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ARTICLE

Clinical nutrition

Strategies to increase protein intake at mealtimes through a novel high-frequency food service in hospitalized patients

Dorian N. Dijxhoorn[1] · Vera E. IJmker-Hemink[2] · Geert J. A. Wanten[1] · Manon G. A. van den Berg[2]

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Abstract

Background/Objectives Additional strategies should be applied to optimize hospital food services, in order to increase the number of patients with adequate protein intake at mealtimes. Therefore, we aim to specify the differences in protein intake per mealtime between the traditional three meals a day food service (TMS) and a novel six times a day food service containing protein-rich food items, FoodforCare (FfC).

Subjects/Methods This was a post-hoc analysis of a prospective cohort study comparing the TMS (July 2015 − May 2016; $n = 326$) to FfC (January 2016 − December 2016; $n = 311$) in adult hospitalized patients.

Results Protein intake (g) was higher with FfC at all mealtimes ($p < 0.05$) except for dinner (median [IQR] at breakfast: 17 [6.5–25.7] vs. 10 [3.8–17]; 10:00 a.m.: 3.3 [0.3−5.3] vs. 1 [0−2.2]; lunch: 17.6 [8.4−25.8] vs. 13 [7−19.4]; 2:30 p.m.: 5.4 [0.8–7.5] vs. 0 [0–1.8]; 7:00 p.m.: 1 [0–3.5] vs. 0 [0–1.7]; 9:00 p.m.: 0 [0–0.1] vs. 0 [0–0]). At dinner, protein intake was highest for both food services (20.9 g [8.4–24.1] vs. 20.5 g [10.5–27.8]).

Conclusions Implementation of a high-frequency food service can improve protein intake at mealtimes during the day and might be a strategy to increase the number of patients with adequate protein intake.

Introduction

Hospitalized patients on oral intake are dependent on the local hospital food service. This service plays an important role in providing enough nutrients, especially proteins, to support patients during their time of (recovery from) illness. The distribution of these proteins during the day, and the per-meal threshold amount of protein intake, seems crucial to achieve optimal anabolic muscle protein synthesis and thereby an increase in muscle mass [1]. Adequate protein intake during hospital stay could therefore be considered as key in the prevention and treatment of malnutrition and related consequences such as an increased risk for complications and a prolonged hospital stay [2–4].

In order to maintain or improve patients' nutritional status, protein synthesis should be equal or greater than protein breakdown respectively. Approximately 10 g of essential amino acids (EAAs) per meal is suggested to be sufficient for a maximal anabolic response during the day. In order to reach this amount, 25–30 g of normal quality proteins per meal or 20 g of high-quality proteins (containing a relatively large amount of EAAs) is necessary [5, 6]. These high-quality proteins are mostly animal origin-derived protein sources with a rapid digestion and absorbing capacity resulting in a greater muscle protein synthetic response. In an elderly population, a higher dose of 25–30 g of such high-quality proteins per meal is recommended, because of a higher per meal protein threshold to promote anabolism [7, 8] and a higher protein ingestion seems beneficial to support good health, promote recovery from illness and maintain functionality [9]. In clinical practice, the integration of protein-rich food items in hospital food services, with an adequate amount of EAAs, are therefore important for maximal stimulation of muscle protein synthesis [10].

Recently, we performed a prospective cohort study ($n = 637$) and compared FoodforCare (FfC), a novel six meals a day food service containing protein-rich food items, with a

✉ Dorian N. Dijxhoorn
Dorian.Dijxhoorn@radboudumc.nl

1 Department of Gastroenterology and Hepatology, Radboud University Medical Center, Nijmegen, Netherlands

2 Department of Gastroenterology and Hepatology—Dietetics and Intestinal Failure, Radboud University Medical Center, Nijmegen, Netherlands

Table 1 Provided food items per mealtime for the traditional meal service and FoodforCare meal service

Mealtime (hour)	Traditional meal service	FoodforCare
7:30 a.m.	Cold food items e.g. slices of bread with several fillings and bread spreads or yoghurt	Slices of protein-rich bread with several bread spreads, or milk-based products, like yoghurt or oatmeal
10:00 a.m.	Small snack (not specifically protein-rich), such as biscuit or banana	Fruit salads or protein-rich shakes/smoothies
12:00 p.m.	Cold food items e.g. slices of bread with several fillings and bread spreads or yoghurt	Protein-rich sandwiches, salads and hot soups
2:30 p.m.	Small snack (not specifically protein-rich)	Protein-rich snacks, like wraps, sausages and cheese
5:00 p.m.	Choices for meat, rice/pasta/potatoes and vegetables with various portion sizes and a dessert such as yoghurt.	Small pans consisting protein-rich warm meals, such as potatoes with vegetables and meat/fish or pasta and a small protein-rich dessert
7:00 p.m.	If desired by the patient: small snack such as fruit or a cookie (not specifically protein-rich)	Protein-rich snacks, like cake, sausages and cheese
After 7:00 p.m.	Patients could ask the attending nurses for food and drinks	Patients could ask the attending nurses for food and drinks

traditional three meals a day food service (TMS). FfC resulted in higher daily protein intake, when compared to TMS, and a higher percentage of patients achieved their individual protein requirements (23 vs. 8%) [11]. Since we, as in other care settings, aim to further increase the number of patients with adequate protein intake, additional strategies should be applied to optimize hospital food services. For example, information is lacking on whether patients achieve adequate protein intake at certain mealtimes and which items specifically contribute to protein intake. Therefore, we decided to reanalyze our collected data with respect to protein intake per mealtime and the contribution of specific food items.

Our primary objective was to specify the differences in protein intake per mealtime between the TMS and FfC, and determine whether patients achieve optimal protein intake at mealtimes after implementation of FfC. Secondly, we aim to identify which food items contribute the most to a high protein intake and which items are frequently consumed but low in protein.

Materials and methods

Study design

This was a post-hoc analysis of a prospective cohort study that consecutively compared two food services: TMS (July 2015 – May 2016; $n = 326$) and FfC (January 2016 – December 2016; $n = 311$) (clinicaltrials.gov: NCT03195283). All patients ($n = 637$) were enrolled in our academic center in Nijmegen, Netherlands, at the Departments of Gastroenterology, Urology/Gynaecology, and Orthopedics. At admission, Dutch-speaking patients aged 18 years or older having oral intake for at least one full day were included. Exclusion criteria were tube- or parenteral feeding, not able to adequately answer our questions, and a language barrier. The Medical Ethics Committee of the Radboudumc indicated that no formal approval was required for this study (2015-1805). All patients provided written informed consent prior to enrollment.

Meal services

Traditional meal service

Main meals were served three times a day by nutritional assistants (Table 1). Patients decided in the morning what they preferred for dinner from a menu. Evening meals were cooked in the hospital kitchen 1–2 days before serving and chilled for storage until being reheated and served. A small snack was provided between each main meal and after dinner if desired by the patient. Drinks, like coffee, tea and milk were served six times a day. After these scheduled mealtimes, patients could ask the attending nurse for food and drinks.

FoodforCare meal service

Meals were delivered six times a day (three main meals and three in-between meals) by nutritional assistants (Table 1). At the bedside, patients were offered one or more small protein-rich food items from a choice of three. Special attention was given to the meals' presentation in the way they were prepared and served. Nutrition assistants advised patients in choosing the most optimal food item based on the patient's needs (patients at risk for malnutrition were encouraged to order more protein-rich food items), patient's diet and personal preferences (e.g. vegetarian, halal) registered in the electronic patient record. Evening meals were prepared in the external kitchen, transported the next morning and chilled for storage until being served the same evening or the day after. After 7:00 p.m. patients could ask the attending nurses for food and drinks.

Individual dietary counseling by a dietitian was executed as usual and concerning policies stayed the same over time.

Primary outcomes

Protein intake per mealtime

The primary outcome for this study was defined as the protein intake (g) per mealtime at the first day of full oral intake.

Intake was measured by subtracting the weight of each food item at the end of each mealtime from the weight at serving time. The researcher or research assistants came along every mealtime to register food intake and to collect all leftovers. A dietary recall took place to check whether all consumed food and drinks were registered and leftovers were measured on a calibrated scale (KERN, PFB 6000-1M). Food items consisting of more than one ingredient (e.g. meat and vegetables) were measured separately. The weight of all leftovers were imported in a digital tablet (Samsung Android 5.1.1) and stored at NetCon B.V. (Rotterdam, Netherlands). The weight and amount of protein per item at serving time was based on the recipe of the meals served by the hospital kitchen of Radboudumc and the external kitchen of FfC, derived from the Dutch Food Composition Database [12]. Subsequently, protein intake per mealtime was calculated based on the proportion of food eaten per mealtime. A minimum of 20 g high-quality proteins per meal was set as minimum requirements to be sufficient for a maximal anabolic response [5, 6]. In total, measurements were performed for all seven mealtimes during the day (Table 1).

Secondary outcomes

Protein intake per food group

All ordered items at the first day of oral intake were assigned to food groups (19 categories), according to the Dutch Food Composition Database [12]. Assignment of composite food items (e.g. fruit shake), in which ingredients could not have been measured separately, were based on the most protein dense ingredient (in this case "dairy").

Per food group, the number of portions per patient and the corresponding daily protein intake were established for both services. Food groups with the highest contribution to protein intake and food groups frequently consumed (>1 portion per patient) but relatively low in protein were reported.

Statistical analysis

Baseline characteristics of participants were described as mean ± standard deviation (SD) or median and interquartile range [IQR] in case of continuous data, depending on the distribution, or frequencies and percentages in case of categorical data. The protein intake per mealtimes and the daily protein intake per food group were compared between food services using the independent Mann−Whitney *U* tests. Missing data of nutritional intake (overall < 3%) were analyzed by imputation of mean percentages intake at the corresponding day of the specific cohort. Initial power analysis is reported in previous publication. For all statistical tests, a two-tailed p value < 0.05 was considered to be statistically significant. All data were analyzed with the software package SPSS (version 22, SPSS Inc. Chicago, IL, USA).

Results

Patient characteristics

Flowchart

A total of 637 patients (TMS: $n = 326$; FfC: $n = 311$) were included for analysis, as shown in Fig. 1.

Demographics

Baseline characteristics are shown in Table 2. Characteristics were comparable between the two food services, except for the proportion of patients with an oncological disease (19.9% in TMS group vs. 27.3% in the FfC group, $p = 0.03$) and the number of patients with a MUST score of zero (77.6% in the TMS group vs. 70% in the FfC group, $p = 0.03$). An extended baseline table was previously published [11].

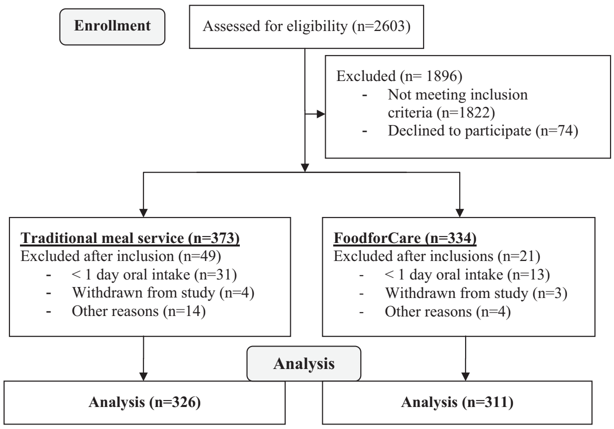


Fig. 1 Flowchart of inclusion of participants from July 2015 to December 2016

Table 2 Baseline characteristics of patients in the TMS (July 2015 – May 2016) and the FfC study arm (January 2016 – December 2016)

Variables		TMS n=326	FfC n=311
Gender, n (%)	Male	158 (49)	141 (45)
Age, years[a]		59 ± 17	60 ± 16
	≥70 years, n (%)	93 (29)	92 (30)
Body weight, kg[a]		79 ± 17	78 ± 17
BMI, kg/m^2 [a]		27 ± 5	26 ± 5
MUST 0, n (%)		253 (78)	217 (70)*
MUST 1, n (%)		41 (13)	47 (15)
MUST ≥ 2, n (%)		32 (10)	46 (15)
Length of stay, days[a]		5.0 [3–7]	5.0 [3–7]
Admission, n (%)	Emergency	125 (38)	134 (43)
	Elective	201 (62)	177 (57)
Oncological disease, n (%)		65 (20)	85 (27)*
Surgical procedure, n (%)		203 (62)	190 (61)
Ward, n (%)	Gastroenterology and Hepatology	105 (32)	93 (30)
	Orthopedics	111 (34)	105 (34)
	Urology	72 (22)	76 (24)
	Gynecology	38 (12)	37 (12)

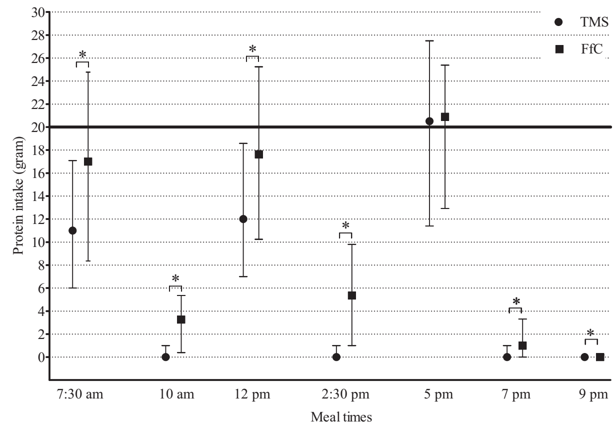
FfC FoodforCare, *TMS* traditional meal service

*Statistically significant difference between groups, $p < 0.05$

[a]Mean ± SD are shown for metric variables and median [interquartile range] are used for nonmetric variables

Protein intake per mealtime

Figure 2 shows the median protein intake (g) per mealtime for both food services at day 1 of full oral intake. In the FfC group, protein intake was higher at all mealtimes ($p < 0.05$), except at dinner. Highest protein intake was reached during the main meals in both groups. At 9:00 p.m., lowest intake was achieved (0 [0–0.1]). The minimal threshold that is suggested to be beneficial for muscle protein synthesis (20 g) was only met at dinner in both food services. The threshold was almost reached at breakfast and lunch (17 and 17.6 g, respectively).



	7:30 am	10 am	12 pm	2:30 pm	5 pm	7 pm	9 pm
TMS	10 [3.8-17]	1 [0-2.2]	13 [7-19.4]	0 [0-1.8]	20.5 g [10.5-27.8]	0 [0-1.7]	0 [0-0]
FfC	17 [6.5-25.7]	3.3 [0.3-5.3]	17.6 [8.4-25.8]	5.4 [0.8-7.5]	20.9 g [8.4-24.1]	1 [0-3.5]	0 [0-0.1]

Fig. 2 Protein intake (median [IQR]) per mealtime for both services. *Statistically significant difference between groups, $p < 0.05$. Horizontal line at 20 g represents the *minimal* threshold that is suggested to be beneficial for muscle protein synthesis [5, 21]. FfC FoodforCare, IQR interquartile range, TMS traditional meal service

Protein intake per food group

Table 3 shows the consumed number of portions and daily protein intake per patient (median [IQR]) for food groups with the highest contribution to protein intake and food groups frequently consumed (>1 portion per patient) but relatively low in protein. Daily protein intake per patient was higher in the FfC group, compared with the TMS, for the following food groups: *Meat and poultry* and *Cheese*. Food items contributing to high protein intake were i.e. meat, chicken and pasta served with cheese at dinner, and also small Caesar salads, wraps, sandwiches and pieces of pizza served with cheese at other mealtimes. Food groups with a higher protein intake per patient in the TMS group were *Eggs* and *Dairy*. Examples of food items contributing to high protein intake were custard/yoghurt (with a fruit taste) at various mealtimes, omelet at dinner and boiled egg at breakfast/lunch.

Discussion

In this study, we show that FfC, a novel high-frequency food service with protein-rich meals, improved protein intake per mealtime compared to the TMS. The minimal

Table 3 Consumed number of portions and daily protein intake per patient (median [IQR]) for food groups contributing to highest protein intake and food groups frequently consumed but low in protein per food group

Food groups[a]	TMS			FfC		
	Patients (*n*)	Portions per patient (*n*)	Protein intake per patient (g)	Patients (*n*)	Portions per patient (*n*)	Protein intake per patient (g)
Contribute to high protein intake						
Meat and poultry	250	2.0 [1.0–3.0]	17.2 [8.0–22.1]	281	3.0 [2.0–4.0]	20.2 [9.8–29.4]*
Dairy	276	2.0 [1.0–3.0]	13.0 [6.0–21.4]	292	2.0 [2.0–3.0]	9.4 [5.8–14.6]*
Cheese	246	2.0 [1.0–3.0]	10.0 [5.0–10.3]	257	2.0 [1.0–3.0]	11.0 [6.0–17.8]*
Bread	309	4.0 [3.0–5.0]	9.0 [5.6–12.0]	300	3.0 [2.0–4.0]	10.5 [6.3–15.1]
Fish	42	1.0 [1.0–1.0]	10.0 [10.0–12.3]	137	1.0 [1.0–1.0]	13.4 [6.6–18.6]
Eggs	124	1.0 [1.0–1.0]	7.0 [7.0–7.0]	134	1.0 [1.0–1.0]	6.0 [6.0–6.0]*
Legumes	1	1.0 [NA]	12.34 [NA]	25	1.0 [1.0–1.0]	2.7 [1.1–8.3]
Soy and vegetarian products	1	1.0 [NA]	3.0 [NA]	4	1.5 [1.0–2.8]	7.00 [4.5–15.5]
Savory bread spreads	21	1.0 [1.0–2.0]	3.5 [3.0–4.0]	3	1.0 [1.0–1.0]	5.5 [5.5–5.5]
Grain products	105	1.0 [1.0–1.0]	3.0 [1.1–7.9]	54	1.0 [1.0–1.0]	3.1 [1.9–3.9]
Frequently consumed—low in proteins (>1 portion per patient)						
Alcoholic and nonalcoholic drinks	324	8.0 [5.0–10.0]	0.0 [0.0–1.9]	311	8.0 [6.0–10.0]	0.0 [0.0–1.6]
Fats, oils and savory sauces	308	3.0 [2.0–5.0]	0.0 [0.0–0.0]	291	3.0 [2.0–4.0]	0.1 [0.0–0.4]
Sugar, sweets, sweet spreads, sauces	217	2.0 [1.0–3.0]	0.0 [0.0–0.0]	188	2.0 [1.0–3.0]	0.0 [0.0-0.0]

FfC FoodforCare, *NA* IQR not applicable because $n = 1$, *TMS* traditional meal service

*Significant difference of protein intake per patient (g) between services ($p < 0.05$)

[a]Food groups are based on the Dutch Food Composition Database 2013 [12]

level that is suggested to be beneficial for muscle protein synthesis (20 g) was only achieved at dinner in both food services. Food groups with the highest protein intake per patient were *Meat and poultry, Dairy, Cheese and Fish* for the TMS group, and *Meat and poultry, Cheese, Bread and Fish* for the FfC group. Food items frequently consumed and low in protein were *alcoholic and nonalcoholic drinks*, *fats, oils and savory sauces* and *sugar, sweets, sweet spreads* and *sauces*.

Of note, our results show that with FfC protein intake remains highest during the main meals, except for dinner, despite the fact that total protein intake improves by means of the in-between meals. This suggests that these in-between meals do not lower the intake during main meals, and as such are relevant to improve overall daily protein intake. Another study also concluded that care settings might help to improve dietary intake by serving smaller energy and protein-rich meals more frequently [13]. The higher proportion of oncological patients and the lower proportion of patients with a MUST score of zero in the FfC group were not considered as confounding factors for our analysis, since we previously confirmed that the difference in daily protein between the TMS and FfC service was not influenced by the differences in these patient characteristics [11]. In clinical setting, the use of oral nutritional supplements (ONS) high in protein might contribute to a high protein intake per mealtime. In our study, the number of patients using ONS and its contribution to protein intake was very limited in both groups ($n = 14$ in TMS groups and $n = 8$ in FfC group) and, therefore, not included in our analysis. Unfortunately, few other studies reported on protein intake per mealtime, all including elderly patients. A recent randomized controlled trial investigated the effect of adding protein-enriched products to the standard menu of a room service concept, and concluded that protein intake was highest during the main meals, but protein intake remained the same with the in-between meals during afternoon and evening [14]. This latter finding may be due to the fact that in this study in-between items were only delivered on patients' request, instead of proactive delivery six times a day, and patients might be used to eat meals three times a day. These authors, however, used 25 g of protein as a threshold to be beneficial for muscle protein synthesis, as they included an older population with a mean age of 78.5 years. Despite the fact that we included an adult population of all ages, we decided to use 20 g as a threshold since the minority of the patients were ≥70 years (30%). For these older patients, results on protein intake per mealtime should be interpreted with caution since they benefit from a higher threshold. Another study showed that using a combination

Table 4 Summary of possible strategies that might increase the number of patients with optimal protein intake per mealtime during hospitalization

Recommendations	
Meal service	• Optimization of meal services, such as considering in-between meals and stimulating patients to order protein-rich food items.
Mealtimes	• Stimulate ingestion of high-quality proteins at mealtimes (e.g. leucine) and before sleep (e.g. casein), taking the explanations for low presleep intake into account.
Food items	• Care settings should critically review the quantity of food items ordered and their contribution to protein intake. • Consider food items containing a high amount of EAAs. • Replace food items frequently ordered but relatively low in protein by protein-rich alternatives.
Education	• Create awareness about the relevance of protein intake among patients and health-care givers. • Give patients and health-care givers insight in patient's individual protein requirement and protein content per food item.

of smaller portions of increased energy and protein density and in-between meal snacks increases energy intake (kcal) at lunch and supper; however, no difference in protein intake (g) was established at these mealtimes [15]. A study analyzing protein distribution in healthy community-dwelling ($n = 707$), frail ($n = 194$), and institutionalized ($n = 276$) elderly reported highest protein intake at lunch and dinner, and a relatively low intake at breakfast (10 ± 10 g vs. 8 ± 5 g vs. 12 ± 6 g). Therefore, increasing the amount of protein-containing food sources at breakfast might also be a relevant strategy in elderly patients in the out-of-hospital setting [16].

Based on our analysis with regard to food groups, multiple strategies can be recommended to further improve (high-quality) protein intake above 20 g per meal [5]. Interestingly, food groups with a high protein intake per patient were mainly those frequently consumed, which may suggest a preference of patients, mostly for animal origin-derived protein sources, resulting in a relatively high contribution of EAAs. To further increase protein intake containing a relatively high amount of EAAs, low-protein food groups (such as *alcoholic and nonalcoholic drinks* and *sweet spreads*) could be replaced by protein- and EEA-rich alternatives from those frequently consumed food groups, like *diary, meat and poultry* and *cheese*. Nutritional assistants can subsequently play a key role in guiding patients to choose this option. Patients and health-care givers should also be made aware about the relevance of adequate protein intake and they should get insight in patient's individual protein requirement and protein content per food item. Other health-care institutions in various settings may also optimize their food service by critical appraisal of the quantity of food items ordered and their contribution to high-quality protein intake and protein intake in general. For instance, the previously mentioned room service concept showed beneficial results on protein intake for various food groups by adding protein-enriched products to the menu [14]. Food groups contributing to highest protein intake, in some way comparable to our study, were *meat, dairy* and *cheese* in the control group and *dairy, bread* and *drinks* (all including protein-enriched products) in the intervention group. However, enrichment of products might be inferior to protein-rich products since the taste of the former can be unpleasant for patients. Finally, adequate protein intake should always be integrated with exercise to achieve an optimal anabolic response and maintain muscle strength and muscle mass.

Although the protein intake per mealtime improved in the FfC group, the goal of 20 g of high-quality proteins was only reached during dinner. An important finding in this respect seems to be the very low-protein ingestion prior to sleep. Improving the ingestion of especially casein protein (dairy) at this time is an effective strategy to stimulate overnight muscle protein synthesis [17]. This might especially be a challenge in patients with abdominal complaints, mainly those who suffer from gastro-esophageal reflux or delayed gastric emptying. Various explanations for this low presleep intake may be considered which could be generalized to other care settings. For example, patients may not feel like eating due to fatigue and/or loss of appetite or they are simply not used to having meals immediately prior to sleep [18]. Logistic circumstances should also be considered, such as the fact that nutritional assistants are not present at wards at this time of the day, while the attending nurses have other patient care-related priorities at the start of their busy night shift. Table 4 shows our recommendations to improve protein intake at mealtimes.

One of the strengths of this study is that we performed 24 h measurements on nutritional intake and included all ordered drinks and food items of patients, whereas various studies only focused on intake at lunch time and/or dinner [15, 19]. As a result, we were able to perform specific analyses on intake per mealtime. Analyses on food groups are, despite their rarity in literature, crucial to improve insight in the contribution of specific food items to (high-quality) protein intake, and enable recommendations for clinical practice. Nonparametric univariate analysis for data on protein intake per mealtime and food groups were required. Protein intake during in-between meals was not normally distributed, as expected, and wide ranges of protein intake exist within some food groups (i.e. sugar, sweets), respectively. Future research should also focus on energy intake of patients, given that malnourished patients also need adequate calorie intake to avoid protein breakdown [20].

In conclusion, protein intake was highest during the main meals and improved during the in-between meals after implementation of a six times a day hospital food service containing protein-rich meals. Food groups with the highest protein intake per patient were *Meat and poultry, Dairy, Cheese and Fish* for the TMS, and *Meat and poultry, Cheese, Bread and Fish* for the FfC service. Several strategies are recommended to optimize food services that might increase the number of patients with adequate protein intake per mealtime and, ultimately, the number of patients achieving their daily individual protein requirements.

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Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

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