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CLINICAL STUDY

Food Intake and Nutritional Status in Stable Hemodialysis Patients

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This is a cross-sectional, multicenter, controlled study aiming to evaluate changes of actual dietary nutrient intake in 94 stable hemodialysis patients in respect to 52 normal subjects and guideline recommendations, and to assess the prevalence of signs of malnutrition. Energy and nutrients intake assessment was obtained by a three-day period food recall. Anthropometric and biochemical parameters of nutrition, bioelectric impedance vector analysis, and subjective global assessment (SGA) have been performed to assess nutritional status. SGA-B was scored in 5% of the patients. Body mass index < 20 Kg/m^2, serum albumin <35 g/L, nPNA < 1.0 g/Kg, and phase angle <4.0° were detected in 16.3%, 16%, 23%, and 8.0 % of patients, respectively. HD patients showed a lower energy and protein intake in respect to controls, but no difference occurred when normalized per ideal body weight (29.3 ± 8.4 vs. 29.5 ± 8.4 Kcal/Kg i.b.w./d and 1.08 ± 0.35 vs. 1.12 ± 0.32 Kcal/Kg i.b.w. /d, respectively). Age was the only parameter that inversely correlates with energy ($r = -0.35$, $p < 0.001$) and protein intake ($r = -0.34$, $p < 0.001$). This study shows that in stable dialysis patients, abnormalities of nutritional parameters are less prevalent than expected by analysis of dietary food intake. Age is the best predictor of energy and protein intake in the dialysis patients who ate less than normal people, but no difference emerged when energy and protein intakes were normalized for body weight. These results recall the attention for individual dietetic counseling in HD patients, and also for a critical re-evaluation of their dietary protein and energy requirements.

Keywords diet, dialysis, nutritional status, protein intake, malnutrition

INTRODUCTION

Several cohort studies have revealed that protein-energy malnutrition is quite common in hemodialysis patients, and is associated with increased morbidity and mortality, reduced physical function, and poor quality of life.[1–3] Two types of malnutrition have been described in the dialysis population: defective nutrition due to a poor nutrients intake—the so-called *true malnutrition*—and abnormal body composition with a reduction of somatic and visceral protein pool, as a result of a catabolic condition linked to a pro-inflammatory state.[4] In fact, malnutrition and inflammation often co-exist in hemodialysis patients, and are associated with accelerated atherosclerosis: this condition is called malnutrition-inflammation-atherosclerosis (MIA) syndrome.[5] This condition negatively affects the

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clinical outcome of hemodialysis population, increasing cardiovascular disease and events.

A regular assessment and monitoring of nutritional status is mandatory in ESRD patients; unfortunately, there is no nutritional marker that can be easily performed in a reproducible manner and that is not affected by other confounding conditions, such as inflammation. Thus, one usually must measure different biochemical, anthropometric, and functional parameters to draw a real evaluation of the nutritional status. Additionally, ESRD patients may be often affected by relevant complications or co-morbidities, such as diabetes, obesity, congestive heart failure, coronary disease, lower limb ischemic disease, and infections, which may negatively influence dietary food intake and nutritional status. Moreover, ESRD is associated with loss of appetite and reduced food intake, especially when toxins removal by hemodialysis is inadequate. In addition, the level of physical activity or geographical, cultural, and traditional factors may induce changes in the dietary habits of the general population, including hemodialysis patients. Thus, the assessment of quality and quantity of food intake is another important step in the management and treatment of HD patients. Nutritional guidelines suggest daily energy intake higher that 30–35 Kcal/Kg ideal b.w. and daily protein intake higher than 1.1–1.2 g/Kg ideal b.w.[6,7] Many studies reported that these recommendations are far from being fully obtained.[8–12] However, the prevalence of abnormalities of nutritional markers is apparently less than expected by the prevalence of inadequate food intake, especially when protein intake is concerned, leading to a discussion about the optimum protein intake in dialysis patients.

In this study, we assessed the dietary habits and nutritional status in a cohort of stable hemodialysis patients, with the aim to detect changes of actual daily nutrient intake in respect to normal subjects and guideline recommendations, and to assess the prevalence of signs of malnutrition.

Subjects and Methods

Ninety-four (60 males and 34 females, age 61 ± 14 years) stable patients with end stage renal disease (ESRD) were recruited for this study. All of the patients on hemodialysis (HD) treatment for at least six months, in hemodialysis units of three different towns in Tuscany, who were collaborating and free from exclusion criteria were asked to participate.

Patients with severe cardiac failure (Stage IV NYHA) or respiratory insufficiency, cancer, dementia, psychiatric or neurologic diseases, or chronic inflammatory systemic diseases were excluded; hospitalization within the last three months and therapy with steroids and/or immunosuppressive drugs were also considered exclusion criteria.

All of the patients were on a thrice-weekly hemodialysis treatment for 210–240 minutes; 53 were on online hemodiafiltration, 16 patients on acetate-free biofiltration, and 25 on standard bicarbonate dialysis. In all of the cases, synthetic and highly biocompatible membranes were used (low-flux and high-flux polysulphone, AN69, polyamide).

The vascular access was native artero-venous fistula in 68 cases, artero-venous graft in 9 cases, and permanent central vein catheter in 17 cases. All of the patients gave their own informed consent to the study.

Fifty-two healthy subjects, comparable for race, age, and sex with the patients, formed the control group for the dietary nutrient intake assessment.

Nutritional Assessment

Nutritional parameters included biochemistry, bioelectric impedance vector analysis (BIVA), height, body weight before and after dialysis, and the Subjective Global Assessment (SGA).[13] Body mass index (BMI) was calculated as follows: post-dialysis body weight (Kg) / height (m^2). A BMI value < 20 kg/m^2 is considered a sign of malnutrition, and it was consistently associated with the highest mortality risk for dialysis population.[2,3]

Predialysis biochemical determinations included serum albumin, C reactive protein, phosphorus, calcium, and hematocrit. Serum albumin was measured by the nephelometric method: albumin levels < 35 g/L could be suggestive of protein malnutrition and represent an unfavorable prognostic sign.[14]

Serum urea level was determined before and after dialysis treatment, and they were used for calculation of single pool Kt/V and nPNA.[15,16] In stable conditions, the latter is considered a surrogate of dietary protein intake: values < 1.0 g/kg i.b.w./d was considered inadequate for ESRD patients on HD treatment.[7,17]

BIVA was performed at the end of the hemodialysis session using a bioelectrical impedance analyzer (BIA/STA, Akern, Florence, Italy) with a distal, tetrapolar technique, delivering an excitation current at 50 kHz.[18] BIVA parameters were measured in duplicate.

BIVA gives two bioelectric parameters: body resistance (R) and reactance (Xc), and the impedance vector (Z) is a combination of R and Xc across tissues. The arc tangent of Xc/R is called phase angle (PA), which is a derived measure obtained from the relation between the direct measures of resistance and reactance reflecting hydration status and soft tissue cellular mass. Reduced phase angle reflects increased extra- to intra-cellular water ratio as well as a decrease in body cell mass; it is a predictor of survival in a number of diseases and also in the dialysis population, where phase angle values lower than 4.0° are associated with increased mortality risk.[19,20]

Although BIVA has several limitations in respect to other methods assessing body composition,[21] BIVA is very useful because of its availability and simplicity.

The RXc graph method consists of a bivariate analysis of the measured electric properties of the body and provides a qualitative estimation of hydration and cellular mass by a comparison with a reference population. Namely, the impedance vector analysis is plotted on the RXc graph reporting sex-specific 50%, 75%, and 95% tolerance ellipses of the healthy population.[22] According to clinical validation studies, vectors falling out of the 75% tolerance ellipse indicate an abnormal tissue impedance, which is interpreted and ranked following the two directions of major and minor axis of tolerance ellipses:

- vector displacements along the major axis of tolerance ellipses indicate progressive changes in body water (i.e., dehydration out of the upper pole and hyper-hydration out of the lower pole); and
- vector displacements along the minor axis indicate changes in body cell mass.

The day-to-day coefficient of variation of BIVA measurement is 1% and the inter-operator variability averaged 2%.[18]

The registered dieticians (DAC, VA) made the SGA and bio-impedance measurements, and they were trained to make the observations in a standardized fashion.

Dietary Nutrient Intake Assessment

All subjects were seen individually by registered dieticians, trained in the same fashion to collect a three-day food record for energy and nutrients intake assessment. The three-day recalls were collected by interviews, during which the subjects were provided with a color photo atlas of common food and their servings in order to help them in estimating the real amounts of consumed food. The three-day dietary recall included a dialysis day, a weekend day, and a non-dialysis day, as suggested by the more recent guidelines.[6,7] The dietary composition was assessed using the tables of food composition provided by the European Oncologic Institute. The total energy and nutrients intake and their distribution among meals were examined. The daily intake for each studied nutrient was calculated as the average of the three-day food records.

Daily energy requirement was estimated by calculation of daily energy expenditure, by Harris-Benedict equation multiplied by an activity factor, according to EBPG guideline on nutrition.[7]

Statistical Analysis

A statistical package, StatView 5 release 5.0.1, was utilized for processing data. Descriptive statistics are given as mean ± standard deviation. Statistical analysis was performed by Student's t test for unpaired and paired data. Linear correlation analysis was performed by Pearson's test. Differences were considered to be statistically significant when $p < 0.05$.

RESULTS

Table 1 reports the anthropometric characteristics and biochemical and BIVA parameters of the studied patients.

SGA assessment showed a good nutritional status in most of the dialysis patients: only three of them received a SGA B score, suggestive of moderate malnutrition. Fifteen patients (16.3%) had a BMI lower than 20 kg/m^2, eighteen patients (19.6%) showed serum albumin levels below 35 g/L, and nPNA lower than 1.0 g/kg/day was calculated in the 23% of the cases. High levels of reactive C protein (>5 mg/L), suggestive of a pro-inflammatory condition, were found in the 47% of the patients.

Serum phosphorus was above 5.5 mg/dL only in seventeen patients (27.8%) and the 16.4% had a Ca × P product over than 55 mg^2/dL^2.

BIVA measurements showed phase angle values lower than 4.0°, suggestive of a high mortality risk in the dialysis population, in a small percentage of patients (8.0%). The vector bivariate analysis revealed sex differences (see Figure 1): most of the impedance vectors obtained for males fell in the normal range with no signs

Table 1

Anthropometric characteristics, biochemical measurements and bioelectrical impedance data, including body cell mass index (BCMI) of male and female hemodialysis patients (mean ± SD)

	Males (n = 60)	Females (n = 34)	*p*
Age, years	61 ± 15	61 ± 14	NS
Time on dialysis, months	73 ± 72	140 ± 102	NS
D body weight, Kg	3.1 ± 0.7	2.6 ± 0.7	< 0.01
Kt/V	1.41 ± 0.22	1.48 ± 0.25	NS
nPNA, g/Kg/d	1.07 ± 0.24	1.07 ± 0.27	NS
Post-dialysis weight, Kg	73.5 ± 15.9	59.6 ± 12.6	< 0.001
BMI, Kg/m^2	25.0 ± 4.2	23.6 ± 5.3	NS
Phosphorus, mg/dL	4.9 ± 1.4	4.7 ± 1.3	NS
Albumin, g/dL	3.9 ± 0.4	3.7 ± 0.4	< 0.05
Hematocrit, %	36.5 ± 4.3	38.3 ± 3.7	< 0.05
Phase angle, °	5.9 ± 1.3	5.1 ± 1.3	< 0.05
BCMI, Kg/m^2	8.6 ± 2.1	7.0 ± 1.8	< 0.01

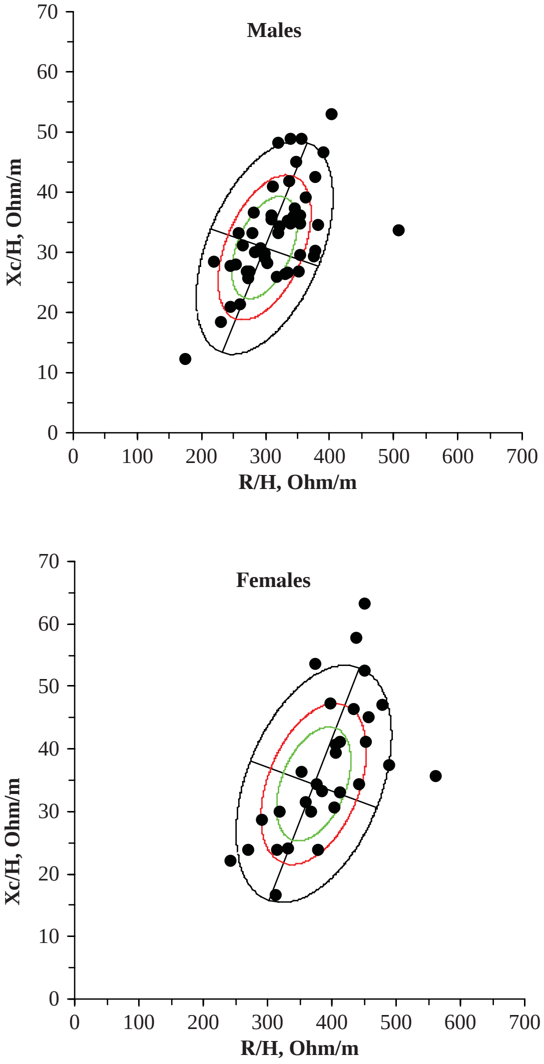

Figure 1. The RXc graph with the impedance vectors of male and female hemodialysis patients.

of hyper-hydration; however, females showed a distribution of the impedance vectors suggesting hyper-hydration and reduction of free fat mass. Also, body cell mass index (BCMI), which is considered a marker of a good nutritional status, was significantly lower in female patients (see Table 1).

Phase angle showed a positive linear relationship with serum albumin (r = 0.44, $p < 0.001$) and negative relationship with age (r = –0.57, $p < 0.001$) or CRP (r = –0.24, $p < 0.05$). Phase angle was also related to actual energy (r = 0.31, $p < 0.01$) and protein (r = 0.39, $p < 0.001$) intake, and persisted also when protein intake was normalized by body weight (r = –0.24, $p < 0.05$).

Low phase angle, low BMI, and hypoalbuminemia were never present in the same patient.

C reactive protein levels higher than 5.0 mg/L were a quite prevalent abnormality, which was detected in 47% of the studied patients; this group of patients showed lower phase angle (4.8 ± 1.0 vs. 6.3 ± 1.5, $p < 0.001$) than patients with normal CRP levels, but no differences in dietary protein and energy intake emerged. To confirm, CRP values were not statistically different in those patients with low protein intake (<0.9 g/Kg/d), and no correlation was found between CRP serum levels and energy or protein dietary intake.

This study included patients with vintage on dialysis from 6 to 444 months (median 60 months); an inverse relationship was found between vintage on HD and BMI (r = – 0.285, $p < 0.05$), but no relationship was observed with other nutritional markers or dietary energy and protein intake.

Absolute daily energy intake was lower in patients than in normal controls, but no difference existed when data were normalized by actual and ideal body weight (see Table 2).

Fifty-seven patients (72%) reported an energy intake lower than 30 kcal/Kg i.b.w./day, and 29 (36%) lower than 25 Kcal/Kg i.b.w./day. Similarly, absolute daily protein intake was lower in patients than in normal controls, but no difference existed when data were normalized by actual and ideal body weight (see Table 2).

Nonetheless, protein intake was below 1.1 g/kg/day in forty-six patients (53%) and below 0.9 g/kg/day in 28 cases (32%).

Table 2

Anthropometric characteristics and daily dietary intake of nutrients resulting from three days' recall analysis in hemodialysis patients and control subjects (mean ± SD)

	Patients (n = 94)	Controls (n = 52)	*p*
Age, years	61 ± 15	62 ± 9	NS
Body weight, Kg	68.5 ± 16.2	73.9 ± 12.8	< 0.01
BMI, Kg/m^2	24.5 ± 4.7	25.7 ± 3.3	< 0.05
Daily dietary intake			
Energy, Kcal	1900 ± 586	2128 ± 566	< 0.05
Proteins, g	70.0 ± 22.9	80.1 ± 20.6	< 0.05
Lipids, g	67.3 ± 26.1	74.0 ± 17.8	NS
Carbohydrates, g	238 ± 81	252 ± 73	NS
Sugars, g	62.2 ± 23.3	65.3 ± 24.6	NS
Starch, g	154 ± 62	156 ± 60	NS
Saturated fats., g	16.5 ± 7.3	18.4 ± 6.6	NS
Unsaturated fats, g	34.3 ± 19.0	39.0 ± 11.9	NS
Cholesterol, mg	182 ± 82	179 ± 80	NS
Energy, Kcal/Kg b.w.	28.9 ± 10.7	29.5 ± 8.4	NS
Energy, Kcal/Kg ideal b.w.	29.3 ± 8.5	30.9 ± 7.4	NS
Proteins, g/Kg b.w.	1.07 ± 0.42	1.12 ± 0.32	NS
Proteins, g/Kg ideal b.w.	1.08 ± 0.35	1.19 ± 0.33	NS

As a whole, dietary protein intake estimated from dietary interview was similar to that estimated by urea modeling. However, data from dietary recall were about 15% lower, on average, than data calculated by urea modeling.

Age was the only parameter that inversely and significantly correlated with normalized energy intake ($r = -0.36$, $p < 0.001$) and normalized protein intake ($r = -0.35$, $p < 0.001$) (see Figure 2).

The amount of food and of nutrient intake was generally lower in patients than in the normal control group (see Table 2). However, the reported intake of carbohydrates—both sugars or starch—and of lipids, including saturated and unsaturated fatty acids, were not statically significant different from normal controls (see Table 2). Accordingly, energy intake from carbohydrates was significantly higher in dialysis patients (50 ± 8 vs. 44 ± 6%, $p < 0.001$).

Dietary analysis of dialysis patients showed also a reduced intake of sodium (1462 ± 737 vs. 1840 ± 769 mg, $p < 0.01$) and potassium (2253 ± 794 vs. 2664 ± 879 mg, $p < 0.01$) as well as other minerals, vitamins, and fiber with respect to controls (see Figure 3). In addition, phosphorus intake was lower in dialysis patients than in controls (997 ± 318 vs. 1148 ± 309 mg, $p < 0.05$), but no difference exists when normalized by body weight (15.6 ± 4.8 vs. 15.3 ± 5.8 mg/Kg/day).

There were no significant differences in the diet composition and nutrients intake between the afternoon or the morning HD sessions but, as expected, we found a different energy distribution; the energy intake at lunch was higher in patients who underwent HD treatment in the morning with respect to the patients of the afternoon session, who compensated with a higher energy intake from breakfast and snacks (see Figure 4).

DISCUSSION

This study shows a good nutritional status in hemodialysis patients who were in stable conditions, free from severe co-morbidities or complications or acute events.

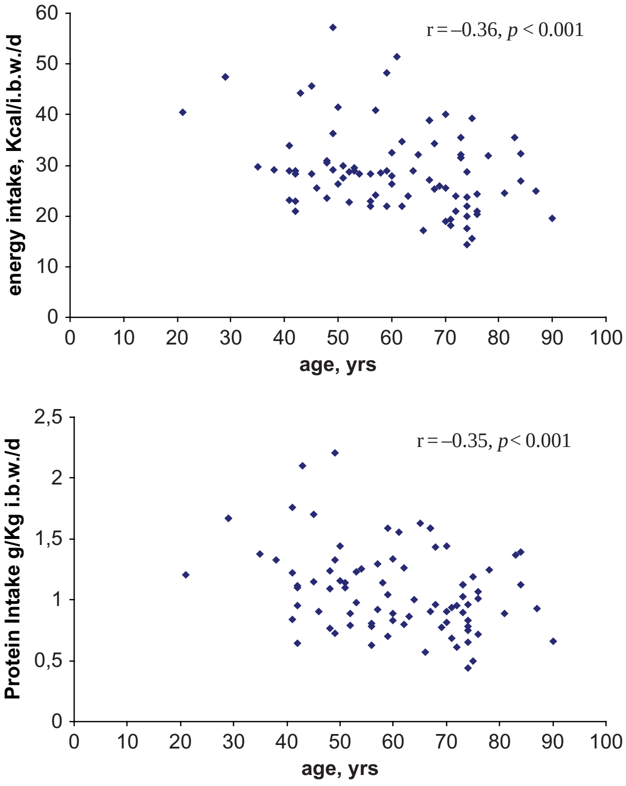

Figure 2. Correlation between age and daily energy or protein intake in the studied dialysis patients.

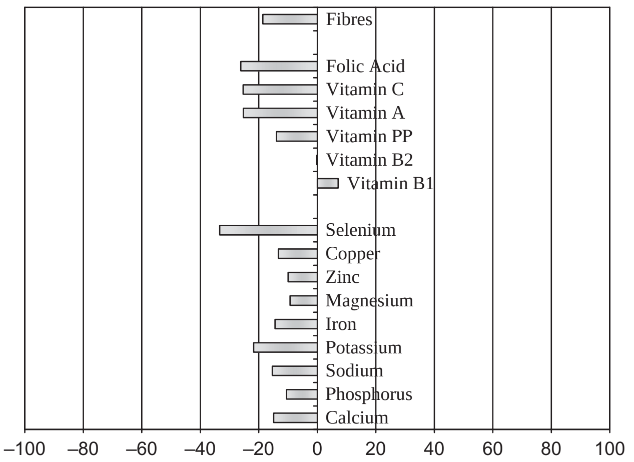

Figure 3. Average dietary intakes of some minerals and vitamins in hemodialysis patients, expressed as percentage change from the intakes of normal controls.

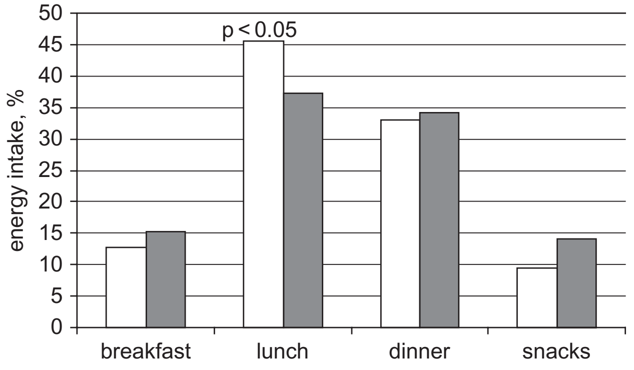

Figure 4. Percentage distribution of the daily energy intake among meals between the morning (empty columns) and the afternoon (full columns) HD sessions.

Instead, the reported energy and protein intakes should be considered inadequate in the majority of the studied patients—that is, they resulted below the minimum recommendation in more than half of cases. However, when compared to normal controls, HD patients reported a reduced daily food intake, but no difference existed when both protein and energy intake were normalized per actual and ideal body weight. Thus, a discrepancy may exist between a quite good nutritional status and the actual energy and protein intakes that were far from the recommendations in most of the patients, but very similar to the dietary habits of sex- and age-matched normal subjects.

SGA-A was scored in the majority of the patients, suggesting a good nutritional status. The SGA method actually remains one of the most reliable tools to assess nutritional status, which is also a good predictor of outcome.[23] Accordingly, only 8% of patients had phase angle values lower than 4.0°, which suggests that a few patients had an abnormal body composition predictive of increased mortality risk in dialysis patients.[19,20]

Many studies stress the protective effect of a higher BMI in dialysis patients; in particular, a BMI of 23 kg/m^2 or higher seems to reduce the risk of morbidity and mortality and is associated with improved survival.[24–26] Conversely, a BMI lower than 20 kg/m^2, suggestive of reduced fat and lean body mass,[7] is considered an index of malnutrition: this was detected only in a small percentage of our patients (16.3%). Hypoalbuminemia was found in the 16% of the patients, and this result agrees with data from other European countries reported in the DOPPS study.[27]

Pre-dialysis serum levels of albumin may be influenced by hydration and inflammation: actually, Kaysen et al. reported that inflammation is the principal cause of decrease in serum albumin in well-dialyzed patients, while dietary protein intake plays an insignificant role.[14]

The values obtained by nPNA calculation, which give an estimate of protein intake, are considered inadequate when < 1.0 g/Kg i.b.w./day: this occurred in 23% of the studied patients.

More interesting data were obtained by the analysis of dietary food intake, which is the only way to evaluate energy intake.

DOQI guidelines recommended a dietary protein intake > 1.2 g/kg/day,[6] and EBPG recommended a dietary protein intake > 1.1 g/kg/day[7] together with a high energy intake (>30–35 Kcal/Kg i.b.w./day).

The results of the dietary habits analysis did not match these recommendations, even if they are quite satisfactory when compared to data from other studies on stable dialysis patients, including also cohorts of patients younger than that selected in the present study.[7–12] This is an important point, as nutrient intake was negatively related to age in our patients, and this is true also in individuals without renal failure.[28]

In fact, several observational studies showed energy intakes lower than 20–25 Kcal/Kg, although many patients did well and did not show any sign of overt malnutrition.

Accordingly, protein intake was better than that reported by other studies, but it was not completely satisfactory, because most of the patients did not reach the recommended intake of 1.1–1.2 g/kg/day.[6,7] Thus, it appeared that the recommendations for energy and protein intake are largely disregarded; nevertheless, the nutritional status of these patients does not seem particularly worrying.

Although it is still debated if the resting energy requirement in dialysis patients is the same, higher, or lower than in those not on dialysis, recent research substantially confirms that is similar to that of healthy individual.[29] So, a possible explanation for the maintenance of a satisfactory nutritional status despite a reduced food intake may be the low physical activity of the dialysis population, who are less active than healthy sedentary controls.[30]

The discrepancy we found between a satisfactory nutritional status and poor accomplishment of the recommended dietary intakes, as already reported in the literature, leads also to controversy about the optimal protein intake in dialysis patients. Our data are well in keeping with those of Ohkawa et al.,[31] who claimed that optimum dietary intake may be less than recommended by DOQI guidelines.[6] Theoretically, protein intake requirement in dialysis patients should be the same as in those not on dialysis (i.e., 0.8–0.85 g/Kg/day[32,33]), plus whatever extra obligatory nitrogen losses are caused by the dialysis procedure. The nitrogen balance data confirm that in stable dialysis patients, a safe requirement of protein intake is about 1 g/kg/day, and attempts at increasing protein intake beyond this value are not warranted.[34]

Namely, no clinical or biochemical benefits were found when patients maintained at a constant protein intake of 0.9–1.1 g/kg/day were shifted to a protein intake higher than 1.1 g/kg/day,[31] and no differences were found when comparing a protein intake of 0.9 g/kg/d to 1.1 g/kg/day, provided the same energy supply (i.e., 28–30 Kcal/Kg/day).[35] In the HEMO study, serum albumin correlates protein intake between 0.4 and 1.0 g/Kg/day, but no further benefit occurred on serum albumin when nPNA was > 1.0 g/kg/day.[36] However, a protein intake higher than 1.24 g/kg/day seems to be associated with greater survival rate.[37]

On the other hand, it is noteworthy that severe reduction of energy intake <25 Kcal/Kg/day and/or protein intake <0.8 g/Kg/day can induce protein wasting and malnutrition even when they occur for one day a week.[38]

In the present study, the comparison with an age-, sex-, and race-matched population living in the same geographical area showed that dialysis patients ate less than normal, but it is noteworthy that both protein and energy intake normalized per body weight was not different between the two groups. This may be due, in part at least, to the lower body weight of patients in respect to control (see Table 2), which may be related to loss of fat and/or lean body mass in HD patients but also to an overweight condition of the control subjects. Actually, BMI values in control group exceeded on average 25 Kg/m^2, suggesting that more than a half of controls were overweight. It is possible that controls tended to underestimate their food intake and/or followed a diet controlled in energy intake.

Obviously, there could be a potential underestimation of energy and nutrients intake through dietary interviews, which could represent a limitation of this kind of investigations. Even if the food record analysis represent the most valid and simple tool for nutrients and calories estimation, the occurrence of a conscious or unconscious underreporting is largely known and recently confirmed in healthy adults[39] as well as in renal failure patients.[40,41]

The three-day recall analysis also showed a reduction of calcium, phosphorus, and sodium content that can be due to a reduction in dairy product intake, which is generally suggested when trying to control serum phosphorus levels. HD patients are also advised to limit the use of salt and salty food to have better blood pressure control and to reduce thirst and interdialytic weight gain.

The reduced intake of iron, vitamin C, folic acid, and potassium is in keeping with reduced food intake, including vegetables and fruit, to limit the risk of hyperkaliemia and of fluid overload. Finally, as expected, HD patients also reported a reduced fluid intake, aiming to limit interdialytic weight gain.

These data come from dialysis patients in stable condition and free from severe co-morbidities, so the results are not exactly representative of the overall HD population. On the other hand, it is well known that severe comorbidities or acute events negatively affects nutritional status and dietary intakes, and thus represent important biases for population studies on nutrition in maintenance hemodialysis patients. Instead, our population is quite older than other series,[9–11] which is important as dietary intake is negatively related to age.

In conclusion, this study showed that in stable dialysis patients, abnormalities of nutritional parameters are less prevalent than expected by analysis of dietary food intake, and that the majority of patients reported a lower than recommended energy and protein intake. Age is the best predictor of energy and protein intake in the dialysis patients who ate less than normal people, but no difference emerged when energy and protein intakes were normalized for body weight. These results recall the attention for individual dietetic counseling in HD patients, and also for a critical re-evaluation of their dietary protein and energy requirements.

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