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ORIGINAL ARTICLE

ANALYSIS OF NUTRITION AND NUTRITIONAL STATUS OF HAEMODIALYSIS PATIENTS

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ABSTRACT

Background. Chronic kidney disease (CKD) is a common disease of civilization where nutrition is part of the treatment. Diet therapy is difficult as it is necessary to control the intake of: energy, protein and minerals – Na, K, Ca and P in the daily food rations (DFR).

Objective. The aim of the study was to assess the nutritional status and diets of haemodialysis (HD) patients.

Material and methods. The study involved 141 haemodialysis patients, at the average age of 65.9. The patients were divided into groups taking into consideration their sex and diagnosis for diabetes. The information on the diets were collected using a 7-day dietary recall. In the DFRs the amount of energy and 22 nutrients were calculated. Obtained results were compared with requirements for HD patients.

Results. Appropriate nutritional status (measured with BMI) was reported for majority of women (70.6%) and almost half of men, however, excessive weight was recognized in every third female patient and more than half male patients, and type I obesity was noted in 7.8% of men. The analysis of the results showed that diets of all examined patients were deficient in energy and protein (except women with diabetes), whereas the consumption of fat was appropriate in both groups of women. The recommendations with respect to the amount of cholesterol were met but dietary fibre was too low. Intake of vitamins B_1, D, C, folates and Ca and Mg was lower and intake of vitamin B_{12} was higher than recommended.

Conclusions. Assessment of the coverage of the demand on nutrients in HD patients should not be based on the analysis of their nutritional status (BMI) only but also on the analysis of diets, especially in case of diabetes.

Key words: *chronic kidney disease, haemodialysis, nutrition, nutritional status*

STRESZCZENIE

Wprowadzenie. Przewlekła niewydolność nerek jest częstą chorobą cywilizacyjną, w której żywienie jest składową procesu leczenia. Dietoterapia jest trudna, ze względu na konieczność kontrolowania energii i spożycia białka oraz składników mineralnych (Na, K, Ca and P) w całodziennych racjach pokarmowych (CRP)

Cel badań. Celem badań była ocena stanu odżywienia i sposobu żywienia hemodializowanych (HD) pacjentów.

Materiał i metody. W badaniach wzięło udział 141 hemodializowanych pacjentów w wieku średnio 65,9 lat, których podzielono na grupy uwzględniając płeć i obecność cukrzycy. Dane na temat sposobu żywienia zebrano metodą bieżącego notowania z 7 dni. W całodziennej racji pokarmowej wyliczono zawartość energii oraz 22 składników diety. Uzyskane wartości porównano z normami dla HD pacjentów.

Wyniki. Prawidłowe BMI stwierdzono u większości kobiet (70,6%) i niespełna połowy mężczyzn, natomiast u co trzeciej pacjentki i ponad połowy pacjentów rozpoznano nadwagę oraz otyłość I stopnia u 7,8% mężczyzn. Analiza wyników wykazała, że sposób żywienia wszystkich badanych był nieodpowiedni pod względem ilości energii, białka w dietach (wyjątek kobiety z cukrzycą), natomiast spożycie tłuszczu było prawidłowe w obu grupach kobiet. Spełniono zalecenia odnośnie ilości cholesterolu, natomiast błonnika w dietach było za mało. U wszystkich badanych wykazano niższą od zaleceń podaż witamin: B_1, D, C, folianów oraz Ca i Mg; nadmierną witaminy B_{12}.

Wnioski. W ocenie pokrycia zapotrzebowania na składniki diety u HD osób należałoby badać nie tylko stan odżywienia, lecz również sposób żywienia, szczególnie w przebiegu cukrzycy.

Słowa kluczowe: *przewlekła niewydolność nerek, hemodializa, żywienie, stan odżywienia*

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INTRODUCTION

In recent years, in Poland and throughout the world, an increased incidence of chronic kidney disease (CKD) caused by diabetes and hypertension has been observed. The number of people requiring renal replacement therapy is growing. According to the data from the reports of voivodeship nephrology consultants in Poland at the end of 2012, there were 18626 dialysed people (haemodialysis and peritoneal dialysis) and at the end of 2013 – 19420 people. These data indicate the increase by 794 patients [49].

The data of the International Diabetes Federation (IDF) published on 14th of November 2013 showed that 382 million people in the world suffer from diabetes. The prevalence of diabetes is constantly rising. IDF estimates that by 2035 the number of people with diabetes will rise to 592 million [15]. In many countries, including Poland, diabetes is the cause of serious complications leading to disability. Due to kidney failure in the course of diabetes more than 3.5 thousand patients are permanently included in the programs of persistent dialysis treatment. Half of those patients suffer from coronary artery disease and 2/3 of deaths of diabetics are caused by cardio-vascular complications [18].

In the last decade, many research studies have reported the existence of the relationship between protein-energy malnutrition and the increase of morbidity and mortality in the group of dialysed patients [41, 44]. Disorders accompanying uremic toxaemia may, along with progressing impairment of kidneys function, affect nutritional status of the patients. In advanced kidney failure there are tendencies for negative nitrogen balance and loss of muscle mass, which in consequence can lead to cachexia.

The aetiology of malnutrition in chronic kidney failure is complex. Bad nutritional status can be attributed to diet restrictions in pre-dialysis period, appetite loss and increased catabolism in dialysis period [31]. Not adhering to dietetic recommendations contributes to low consumption of nutrients, including vitamins, bioelements and energy. Diet intended for dialysis patients is often unaccepted due to its limitations. Moreover, social factors affect the development of malnutrition in this group of patients. The necessity of dialyses forces the patients to resign from work. In consequence, financial restrictions affect the choice of a diet. Reduced absorption of food in patients is observed during the days when dialyses are performed. The patients miss healthy and nutritious meal due to the visit in hospital for dialysis.

Appropriate nutrition is crucial for the health and is important part of the treatment in chronic kidney disease, which causes many metabolic disturbances. One of the qualities of a proper diet is to maintain optimal body weight.

Nutritional mistakes made by dialysis patients may contribute to deterioration of the health. Education and monitoring of the diets and nutritional status of the patients might help to point out the irregularities and enable to correct them, and thus would contribute to improvement in health and quality of life during the treatment.

The goal of this study was to assess the nutritional status and analyse daily food rations of haemodialysis patients.

MATERIAL AND METHODS

The study involved 141 haemodialysis patients treated in several dialysis stations of West Pomeranian Voivodeship. The patients were divided into groups taking into consideration their sex and diagnosis for diabetes: I group – 36 W (66.5 ± 12.1 years old), II group – 15 W with diabetes (69 ± 9.6 years old), III group – 61 M (60.2 ± 10.7 years old), IV group – 29 M with diabetes (68.0 ± 10.2 years old).

The patients were haemodialyzed regularly for at least 3 months (3-18 months). The average time of dialysis treatment was 13 months. All the patients were dialyzed for 3-5 hours three times a week using Fresenius dialysis machine (Homburg, Germany) with polysulfone-based dialysers.

The nutritional status was determined for all the patients based on the body mass index (BMI). It was calculated considering dry body weight (after dialysis). BMI results were interpreted using WHO classification. The range 18.5-24.9 was considered as proper [47].

The assessment of the content of energy and nutrients in daily food rations (DFR) was based on weekly menus noted on ongoing basis by the patients on the days with and without dialysis on an especially prepared questionnaire. 987 menus were analysed using Aliant software (Anmarsoft) based on "Tables of components and nutritional value of food products" [29]. The results were compared with current standards for HD patients considering the recommendations for a diet for diabetics [13, 19]. The size of food ratio was determined using "Photo album of products and dishes" [43]. Diet supplements were not considered in nutritional assessment.

Normality of the analysed variables were tested with the *Kolmogorov–Smirnov Chi*-squared tests at the level of $p<0.05$. Since the distributions varied from normality, to compare the values of analysed parameters within the given sex between the subgroups with and without diabetes, a nonparametric *Mann–Whitney* U test was used. The level of statistical significance was $p < 0.05$. The analyses were performed using Statistica 12 (StatSoft Inc.).

RESULTS AND DISCUSSION

Malnutrition is the most common nutritional disorder during dialysis therapy. Table 1 presents the percentage of examined patients fitting into selected ranges of BMI, an index assessing the nutritional status of patients from particular groups.

Table 1. Percentage of patients with proper and improper body mass index (BMI)

BMI [kg/m^2]	Women (n=51)		Men (n=90)	
	No diabetes	With diabetes	No diabetes	With diabetes
< 18.5	0	0	0	0
18.5 – 24.99	49	21.6	22.2	18.9
25 – 29.99	21.6	7.8	45.6	5.5
30 – 34.99	0	0	0	7.8

In the group of examined patients, 70.6% of women had proper body weight (without diabetes n=25 and with diabetes n=11), as well as 41.1% of men (without diabetes n=20 and with diabetes n=17). Excessive body weight was noted in 29.4% of women (without diabetes n=11 and with diabetes n=4) and type I obesity was observed only in case of 7 men with diabetes.

Other authors in their studies observed initial BMI between 20 and 25 kg/m^2 in majority of the patients [32, 37], and also below 20 kg/m^2 in case of some of them [30, 39]. The review of the literature presented the results of studies indicating systematic body weight loss in chronically haemodialysis patients [40]. Numerous reports confirm that BMI below 25 kg/m^2 is a risk factor of increased mortality in this group of patients [12, 14, 20]. Moreover, Park et al. showed increased survival of dialysis patients with excessive weight (BMI 25-30) or obese (BMI>30) [33].

Appropriate amount of energy in a diet should be provided to maintain desirable body mass of the patients and to limit the process of gluconeogenesis and prevent protein catabolism. Adequate intake of protein is crucial to keep proper nutritional status. Moreover, meals should be small in volume and quantity and they should be consumed at regular intervals during the day. As shown by Cotton, too high one-time supply of protein in case of patients with CKD may lead to accumulation of ammonia in blood (hyperammonaemia) [8].

In this study, the average intake of energy, basic nutrients and vitamins and minerals was compared between the patients with CKD and diabetes and those with CKD without diabetes (Tables 2-5).

An insufficient supply of calories and protein was determined in DFRs of most of the patients participating in this study. The average energy load of DFR in both groups of women was lower than recommended, despite excessive body weight, and it was, on average: 1436.1 ± 434.2 kcal/day in group of women without diabetes (75.4% of the norm) and 1533.5 ± 515.5 kcal/day in group of women with diabetes (89.0% of the norm). The average energy load in DFR in male group was also lower than recommended and amounted to 1461.7 ± 512.5 kcal/day in the group of men without diabetes and 1660.5 ± 61.8 kcal/day in the group of men with diabetes. The supply of energy differed significantly between male groups. In this work the energy from glucose contained in dialysis fluid was not considered, but it can amount to 30% of energetic demand.

Proper consumption of protein was only observed in female group with diabetes. The demand for protein in this group was realized in 95.2%, whereas in the group of women without diabetes - in 77.8%. The highest intake of protein was noted in the group of men with diabetes (62.5 ± 24.2 g/day) and it was significantly higher than in the group of men without diabetes (53.9 ± 21.3 g/day).

The prevalence of protein-energy deficiencies in diets of dialysis patients was confirmed in many Polish [22, 28, 46] and foreign studies [1, 7, 16]. However, *Chazot* et al., based on 5-year observations of the diets of HD patients aged above 60 reported that the intake of energy and protein was at recommended level [6]. The results of another research performed in 2017 did not confirm the results of *Chazot* et al. It was shown that the consumption of energy and protein by HD patients was lower than recommended [20].

The average consumption of fat in DFRs of examined female patients (both groups) was in accordance with the recommendations and amounted to 69.7 ± 11.0 g/day in group of women without diabetes (105.6% of the norm) and 60.9 ± 25,6 g/day in group of women with diabetes (101.5% of the norm). The average content of fat in men's diets was similar to that of women's, however, due to higher demand, the requirement was not sufficiently met (in 69.9% and 89.5%). Moreover, the differences in fat intake in men's diets were statistically significant. High consumption of this component in haemodialysis patients was noted in studies by *Arslan* et al. [2] and *Kardasz* and *Ostrowska* [22]. High-fat diet containing saturated fatty acids is one of the causes of atherosclerotic changes in vessels, including those in kidneys, which in turn increase the risk of MIA (malnutrition-inflammation-atherosclerosis) syndrome.

The average content of cholesterol in patients' diets was in accordance with the recommendations (<300 mg/day). The consumption for this component in women's diets was at a similar level (242.6 ± 82.3 mg without diabetes and 234.0 ± 131.4 mg with diabetes), whereas in group of men without diabetes (185.6 ± 171.5) mg the intake was significantly lower than in group of men with diabetes (266.3 ± 170.6 mg). Among examined patients there were people who exceeded upper limit of recommended intake. These were 4 women without diabetes (11.1%), 4 women with diabetes (26.7%), 10 men without diabetes (16.4%) and 6 men with diabetes (20.7%). In those patients, high consumption of cholesterol might have contributed to high level of LDL in blood, which could affect the development of cardiovascular diseases [2].

Table 2. Energetic value and content of basic nutrients in DFRs of haemodialysis patients

Component	Indexes	Women		Men	
		No diabetes	With diabetes	No diabetes	With diabetes
Energy [kcal/day]	average ± SD	1436.1 ± 434.2	1533.5 ± 515.5	1461.7 ± 512.5*	1660.5 ± 61.8*
	min. - max.	242.6 – 2410.0	437.3 – 3075.6	598.7 – 3149.5	217.8 – 4161.7
	% of norm	75.4	89.0	55.0	72.0
Protein [g/day]	average ± SD	50.2 ± 16.2	55.5 ± 21.2	53.9 ± 21.3*	62.5 ± 24.2*
	min. - max.	10.2 – 100.6	12 – 118.7	20.2 – 136.1	3.6 – 169.7
	% of norm	77.8	95.2	59.9	80
Fat [g/day]	average ± SD	69.7 ± 11.0*	60.9 ± 25.6*	60.1 ± 27.2*	68.0 ± 34.7*
	min. - max.	45.9 – 97.5	8.6 – 155.1	12.5 – 159.6	1.8 – 207.3
	% of norm	105.6	101.5	69.9	89.5
Carbohydrates [g/day]	average ± SD	298.7 ± 104.5*	208.1 ± 78.5*	213.7 ± 86.0	218.1 ± 86.2
	min. - max.	53.8 – 530.7	69.9 – 460.4	59.8 – 503.1	54.3 – 497.5
	% of norm	100.6	70.1	68.9	70.4
Cholesterol [mg/day]	average ± SD	242.6 ± 82.3	234.0 ± 131.4	185.6 ± 171.5*	266.3 ± 170.6*
	min. - max.	132.1 – 438.8	28.1 – 957.1	0 – 972.7	0 – 867.1
Fibre [g/day]	average ± SD	12.8 ± 4.7*	18.2 ± 6.3*	13.0 ± 5.1*	19.6 ± 6.6*
	min. - max.	3.2 – 24.6	5.5 – 37.9	4.7 – 30.8	9.1 – 40.5
	% of norm	42.7	60.7	43.3	65.3

*significance of differences p<0,05

Recommended intake of carbohydrates is no lower than 130 g. Such amount ensures proper function of central nervous system and erythrocytes. In this study, a proper intake of carbohydrates was observed in both groups of women and men (at the average level of 253.4 g in women and 215.9 g in men). The average content of carbohydrates in diets of women with and without diabetes differed significantly. Among the examined patients there were 35 people (9W without diabetes, 3W with diabetes, 15M without diabetes, 8M with diabetes) who consumed less than 130 g of carbohydrates. Insufficient consumption of total carbohydrates in chronic dialysis patients was also reported by other authors [22, 36]. In case of insufficient amount of carbohydrates in a diet the metabolism of fats is incomplete. It promotes the accumulation of ketones and, in consequence, the development of metabolic acidosis. Acidosis increases anorexia, reduces the synthesis of albumins, increases the release of cortisol and enhances protein catabolism, thus intensifying malnutrition and muscle mass loss [27, 48].

Analysis of the menus showed low consumption of dietary fibre in all groups of examined patients, regardless of their sex. Significantly lower intake of dietary fibre was noted in groups of patients without diabetes (on average 12.9 ± 4.9 g/day) in comparison to patients with diabetes (on average 18.9 ± 6.5 g/day). These results are similar to that of others [22, 37].

Insufficient consumption of the majority of main nutrients resulted in the fact that the structure of energy from macronutrients in examined diets was inappropriate (Table 3). There was too little share of energy coming from carbohydrates and proteins and the average percentage of energy from fats exceeded recommendations. The results were confirmed by other authors [22, 32, 36]. Other results were obtained by dos Santos et al., who observed proper intake of energy from carbohydrates and fats [11].

Table 3. The structure of consumed energy in examined groups of patients

Source of energy	Women		Men	
	No diabetes	With diabetes	No diabetes	With diabetes
protein	14	14.5	14.8	15.1
fat	43.7*	35.7*	37	36.9
carbohydrates	42.3*	49.8*	48.2	48

*significance of differences with p<0.05

In patients' DFRs the contents of almost all analysed mineral compounds were low, except sodium in group of men without diabetes, potassium, iron and copper in dialysis patients with diabetes, and zinc in women with diabetes (Table 4).

Table 4. Average content of selected mineral elements in DFRs of haemodialysis patients

Element	indexes	Women		Men	
		No diabetes	With diabetes	No diabetes	With diabetes
Sodium [mg/day]	average ± SD	1605.7 ± 609.2*	1445.7 ± 694.6*	1978.4 ± 866.6*	1643.9 ± 943.1*
	min. - max.	172.6 - 3755.2	333.5 - 4168.7	407.9 - 4949.6	180.0 - 5977.6
	% of norm	74.7	67.2	92.0	76.5
Potassium [mg/day]	average ± SD	1734.2 ± 755.8*	2578.9 ± 940.9*	1690.1 ± 671.9*	2661.6 ± 900.1*
	min. - max.	428.1 - 5082.1	592.3 - 4821.5	587.6 - 4016.9	946.6 - 6274.3
	% of norm	77.1	114.6	75.1	118.3
Phosphorus [mg/day]	average ± SD	771.1 ± 265.4*	884.2 ± 318.7*	787.9 ± 321.0*	960.7 ± 359.4*
	min. - max.	158 - 1409.8	223.1 - 2091.1	262.9 - 1859.1	109.8 - 2026.8
	% of norm	64.3	73.7	65.7	80.0
Calcium [mg/day]	average ± SD	373.8 ± 199.6	431.2 ± 308.4	214.8 ± 221.3*	394.6 ± 257.8*
	min. - max.	40.9 - 1268.1	59.3 - 2243.5	41.2 - 1357.1	95.4 - 1503.7
	% of norm	29.9	34.5	17.2	31.6
Iron [mg/day]	average ± SD	6.6 ± 2.5*	8.8 ± 3.5*	7.3 ± 3.1*	9.1 ± 3.8*
	min. - max.	1.6 - 13.2	3.3 - 22.9	2.8 - 19.7	2.3 - 32.2
	% of norm	66.0	88.0	73.0	91.0
Magnesium [mg/day]	average ± SD	176.6 ± 77.7*	217.9 ± 76*	172.3 ± 78.8*	215.8 ± 82.3*
	min. - max.	30.8 - 444.9	67.9 - 436	54.2 - 463.4	61.2 - 523.9
	% of norm	55.2	68.1	41	51.4
Zinc [mg/day]	average ± SD	6.1 ± 2.2*	7.3 ± 2.7*	6.8 ± 2.4*	8.2 ± 3.0*
	min. - max.	1.4 - 12.5	2.3 - 16.2	2.9 - 14.2	1.3 - 20.2
	% of norm	76.3	91.3	61.8	74.5
Copper [mg/day]	average ± SD	0.7 ± 0.3*	0.9 ± 0.3*	0.7 ± 0.3*	1.0 ± 0.3*
	min. - max.	0.1 - 1.7	0.3 - 1.7	0.2 - 1.5	0.4 - 2.1
	% of norm	77.8	100.0	77.8	111.1

*significance of differences with $p<0.05$

The intake of sodium in group of men without diabetes fully covered daily demand. The realization of the norm at the average level of 72.8% in other groups may be regarded as sufficient. Statistical analysis showed significantly lower sodium content in diets of people with diabetes in comparison to diets of people without diabetes. Healthy kidneys participate in water-electrolyte balance regulation. In chronic kidney disease the excretion of sodium is disrupted, thus is it necessary to limit its intake with the diet. Moreover, excessive amount of sodium can strengthen already existing sodium-related hypertension and contribute to formation of oedema due to accumulation of water in tissues. In this study, in the DFRs an appropriate or lower than recommended amount of sodium was noted, although potential additional salting of meals was not considered. There are various data reported in the literature. The intake of sodium exceeding recommended amounts was observed by Jin Woo and *Nam-Ho* [20]. On the other hand, diets analysed by *Bataille* et al. and *Bossola* et al. contained lower than recommended amounts of this element [3, 5].

Taking into consideration the necessity for haemodialysis patients to limit potassium, the consumption at the level of 1700 mg/day by patients without diabetes can be regarded as proper. The amount of this element was significantly lower in diets of examined patients without diabetes than in those of patients with diabetes. The average consumption of potassium in DFR of patients with diabetes was higher than recommended and amounted to 2578.9 ± 940.9 mg/day in group of women and 2661.6 ± 900.1 mg/day in group of men. Haemodialysis patients have a tendency for hyperkalaemia, which is one of the most important issues. Reduction in the consumption of potassium is usually achieved by limiting or excluding fruits and vegetables from DFR. It is suggested to reduce the consumption of one large portion per day to two portions of cooked fruits without juice or two small portions of vegetables and salads [35]. Other authors recommend decreasing the intake of potassium by entire elimination of fruits and vegetables from daily menus [34]. Own studies showed that patients without diabetes usually completely resigned from these groups of products in diet, thus the intake of potassium was 1700 mg/day. Such radical limitations may contribute to deficiencies in vitamins, minerals and bioflavonoids, so they are not a good solution.

The results of the study indicate low content of calcium in the diets. The amount of calcium in DFRs of women was on average 402.5 mg, and in case of men – 304.7 mg, versus the recommended 1000 – 1500 mg/day. The lowest intake was noted in group of men without diabetes (214.8 mg) and it was significantly lower than the amount of this element in diets of men with diabetes (394.6 mg). Similar low intake of calcium was reported by *Bossola* et al. [5] and *Sanlier* and *Demircioglu* [37]. Higher consumption of this bioelement than in this study was observed by *Jin Woo* and *Nam-Ho* [20]. Those levels, however, did not exceed recommended daily intake. That was probably caused by reduced consumption of protein with the diet (hence its small intake). Similar relations were observed by other authors [5, 7, 37].

The consumption of phosphorus was lower than suggested by diet recommendations for haemodialysis patients and was, on average, 827.7 mg in female group and 874.3 mg in male group. There were significant differences in phosphorus intake between the patients with and without diabetes. Results obtained by other authors vary. Appropriate or only slightly higher than recommended intake of phosphorus in patients' diets was observed by *Kardasz* et al. [24], whereas *Cupisti* et al. [9] reported its low intake. Hyperphosphatemia is a challenge for the professionals taking care of a patient due to its role in pathogenesis of hyperparathyroidism and calcification. The most common cause is excessive intake of potassium, which is mainly supplied by products rich in protein. However, reduction of protein intake as a method to decrease hyperphosphatemia cannot be recommended for most patients, due to the necessity of replenishing the losses of amino acids and proteins during dialysis. Because phosphorus is ubiquitous in food and diet restrictions are of little effect, there are medications used to bind phosphates in alimentary tract. Moreover, it was shown that hyperphosphatemia decreases with age. It is explained on one hand by worse nutritional status of the patient and on the other hand by more systematic intake of medications binding phosphates in alimentary tract [34].

Despite intensive research on the mechanisms of phosphates absorption from digestive tract and on searching for new drugs, the basic measure against hyperphosphatemia is still to follow diet recommendations. Disrupted balance between parathormone and the levels of calcium, phosphorus and vitamin D is the main cause of vascular calcification and higher risk of death. It should be stressed that avoiding foods containing very large amounts of phosphorus, such as dairy foods, some drinks, meat products, peanuts and products containing baking powder, is still an important therapeutic method for haemodialysis patients [38].

The content of magnesium in food ratios of patients was low and did not exceed 62% of recommended amount in female groups and 60% in male groups. It was shown that the average magnesium intake with diets in patients without diabetes was significantly lower than in case of patients with diabetes, regardless of sex. The main source of magnesium in average food ratio of Poles are grain products, milk and milk products and potatoes. Patients with chronic kidney disease often resigned from these diet components due to the presence of phosphorus and potassium. Studies on nutrition among healthy people report that the intake of magnesium is much lower than recommended. In this study, in DFRs of HD patients an insufficient content of magnesium was also observed. Similar low intake of this element was noted by other authors [9, 37].

Zinc plays a key role in maintaining proper nutritional status in dialysis patients. Deficiency of zinc in blood may be displayed by the loss of appetite, taste disturbances, growth inhibition or slower wound healing. *Kardasz* et al. observed lower concentration of zinc in blood plasma of dialysis patients than in healthy people. They attributed it to low intake of the bioelement with the diet and increasing renal failure [24]. In this study, too small amount of Zn in DFRs of almost all groups of patients was also observed, except women with diabetes. The average consumption of zinc by dialysis patients without diabetes was significantly lower than by patients with diabetes. Daily average intake of this element in men was 7.5±2.7 mg and in women – 6.7±2.5 mg. Comparable too low intake of zinc was reported by other authors [5, 37, 45].

Copper is a component of many enzymes. Appropriate level of this bioelement in a body is maintained through adequate absorption from alimentary tract and its amount contained in food ratio. Copper with zinc are components of superoxide dismutase, which has antioxidative activity. Both elements thus indirectly participate in sweeping free radicals away. Their insufficient intake with a diet can be the cause of reduced activity of SOD. In this study the consumption of copper in haemodialysis patients with diabetes was assessed as proper, but in case of patients without diabetes it was significantly lower (80% of the norm). Similar results were obtained by *Cupisti* et al. [9], whereas in the study of *Szpanowska-Wohn* et al. the consumption of copper was particularly low – not reaching 40% of recommended value [42].

Similar to the works of other authors, here it was shown that the consumption of iron in DFR was low [5, 24, 26]. Proper intake of this element was noted in group of men with diabetes (91% of the norm). Diets of patients with diabetes contained significantly more iron than diets of patients without diabetes. Too low amount of iron in diets of haemodialysis patients with additional insufficient intake of folic acid and vitamin B_{12} may be one of the cause of anaemia in this group of patients. People treated with dialysis lose iron due to bleeding from the digestive tract, giving blood samples for frequent blood tests or due to haemodialysis itself. Iron losses are estimated to ca. 3 g per year [21].

Table 5. Average content of vitamins in DFRs of examined haemodialysis patients

Component	indexes	Women		Men	
		No diabetes	With diabetes	No diabetes	With diabetes
vitamin A [μg/day]	average ± SD	665.4 ± 686.8	960.8 ± 1503.8	633.5 ± 852.9*	870.4 ± 735.2*
	min. - max.	57.3 - 5853.5	146.2 - 11908.8	46.7 - 8235.5	36.4 - 3978.8
	% of norm	95.1	137.3	70.4	96.7
vitamin D [μg/day]	average ± SD	2.8 ± 2.1*	2.0 ± 2.0*	3.2 ± 2.1*	3.5 ± 5.4*
	min. - max.	0.8 - 18.7	0.1 - 14.3	0.2 - 18.4	0 - 46.3
	% of norm	18.7	13.3	21.3	23.3
vitamin E [mg/day]	average ± SD	9.4 ± 4.2*	6.2 ± 3.4*	9.6 ± 4.7*	7.0 ± 4.5*
	min. - max.	1.3 - 21.5	1.6 - 20.0	1.0 - 26.1	0.6 - 29.9
	% of norm	117.5	77.5	96.0	70.0
vitamin B1 [mg/day]	average ± SD	0.7 ± 0.3*	0.8 ± 0.3*	0.8 ± 0.3*	1.0 ± 0.4*
	min. - max.	0.1 - 1.6	0.2 - 2.1	0.3 - 2.2	0.2 - 2.4
	% of norm	63.6	72.7	61.5	76.9
vitamin B2 [mg/day]	average ± SD	0.9 ± 0.4*	1.1 ± 0.6*	0.9 ± 0.4*	1.1 ± 0.5*
	min. - max.	0.2 - 2.1	0.2 - 4.4	0.3 - 3.1	0.2 - 3.1
	% of norm	81.8	100.0	69.2	100.0
vitamin B6 [mg/day]	average ± SD	1.1 ± 0.5*	1.5 ± 0.6*	1.2 ± 0.5*	1.7 ± 0.7*
	min. - max.	0.3 - 3.4	0.4 - 3.0	0.4 - 3.2	0.4 - 4.2
	% of norm	73.3	100.0	70.6	100.0
vitamin B12 [μg/day]	average ± SD	2.7 ± 4.0	3.0 ± 5.8	2.9 ± 4.9	3.5 ± 4.7
	min. - max.	0.1 - 26.7	0.1 - 48.5	0.3 - 50.0	0 - 31
	% of norm	112.5	125.0	120.8	145.8
Folates [μg/day]	average ± SD	107.9 ± 44.5*	158.3 ± 94*	102.0 ± 46.8*	144.7 ± 55.7*
	min. - max.	20.5 - 339.5	47.5 - 748.5	32.3 - 340.4	47.0 - 310.0
	% of norm	26.9	39.6	25.5	36.2
vitamin C [mg/day]	average ± SD	29.1 ± 28.3*	54.1 ± 36.0*	21.0 ± 20.8*	42.7 ± 26.9*
	min. - max.	0 - 149.3	0.5 - 198.0	0 - 105.3	8.9 - 119.6
	% of norm	38.8	72.1	23.3	47.4

*significance of differences with $p<0.05$

Anaemia is a significant problem in the group of patients with CKD treated with repeated haemodialysis. Obtaining and maintaining proper levels of iron in a body is a key factor to produce and keep target level of haemoglobin in blood. Therefore, intravenous and oral administration of iron is used to treat anaemia [21]. Moreover, proper iron stores are essential to receive maximal advantages from using erythropoietin.

Haemodialysis patients are susceptible to deficiencies in water soluble vitamins, especially vitamin C, folic acid and B vitamins. Table 5 presents the average content of selected vitamins in DFR of haemodialysis patients.

Low content of water soluble vitamins was noted in analysed menus. Only in case of vitamin B_{12} the consumption covered daily demand of women and men, and did not statistically differ between the groups. The demand for vitamins B_2 and B_6 was also covered in patients with diabetes. Average content of vitamin B_1 in DFR of haemodialysis patients without diabetes was significantly lower than in case of patients with diabetes and amounted to, respectively, W 0.7 ± 0.3 mg/day and M 0.8 ± 0.3 mg/day. and W 0.7 ± 0.3 mg/day and M 1.0 ± 0.4 mg/day. Insufficient consumption of thiamine among haemodialysis patients was shown in other studies [7, 25]. *Cupisti* et al. observed higher by ca. 10% intake of vitamin B_1 in diet of haemodialysis patients in comparison with the control group (healthy people). In the same study it was noted that both haemodialysis and healthy people consumed meals with proper content of riboflavin [9]. In this study it was shown that patients with diabetes consumed significantly higher amounts of vitamins B_2 and B_6 than the groups without diabetes. For patients with diabetes, the average content of these vitamins in diets met the requirements in 100%. The average consumption of these two vitamins in groups without diabetes was within 70-80% of the norm. Inadequate fulfilment of the recommendations was shown by *Cho* et al. [7] and *Jankowska* et al. [17]. Here, high intake of vitamin B_{12} with diets of examined people confirms the results obtained by *Kardasz* et al. [23]. However, *Jankowska* et al. [17] and *Alshatwi* et al. [1] in their studies observed low intake of this vitamin in haemodialysis patients, which can increase the risk of megaloblastic anaemia.

Analysis of menus revealed very low intake of folates and vitamin C in all the patients. The average content of both these vitamins was significantly higher in groups with diabetes than in people without diabetes, regardless of the sex. The requirement for folates in groups without diabetes was met at the level of 25%, whereas in case of patients with diabetes – in almost 40%. Moderate hyperhomocysteinaemia is often observed among dialysis patients. It is a risk of cardiovascular diseases and relates to, among others, low concentration of B vitamins and folic acid in blood plasma. The studies performed by *Delfino* et al. proved that oral supplementation with folic acid (10 mg/day for 2 years) reduces the concentration of homocysteine by almost 70% [10]. *Bayes* et al. used folic acid at that dose three times a week. Besides decreasing the level of homocysteine by 44% he also achieved the reduction in malondialdehyde (MDA) by 40% [4]. The results suggest that folic acid has an indirect antioxidative activity by decreasing peroxidative activity of homocysteine, which leads to reduced oxidative stress. The highest intake of vitamin C was observed in HD women with diabetes (54.1 ± 36.0 mg/day, which met the recommendations in 72.1%).

Proper level of fat soluble vitamins: E and A, in a diet is important due to their antioxidative role in the organism. In this study it was shown that the intake of these vitamins met the requirements in most of examined groups. The average intake of vitamin A in group of men was significantly higher for patients with diabetes than those without. DFRs of haemodialysis patients without diabetes contained significantly higher levels of tocopherol than diets of patients with diabetes, regardless of the sex. Similar results were obtained by other authors [7, 37]. However, some authors reported reduced content of vitamin E [17] and vitamin A [5, 25] in the diets.

Due to the role of vitamin D in the regulation of calcium-phosphorus balance it should be supplied at proper amounts in DFR, especially in dialysis patients. Numerous studies confirm lower than recommended intake of vitamin D in the group of haemodialysis patients [3, 17, 37].

CONCLUSIONS

1. The results of this study indicate the need for nutritional education for haemodialysis patients, especially those with diabetes, due to numerous mistakes related to energy consumption, intake of main nutrients, vitamins and mineral compounds.
2. Adherence to diet recommendations may prevent or decrease the risk of complications of chronic kidney disease and improve the quality of life of chronic patients.

Conflict of interest

The authors declare no conflict of interest.

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