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ORIGINAL ARTICLE

The Effect of Dietician Education Program on Nutritional Knowledge, Dietary Intake and Phosphate Control in Patients with Renal Failure

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ABSTRACT

Background: Limited fluid and electrolyte intake are part of standard diet of patients with renal failure on maintenance hemodialysis (MHD). However, non-adherence is common and may be explained by patients' insufficient nutritional knowledge. Therefore, we investigated the influence of a dietary counseling on MHD patients' knowledge about nutrients and their subsequent consumed diet, with particular attention to the intake of phosphates and the phosphorus to protein intake ratio (i.e., the phosphorus content per gram of dietary protein intake per day).

Methods: Forty-five MHD patients participated in this experimental study. At baseline, participants were interviewed by a dietician to assess their dietary habits and knowledge about nutrients and health-related consequences of electrolyte imbalances. In addition, they completed a nutrient intake diary during three consecutive days. Subsequently, individual dietary counseling, by means of personal advice was reinforced with the use of printed tables addressing the composition of food products and the phosphorus to protein intake ratio. Dietary counseling was repeated at three, six and nine months of follow-up. The interview with the dietician was repeated after one year.

Results: Forty-five MHD patients completed the study. Their knowledge about nutrients and their dietary habits and food preparation mode improved significantly after the counseling program. Especially, caloric intake and dietary composition became more adequate and balanced, respectively. Moreover, the phosphorus to protein intake ratio improved, as well as patients' intake of phosphate binders.

Conclusion: This study showed that nutritional counseling improved MHD patients' knowledge about nutrients and subsequently diet composition and phosphate intake.

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Introduction

In patients with renal failure on maintenance hemodialysis (MHD), 18-94 percent is affected by malnutrition (1-4). The combination of insufficient caloric intake, anorexia and protein energy wasting is at the basis of malnutrition in this population (5-10). Moreover, the required restrictions on the intake of fluids and specific micronutrients (e.g., phosphorus, potassium, sodium or calcium) constrain MHD patients to adjust their dietary habits and complicate the intake of an adequate diet. Therefore, a careful evaluation of the quality and quantity of dietary intake should be part of MHD patients' standard care and may reduce the risk of micronutrient imbalances and associated health risks (11-20).

Special attention should be given to the dietary intake of phosphorus, as hyperphosphatemia increases the risk of cardiovascular morbidity and mortality in MHD patients (21-25). Besides a high dietary phosphorus intake, also high phosphorus content per gram of dietary protein intake (i.e., the dietary phosphorus to protein ratio) is associated with increased mortality risk in MHD patients and should be evaluated (26-30). Moreover, taking into account the source of dietary phosphorus is of interest. For instance, processed, preserved or enhanced foods and soft drinks contain inorganic phosphorus, which is absorbed more easily by the intestines and may consequently increase the risk of hyperphosphatemia (31-35).

Finally, it is relevant to evaluate patients' adherence to phosphate binding medication, which reduce the intestinal absorption of dietary phosphorus. However, non-adherence to phosphates binders' therapy is prevalent among MHD patients (22-74%) (30). Nevertheless, several studies recently showed the effectiveness of educational or behavioral interventions to control serum phosphate levels in MHD patients (36). Most studies only focused on one facet of phosphate control, either dietary intake or phosphate binding therapy. Yet they have mutual importance in successfully treating hyperphosphatemia in MHD patients. Moreover, little evidence exists on how patient's knowledge may be important for phosphate control. Indeed, basic knowledge about food products and containing micronutrients, such as phosphorus, potassium, sodium and calcium, is usually limited in MHD patients (14, 15, 37).

This may hinder to comprehend the importance of adhering to complex dietary restrictions and may impede the implementation of a customized, yet balanced diet. Similarly, limited knowledge regarding the purpose of phosphate binding medication may be associated with non-adherence (38). Finally, whether educational interventions may improve MHD patients' phosphorus to protein intake ratio in particular, has not been thoroughly investigated yet. Therefore, we designed a study to assess whether a dietary counseling program may have beneficial effects on MHD patients' knowledge about food products and their containing micronutrients that require special care in patients on chronic hemodialysis (i.e., phosphorus, potassium, sodium and calcium), patients' dietary habits and adherence to phosphate binding therapy. Particular attention was given to the effects on patients' dietary phosphorus to protein intake ratio.

Materials and Methods

Between January 2013 and December 2015, all sixty-six patients at our Hemodialysis Unit undergoing MHD treatment for at least six months, currently receiving phosphate binding therapy (sevelamer and calcium carbonate) and having sufficient understanding of the Italian language to participate in the were considered eligible. Eight patients were excluded according to the following exclusion criteria: <18 years of age, inability to answer the questionnaires because of hearing or reading problems, dementia, actual instability of clinical condition requiring hospitalization, liver failure or active cancer. The remaining 58 patients were included in this study after signing informed consent. This semi-experimental study was approved by the local medical ethical committee. All the study steps were performed in accordance with the Helsinki Declaration.

Participants received conventional 4 hours HD treatment three times a week using high permeability membranes. The blood flow ranged from 250 to 300 mL/min and dialysate flow kept constant at 500 mL/min. To assess patients' knowledge about food composition and nutrients, a questionnaire was administered by a dietician (Table 1). The first section reported participants' family and socio-economic status. The second part assessed patients' knowledge about the medical consequences of micronutrient (P, Ca, K and Na) or lipid imbalances. The third section investigated participants' knowledge about food composition and the last part evaluated which kind of food products patients used to consume. The questionnaire was administered prior to the counseling program and one year later.

In order to assess participants' dietary habits and nutrient intake, the dietician developed a nutrition diary in line with diaries used in other studies regarding MHD patients' dietary habits (3, 9-18). Participants were requested to complete the diary

Table 1: Dietary interview to assess patients' knowledge about nutrients and food composition.

1. Family and socio-economic status						
Family status						
Single	Living with family	Assisted by caregiver	Living in a community			
Education						
None	Elementary school	High school	College or university			
Work activity						
Disable	Unemployed/retired	Sedentary work	Physical work			
2. Consequences of micronutrient or lipid disorders on the body						
Which body part(s) can be affected by a phosphorus imbalance?						Number of right answers
None	Bone*	Heart*	Skin (itch)*	General survival	I do not now	
Which body part(s) can be affected by a calcium imbalance?						
None	Bone*	Heart*	Skin (itch)	General survival*	I do not now	
Which body part(s) can be affected by a potassium imbalance?						
None	Bone	Heart*	Skin (itch)	General survival*	I do not now	
Which body part(s) can be affected by a sodium imbalance?						
None	Bone*	Heart*	Skin (itch)	General survival	I do not now	
Which body part(s) can be affected by a TG/Cholesterol imbalance?						
None	Bone	Heart*	Skin (itch)	General survival*	I do not now	
3. Food composition						
Indicate the three food products with the highest phosphorus content						Total score
Cheese (5)	Eggs (4)	Tuna fish (3)	Rice (2)	Potatoes (1)	Honey (0)	
Indicate the three food products with the highest calcium content						
Cheese (5)	Almond (4)	Milk (3)	Bread (2)	Chicken (1)	Apple (0)	
Indicate the three food products with the highest potassium content						
Beans (5)	Potatoes (4)	Ham (3)	Bananas (2)	Cheese (1)	Pasta (0)	
Indicate the three food products with the highest sodium content						
Ham (5)	Cheese (4)	Cookies (3)	Spinach (2)	Potatoes (1)	Pasta (0)	

4. Indicate whether you use the following food products with yes or no

Fresh fruits/ vegetables		Cooked fruits/ vegetables		Packed or canned food, pre-cooked preserved in salt or oil		Biscuits crackers whole grain flours		Carbonated sugary drinks		Sausages or sliced meat extracts/ broths	
Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No

Legend: Section 2: Asterisks indicate the right answers. The number of correct answers was added per micronutrient. Section 3: Numbers between brackets indicate the best answers. Patients could indicate maximum three food products, obtaining an overall score between 3 and 12 per micro-nutrient. Section 4: The percentage of affirmative answers was calculated per group of food products.

five-times-a-day (during breakfast, mid-morning snack, lunch, mid-afternoon snack and dinner) during three consecutive days including a two-day interdialytic interval. Prior instructions on how to log food servings were given by the dietician (e.g., ideally foods' raw weight; alternatively dry or liquid measures such as a coffee spoon or cup). When participants returned their diary, the content was reviewed together with the dietician to clarify potential uncertainties. Thereupon, the dietician calculated the caloric intake and macro- and micro-nutrient content of the meals and drinks consumed during these three days by means of the food composition tables of the Italian National Institute of Research for food and Nutrition (33). These tables represent the natural nutrient content of raw, unprocessed food.

Moreover, the following parameters were calculated: daily kilocalories (Kcal) intake, percentage of macro-nutrients intake (given that a balanced diet contains 20-35% of lipids, 12-15% of proteins and 50-60% of carbohydrates), daily protein intake (grams of protein intake per kilogram of body weight), and the daily phosphorus to protein ratio (calculated as the quantity of phosphorus intake per day (in milligrams) divided by the quantity of protein intake per day (in grams). Based on their phosphorus to protein ratio, patients were categorized in four *a priori* selected classes suggested by Noori *et al.* (i.e., class I: daily P/protein ratio <12 mg/g, class II: 12 to

<14 mg/g (recommended range), class III: 14 to <16 mg/g, class IV: ≥16 mg) (23).

Finally, participants' daily energy requirement, depending on basal energy expenditure and physical activity, was calculated based on tables of the Italian Society of Human Nutrition (SINU) providing reference values for energy and nutrient intake (34). Participants completed the nutrition diary twice, once prior to the counseling program and one year later. When patients returned their nutrition diary, the dietary counseling program started. This program consisted of collective teaching by means of informatory slides and individual counseling by a dietician and physician. An informatory slide presentation about caloric, protein, lipid and carbohydrate content and micronutrient (P, K, Na, Ca) content of food products was provided during patients' regular HD session. Special attention was given to the composition of processed, preserved or enhanced food and soft drinks because they contained inorganic phosphorus.

In addition, patients were taught about different methods of food preparation, since some were preferable to others, as they reduced the quantity of phosphorus and other micronutrients in foods. Moreover, patients were instructed to follow a balanced diet and to comply with the allowed amount of fluid intake (i.e. a daily total liquid intake of 500-700 mL more than the amount of residual diuresis per day). Finally, patients received a brochure, containing all the dietary information learned, to take home (Appendix 2). In addition, individual dietary counseling was provided during patients' regular HD treatment, in order to reduce the quantity of daily phosphorus intake; while maintaining the same amount of daily protein intake. To this end, educational materials, such as printed tables representing the nutrient composition and phosphorus to protein ratio of commonly consumed food products were used.

According to the international recommended ranges of both daily protein and phosphorus intake (1-1.2 g/day and 800-1000 mg/day, respectively) (39) and on that basis and Noori *et al.*'s suggested classes of phosphorus to protein ratio, the MHD patients were divided into four categories: A) patients with higher P, but lower protein intake than recommend; B) patients with higher P, but normal protein intake; C) patients with both higher P and protein intake (overfeed); and D) patients with both lower P and protein intake (malnourished). Once a month, a follow-up meeting with the physician and dietician was scheduled during patients' regular HD session. On these occasions, patients' doubts (if any) were discussed and their adherence to dietary recommendations was inquired.

The effects of phosphate binding medication and its correct use were addressed during the collective teaching, the individual counseling and monthly follow-up, and in the brochure patients received to take home. Therapeutic adherence to phosphate binders was evaluated based on the ratio of the annually prescribed quantity of phosphate binders by the physician and the effectively annually administered quantity of phosphate binders by the nurses of the HD unit to participant. Therapeutic adherence was examined before the counseling program started and one year later by means of the aforementioned pill count ratio, and by inquiring during the monthly follow-up meeting. Demographical and clinical information was obtained at the moment of inclusion. Venous blood samples for biochemical parameters were collected before the counseling program started and monthly, and up to one year later. All analyses took place at the same laboratory.

Statistical analyses were performed using MedCalc Software (Belgium Version 12.5 for Microsoft Windows). Assumptions of normality and equality of variances of continuous variables were checked by applying the Kolmogorov–Smirnov test. Data of continuous variables were reported as mean±standard deviation (SD). Data of categorical and interval variables were reported as frequencies or median and interquartile range (IQR), respectively. To investigate differences in the variables under investigation (i.e., patients' nutrient knowledge, their dietary habits and intake of macro-and micronutrients and adherence to phosphate binders) before and after the intervention counseling program, the appropriate parametric or non-parametric tests were used (i.e., t-test, analysis of variance (ANOVA), Friedman's test, Mann–Whitney and Chi-Square test, respectively). Statistical significance was assessed at $p<0.05$.

Results

During the entire study period, eight of the initially included participants died, three underwent kidney transplantation and two were transferred to another dialysis center. The remaining 45 patients were included in the statistical analyses. Their demographical, social and clinical characteristics were presented in Table 2. Table 3 shows that participants' basic knowledge about the health-related risks of nutrient imbalances was poor prior to the counseling program. However, one year later, their knowledge significantly improved (Table 3). Similarly, participants' knowledge about food products and their containing micronutrients (Ca, P, K and Na) significantly improved after one year in comparison with their knowledge before the intervention program (Table 4).

Table 2: Baseline demographic, social and clinical characteristics of participants (N=45).

Characteristics	Value	
Age years (Mean±SD)	59.4±17.2	
Gender male (%)	60%	
Education	No.	(%)
None	1	(2)
Elementary school	15	(33)
High school	20	(45)
College or university	9	(20)
Marital status	No.	(%)
Married/partnership	38	(85)
Single/divorced/widow	7	(15)
Causes of ESRD	No.	(%)
Glomerulonephritis	11	(25)
Interstitial nephritis	6	(13)
Polycystic kidney disease	4	(8)
Hypertension	17	(38)
Diabetes	5	(12)
Others/unknown	2	(4)
Dialysis years (Mean±SD)		8.7±7.8
Body mass index	No.	(%)
<18.5	5	(11)
18.5-24.9	25	(56)
25-29.9	12	(27)
≥30	3	(6)

Table 3: Participants' knowledge about health-related risks of micronutrient imbalances and excessive intake of lipids.

Variable	Number of correct answers on the questionnaire Median (IQR)		p^a
	Before counceling	One year later	
Phosphorous	1 (0-1)	3 (2-4)	<0.001
Calcium	0 (0-1)	2 (1-2)	<0.001
Potassium	0 (0-1)	2 (1-2)	<0.001
Sodium	0 (0-1)	2 (0.75-2)	<0.001
Triglycerides/Cholesterol	1 (0-1)	2 (1.75-2)	<0.001

[a]Wilcoxon test (paired samples), IQR: Interquartile Range

Table 4: Knowledge about food products and their containing micronutrients, respectively, before the counseling program and 12 months later.

	Total score* of correct answers on the questionnaire Median (IQR)		p^a
Variable	Before counceling	One year later	
Phosphorus	8 (5-12)	9 (8-12)	<0.002
Calcium	9 (5.75-12)	12 (11.75-12)	<0.001
Potassium	9 (3-11)	11 (10-11)	<0.005
Sodium	9 (3.75-10.25)	11 (10-12)	<0.001

*Total Score obtained from the answers given in section three of Table 1. [a]Wilcoxon test (paired samples). IQR: Interquartile Range

The patients' dietary habits and intake after one year changed relative to their habits and intake prior to the counseling program. For instance, the number of MHD patients consuming fruit and cooked vegetables increased after dietary counseling (from 77.7% to 85.4%, p=0.023). In addition, the number of patients consuming foods rich in inorganic phosphorus significantly decreased. The consumption of packed, canned and pre-cooked foods and foods preserved in salt or oil decreased from 32.3% to 25.6% (p=0.001). Likewise, the consumption of carbonated and sugary drinks reduced from 9.8% to 5.5% (p=0.001), and the

Table 5: Biochemical and nutritional parameters before (pre) and after (post) dietary counseling (N=45).

Biochemical parameters (serum concentrations)	Pre median (IQR)	Post median (IQR)	p^a
Hemoglobin (g/dL)	11.4 (10.6-12.0)	11.2 (10.7-11.8)	0.437
Albumin (mg/dL)	4.0 (3.8-4.1)	4.0 (3.8-4.1)	0.296
Phosphorus (mg/dL)	4.7 (4.0-6.2)	4.5 (3.6-6.1)	0.353
Calcium (mg/dL)	9.5 (8.9-9.7)	9.3 (8.8-9.5)	0.209
Potassium (mg/dL)	5.4 (5.0-5.8)	5.2 (4.7-5.8)	0.161
Parathyroid hormone (PTH pg/mL)	308 (192.1-468.6)	287(209.9-440.2)	0.791
Urea nitrogen (mg/dL)	77 (68.3-90.0)	76 (67.0-88.8)	0.209
Creatinine (mg/dL)	11.1 (9.2-14.1)	10.6 (8.6-13.6)	0.505
Uric acid (mg/dL)	7.3 (6.3-8.4)	6.7 (6.0-8.1)	0.219
25-Hydroxy vitamin D (ng/mL)	9.6	9.1	0.541
Nutritional parameters			
Total daily Caloric Intake (Kcal)	1518 (1365.8-1938.1)	1431 (1173.1-1646.8)	0.010
Daily caloric intake pro Kg ideal body weight	25.5 (21.0-30.0)	23 (19.5-26.5)	0.013
% of daily caloric intake from protein	14.8 (12.6-17.4)	16.4 (14.9-18.4)	0.001
% of daily caloric intake from lipid	37.2 (32.2-39.7)	32.1 (26.9-36.3)	0.004
% of daily caloric intake from carbohydrates	48 (45.3-52.5)	51.5 (48.0-55.5)	0.010
Calcium dietary intake mg/day	436 (322.5-581.8)	401 (305.9-83.6)	0.872
Phosphates dietary intake mg/day	834 (614.0-1047.7)	810 (646.5-24.8)	0.502
Total protein intake g/day	56.8 (48.1-78.2)	57.4 (46.7-67.1)	0.872
Protein intake pro Kg ideal body weight (g/Kg/day)	0.93 (0.82-1.19)	0.93 (0.75-1.15)	0.890
Phosphorus/protein ratio (P mg day/Protein g day)	14.1 (12.9-15.2)	13.4 (12.9-15.0)	0.619
Dry weight (kg)	62.5 (55.2-72.8)	62.1 (55.7-73.5)	0.206
Interdialytic weight increment (kg)	2.7 (1.9-3.4)	2.8 (2.1 to 3.4)	0.177

[a] Wilcoxon test (paired samples). IQR: Interquartile Range

consumption of salami and sliced foods decreased from 85.4% to 54.5% (p=0.001).

Furthermore, Table 5 represents participants' biochemical and nutritional parameters before counseling and one year later. For instance, patients' overall daily caloric intake slightly declined after dietary counseling compared with their intake prior to the program (1431 Kcal versus 1518 Kcal, p=0.010). However, the intake of macronutrients was more balanced after counseling, with a significant increase in daily caloric intake deriving from proteins and carbohydrates (p=0.001 and p=0.010, respectively), and a significant reduction in caloric intake deriving from lipids (p=0.004). With respect to the intake of micronutrients, patients' daily intake of Ca and P decreased after the counseling program, but these differences were not statistically significant. Additionally, before and after the program, P intake (mg/day) was strongly associated with protein intake (g/day) (Coefficient of determination R^2=0.66 and 0.89 respectively, p=0.0001), but it did not correlate with serum P levels (Figure 1A and 1B, respectively).

Interestingly, patients' phosphorus to protein ratio improved over the study period. Before the counseling program 5%, 41%, 44% and 10% of participants were categorized in Noori *et al.*'s classes I-IV, respectively. Afterwards, the classification distribution significantly changed to 5%, 51%, 36%

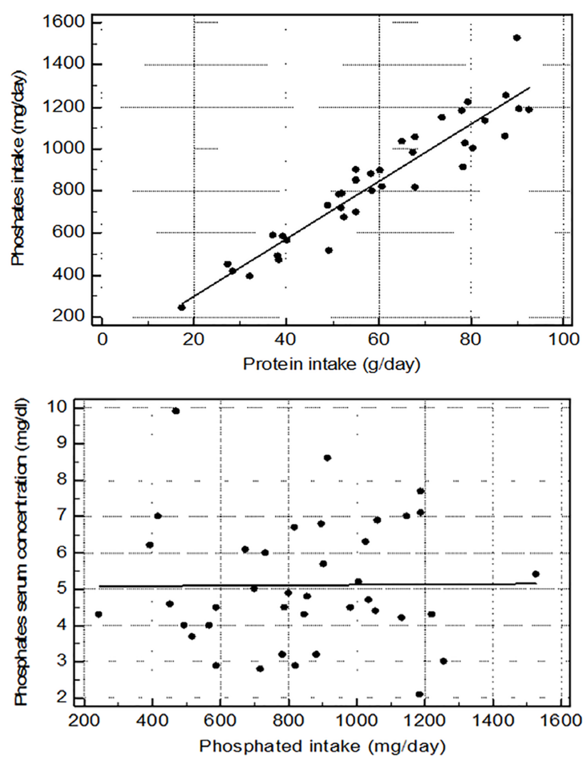

Figure 1: Relationship of P intake with protein intake (A) and serum P levels (B). Legend: Scatter diagram and regression line of protein intake (g/day) and phosphates intake (mg/day) (Regression equation y=27.4200+13.6444 x; Coefficient of determination R^2=0.89, Significance level of p<0.0001).

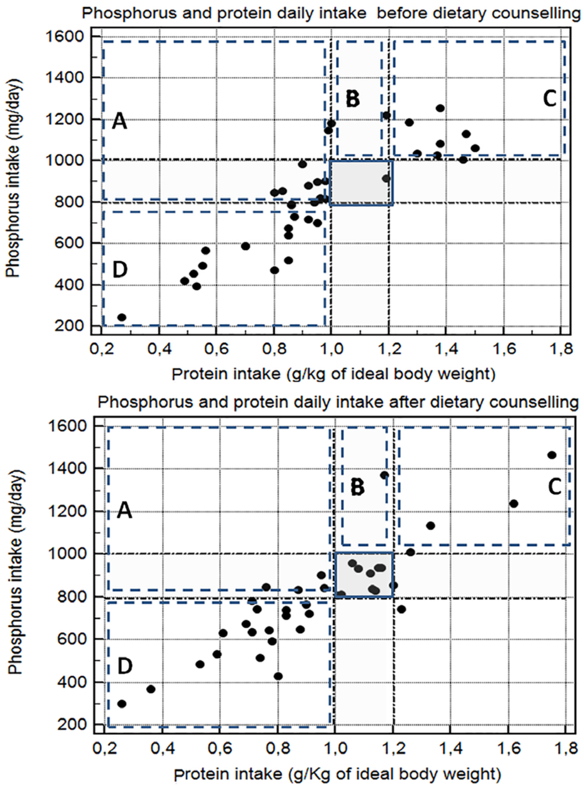

Figure 2: Scatter diagram of protein intake (g/Kg of ideal body weight) and phosphorus intake (mg/day) before (top) and after dietary counseling (bottom). The graph shows the range (light grey rectangle) of protein and phosphates intake recommended by the international guidelines (15-20). Excluding patients within the recommended protein and phosphates intake range (dark grey rectangle), four classes of patients were identified: A) patients with hyper-phosphoric and hypo-protein intake; B) patients with hyper-phosphoric and normal protein intake; C) patients with hyper-phosphoric and hyper-protein intake (overfeed); and D) patients with hypo-phosphoric and hypo-protein intake (malnourished). Two and 10 patients achieved both targets of protein and phosphorus intake, respectively before and after the dietary counseling ($p<0.027$).**Figure 2:** Scatter diagram of protein intake (g/Kg of ideal body weight) and phosphorus intake (mg/day) before (top) and after dietary counseling (bottom). The graph shows the range (light grey rectangle) of protein and phosphates intake recommended by the international guidelines (15-20). Excluding patients within the recommended protein and phosphates intake range (dark grey rectangle), four classes of patients were identified: A) patients with hyper-phosphoric and hypo-protein intake; B) patients with hyper-phosphoric and normal protein intake; C) patients with hyper-phosphoric and hyper-protein intake (overfeed); and D) patients with hypo-phosphoric and hypo-protein intake (malnourished). Two and 10 patients achieved both targets of protein and phosphorus intake, respectively before and after the dietary counseling ($p<0.027$).

and 8.0%, respectively ($p=0.005$). Moreover, Figure 2 shows the distribution of patients according to their daily protein intake (g/Kg of ideal body weight) and daily phosphorus intake (mg) before and after the counseling program (top and bottom panel, respectively). After the counseling program, fewer patients consumed more than the recommended daily dose of dietary P (i.e. 800-1000 mg/day). Significantly, more participants (10 out of 45) met the recommended target range of both daily protein and phosphorus intake relative to the number of patients meeting these criteria before the intervention (2 out of 45, $p=0.027$, Figure 2 bottom). Finally, participants' therapeutic adherence to phosphate binders after one year of counseling (M=0.81±0.40) significantly improved in comparison with their adherence before the intervention program (M=0.63±0.40, $p=0.0001$).

Discussion

The present study, as a first point, found that MHD patients' basic knowledge about macro-and micro-nutrients in foods and their associated medical consequences in case of imbalances was poor. Their basic knowledge regarding food products and food preparation methods containing inorganic phosphorus was also limited. However, one year later, after they received collective teaching and individual counseling, patients' nutritional knowledge significantly improved. These findings are for the most part in line with previous studies. Cupisti *et al.* reported that MHD patients' knowledge of phosphorus and other nutrients related to dietary management of end-stage renal disease, such as potassium, sodium and nutrients, was significantly less and only slightly better in comparison with dialysis nurses and the general population, respectively (40).

Moreover, Pollock *et al.* showed that MHD patients' knowledge of dietary phosphorus content in particular was poor compared to other nutrients (14). similarly, the study of Poduval *et al.* demonstrated that 74% of the 117 studied MHD patients failed to identify foods rich in phosphorus and 61% was unaware of complications related to a high calcium-phosphorus product (e.g., cardiac mortality) (15). Interestingly, they found that patients with at least some college education had higher knowledge scores and lower calcium-phosphorus products. However, Reddy *et al.* also showed that a combination of educational initiatives, such as teaching sessions in small groups and the use of booklets or audio cassettes, was effective in enhancing patients' knowledge about phosphorus and phosphate binders (30). However, they did not provide individual counseling and their follow-up period only lasted a month (30).

Second, our results showed that not only patients' nutritional knowledge, but also their dietary habits and intake improved one year after the counseling program. In particular, our findings demonstrated a small reduction in daily phosphorus intake and an improvement in the phosphorus to protein intake ratio. Moreover, daily protein intake and serum albumin levels remained unchanged. These results may indicate that patients became aware of consuming foods with high protein but low phosphorus content. In effect, reducing protein intake in order to reduce phosphorus intake is associated with an increased mortality risk (1, 3). A high protein intake with optimal P management is, on the other hand, associated with the best survival of MHD patients (24, 25).

However, serum phosphorus levels did not significantly change after the counseling program and did not correlate with daily phosphorus intake. This is in line with other studies that did not find a correlation between phosphorus intake and serum phosphorus concentration (23, 31). However, other authors demonstrated that an educational program succeeded to significantly reduce serum P concentrations (40). Actually, serum phosphorus concentration in MHD patients is determined by multiple factors. For instance, organic phosphorus in seeds and legumes is less readily absorbed by the intestine and is less bioavailable compared with inorganic phosphorus deriving from food additives (40).

Moreover, serum phosphorus concentrations also depend on patients' adherence to phosphate binders and the efficacy of phosphorus clearance during the HD procedure. Effectively, in line with other studies, the present study showed the effectiveness of educational or behavioral interventions on adherence to phosphate control (expressed as direct pill counts) in patients receiving hemodialysis (37). Furthermore, we demonstrated that mapping MHD patients according to their daily phosphorus and protein intake, as was illustrated in Figure 2, may help to identify patients' characteristics and necessities, compared with the single determination of serum P concentration. For instance, physicians might be able to better identify patients who need to reduce their excessive protein intake, or who need to intensify their therapy with phosphates binders or the intake of proteins with lower P content. Moreover, patients with an adequate protein intake though a disproportionate P intake can be detected. Subsequently, a thorough dietary counseling may reveal whether this is the result of an excessive intake of inorganic phosphorus (4).

Finally, the present study showed that MHD patients' average intake of proteins and energy was less than recommended (i.e. 1.0-1.2 g/kg/day and 30 kcal/kg/day, respectively), even after they received dietary counseling. These results are in line with previously published studies reporting MHD patients' protein intake is usually low (less than 1.0 g/kg/day in approximately 50% of subjects) (4). Therefore, it is important to not postpone nutritional interventions and start when spontaneous energy intake drops below 30 kcal/kg/day and protein intake below 1.0 g/kg/day. However, although dietary counseling may improve MHD patients' dietary habits, it will be challenging to completely correct their negative energy balance since several other factors, such as acidosis, inflammation, uremic toxins and depression, contribute to their malnutrition (1). Limitations include the number of patients examined, the drop-out of patients during follow-up and its short duration. These limitations do not allow evaluating the impact of dietary counseling on cardiovascular morbidity and mortality and on drug-economy (e.g. dose reduction of phosphates binders).

Conclusion

This study showed that dietary counseling improved MHD patients' knowledge about the effects of microelements on the body (in particular P) and their knowledge about the content of food products. Furthermore, MHD patients' dietary composition improved after counseling, even though the total energy intake did not significantly increase. Therefore, the introduction of dietary counseling in standard clinical care, for instance during their regular treatment sessions, may help to identify patients' dietary errors, particularly with regard to P intake, and to improve patients' diet. After all, an individualized approach with regular follow-up is required for an optimal phosphorus control in MHD patients.

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Conflict of Interest

None declared.

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