall energy (kcal) and protein (g) content were considered for each dish/portion of food. The amount of food consumed at each meal was estimated by three researchers (L.B., E.D.B., C.L.D.P.) by comparing the pictures taken before and after the meal. For each food, estimate of intake was made after comparing the differences between the provided and the discarded food according to a five-degree approximation scale (0%, 25%, 50%, 75%, 100%). Before starting the study, the researchers' agreement in estimating the percentage of assumed meals was evaluated on a sample of 30 pictures via Cohen κ statistics. The overall and inter-observer agreements was 'almost perfect' (range: κ = 0.91–0.94) (Landis and Koch, 1977). Daily measured energy (kcal/day) and protein (g/day) intakes were then determined by calculating the caloric values of effectively eaten food as a percentage of the known amounts of calories and protein, respectively, provided by the whole portion.

2.5.3. Follow-up

The adequacy of nutritional intake was explored as the difference between the mean daily energy intake and the daily energy requirement (Δkcal) and between the mean daily protein intake and the daily protein requirement (ΔProt). Six days after admission, PhA, BMI, MUAC and TAA were reassessed. The impact of nutritional intake on LOS, in-hospital and 30-day post-discharge mortality and the NRS-2002 score at both admission and follow-up was explored.

2.5.4. Data analysis

All data are shown as means ± standard deviation (SD). The statistical analyses was performed using SPSS software for Windows, version 22.0 (Armonk, NY; IBM Corp.). Nominal variables (e.g. gender, causes for incomplete food intake, mortality) were described as numbers and percentages. Continuous variables (e.g. energy and protein intake, PhA, MUAC, BMI, laboratory data) were described as means ± SD, median and inter-quartile ranges (IQRs). Differences between means were analysed by paired or unpaired Student's *t*-tests, as appropriate, after considering via Levene's test whether the subgroups had equal variance; the degrees of freedom (df) were also reported.

Bivariate association between LOS and respective Δkcal and ΔProt was investigated with Pearson's correlation coefficient (r); positive or negative correlations were interpreted as follows: little or null (0–0.30), low (0.30–0.50), moderate (0.50–0.70), high (0.70–0.90) and very high (0.90–1) (Hinkle et al., 2003).

Stepwise multiple linear regression models were used to examine the independent association between the explored variables and the respective mean daily energy and protein intake. Only variables significantly related to mean daily energy or protein intake in the bivariate analyses were included. Since MUAC and TAA ($r = 0.996$; $p < 0.001$) as well as CRP and the CRP/albumin ratio ($r = 0.976$; $p < 0.001$) were strongly correlated, we inserted only MUAC and the CRP/albumin ratio in the regression models to avoid collinearity. Since the data on the CRP/albumin ratio and lymphocytes had a skewed distribution, a square root transformation was performed to obtain a more normal distribution. Categorical data with more than two options (INA) were coded as dummy variables. In summary, age, albumin, lymphocytes, INA, NRS-2002 ≥ 3, MUAC, impaired self-feeding, and C-reactive protein/albumin ratio were entered in the regression analysis algorithm. For all tests, statistical significance was set at an alpha level of $p = 0.05$.

3. Results

3.1. General data

During the study period, 202 patients were admitted to the Internal Medicine Unit and were assessed for potential inclusion in the study. Of these, 89 (44.1%) met the inclusion criteria. Two patients were excluded because they refused to participate and six were excluded because of their LOS at the hospital was shorter than 5 days. The final study population included 81 patients (37 males, 45.7%; 44 females, 54.3%). Table 1 shows the main characteristics of the enrolled population and their conditions at hospital admission.

For enrolled patients, the mean daily basal energy expenditure was 1,207.5 ± 227.2 kcal (median: 1169.0; IQR: 1041.0–1307.5) and the mean daily energy requirement was 1,666.9 ± 438.1 kcal (median: 1,591.0; IQR: 1,358.5–1,835.5), whilst the mean daily protein requirement was 71.3 ± 18.6 g (median: 71.4; IQR: 58.8–80.5).

3.2. Effective energy and protein intake

The effective food intake was monitored for a total of 1208 (99.4%) meals. In 278 cases (23.0%), meals were fully eaten. The main reasons for the incomplete intake of the remaining 930 meals are described in Fig. 1.

Mean daily energy intake was 669.0 ± 573.9 kcal/day (median: 588.3; IQR: 172.3–1082.6), and mean daily protein intake was 30.7 ± 25.8 g/day (median: 27.2; IQR: 7.6–52.5). Overall, patients consumed daily an amount of calories (mean energy intake: 669.0 ± 573.9 kcal/day, daily energy requirement: 1666.9 ± 438.1 kcal/day; $t = -15.177$, df = 80, $p < 0.001$) and proteins (mean protein intake: 30.7 ± 25.8 g/day, daily protein requirement: 71.3 ± 18.6 g/day; $t = -11.072$, df = 80, $p < 0.001$) lower than required (Fig. 2a and b). With respect to energy intake, 4 (4.9%) patients consumed > 100% of their daily energy requirement, 10 (12.3%) 76–100%, 14 (17.3%) 51–75% and 20 (24.7%) 26–50%, and the remaining 33 patients (40.7%) consumed ≤ 25%. With respect to protein intake, 12 (14.8%) patients consumed > 100% of their daily protein requirement, 9 (11.1%) 76–100%, 10 (12.3%) 51–75% and 17 (21.0%) 26–50%, and the remaining 33 patients (40.7%) consumed ≤ 25%.

Table 1
Main characteristics and conditions of patients enrolled in the study at hospital admission and discharge.

Variable	Data
Age (years)[e]	80.7 ± 11.5 (81; 75–89.5)
Medical diagnosis of admission[f]	
Infection/sepsis	34 (42.0%)
Anaemia, cancer	7 (8.6%)
Dehydration, heart failure, digestive and metabolic disease	6 (7.4%)
Respiratory failure	5 (6.2%)
Trauma/burns	4 (4.9%)
Nutritional Risk Score 2002 ≥ 3[f]	42 (51.9%)
Body mass index (kg/m^2)[e]	23.5 ± 4.3 (23.1; 20.5–26.1)
Middle-upper arm circumference (cm)[e]	25.6 ± 4.4 (25.0; 21.8–29.0)
Total arm area (cm^2)[e]	53.7 ± 18.3 (49.8; 37.7–67.0)
Feeding self-care deficit (yes)[f]	57 (70.4%)
Creatinine (mg/dL)[a,e]	1.28 ± 0.97 (0.95; 0.70–1.49)
Albumin (mg/dL)[b,e]	3.0 ± 0.6 (3.0; 2.7–3.4)
C-reactive protein (mg/dL)[a,e]	75.4 ± 85.1 (44.7; 15.5–103.6)
Lymphocytes (cells x 10^3/μL)[c,e]	1.2 ± 0.7 (1.0; 0.7–1.7)
C-reactive protein/albumin (ratio)[b,e]	28.3 ± 35.4 (14.4; 4.8–42.2)
Instant Nutritional Assessment[c,f]	
1	4 (5.1%)
2	10 (12.8%)
3	22 (28.2%)
4	42 (53.8%)
Phase angle (degrees)[e]	3.5 ± 2.3 (3.2; 2.3–4.1)
Mortality[f]	
In hospital	14 (17.3%)
30 day[a]	22 (27.2%)
Length of hospital stay (days)[e]	
All patients	13.7 ± 8.2 (12.0; 8.0–17.0)
Patients surviving until hospital discharge[d]	13.2 ± 7.3 (11.0; 8.0–17.0)

[a] n = 80.
[b] n = 79.
[c] n = 78.
[d] n = 67.
[e] mean ± standard deviation (median; interquartile range).
[f] number (percentage).

3.3. Relationships between nutritional variables and effective energy and protein intake

MUAC, TAA, serum albumin, serum CRP, the CRP/albumin ratio and the INA score at admission were lower and age was higher for patients who consumed < 50% of both daily energy and protein requirements, whereas blood lymphocyte count was only related to daily protein requirement < 50% (Table 2). In addition, both the daily energy and protein intake were lower in patients with an NRS ≥ 3 (energy intake [NRS ≥ 3: 525.0 ± 490.1 kcal/day; NRS < 3: 824.0 ± 621.8 kcal/day; $t = 2.412$, df = 79, $p = 0.018$]; protein intake [NRS ≥ 3: 24.2 ± 22.6 g/day; NRS < 3: 37.8 ± 27.5 g/day; $t = 2.425$, df = 79, $p = 0.018$]) and in patients with an impaired ability to perform or complete self-feeding activities (energy intake [impaired

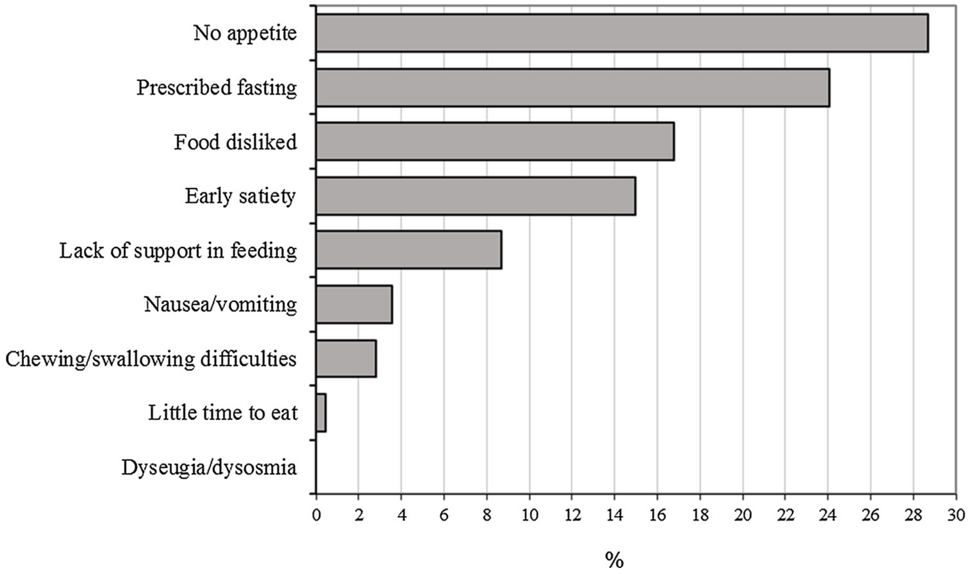

Fig. 1. Reasons for reduced food intake in patients who did not complete their meals (meals: n = 930; patients: n = 81).

self-feeding: 497.1 ± 485.7 kcal/day; able to self-feed: 1077.2 ± 569.3 kcal/day; $t = 4.662$, df = 79, $p < 0.001$]; protein intake [impaired self-feeding: 23.1 ± 22.5 g/day; able to self-feed: 48.9 ± 24.5 g/day; $t = 4.596$, df = 79, $p < 0.001$]).

In multivariate analyses, MUAC, the CRP/albumin ratio and an impaired ability to perform or to complete self-feeding activities were the only significant predictors of risk for poor energy and protein intake. The final regression models explained 43% and 44% of variance in mean daily energy and protein intake, respectively (Table 3). Higher MUAC values at admission were associated with higher mean daily energy and protein intake, whilst a higher CRP/albumin ratio predicted lower mean daily energy and protein intake. Similarly, both mean daily energy and protein intake were lower for patients showing impaired feeding or self-care.

3.4. *Impact of effective energy and protein intake on clinical outcomes*

Bio-anthropometric data were assessed during a follow-up exam for 70 patients. A reduction in MUAC (admission: 26.0 ± 4.2; follow-up: 25.7 ± 4.2; $t = 2.067$, df = 68, $p = 0.043$) and a non-significant trend towards TAA reduction (admission: 55.1 ± 17.6; follow-up: 53.8 ± 17.4; $t = 1.962$, df = 68, $p = 0.054$) were found. No significant differences in BMI (admission: 23.6 ± 4.4; follow-up: 23.4 ± 4.3; $t = 1.027$, df = 70, $p = 0.308$) or PhA (admission: 3.2 ± 1.9; follow-up: 3.0 ± 1.5; $t = 1.108$, df = 68, $p = 0.272$) were observed.

Both mean daily energy and protein intakes were lower in patients who deceased before discharge (energy intake [discharged: 769.7 ± 570.2 kcal/day; deceased: 186.8 ± 271.3 kcal/day; $t = 5.797$, df = 41, $p < 0.001$]; protein intake [discharged: 35.3 ± 25.6 g/day; deceased: 8.7 ± 12.6 g/day; $t = 5.795$, df = 39, $p < 0.001$]). This finding was also confirmed for 30-day mortality (energy intake [survived: 828.7 ± 571.3 kcal/day; deceased: 265.8 ± 347.6 kcal/day; $t = 5.338$, df = 62, $p < 0.001$]; protein intake [survived: 37.8 ± 25.5 g/day; deceased: 12.9 ± 17.2 g/day; $t = 5.026$, df = 56, $p < 0.001$]). All surviving patients consumed > 75% of their daily energy and daily protein requirement.

Following hospital discharge, amongst those who survived (n = 67), LOS was longer for patients who consumed < 50% of both daily energy (> 50%: 10.9 ± 5.8 days; ≤50%: 14.7 ± 7.9 days; $t = -2.080$, df = 65, $p = 0.041$) and protein (> 50%: 10.9 ± 5.6 days; ≤50%: 14.9 ± 8.0 days; $t = -2.219$, df = 65, $p = 0.030$) requirement.

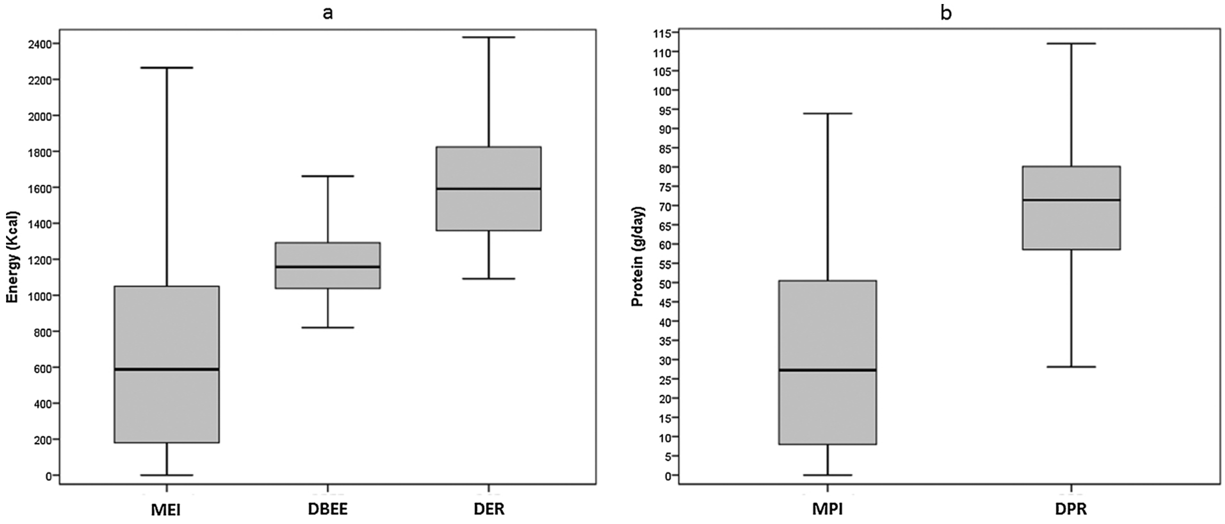

Fig. 2. a) Differences amongst the mean daily energy intake (MEI), daily basal energy expenditure (DBEE) and daily energy requirement (DER). b) Differences between the mean daily protein intake (MPI) and daily protein requirement (DPR).

Table 2
Relationships between nutritional variables and effective energy and protein intake.

Parameter	MEI ≥ 50% DER mean ± SD	MEI < 50% DER mean ± SD	*t*-value	*df*	*p*-value	MPI ≥ 50% DPR mean ± SD	MPI < 50% DPR mean ± SD	*t*-value	*df*	*p*-value
Age (years)	76.9 ± 10.7	82.8 ± 11.5	−2.261	79	0.026	76.0 ± 12.6	83.7 ± 9.8	−3.042	79	0.003
Body mass index (kg/m^2)	23.1 ± 4.3	23.8 ± 4.4	−0.616	79	0.540	24.0 ± 4.5	23.3 ± 4.2	0.777	79	0.439
MUAC (cm)	27.1 ± 3.4	24.8 ± 4.7	2.328	79	0.022	27.9 ± 3.6	24.2 ± 4.2	4.030	79	< 0.001
Total arm area (cm^2)	59.5 ± 14.6	50.7 ± 19.4	2.108	79	0.038	63.0 ± 16.1	48.0 ± 17.3	3.895	79	< 0.001
Phase angle (degrees)	3.4 ± 1.4	3.6 ± 2.7	−0.443	79	0.659	3.3 ± 1.4	3.7 ± 2.8	−0.776	79	0.440
Creatinine (mg/dL)[a]	1.2 ± 0.8	1.3 ± 1.1	−0.574	79	0.567	1.2 ± 0.8	1.3 ± 1.1	−0.479	78	0.633
Albumin (mg/dL)[b]	3.3 ± 0.5	2.8 ± 0.5	3.308	77	0.001	3.2 ± 0.5	2.9 ± 0.6	2.104	77	0.039
C-reactive protein (mg/dL)[a]	36.6 ± 41.8	96.3 ± 95.0	−3.888	76	< 0.001	51.3 ± 76.1	90.6 ± 87.7	−2.052	78	0.044
Lymphocytes (cells*10^3/μL)[c]	1.4 ± 0.8	1.1 ± 0.7	1.850	76	0.068	1.5 ± 0.9	1.1 ± 0.5	2.774	42	0.008
CRP/albumin (ratio)[b]	11.8 ± 14.1	37.4 ± 40.1	−4.121	69	< 0.001	18.4 ± 30.6	34.8 ± 37.0	−2.053	77	0.043
INA[c]	2.9 ± 1.0	3.5 ± 0.7	−3.211	76	0.002	3.0 ± 1.0	3.5 ± 0.8	−2.503	76	0.014

MEI: mean daily energy intake; DER: daily energy requirement; MPI: mean daily protein intake; DPR: daily protein requirement; df: degrees of freedom; MUAC: middle-upper arm circumference; CRP: C-reactive protein; INA: Instant Nutritional Assessment.

[a] n = 80.

[b] n = 79.

[c] n = 78.

Moreover, a significant low negative correlation was shown between LOS and both Δkcal (r = −0.384; p = 0.001) and ΔProt (r = −326; p = 0.007).

4. Discussion

Considering a population of hospitalized older adults who were malnourished or at risk for malnutrition, the data of the present study showed several novel findings: a lower MUAC, a higher CRP/albumin ratio and an impaired ability to perform or complete self-feeding activities are all independently associated with reduced energy and protein intake during hospitalization. In addition, we found that reduced energy and protein intake, which characterised a large proportion of patients during the first 5 days following hospital admission, marked a population of older adult individuals with higher LOS and increased in-hospital and 30-day mortality after discharge. This latter finding confirmed data from a previous study on the general hospital population in which a significant percentage of patients admitted to acute care settings did not meet their individual recommended energy and protein needs (Thibault et al., 2011); these results in addition to the current ones highlight that this situation has remained unchanged over the course of 10 years.

Previous studies demonstrated that MUAC and the CRP/albumin ratio could be used to identify patients at risk of in-hospital death (Asiimwe, 2016; Slee et al., 2016). To the best of our knowledge, the present study is the first to show the usefulness of these variables in predicting risk for insufficient nutritional intake during the first few days following hospital admission. Conversely, in the present study variables such as PhA, BMI and the NRS-2002 score did not demonstrate to be predictive for energy and protein intake. However, it should be noted that 97.5% of the patients enrolled (42/49 women; 34/38 men) in our investigation presented a PhA lower than normal at admission. Thus, the low baseline values may have limited the impact of PhA as a predictor of malnutrition during hospitalization. In addition, the short follow-up period (5 days) may have further offset the impact of PhA change on the study variables. Even so, after the follow-up period, a statistically significant reduction in MUAC was evidenced; this finding suggests that MUAC was the only tool able to identify very early significant modifications in nutritional status following hospital admission.

In the older adults, MUAC shows low sensitivity in detecting malnutrition (Asiimwe et al., 2015) but high predictive capacity for mortality (Powell-Tuck and Hennessy, 2003; Tsai et al., 2012). In a recent study, amongst 8 different anthropometric measures, decreased MUAC had the strongest association with mortality in older adults (de Hollander et al., 2013). Since loss of upper arm function, which maintains local muscle mass, strongly impacts MUAC (Chumlea, 2006), reduced MUAC can occur as a consequence of terminal function decline (Lunney et al., 2003) and is a reliable prognostic factor for mortality in addition to reduced energy and protein intake in geriatric acute patients.

Similar to MUAC, the CRP/albumin ratio is a good predictor of in-hospital mortality and of length of hospital stay (Budzyński et al., 2016) but is not necessarily related to the nutritional state of older adults given the influence of CRP levels on inflammation (Bouillanne et al., 2011). In addition, the current data show that the CRP/albumin ratio marks a population at risk of malnutrition, which further aggravates the risk of negative outcomes during hospital stays. As a result, the use of two simple indicators (MUAC and the CRP/albumin ratio) and the observation of impaired neuromuscular and cognitive function allows the risk of energy and protein malnutrition during hospital stays to be assessed. Notably, we want to highlight the particular novelty of the finding concerning the impaired feeding self-care as a predictive variable for the risk of malnutrition, since most nutritional screening tools (e.g. NRS-2002, MUST) do not take into account functional aspects, whilst others (e.g. MNA) only consider impaired mobility as a

Table 3

Stepwise multiple linear regression of mean measured energy intake (MEI) and measured protein intake (MPI) on study variables. Variables excluded from both final models: age, albumin, lymphocytes, Instant Nutritional Assessment and Nutritional Risk Score 2002 ≥ 3.

Dependent variable	Predictors	B	SE	β	*t*-values	*p*-values
MEI (kcal/day) R^2 0.430; $p < 0.001$	Middle-upper arm circumference	60.372	12.504	0.461	0.461	< 0.001
	Impaired self-feeding[a]	−338.067	117.422	−0.274	−2.879	0.005
	C-reactive protein/albumin ratio	−4.225	1.436	−0.262	−2.942	0.004
	Constant	*−515.244*	*359.257*	/	*−1.434*	*0.156*
MPI (g/day) R^2 0.440; $p < 0.001$	Middle-upper arm circumference	2.859	0.558	0.485	5.125	< 0.001
	Impaired self-feeding[a]	−14.446	5.238	−0.260	−2.758	0.007
	C-reactive protein/albumin ratio	−0.183	0.064	−0.253	−2.864	0.005
	Constant	*−26.902*	*16.026*	/	*−1.679*	*0.097*

MEI: mean daily energy intake; MPI: mean daily protein intake. SE: standard error.

[a] Impaired ability to perform or to complete self-feeding activities.

functional risk factor.

As described above, a negative daily energy and protein balance during the first 5 days of hospitalization was associated in our study population with a risk of in-hospital and 30-day mortality and with a longer LOS in the hospital. Another study collected data from more than 16,000 patients during a single-day audit of hospital food intake and found that 60% of them did not eat their full regular meal; this study also documented a progressive increase in hospital and 30-day mortality in association with decreased food intake (Hiesmayr et al., 2009). However, differently from our research, in the cited study the percentage of food intake was collected based on a subjective patients' self-estimation. Moreover, neither the energy/protein composition of the meals, nor the patients' specific daily energy and protein requirements were measured.

Our study confirmed that malnutrition is still a serious concern for hospitalized patients, especially for those at high risk or already malnourished who we would reasonably expect to receive greater nutritional attention. However, nutritional intake was strikingly inadequate in covering energy demand and especially in meeting protein requirements. Protein-energy malnutrition strongly contributes to increased risk of sarcopenia, impaired muscle strength and function and poorer immune and health status in the older adults (Boirie et al., 2014). A protein intake of 1–1.5 g/kg/day or about 10–12% of total caloric intake has been proposed as optimal for older adults in order to decrease the risk of frailty (Beasley et al., 2010; Raynaud-Simon et al., 2011). In this study, mean protein intake was 0.5 ± 0.4 g/kg/day (median: 0.4; IQR 0.1–0.8), which is largely inadequate to cover the increased protein needs of the study population. This finding emphasises that, as previously reported in the literature, identifying patients as being at risk for protein-energy malnutrition is not sufficient if it does not translate into appropriate treatments during hospital stay. Indeed, after being screened as 'at high risk' only a small proportion of patients are referred to a nutritional expert and received energy-enriched diets or additional food (Tannen and Lohrmann, 2013).

Accurate monitoring of patient food intake should be mandatory because hospital underfeeding is an important risk factor for malnutrition (Fuchs et al., 2008). Standard visual methods to assess food intake generally do not accurately reflect energy and protein intake (Husted et al., 2017). In contrast, the photographic method is tool that has been validated for assessing nutritional intake in hospitalized older adults (Monacelli et al., 2017). In addition to monitoring food intake, the method that we adopted allowed for the accurate documentation of overall energy and protein intake. However, as previously documented (Sullivan et al., 2016), this process required significant time and human resources. Although photographic documentation is not necessarily time intensive, a significant workload derived from the data analysis, which had to be carried out at least once daily in order to provide information having clinical significance. An accurate monitoring of energy and protein intake could be reserved for patients identified as malnourished or at risk for malnutrition by nutritional screening tools. Furthermore, in the case of critically reduced nutritional intake, the cause of inadequate nutrition should be documented in order to take targeted corrective actions.

A somewhat unexpected figure came from the analysis of the causes of reduced food intake. The most frequent reason for reduced food intake was lack of appetite; this finding is consistent with the literature (Tannen and Lohrmann, 2013). Surprisingly, prescribed fasting was found to be a cause almost as frequent. Total cessation of oral feeding is a common practice in hospitals, so patients can inadvertently spend long periods of fasting during hospitalization (Lamb et al., 2010). Medically ordered fasting is common and often fasting time exceed guidelines recommendation, leading to a potential worsening in pre-existing condition or inducing a catabolic state in different malnourished or at risk populations (Vidot et al., 2016). Regardless of whether it was appropriately prescribed or not, fasting practices without an inadequate artificial nutritional support may heavily contribute to hospital-related malnutrition (Arenas Moya et al., 2016).

We showed both energy and protein intake to be significantly lower in patients with impaired ability to perform or to complete self-feeding activities, although lack of support for feeding was documented as the main reason for reduced food intake in less than 10% of cases. In hospitalized older adults, an increase in nutrient intake (particularly proteins) was related to better functional status (Dennis et al., 2012); however, even structured strategies to support food intake such as Protected Mealtimes have proven to be ineffective in improving energy and protein intake and avoiding malnutrition (Porter et al., 2017). Probably, the impaired ability to perform or to complete self-feeding activities, related to acute or pre-existing conditions, should be interpreted as an important indicator of actually compromised functional status linked to disease-related malnutrition that, in the absence of early and more comprehensive intervention strategies, exposes the patient to a high risk of malnutrition and poor outcome.

Providing high-quality nutritional care represents a challenge to all involved health professionals, so that an interdisciplinary approach is essential. According to the nursing process, nurses are called to identify expected outcomes for an individualized plan towards patients showing needs in nutrition domain, and to use their prescriptive authority as part of the nutrition care plan to expedite the nutrition care process (DiMaria-Ghalili et al., 2016). However, it should be noted that nurses might have deeply different prescriptive authority due to their educational background, position and practice environment, as well as the variation of professional laws in different Countries. Nurses feel often alone in ensuring nutrition to malnourished older patients, burdened by a heavy ethical and professional responsibility frustrated by the inability to involve doctors in sharing the goals of nutritional care (Eide et al., 2015a,b). The different roles of clinicians involved in nutrition care should be redefined to promptly recognise and diagnose all at risk and malnourished patients, in order to rapidly implement comprehensive nutrition care plans including continuous monitoring and shared decisions (Tappenden et al., 2013) as, for example, discuss the indication of submitting patient to fasting. Nurses are the only clinicians to provide care with a close continuity for twenty-four hours a day, consequently they have a specific responsibility in patients' nutritional monitoring and in securing them an adequate food intake (Tannen and Lohrmann, 2013). A promptly start of artificial nutrition should be thus early considered when indicated. In particular, patients requiring nutrition therapy or receiving artificial nutrition should be managed by a multidisciplinary nutrition support team of specialized physicians, nurses, dietitians, speech therapists and pharmacists (Cederholm et al., 2017). In intensive care settings, strategies where the responsibility for autonomously starting and timely escalating enteral feeding was assigned to the nursing staff have been clearly demonstrated as effective in increasing the delivery of the enteral nutrition, and to be associated with reductions in infection, hospital length of stay and mortality (Friesecke et al., 2014; Padar et al., 2017). Unfortunately, outside of the ICUs the focus on nutrition seems to be very much lower, as the recommended nutritional care are often not implemented and most nutritionally-risking older patients are not identified or treated according to their needs (Eide et al., 2016). Probably, in non-intensive acute wards nutrition is not perceived as a priority, and all the health professionals seem often not to understand the importance and the consequences of neglecting nutritional care. Moreover, the documentation of nutritional information, both on patient admission and during hospital stay, is considered by nurses as insufficient and arbitrary. In particular, older patients are seldom screened for nutritional risk, and data as body weight, appetite and nutritional needs/risks are collected randomly, in an incomplete way and without using validated screening tools (Halvorsen et al., 2016). This is not a simple problem to solve, since food intake in hospitalized older adults is influenced by many variables. Multidisciplinary interventions based on sharing the importance of nutrition as a key factor of hospital care are needed to improve energy/protein intake and limit the risk of undesirable outcomes (Hope et al., 2017).

4.1. Limitations

The daily energy and protein requirements were calculated using the Harris-Benedict equation corrected for stress/activity factors based on patients' conditions upon admission and were not measured using indirect calorimetry. However, given the wide gap found between required and effective food intake, we believe that the lack of such information did not alter the results of the study.

The associations between mean daily energy/protein intake and the outcomes were analysed through bivariate analyses only. Since we did not collect data about other variables that may have influenced the outcomes (e.g., severity of medical condition, comorbidities, administered therapies), the deepening of these associations through multivariate analyses was impossible.

5. Conclusions

This study evaluated variables associated with malnourishment or the risk of malnutrition in a population of older adults at time of admission to a medical ward. In the results, this study confirmed that MUAC, the CRP/albumin ratio and impaired self-feeding are easily obtainable indicators of impaired energy and protein intake. Furthermore, these indicators have been notably associated with poor clinical outcomes.

This finding is relevant to clinical practice because all three variables are readily accessible and easy to measure (compared to other anthropometric measures), particularly for hospitalized, bedridden patients who require regular nutritional monitoring. Based on our results and on previously published data, we suggest that impairment in self-feeding activities is integrated as a screening criterion for malnutrition risk along with MUAC and the CRP/albumin ratio.

We propose that an accurate daily energy/protein intake calculation should be adopted in addition to the simple monitoring of taken food percentages for patients identified as malnourished or at risk for malnutrition by appropriate nutritional screening tools, while the photographic method should be wider used as a research method. Furthermore, in the case of critically reduced nutritional intake (e.g., $< 50\%$), we suggest that the causes of inadequate nutrition are documented in order to take prompt, targeted multidisciplinary shared corrective actions.

Further larger studies are needed to confirm the predictive power of nutritional screening variables in determining patient food intake and outcome and should consider other potentially significant factors.

Funding

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Conflict of interest

No conflict of interest has been declared by the authors.

Acknowledgments

The authors thank Dr. Paolo Corso and Dr. Vid Vičič for their kind collaboration.

References

Agarwal, E., Ferguson, M., Banks, M., Bauer, J., Capra, S., Isenring, E., 2012. Nutritional status and dietary intake of acute care patients: results from the Nutrition Care Day Survey 2010. Clin. Nutr. 31 (1), 41–47.

Agarwal, E., Ferguson, M., Banks, M., Batterham, M., Bauer, J., Capra, S., Isenring, E., 2013. Malnutrition and poor food intake are associated with prolonged hospital stay, frequent readmissions, and greater in-hospital mortality: results from the Nutrition Care Day Survey 2010. Clin. Nutr. 32 (5), 737–745.

Amaral, T.F., Matos, L.C., Teixeira, M.A., Tavares, M.M., Alvares, L., Antunes, A., 2010. Undernutrition and associated factors among hospitalized patients. Clin. Nutr. 29 (5), 580–585.

Arenas Moya, D., Plascencia Gaitan, A., Ornelas Camacho, D., Arenas Marquez, H., 2016. Hospital malnutrition related to fasting and underfeeding: is it an ethical issue? Nutr. Clin. Pract. 31 (3), 316–324.

Asiimwe, S.B., Muzoora, C., Wilson, L.A., Moore, C.C., 2015. Bedside measures of malnutrition and association with mortality in hospitalized adults. Clin. Nutr. 34 (2), 252–256.

Asiimwe, S.B., 2016. Simplifications of the mini nutritional assessment short-form are predictive of mortality among hospitalized young and middle-aged adults. Nutrition 32 (1), 95–100.

Barker, L.A., Gout, B.S., Crowe, T.C., 2011. Hospital malnutrition: prevalence, identification and impact on patients and the healthcare system. Int. J. Environ. Res. Public Health 8 (2), 514–527.

Bauer, J., Biolo, G., Cederholm, T., Cesari, M., Cruz-Jentoft, A.J., Morley, J.E., Phillips, S., Sieber, C., Stehle, P., Teta, D., Visvanathan, R., Volpi, E., Boirie, Y., 2013. Evidence-based recommendations for optimal dietary protein intake in older people: a position paper from the PROT-AGE study group. J. Am. Med. Dir. Assoc. 14 (8), 542–559.

Beasley, J.M., LaCroix, A.Z., Neuhouser, M.L., Huang, Y., Tinker, L., Woods, N., Michael, Y., Curb, J.D., Prentice, R.L., 2010. Protein intake and incident frailty in the Women's Health Initiative observational study. J. Am. Geriatr. Soc. 58 (6), 1063–1071.

Bjornsdottir, R., Oskarsdottir, E.S., Thordardottir, F.R., Ramel, A., Thorsdottir, I., Gunnarsdottir, I., 2013. Validation of a plate diagram sheet for estimation of energy and protein intake in hospitalized patients. Clin. Nutr. 32 (5), 746–751.

Boirie, Y., Morio, B., Caumon, E., Cano, N.J., 2014. Nutrition and protein energy homeostasis in elderly. Mech. Ageing Dev. 136–137, 76–84.

Bouillanne, O., Hay, P., Liabaud, B., Duche, C., Cynober, L., Aussel, C., 2011. Evidence that albumin is not a suitable marker of body composition-related nutritional status in elderly patients. Nutrition 27 (2), 165–169.

Bounoure, L., Gomes, F., Stanga, Z., Keller, U., Meier, R., Ballmer, P., Fehr, R., Mueller, B., Genton, L., Bertrand, P.C., Norman, K., Henzen, C., Laviano, A., Bischoff, S., Schneider, S.M., Kondrup, J., Schuetz, P., 2016. Detection and treatment of medical inpatients with or at-risk of malnutrition: suggested procedures based on validated guidelines. Nutrition 32 (7–8), 790–798.

Budzyński, J., Tojek, K., Czerniak, B., Banaszkiewicz, Z., 2016. Scores of nutritional risk and parameters of nutritional status assessment as predictors of in-hospital mortality and readmissions in the general hospital population. Clin. Nutr. 35 (6), 1464–1471.

Cederholm, T., Barazzoni, R., Austin, P., Ballmer, P., Biolo, G., Bischoff, S.C., Compher, C., Correia, I., Higashiguchi, T., Holst, M., Jensen, G.L., Malone, A., Muscaritoli, M., Nyulasi, I., Pirlich, M., Rothenberg, E., Schindler, K., Schneider, S.M., de van der Schueren, M.A., Sieber, C., Valentini, L., Yu, J.C., Van Gossum, A., Singer, P., 2017. ESPEN guidelines on definitions and terminology of clinical nutrition. Clin. Nutr. 36 (1), 49–64.

Chumlea, W.C., 2006. Is the MNA valid in different populations and across practice settings? J. Nutr. Health Aging 10 (6), 524–527.

Corrêa, C.R., Angeleli, A.Y.O., Camargo, N.d.R., Barbosa, L., Burini, R.C., 2002. Comparação entre a relação PCR/albumina eo índice prognóstico inflamatório nutricional (IPIN). J. Bras. Patol. Med. Lab. 38 (3), 183–190.

Cox Sullivan, S., Bopp, M.M., Roberson, P.K., Lensing, S., Sullivan, D.H., 2016. Evaluation of an innovative method for calculating energy intake of hospitalized patients. Nutrients 8 (9).

de Hollander, E.L., Bemelmans, W.J., de Groot, L.C., 2013. Associations between changes in anthropometric measures and mortality in old age: a role for mid-upper arm circumference? J. Am. Med. Dir. Assoc. 14 (3), 187–193.

Dennis, R.A., Johnson, L.E., Roberson, P.K., Heif, M., Bopp, M.M., Garner, K.K., Padala, K.P., Padala, P.R., Dubbert, P.M., Sullivan, D.H., 2012. Changes in activities of daily living, nutrient intake, and systemic inflammation in elderly adults receiving recuperative care. J. Am. Geriatr. Soc. 60 (12), 2246–2253.

DiMaria-Ghalili, R.A., Gilbert, K., Lord, L., Neal, T., Richardson, D., Tyler, R., Guenter, P., 2016. Standards of nutrition care practice and professional performance for nutrition support and generalist nurses. Nutr. Clin. Pract. 31 (4), 527–547.

Dudek, S.G., Dudek, S.G., 2013. Nutrition Essentials for Nursing Practice. Lippincott Williams & Wilkins.

Eide, H.D., Halvorsen, K., Almendingen, K., 2015a. Barriers to nutritional care for the undernourished hospitalised elderly: perspectives of nurses. J. Clin. Nurs. 24 (5–6), 696–706.

Eide, H.K., Benth, J.Š., Sortland, K., Halvorsen, K., Almendingen, K., 2015b. Prevalence of nutritional risk in the non-demented hospitalised elderly: a cross-sectional study from Norway using stratified sampling. J. Nutr. Sci. 4, e18.

Eide, H.K., Šaltytė Benth, J., Sortland, K., Halvorsen, K., Almendingen, K., 2016. Are nutritional care adequate for elderly hospitalized patients? A cross-sectional study. SAGE Open 6 (4), 1–9.

Elia, M., Zellipour, L., Stratton, R.J., 2005. To screen or not to screen for adult malnutrition? Clin. Nutr. 24 (6), 867–884.

Fairclough, E., Cairns, E., Hamilton, J., Kelly, C., 2009. Evaluation of a modified early warning system for acute medical admissions and comparison with C-reactive protein/albumin ratio as a predictor of patient outcome. Clin. Med. 9 (1), 30–33.

Ferrie, S., Rand, S., Palmer, S., 2013. Back to basics: estimating protein requirements for adult hospital patients. A systematic review of randomised controlled trials. Food Nutr. Sci. 4 (2), 201.

Franklin, N., 2014. Malnutrition and the role of nurses: a nursing issue. Aust. Nurs. Midwifery J. 21 (7), 33.

Friesecke, S., Schwabe, A., Stecher, S.S., Abel, P., 2014. Improvement of enteral nutrition in intensive care unit patients by a nurse-driven feeding protocol. Nurs. Crit. Care 19 (4), 204–210.

Fuchs, V., Mostkoff, D., Salmean, G.G., Amancio, O., 2008. Nutritional status in hospitalized patients in a public hospital in Mexico City. Nutr. Hosp. 23 (3), 294–303.

Halvorsen, K., Eide, H.K., Sortland, K., Almendingen, K., 2016. Documentation and communication of nutritional care for elderly hospitalized patients: perspectives of nurses and undergraduate nurses in hospitals and nursing homes. BMC Nurs. 15, 70.

Heardman, T., Kamitsuru, S., 2014. NANDA International Nursing Diagnoses: Definitions & Classification, 2015–2017. Wiley Blackwell, Oxford.

Hershkovich, S., Stark, A.H., Levi, C.S., Weiner, D., Gur, O., Rozen, G.S., 2017. A tailored automated nutrition screening tool for rapid identification of risk in acute-care hospital settings. Eur. J. Clin. Nutr. 71 (2), 284–286.

Hickson, M., Connolly, A., Whelan, K., 2011. Impact of protected mealtimes on ward mealtime environment, patient experience and nutrient intake in hospitalised patients. J. Hum. Nutr. Diet. 24 (4), 370–374.

Hiesmayr, M., Schindler, K., Pernicka, E., Schuh, C., Schoeniger-Hekele, A., Bauer, P., Laviano, A., Lovell, A.D., Mouhieddine, M., Schuetz, T., Schneider, S.M., Singer, P., Pichard, C., Howard, P., Jonkers, C., Grecu, I., Ljungqvist, O., 2009. Decreased food intake is a risk factor for mortality in hospitalised patients: the Nutrition Day survey 2006. Clin. Nutr. 28 (5), 484–491.

Hinkle, D.E., Wiersma, W., Jurs, S.G., 2003. Applied Statistics for the Behavioral Sciences.

Hope, K., Ferguson, M., Reidlinger, D.P., Agarwal, E., 2017. I don't eat when I'm sick: older people's food and mealtime experiences in hospital. Maturitas 97, 6–13.

Husted, M.M., Fournaise, A., Matzen, L., Scheller, R.A., 2017. How to measure energy and protein intake in a geriatric department – a comparison of three visual methods. Clin. Nutr. ESPEN 17, 110–113.

Jouinot, A., Vazeille, C., Durand, J.P., Huillard, O., Boudou-Rouquette, P., Coriat, R., Chapron, J., Neveux, N., De Bandt, J.P., Alexandre, J., Cynober, L., Goldwasser, F., 2017. Resting energy expenditure in the risk assessment of anticancer treatments. Clin. Nutr (Jan. 19).

Kondrup, J., Allison, S.P., Elia, M., Vellas, B., Plauth, M., 2003. ESPEN guidelines for nutrition screening 2002. Clin. Nutr. 22 (4), 415–421.

Kubrak, C., Jensen, L., 2007. Malnutrition in acute care patients: a narrative review. Int. J. Nurs. Stud. 44 (6), 1036–1054.

Kyle, U.G., Soundar, E.P., Genton, L., Pichard, C., 2012. Can phase angle determined by bioelectrical impedance analysis assess nutritional risk? A comparison between healthy and hospitalized subjects. Clin. Nutr. 31 (6), 875–881.

Lahmann, N.A., Tannen, A., Kuntz, S., Raeder, K., Schmitz, G., Dassen, T., Kottner, J., 2015. Mobility is the key! Trends and associations of common care problems in German long-term care facilities from 2008 to 2012. Int. J. Nurs. Stud. 52 (1), 167–174.

Lamb, S., Close, A., Bonnin, C., Ferrie, S., 2010. 'Nil By Mouth'–are we starving our patients? E Spen Eur. E J. Clin. Nutr. Metab. 5 (2), e90–e92.

Landis, J.R., Koch, G.G., 1977. The measurement of observer agreement for categorical data. Biometrics 33 (1), 159–174.

Lukaski, H.C., Bolonchuk, W.W., Hall, C.B., Siders, W.A., 1986. Validation of tetrapolar bioelectrical impedance method to assess human body composition. J. Appl. Physiol. 60 (4), 1327–1332.

Lukaski, H.C., Kyle, U.G., Kondrup, J., 2017. Assessment of adult malnutrition and prognosis with bioelectrical impedance analysis: phase angle and impedance ratio. Curr. Opin. Clin. Nutr. Metab. Care 20 (5), 330–339.

Lunney, J.R., Lynn, J., Foley, D.J., Lipson, S., Guralnik, J.M., 2003. Patterns of functional decline at the end of life. JAMA 289 (18), 2387–2392.

McCarron, M.M., Devine, B.J., 1974. Clinical pharmacy: case studies: case number 25 gentamicin therapy. Drug Intell. Clin. Pharm. 8 (11), 650–655.

McClave, S.A., DiBaise, J.K., Mullin, G.E., Martindale, R.G., 2016. ACG clinical guideline: nutrition therapy in the adult hospitalized patient. Am. J. Gastroenterol. 111 (3), 315–334.

Mika, C., Herpertz-Dahlmann, B., Heer, M., Holtkamp, K., 2004. Improvement of nutritional status as assessed by multifrequency BIA during 15 weeks of refeeding in adolescent girls with anorexia nervosa. J. Nutr. 134 (11), 3026–3030.

Monacelli, F., Sartini, M., Bassoli, V., Becchetti, D., Biagini, A.L., Nencioni, A., Cea, M., Borghi, R., Torre, F., Odetti, P., 2017. Validation of the photography method for nutritional intake assessment in hospitalized elderly subjects. J. Nutr. Health Aging 21 (6), 614–621.

Mudge, A.M., Ross, L.J., Young, A.M., Isenring, E.A., Banks, M.D., 2011. Helping understand nutritional gaps in the elderly (HUNGER): a prospective study of patient factors associated with inadequate nutritional intake in older medical inpatients. Clin. Nutr. 30 (3), 320–325.

Nagano, A., Yamada, Y., Miyake, H., Domen, K., Koyama, T., 2015. Comparisons of predictive equations for resting energy expenditure in patients with cerebral infarct during acute care. J. Stroke Cerebrovasc. Dis. 24 (8), 1879–1885.

Naithani, S., Whelan, K., Thomas, J., Gulliford, M.C., Morgan, M., 2008. Hospital inpatients' experiences of access to food: a qualitative interview and observational study. Health Expect. 11 (3), 294–303.

Pablo, A.M., Izaga, M.A., Alday, L.A., 2003. Assessment of nutritional status on hospital admission: nutritional scores. Eur. J. Clin. Nutr. 57 (7), 824–831.

Padar, M., Uusvel, G., Starkopf, L., Starkopf, J., Reintam Blaser, A., 2017. Implementation of enteral feeding protocol in an intensive care unit: before-and-after study. World J. Crit. Care Med. 6 (1), 56–64.

Patel, M.D., Martin, F.C., 2008. Why don't elderly hospital inpatients eat adequately? J. Nutr. Health Aging 12 (4), 227–231.

Perier, C., Triouleyre, P., Terrat, C., Chomette, M.C., Beauchet, O., Gonthier, R., 2004. Energy and nutrient intake of elderly hospitalized patients in a steady metabolic status versus catabolic status. J. Nutr. Health Aging 8 (6), 518–520.

Porter, J., Ottrey, E., Huggins, C.E., 2017. Protected mealtimes in hospitals and nutritional intake: systematic review and meta-analyses. Int. J. Nurs. Stud. 65, 62–69.

Powell-Tuck, J., Hennessy, E.M., 2003. A comparison of mid upper arm circumference, body mass index and weight loss as indices of undernutrition in acutely hospitalized patients. Clin. Nutr. 22 (3), 307–312.

Raja, R., Gibson, S., Turner, A., Winderlich, J., Porter, J., Cant, R., Aroni, R., 2008. Nurses' views and practices regarding use of validated nutrition screening tools. Aust. J. Adv. Nurs. 26 (1), 26.

Raynaud-Simon, A., Revel-Delhom, C., Hebuterne, X., 2011. Clinical practice guidelines from the French Health High Authority: nutritional support strategy in protein-energy malnutrition in the elderly. Clin. Nutr. 30 (3), 312–319.

Roza, A.M., Shizgal, H.M., 1984. The Harris Benedict equation reevaluated: resting energy requirements and the body cell mass. Am. J. Clin. Nutr. 40 (1), 168–182.

Sauer, A.C., Alish, C.J., Strausbaugh, K., West, K., Quatrara, B., 2016. Nurses needed: identifying malnutrition in hospitalized older adults. NursingPlus Open 2, 21–25.

Seltzer, M.H., Bastidas, J.A., Cooper, D.M., Engler, P., Slocum, B., Fletcher, H.S., 1979. Instant nutritional assessment. JPEN J. Parenter. Enteral Nutr. 3 (3), 157–159.

Slee, A., Birch, D., Stokoe, D., 2016. The relationship between malnutrition risk and clinical outcomes in a cohort of frail older hospital patients. Clin. Nutr. ESPEN 15, 57–62.

Souza, T.T., Sturion, C.J., Faintuch, J., 2015. Is the skeleton still in the hospital closet? A review of hospital malnutrition emphasizing health economic aspects. Clin. Nutr. 34 (6), 1088–1092.

Stratton, R.J., Hackston, A., Longmore, D., Dixon, R., Price, S., Stroud, M., King, C., Elia, M., 2004. Malnutrition in hospital outpatients and inpatients: prevalence, concurrent validity and ease of use of the 'malnutrition universal screening tool' ('MUST') for adults. Br. J. Nutr. 92 (5), 799–808.

Sullivan, S.C., Bopp, M.M., Weaver, D.L., Sullivan, D.H., 2016. Innovations in calculating precise nutrient intake of hospitalized patients. Nutrients 8 (7).

Tannen, A., Lohrmann, C., 2013. Malnutrition in Austrian hospital patients. Prevalence, risk factors, nursing interventions, and quality indicators: a descriptive multicentre study. J. Adv. Nurs. 69 (8), 1840–1849.

Tappenden, K.A., Quatrara, B., Parkhurst, M.L., Malone, A.M., Fanjiang, G., Ziegler, T.R., 2013. Critical role of nutrition in improving quality of care: an interdisciplinary call to action to address adult hospital malnutrition. J. Acad. Nutr. Diet. 113 (9), 1219–1237.

Thibault, R., Chikhi, M., Clerc, A., Darmon, P., Chopard, P., Genton, L., Kossovsky, M.P., Pichard, C., 2011. Assessment of food intake in hospitalised patients: a 10-year comparative study of a prospective hospital survey. Clin. Nutr. 30 (3), 289–296.

Tsai, A.C.-H., Lai, M.-C., Chang, T.-L., 2012. Mid-arm and calf circumferences (MAC and CC) are better than body mass index (BMI) in predicting health status and mortality risk in institutionalized elderly Taiwanese. Arch. Gerontol. Geriatr. 54 (3), 443–447.

Vidot, H., Teevan, K., Carey, S., Strasser, S., Shackel, N., 2016. A prospective audit of preprocedural fasting practices on a transplant ward: when fasting becomes starving. J. Clin. Nurs. 25 (5-6), 829–835.