Nutrient intake assessed with Diet History Questionnaire II, in relation to long-term calcium-phosphate control in hemodialysis patients with end-stage renal failure

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Abstract

Background. Diet is a key factor that determines proper alignment of calcium-phosphate and nutritional status among hemodialysis (HD) patients.

Objectives. To assess the nutrient intake in relation to long-term calcium-phosphate control in HD patients with end-stage renal failure.

Material and methods. The study included 107 patients (66 men, 41 women) from 10 dialysis centers in the Upper Silesia region of Poland. To analyze the diet composition during the previous year, a portion-sized version of the Diet History Questionnaire II (DHQ-II) from National Institutes of Health was used. The nutrient intake was assessed in accordance with the most complex recommendations on HD patients' nutrition – K/DOQI Clinical Practice Guidelines for nutrition in chronic renal failure. Poor long-term alignment of calcium-phosphate homeostasis was defined as the presence of over 50% monthly phosphorus concentrations exceeding 5 mg/dL, and for calcium 10.2 mg/dL, during the last 6-month period.

Results. Lower than recommended protein intake was found in 63% of HD patients (average consumption: 0.9 ±0.5 g/kg/day). Most of the patients consumed too much fat (33.5 ±6.7% of daily energy intake) and sodium (2912 ±1542 mg/day). In 42% of patients, dietary phosphorus intake was consistent with the recommendations (13.3 ±7.5 mg/kg/day). Protein intake over 1.2 g/kg/day resulted in an increased consumption of phosphorous, but did not increase the risk of misalignment of phosphorus concentrations (OR = 1.15 [0.40–3.27]); p = 0.8). Poor control of serum phosphorus concentrations was observed in 69% of patients (they were on average 8 years younger). The average intake of protein and phosphate in the groups with good or not satisfactory serum phosphorus alignment did not differ significantly.

Conclusions. Adequate control of protein intake is not sufficient to obtain phosphorus alignment, especially in younger HD patients.

Key words: diet, hemodialysis, food frequency questionnaire, calcium-phosphate control, nutrient intake

Introduction

Cardiovascular disease is the most common cause of death in patients with end-stage kidney disease (ESKD) on renal replacement therapy. Epidemiological studies have shown that one of the major causes of increased morbidity and mortality in this group of patients are the disturbances of the calcium-phosphate metabolism.[1] Diet is a key factor that determines both calcium-phosphate balance and nutritional status in hemodialysis (HD) patients, and is an essential component of the therapeutic approach in this population.[2]

The primary role of diet in the non-dialysis stage of chronic kidney disease (CKD) is to reduce uremic toxemia and to diminish the risk of developing renal osteodystrophy and hyperkalemia. This includes a restriction of daily protein intake up to 0.6–0.75 g/kg of body mass, and food rich in phosphorus additives. Nutritional recommendations change considerably after the initiation of dialysis. Due to an increased risk of developing protein-energy malnutrition, higher daily protein intake is recommended (1.2 g/kg body mass/day), while maintaining the dietary phosphate restriction (Table 1).[3,4]

A low-phosphate diet is difficult to follow for a long period of time, as most nourishment with high protein content (products of animal origin, e.g., meat and dairy products) are also a rich source of phosphorus. This often complicates the choice of food, leading to monotony of the diet, and consequently a lack of acceptance of the recommendations by numerous patients.[5]

The basic criterion for good calcium-phosphate control, in accordance with the recommendations of the Working Group of the Polish Society of Nephrology on the quality of treatment in hemodialysis ESKD patients, is obtaining proper values of serum concentrations of calcium (8.4–10.2 mg/dL) and phosphorus (2.5–5.0 mg/dL). The concentration of native (intact) parathyroid hormone (PTH) should be in the range of 2–9 times the upper limit of the reference kit (~130–600 pg/mL).[6] It should be emphasized that there are some discrepancies between Polish recommendations and the latest (2009) Kidney Disease: Improving Global Outcomes (KDIGO) CKD-MBD Work Group clinical practice guidelines for the diagnosis, evaluation, prevention, and treatment of chronic kidney disease – mineral and bone disorder, and older (2003) National Kidney Foundation Kidney Disease Outcomes Quality Initiative (NKF K/DOQI) guidelines on bone metabolism and disease in chronic kidney disease.[7,8] KDIGO guidelines do not give specific reference ranges of calcium, phosphorus, and intact PTH levels. They emphasize the role of trends in laboratory values on therapeutic decision-making, and recommend that clinical laboratories should inform clinicians on the actual method used and report any change in the assays. According to K/DOQI recommendations, serum levels of phosphorus should be maintained between 3.5 mg/dL and 5.5 mg/dL, serum levels of corrected total calcium within the normal range for the laboratory, preferably toward the lower limit (8.4–9.5 mg/dL), and the target range of plasma levels of intact PTH in dialysis patients should be of 150–300 pg/mL.[8]

The percentage of patients with hyperphosphatemia in dialysis units, according to the Working Group of the Polish Society of Nephrology, should be less than 45%.[6] Serum calcium should be definitely below 10.2 mg/dL, as greater values have been related to increased mortality in HD patients.[7,9]

Table 1. Recommended energy, macro- and micronutrient intake in HD patients (in accordance with K/DOQI recommendations (*) or EBPG on nutrition (†))[11,12]

Macronutrient intake	Recommended intake
Protein intake[a]	1.2 g/kg body mass/day (≥ 1.2–1.3 g/kg body mass/day for patients who are actually ill or have more severe protein-energy wasting)* at least 1.1 g/kg ideal body mass/day in clinically stable chronic HD patients†
Energy intake[b]	35 kcal/kg body mass/day for those who are < 60 years of age and 30–35 kcal/kg body mass/day for individuals of 60 years or older* 30–40 kcal/kg ideal body mass/day, adjusted to age, gender, and to the best estimate of physical activity level†
Fat intake	30% of daily energy intake*
Saturated fat	up to 10% of daily energy intake*
Polyunsaturated fatty acids	up to 10% of daily energy intake*
Monounsaturated fatty acids	up to 20% of daily energy intake*
Carbohydrates[c]	the rest of non-protein calories*
Total fiber	20–25 g/day*
Sodium	750–2000 mg/day* ≤ 2000–2300 mg of sodium or 5–6 g (75 mg/kg body mass)/day of sodium chloride†
Potassium	up to 70–80 mEq/day* 50–70 mmol (1950–2730 mg) or 1 mmol/kg ideal body mass in patients with pre-dialysis serum potassium > 6 mmol/L†
Phosphorus	10–17 mg/kg body mass/day* 800–1000 mg†
Calcium[d]	≤ 1000 mg/day* ≤ 2000 mg/day†
Magnesium	200–300 mg/day*
Iron	requirements vary according to the dose of administered erythropoietin* 8 mg/day for men, and 15 mg/day for women is recommended†
Zinc	15 mg/day* 8–12 mg/day of elemental zinc for women, and 10–15 mg/day for men†

EBPG – European Best Practice Guidelines; [a] minimum of 50% of total protein intake should be derived from high-quality protein; [b] in overweight or obese patients, limitation of total energy intake is recommended in order to reduce weight; [c] preferably complex carbohydrates; [d] both dietary calcium intake and oral calcium-based phosphate binders.

There is a lack of data regarding the percentage of HD patients that follow the recommended levels of macro- and micronutrients in their diet. Therefore, the aim of the study was to assess nutrient intake in relation to long-term calcium-phosphate control in hemodialysis ESKD patients.

Material and methods

Study population and data collection

The study population consisted of 107 patients (66 males, 41 females) from 10 dialysis centers in the Upper Silesia Region of Poland undergoing hemodialysis 3 times per week in morning sessions, who had been on HD therapy for at least 6 months and who gave written consent for participation in this study. Among the exclusion criteria were gastrointestinal tract diseases and current hospitalization. The study protocol was approved by the Bioethical Committee of the Medical University of Silesia in Katowice (KNW 22/KB1/185/I/11/12). Figure 1 shows a flow chart of the study.

Clinical and laboratory data was retrieved from the medical records of the dialysis centers. Residual renal function was assessed on the basis of residual diuresis reported by the patients.

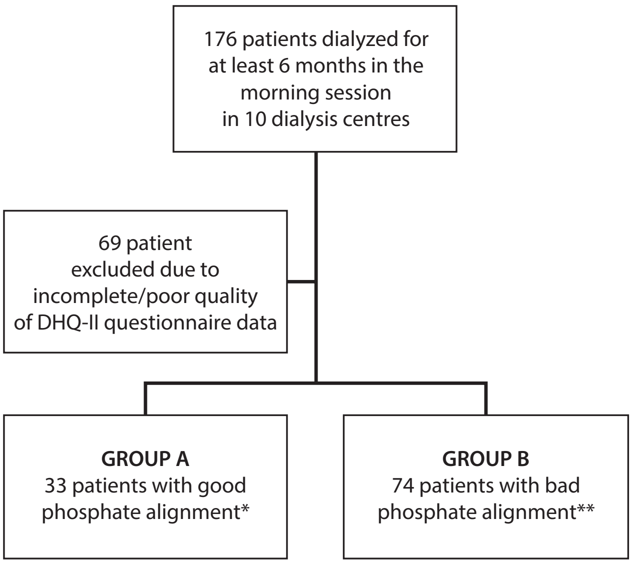

Fig. 1. Flow chart of the study

* < 50% monthly phosphorus levels ≥ 5 mg/dL; ** ≥ 50% monthly phosphorus levels ≥ 5 mg/dL.

Diet assessment

To analyze the composition of patient diet during the previous year, a portion-size version of the food frequency questionnaire by the National Institutes of Health – Diet History Questionnaire II (DHQ-II) was used.[10] Patients were instructed on how to complete the questionnaire, and written instructions were provided. The analysis of the survey was performed using the computer program Diet Calc (National Cancer Institute, Bethesda, USA), and adopted as the standard value in accordance with the most complex recommendations on HD patients' nutrition – K/DOQI Clinical Practice Guidelines for nutrition in chronic renal failure (Table 1).[11] Consumption of energy, protein and phosphorus was expressed per kilogram of current body mass.[7] Other nutrient intake (carbohydrates and fats) was presented as total daily intake and percentage of daily energy. Nutritional status was assessed on the basis of anthropometric measurements (body mass and height) used to calculate body mass index (BMI; kg/m^2), stratified in line with WHO recommendations for Caucasians.

Analysis of calcium-phosphate parameter alignment

To evaluate the parameters of the calcium-phosphate metabolism, the results of monthly routine assessments of phosphorus, calcium, and iPTH concentrations were used. These included results from the last 6 months preceding the analysis of the diet. Recommended daily doses of oral phosphate binding drugs (calcium carbonate and sevelamer hydrochloride) were incorporated. The criterion of bad calcium-phosphate alignment was the occurrence of phosphorus concentrations exceeding 5 mg/dL, and calcium over 10.2 mg/dL in ≥50% of monthly assessments (according to the recommendations of the working group of the Polish Society of Nephrology concerning the quality criteria of dialysis in ESKD patients).[6]

Statistical analysis

For the statistical analysis, Statistica software v. 11.0 (StatSoft Inc., Tulsa, USA) was used. Data was presented as mean values ±standard deviation. The distribution of the examined variables was checked by Shapiro-Wilk test. Categorical variables were compared using χ^2 tests, while quantitative variables with ANOVA or Mann-Whitney U test, as appropriate. Logistic regression was used to calculate odds ratios (OR). The threshold for statistical significance was set at $\alpha = 0.05$. The statistical review of the study was performed by a biomedical statistician.

Results

Overall characteristics of patients

Detailed patient characteristics, including anthropometric data, causes of CKD, concomitant diseases, dialysis parameters, pharmacotherapy, and the degree of calcium-phosphate alignment is shown in Table 2.

Table 2. Patients' characteristics, mean ±SD (group A – patients with < 50% monthly phosphorus levels ≥ 5 mg/dL; group B – patients with ≥ 50% monthly phosphorus levels ≥ 5 mg/dL)

Variables	All patients (n = 107)	Group A (n = 33)	Group B (n = 74)	p-value
Gender [male/female]	66/41	19/14	47/27	ns
Age [years]	61.9 ±14.8	67.4 ±12.5	59.4 ±15.2	p < 0.01
Body mass [kg]	73.0 ±15.0	74.8 ±14.1	72.5 ±15.4	ns
Height [m]	1.68 ±0.08	1.69 ±0.07	1.67 ±0.09	ns
BMI [kg/m^2]	26.1 ±4.8	26.3 ±4.4	26.0 ±5.0	ns
underweight [n (%)]	2 (1.9)	0	2 (2.7)	
normal weight [n (%)]	46 (43.0)	14 (42.4)	32 (43.2)	
overweight [n (%)]	38 (35.5)	12 (36.4)	26 (35.1)	
obesity [n (%)]	21 (19.6)	7 (21.1)	14 (18.8)	
I grade obesity [n (%)]	15 (14.0)	6 (18.2)	9 (12.2)	
II grade obesity [n (%)]	6 (5.6)	1 (3.0)	5 (6.8)	
Time on dialysis [months]	53 ±52	35 ±32	61 ±58	p < 0.01
Kidney transplantation [n]	9	0	9	
Renal failure cause				
diabetes [n]	31	10	21	
hypertension [n]	12	6	6	
nephrolithiasis [n]	6	4	2	
glomerulonephritis [n]	15	2	14	
interstitial nephritis [n]	6	0	4	
ADPKD [n]	9	2	7	
vasculitis [n]	3	1	2	
ischemia [n]	2	1	1	
other or unknown [n]	23	7	16	
Co-morbidities				
hypertension [n (%)]	99 (92.5)	33 (100)	66 (89.2)	ns
ischemic heart disease [n (%)]	57 (53.3)	24 (72.7)	33 (44.6)	p < 0.01
myocardial infarction [n (%)]	20 (18.7)	8 (24.2)	12 (16.2)	ns
stroke [n (%)]	6 (5.6)	3 (9.1)	3 (4.1)	ns
diabetes [n (%)]	40 (37.4)	14 (42.4)	26 (35.1)	ns
hypercholesterolemia [n (%)]	25 (23.4)	10 (30.3)	15 (20.3)	ns
parathyroidectomy [n (%)]	6 (5.6)	2 (6.1)	4 (5.4)	ns
cancer [n (%)]	17 (15.9)	6 (18.2)	11 (14.9)	ns
PCI [n (%)]	9 (8.4)	1 (3.0)	8 (10.8)	ns
CABG [n (%)]	7 (6.5)	4 (12.1)	3 (4.1)	ns
Dialysis parameters				
vascular access				
arterio-venous fistula [n (%)]	75 (70.0)	22 (66.7)	53 (71.6)	ns
central venous catheter [n (%)]	32 (29.9)	11 (33.3)	21 (28.4)	ns
dialysis session duration [h]	3.8 ±0.4	3.8 ±0.5	3.8 ±0.4	ns
ultrafiltration [L]	2.5 ±0.9	2.2 ±1.0	2.6 ±0.8	p < 0.05
residual diuresis [mL]	492 ±534	597 ±535	446 ±531	ns
residual diuresis > 500 mL/day [n (%)]	31 (29.0)	12 (36.4)	19 (25.7)	ns
Pharmacotherapy				
iron [mg/week]	33 ±40	35.6 ±41.5	32.1 ±39.6	ns
calcium carbonate [g/day]	3.3 ±2.7	3.5 ±2.5	3.3 ±2.8	ns
alfadiol [n (%)]	36 (33.6)	9 (27.3)	27 (36.5)	ns
cinakalcet [n (%)]	15 (14.0)	1 (3.0)	12 (16.2)	ns
sevelamer [n (%)]	3 (2.8)	0	3 (4.1)	ns
Biochemical parameters				
phosphorus [mg/dL]	5.8 ±1.5	4.3 ±0.5	6.5 ±1.3	p < 0.001
calcium [mg/dL]	8.6 ±0.9	8.5 ±1.0	8.6 ±0.8	ns
poor serum calcium alignment [n (%)]	2 (1.9)	0	2 (2.7)	ns
iPTH [pg/mL]	466 ±441	451 ±501	472 ±414	ns

BMI – body mass index; ADPKD – autosomal dominant polycystic kidney disease; PCI – percutaneous coronary intervention; CABG – coronary bypass grafting; iPTH – intact parathyroid hormone.

Assessment of calcium-phosphate alignment

The mean 6-month serum calcium and phosphorus levels in the study group were 8.6 ±0.9 mg/dL and 5.8 ±1.5 mg/dL, respectively. Nearly 70 % of patients (n = 74) had bad phosphate alignment (≥50% monthly phosphorus levels ≥5 mg/dL; group B). Patients with good phosphate alignment (group A) were on average 8 years older than those with poorly controlled phosphate metabolism ($p < 0.05$), and they were also characterized by a nearly 2-fold shorter dialysis vintage and lower ultrafiltration ($p < 0.005$ and $p < 0.05$, respectively). Both groups did not differ in the other assessed factors except bad calcium alignment, which occurred only in group B (Table 2).

Macro- and micronutrient intake of HD patients in relation to the recommendations

The intake of energy, and macro- and micronutrients in relation to the recommended values in HD patients is shown in Table 3. A high percentage of patients (80%) had lower than recommended energy (22.7 ±12.4 kcal/ /kg/day) and fiber (14.2 ±7.1 g/day) intake. Almost two thirds of patients consumed less protein than is recommended (0.9 ±0.5 g/kg/day). The majority of patients consumed more fat, sodium and calcium (33.5 ±6.7%; 2912 ±1542 mg/day; and 583 ±364 mg/day, respectively) compared to recommendations. The average intake of phosphorus was 13.3 ±7.5 mg/kg body mass/day. Only in 40% of patients was the intake within the recommended range.

The degree of phosphorus alignment in relation to the intake of energy, macro- and micronutrients is shown in Table 4. The mean intake of protein and phosphorus in patients with good and bad phosphorus alignment did not differ significantly. High intake of protein (>1.2 g/kg body mass/day) resulted in a significant increase in phosphate intake ($p < 0.05$) (Fig. 2). However, protein intake >1.2 g/kg body mass/day did not increase the risk of phosphorus misalignment (OR = 1.15 [0.40–3.27]; p = 0.8).

Discussion

Currently, there are 2 specific renal nutrition guidelines available for daily practice – the Clinical Practice Guidelines for nutrition in chronic renal failure, released in 2000 by NKF K/DOQI, and the more recent (2007) European

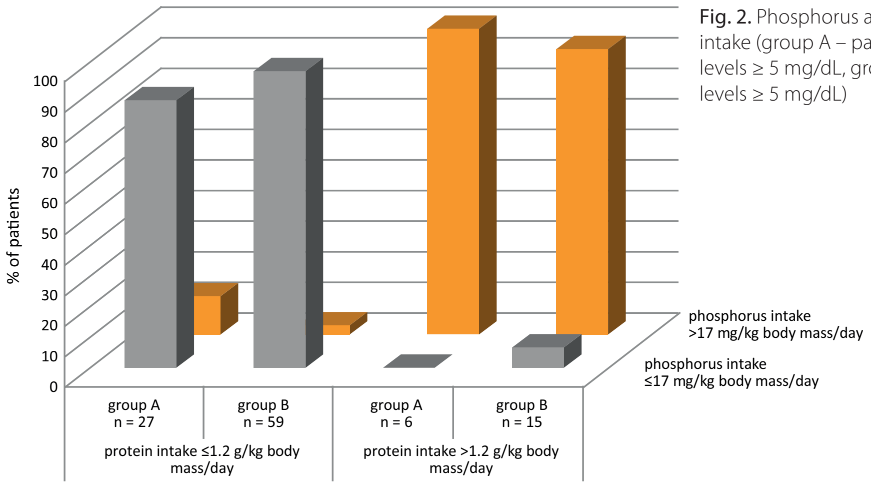

Fig. 2. Phosphorus alignment according to protein and phosphorus intake (group A – patients with less than 50% monthly phosphorus levels ≥ 5 mg/dL, group B – patients with ≥ 50% monthly phosphorus levels ≥ 5 mg/dL)

Table 3. Energy, macro- and micro-nutrient intake in 107 hemodialysis patient diets in comparison to K/DOQI recommendations

Variable	% of patients		
	below recommended level	according to recommendation	over recommended level
Protein intake[a]	62.6	17.8	19.6
Energy intake	82.8	9.5	7.6
Fat intake (% of daily energy)[b]	10.3	16.8	72.9
Carbohydrate intake (% of daily energy)[c]	24.3	74.7	0.9
Fiber intake	81.3	13.0	5.6
Sodium	3.7	26.1	70.0
Potassium	65.4	10.3	24.3
Phosphorus	34.6	42.0	23.4
Calcium	0	18.6	81.4
Magnesium	46.7	35.5	17.7

[a] refers to 1.0–1.2 g/kg body mass/day; [b] refers to 25–30% of daily energy intake; [c] refers to 45–75% of daily energy intake.

Table 4. Energy, macro- and micronutrient intake in HD patients with good and bad phosphorus alignment

Variable	Group A (n = 33)	Group B (n = 74)	p-value
Protein intake (g/kg body mass/day)	0.9 ±0.4	0.9 ±0.6	ns
Energy intake (kcal/kg body mass/day)	23.8 ±12.4	22.2 ±12.5	ns
Fat intake (% of daily energy)	34.6 ±6.0	33.1 ±7.0	ns
Carbohydrate intake (% of daily energy)	50.6 ±7.2	51.4 ±9.2	ns
Dietary fiber intake (g/day)	16.5 ±8.9	13.1 ±6.0	p = 0.06
Sodium intake (mg/day)	3189 ±1619	2789 ±1501	ns
Potassium intake (mEq/day)	68.5 ±34.6	59.6 ±33.4	ns
Phosphorus intake (mg/kg body mass/day)	13.8 ±7.0	13.1 ±7.7	ns
Calcium intake (mg/day)	4102 ±2454	3809 ±2850	ns
Magnesium intake (mg/day)	247 ±129	212 ±106	ns

Best Practice Guideline (EBPG) on Nutrition in Chronic Kidney Disease.[11,12] It should be emphasized that there are several differences between those 2 documents (Table 1), and consensus has not been published yet.

There is limited data in the literature concerning nutrition knowledge and its adequacy to the nutritional recommendations in CKD patients in Poland, and they refer mostly to the non-dialysis population.[13,14] One potential reason that could explain this fact is the difficulty in assessing the nutritional habits and diet of HD patients, mainly due to the need for precise recording of the size and type of food portions when using quantitative methods of diet assessment (a 24-hour diet interview or a 3-day food diary). Qualitative methods of diet assessment such as the DHQ-II questionnaire used in this study may be an alternative in the population of HD patients.

The unbalanced diet of dialysis patients may lead either to the shortage or the excess of specific nutrients.[15] Proper energy intake in HD patients (30 kcal/kg body mass/day for patients ≤60 years of age, and 30–35 kcal/kg body mass/day for those over 60 years according to K/DOQI) is one of the determinants of normal nutritional status, and protects against malnutrition. In the present study, energy intake that was too low was the most common disorder seen in HD patients; it affected more than 80% of respondents. Similarly, energy intake that was too low was observed in 2 other studies using a 24-h diet interview in 92 and 38 Polish HD patients.[16,17] Also in these studies, inadequate protein and fiber consumption was frequently observed. Recently, a paper by Luis et al. reported similar results for the Spanish population. Performing an analysis of 3-day dietary records of 91 HD patients, they observed that only 11% and 15% of patients (based on K/DOQI guidelines and EBPG, respectively) fulfilled the recommended energy intake. This study also showed that a relatively low percentage of patients consumed enough protein and fiber (41% and 22%, respectively).[18] It is more difficult to increase the intake of fiber than of protein. The main sources of dietary fiber are fruits, vegetables, whole grains, and seeds. These sources are often rich also in potassium and phosphorus. However, a limited number of selected fruits (e.g., black currants, red currants, raspberries, white currants, and blackberries) and vegetables (e.g., green peas, broad beans, Brussels sprouts, and celeriac) should be more recommended than others to increase fiber intake (Table 5).

It should be emphasized that a significant association between the state of education concerning kidney diseases and its treatment (including the nutritional aspect), patient compliance and the number of complications (e.g., hyperphosphatemia) was observed.[2,19] In the present study, we did not assess the level of patients' knowledge on diet recommendations specific for the HD population, nor the degree of compliance with the prescribed doses of phosphate-binding drugs, which is one of the limitations of the study.

Despite education regarding the need to limit dietary sources of phosphorus, and common use of phosphate-binding drugs, the percentage of HD patients diagnosed with hyperphosphatemia remains high. In a previously published study, we observed serum phosphorus levels exceeding 5.5 mg/dL in 56% of HD patients.[20] In a recent epidemiological study that assessed the rank of calcium and phosphorus alignment among HD patients in Poland in the years 2003–2009, phosphorus concentrations higher than 6 mg/dL were observed in 51% of patients.[21] With more stringent recommendations, consistent with current NKF K/DOQI criteria, the percentage of people characterized by poorly controlled serum phosphorus levels in the study group was significantly higher, as high as 69%.[21]

It is worth noting that the group with poorly controlled serum phosphorus concentration was significantly younger (on average by 8 years) compared to patients with good alignment, as in the previous study.[20] Both groups had similar doses of oral phosphate binders prescribed, and phosphorus intake from protein. In addition, almost all patients with increased protein intake (>1.2 g/kg body mass/day) consumed excessive amounts of phosphorus. Therefore, the reason for poor serum phosphorus alignment is rather related to the fact that inorganic phosphorus intake (i.e., beverages and highly processed foods) is greater in the younger population.

Table 5. Amount of protein, phosphorous and potassium in fiber-rich fruits, vegetables and seeds (according to Polish tables of composition and nutritional value of food)[23]

Variables	Dietary fiber (g/100 g)	Protein (g/100 g)	Potassium (mg/100 g)	Phosphorus (mg/100 g)
Fruits				
Dried figs	12.9	3.6	938	122
Dried dates	8.7	2.0	688	58
Black currants	7.9	1.3	336	58
Red currants	7.7	1.1	259	33
Raspberries	6.7	1.3	203	33
Dried bananas	6.4	3.8	1493	76
White currants	6.4	1.0	275	23
Avocado	3.3	2.0	600	41
Blackberries	3.2	0.8	62	14
Gooseberries	3.0	0.8	230	26
Vegetables				
Soy (dry seeds)	15.7	34.3	2132	743
White beans (dry seeds)	15.7	21.4	1188	437
Peas (dry seeds)	15.0	23.8	937	388
Red lentils (dry seeds)	8.9	25.4	874	301
Horseradish	7.3	4.5	740	120
Green peas	6.0	6.7	353	122
Broad beans	5.8	7.1	261	57
Brussels sprouts	5.4	4.7	416	33
Parsley root	4.9	2.6	399	77
Celeriac	4.9	1.6	320	80
Seeds				
Poppy seeds	20.5	20.1	963	1022
Sesame seeds	7.9	23.2	387	775
Sunflower seeds	6.0	24.4	793	784
Pumpkin seeds	5.3	24.5	810	1170
Flax seeds	3.9	24.5	762	722

It should be emphasized that the questionnaire used in the study did not take into account the intake of inorganic phosphates, which are often present in large amounts in highly processed foods, and account for a significant percentage of added preservatives (e.g., in meats or soft drinks). These products may be a source of the so-called 'hidden phosphorus', easily absorbed by the gastrointestinal tract.[22] Therefore, in CKD patients the DHQ-II questionnaire cannot be the only tool used to assess phosphorus intake.

Conclusions

Adequate control of protein intake is not sufficient to obtain phosphorus alignment, especially in younger HD patients.

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