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Nutritional status of hemodialysis patients

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Abstract

Hemodialysis patients are vulnerable population group and they, among other, should take special care on food and fluid intake with emphasis on energy, potassium, phosphorus, sodium and protein intake. The nutritional status of patients (n=14) was assessed through measurement of body weight, body height, upper arm circumference, lower leg circumference and handgrip dynamometry; as well as selected biochemical parameters: urate concentration, calcium and phosphate levels, total protein, creatinine, albumin and globulin ratio and C-reactive protein; and dietary assessment method: 3-day food record (3DD). Using range between 18.5 and 24.9 kg/m^2 as cut-off, 35.7 and 57% of patients were classified as adequately nourished and overweight, respectively. According to results of 3DD, most of the subjects are supposed to align their micro- and macro- nutrients intake with the recommendations, with emphasis on the increasing intake of protein and energy as well as on decreasing intake of potassium, phosphorus, sodium and energy.

Keywords: *hemodialysis, nutritional status, food intake, 3-day dietary record*

Sažetak

Pacijenti na hemodijalizi su osjetljiva skupina bolesnika koji u prehrani posebnu pažnju trebaju obratiti na unos nutrijenata i tekućine s naglaskom na ukupan unos energije, kalija, fosfora, natrija i proteina. U ovom radu provedena je procjena nutritivnog statusa 14 pacijenata mjerenjem (I) antropometrijskih parametara: tjelesne mase i visine, opsega nadlaktice i lista te dinamometrije šake; (II) biokemijskih parametara u serumu: koncentracija urata, kalcija i fosfata, ukupnih proteina, albumina, kreatinina, C-reaktivnog proteina te omjer albumina i globulina; kao i primjenom (III) dijetetičke metode: trodnevni dnevnik prehrane (3DD).

Istraživanje je pokazalo da je 57% uključenih ispitanika imalo prekomjernu tjelesnu masu, dok ih je 35,7% bilo adekvatno uhranjeno. Prema rezultatima provedenog 3DD-u vidljivo je da bi većina ispitanika svoj unos makro i mikronutrijenata trebala uskladiti s preporukama, a poseban naglaska stavlja se na povećavanje unosa proteina i energije te smanjivanje unosa kalija, fosfora i natrija.

Ključne riječi: *hemodijaliza, nutritivni status, prehrambeni unos, trodnevni dnevnik prehrane*

Introduction

Acute and chronic renal failures are the most common renal function disorders which can lead to renal function replacement therapy. This kind of therapy includes hemodialysis and peritoneal dialysis, while kidney transplantation is applied in terminal stage of renal failure. While acute renal failure can be cured in most cases by applying the proper therapy with more than 90% of patients keeping renal function, the only option for patients with chronic renal failure and hemodialysis is the the replacement therapy (Štimac, 2014). More than 16000 cases of renal failure and 229 deaths caused by chronic renal failure were registered in Croatia in 2012. Every year 600-700 new patients in Croatia start hemodialysis treatment (Čala et al., 2007), emphasising the importance of dealing with this condition. One of the most common complications in patients on hemodialysis is malnutrition implying inadequate nutrient and energy intake (NKF, 2000). Malnutrition is diagnosed in 30-40% of patients with renal failure and causes high morbidity and mortality rate in the hemodialysis population (Wright & Jones, 2011). Additionally, there is a wide range of disorders caused by renal malfunction including fluid disorders, electrolyte imbalance, hypercalcemia, hyperphosphatemia and hyperlipidaemia (Žura & Šakić, 2013), while hemodialysis causes energy imbalance, protein degradation and loss of amino acids (Hudorović et al., 2011). In order to minimize the negative consequences of hemodialysis, nutrition must be adjusted and individualised for the patients together with regular conducting of nutritional assessment (Wright & Jones, 2011). The main goals of nutrition therapy for patients on hemodialysis are to satisfy nutritional needs, prevent malnutrition and avoid numerous complications caused by chronic kidney disease (Kondrup et al., 2003). The main dietary recommendations refer to fluid, salt, pro-

tein, potassium, calcium, and phosphorus intake. Nutritional intake for the hemodialysis population should provide daily energy intake of 30 to 35 kcal/kg body mass, while daily intake of macronutrients should be 1.2-1.5 g/kg body mass of protein, ≤30% of recommended daily energy intake of fats and 55-60% of recommended energy intake for carbohydrates. Patients should have 3-5 meals per day while one meal during a hemodialysis treatment is obligatory. Daily intake of sodium should be 1800-2500 mg, potassium 200-2500 mg, phosphorus 800-1000 mg and recommendation for calcium is not to exceed 1500 mg. If phosphate binders are used, daily intake of calcium can be increased to 2000 mg. Daily intake of fluids should be 1000 mL with additional intake for daily urinary excretion. Approach to every patient should be individualized, and should rely on patient's biochemical laboratory results (Official Gazette, 2015). Among the population on hemodialysis, it is very important to maintain the optimal serum phosphate concentration. Together with avoiding the food naturally rich with phosphorus very important is food preparation. As it was observed earlier food preparation such as boiling in water and stewing in oil containing some water can significantly reduce the phosphorus content without impact on protein content (Vrdoljak et al., 2015). Biochemical methods are tools used for indirect estimation of nutritional protein intake and can be used as clinical criteria in diagnosing malnutrition. Research shows that serum albumin is a strong mortality predictor for patients on hemodialysis (Iseki et al., 1993) while hypoalbuminemia is often associated with high total mortality rate and cardiovascular mortality of patients on hemodialysis (Fouque et al., 2007). Patients with high serum CRP levels and diagnosed malnutrition have a higher mortality risk (Hung et al., 2005). Low serum creatinine level is an indicator of bad nutritional status and negative disease outcome (Heimburger et al., 2000), while high serum creatinine level is a result of low glomerular filtration rate (Štolić, 2010).

The aim of this study was to perform screening of a nutritional intake and nutritional status of the patients suffering from chronic kidney failure undergoing dialysis in Brod-Posavina County.

Subjects and Methods

Subjects

The study was conducted at General Hospital "Dr. Josip Benčević", Slavonski Brod, during April 2016. It included 14 patients, both male (n=9) and female (n=5), aged from 50 to 83, suffering from chronic kidney failure and undergoing hemodialysis lasting from 39 to 363 months. All patients underwent hemodialysis three times per week (Monday, Wednesday and Friday) in duration of 4-5 hours. Dialysis was performed using bicarbonate solution on high- and low-permeability polysulfonate dialysers with standard flow rates of blood and dialysate. The dialysate contained 0.5 mmol/L magnesium, 2.0 mmol/L potassium and 1.25–1.50 mmol/L calcium. All patients included were informed with the research protocol, participated voluntarily and signed a written informed consent before the start of the study. The study was conducted in accordance with the principles of the Declaration of Helsinki, and the study protocol was approved by the ethics committee. Patients were prepared for the therapy according to the protocol what, among other included consumption of the meal prepared in the hospital before and after undergoing the hemodialysis according to recommendations for special diet for patients on hemodialysis (Official Gazette, 2015).

During the hemodialysis general questionnaire and functional measurements were conducted with patients, instruction for dietetic methods were provided and after the hemodialysis anthropometric measurements were performed.

Anthropometric methods

Anthropometric measurements were performed within 30 minutes from hemodialysis. For every parameter 3 consecutive measurements were performed, and the mean was calculated. The body height (cm) and body weight (kg) were measured using the scale with attached stadiometer (Seca, Type 710-220, GmbH & Co., Germany). The height was measured with precision of 0.1 cm, and body weight with precision of 0.1 kg. During the measurement subjects were barefoot with minimal clothing. Measurements were performed by a team of trained personnel according to standard instructions (Lee & Nieman, 2012) with great care and as fast as possible due to the vulnerability of the patients. Body mass index (BMI) was calculated from obtained measures for each subject and expressed in units of measure of kg/m^2. Mid-arm and calf circumference were measured with flexible, inelastic measuring tape with precision of 0.1 cm (Seca 201 - Ergonomic circumference measuring tape, GmbH & Co., Germany) at non-dominant part of the body with patients sitting down with muscles relaxed. Hand dynamometer (Seca, GmbH & Co., Germany) was used to get measure of hand grip strength and was used on both hands with patients sitting and elbows set at 90º angle. According to the obtained results patients can be distributed into categories: excellent, good, fair, poor and need improvement (Geerling et al., 1999).

Biochemical methods

Blood samples were collected from the patients during monthly routine control. Analyses of the samples was performed at the Biochemical laboratory of the General hospital „Dr. Josip Benčević". The serum concentrations of sodium, potassium, calcium, phosphates, total protein, albumin, globulin, albumin to globulin ratio (A/G), creatinine and C-reactive protein (CRP), urates and creatinine were determined. Selected biochemical parameters were assessed using standard laboratory methods (e.g. reflectometry) (Tietz, 1987; Tietz, 1989; Thomas, 1998).

Dietary assessment method

Dietary method used for assessment of nutritional intake was 3-day-dietary record (3DD). The patients were supplied with forms and detailed instructions for recording the food and beverages during the hemodialysis at the beginning of this investigation so they could provide detailed description of the food and its weight, same as the way of preparation, together with the recipes for meals. They were asked to record all foods and beverages consumed over 3 consecutive day period (Sunday, Monday and Tuesday), one of which they spent in the hospital undergoing the hemodialysis, where they

got two meals. Patients determined their portion size using kitchen scales combined with description by relative comparison with utensils. Dietary records do not rely on memory, but they require highly motivated patients who are ready to record their dietary intake without changing their usual dietary pattern. After 3DD general questionnaire was conducted with every patient and 3DD records brought were checked together with patients during the hemodialysis. All 3DD were analysed using the computer software *Prehrana* (Infosistem d.d., Zagreb, Croatia) intended for planning hospital nutrition, based on literature data for nutrients, among all total protein and phosphorus content in fresh, unprocessed foods (Kaić-Rak & Antonić, 1990), adjusted with changes of those nutrients concentrations arising during food processing (Vrdoljak et al., 2015).

Statistical analysis

For analysis of obtained data *Microsoft Excel 2013* (Microsoft, Seattle, WA, USA) and *SPSS* statistical package (version 17.0, SPSS Inc., Chicago, IL, USA) were used. Descriptive analysis of selected parameters (3DD, anthropometric, functional and biochemical parameters) was assessed as a basic statistic method. Student's t test was used for determining gender difference. Regression analysis for estimation of correlation between selected parameters was used. All results are presented as the means ± SD and differences were considered significant when p values <0.05. All obtained result should be interpreted carefully due to the small number of patients.

Results and Discussion

Patients in this study were of both gender, nine females aged 50–82 (average 70.9±11.7) years and five males aged 75–83 (average 80.2±3.1) years. Significant gender difference (*p=0,048*) according to age was observed. At the time of the study, they were undergoing hemodialysis in the time period from 39 to 363 months. According to the duration of hemodialysis therapy, 14% of patients are undergoing therapy for 3 to 5 years, 43% of patients 5 to 10 years, 29% of patients 10-15 years and 7% of patients in the categories undergoing therapy for 15 to 20 years and more than 20 years. As it is shown in table 1 there was no significant gender difference according to strength nor according to anthropometric parameters except in height and weight. Males were significantly higher and had higher body weight compared to females, but there was no significant difference according to BMI, what was expected because males are on average higher and have higher body mass compare to females and due to previous study conducted in Croatia where the average body weight for people older than 60 years was 69.74±12.44 kg for females and 82.26±31.33 kg for males, with body height 164.67±6.48 cm for females and 174.50±11.79 cm for males (Milanović et al., 2012). Even though body weight of patients in this study is on average lower than in the average population of the same age after insight into patients medical history there was no observed significant change in body weight during the last six months from that can be concluded that patients are taking care of their body weight by complying the nutritional recommendations (Bernes, 2017).

Table 1. *Anthropometric characteristics of patients according to gender.*

Parameter	Gender	Min	Max	**Average**	**SD**	p^a
Body mass (kg)	Female	43.2	79.4	57.9	9.2	*0.001**
	Male	58.0	80.5	70.1	8.5	
Body height (cm)	Female	142.0	167.0	160.0	7.7	0.003*
	Male	163.7	173.5	168.7	4.1	
BMI (kg/m^2)	Female	15.9	26.3	23.5	3.5	0.525
	Male	20.8	26.9	21.3	2.2	
Mid-arm circumference (cm)	Female	20.2	29.8	24.5	2.8	0.421
	Male	21.5	28.9	25.9	2.9	
Calf circumference (cm)	Female	20.1	36.8	29.1	4.5	0.255
	Male	27.8	33.0	31.3	2.2	
Left hand strength (dynamometry) (N)	Female	0.0	26.0	5.8	8.3	0.513
	Male	0.0	24.0	9.8	11.4	
Right hand strength (dynamometry) (N)	Female	0.0	26.0	6.6	8.9	0.298
	Male	0.0	23.0	12.2	9.2	

**p<0,05 , [a] student t-test*

More than half of the patients (total of 57.1%) were overweight, while 35.7% of all patients had adequate body weight. Important is to emphasise that body weight was measured after hemodialysis (dry weight) to minimize potential error due to presence of oedema (Gurreebun et al., 2007) and it was found that 100% of our patients had it. Fig. 1 represents the distribution of patients according to gender and their body mass index. According to WHO (*World Health Organisation*)

classification in this study there were no patients that were obese, while most of the patients had adequate body mass or were overweight, with no patient with BMI over 27 kg/m^2 and only undernourished was a female patient undergoing hemodialysis for 363 months (WHO, 2017). According to WHO apparently healthy person with a BMI less than 18.5 kg/m^2 is at higher risk of malnutrition, but within population undergoing hemodialysis higher risk could have even patients with BMI less than 22 kg/m^2 (Costa de Oliviera et al., 2010), the number of those patients in this study is around 21%.

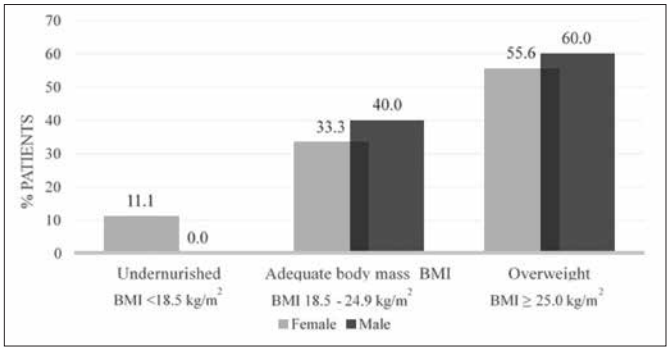

Figure 1. *Distribution of patients according to their body mass index.*

According to previous research BMI alone is not necessary a good tool for assessment of nutritive status of patients on hemodialysis, but in combination with a mid-arm circumference accuracy of estimation is much more precise (Chen et al., 2013). The Malnutrition Action Group, from the British Association of Parenteral and Enteral Nutrition, had established specific mid-arm circumference cutoff values combined with BMI to assess malnutrition in individuals according to which people with a BMI lower than 20 kg/m^2 and with a mid-arm circumference less than 23.5 cm are likely to be underweight (BAPEN, 2011). In this study, 35.7% of patients had a mid-arm circumference lower than 23.5 cm but only 21.4% had pared with BMI less than 20 kg/m^2. Earlier research conducted among elderly population showed mid-arm circumference to be a more reliable indicator of nutritional status than BMI (Wijnhoven et al., 2010). Calf circumference was shown to be a good indicator of nutritive status among elderly (Bonnefoy et al., 2002; Cuervo et al., 2009; Portero-McLellan et al, 2010).

For all patients that had hand grip strength classified in category *need improvement* (Geerling et al., 1999), a possible error might occur due to weakness of patients undergoing the hemodialysis as well as fear of possible blood vessel fracture due to embedded fistula.

Biochemical analyses of the blood samples were performed at the hospital biochemical laboratory according to standard protocols. Results of analyses are shown in table 2. There was no observed statistical difference between genders for all observed parameters. As it can be seen from obtained results (table 2) all patients in this study do not have values in line with the recommendations for serum albumin concentration as well as for serum creatinine concentration. Obtained average serum creatinine concentration is high above the upper value of reference range (Thomas, 1998), what is in accordance with previous studies (NHANES – *National Health and Nutrition Examination Survey*, and KEEP – *Kidney Early Evaluation Program*) which showed that the prevalence of chronic kidney disease characterised by serum creatinine concentration higher than 114.9 μmol/L for males and 132.6 μmol/L for females growing rapidly in patients older than 60 years (Paudel et al., 2013). Opposite, serum albumin concentration were below the lower value of reference range for all patients (Tietz, 1987). Hypoalbuminemia, same as protein malnutrition, is a predictor of mortality and morbidity for patients undergoing haemodialysis (Cooper et al., 2004, Iseki et al., 1993), but lower concentration could be also an indicator of the acute response on the inflammatory process (Heimburger et al., 2000; Jones et al., 1997; Kaysen, 1998). Serum concentration of total protein was within the reference range for half of the patients (Tietz, 1987). Serum concentration of total protein is a result of protein synthesis, catabolism, redistribution and losses by transcapillary transport and it is used as a routine marker for nutritive status (Štolić et al., 2010). Average sodium serum concentration was within the reference range for most of the patients, and concentration of potassium and calcium were within the reference range for 42.9% of patients (Flegar-Meštrić et al., 2000; Tietz, 1989).

Table 2. *Biochemical parameters of patients according to gender.*

Parameter	***Reference range***	**Gender**	Min	Max	**Average**	**SD**	**Within reference range (% of patients)**
Sodium (mmol/L)	136 – 146	Female	136	142	138	1.87	92.9
		Male	135	140	137.6	2.30	
Potassium (mmol/L)	3.9 - 5.1	Female	4.9	5.8	5.3	0.35	**42.9**
		Male	4.3	6.2	5.5	0.79	
Calcium (mmol/L)	2.14 - 2.53	Female	1.69	2.56	2.1	0.26	**42.9**
		Male	2.1	2.71	2.3	0.25	
Phosphorus (mmol/L)	0.79 - 1.42	Female	0.7	1.59	1.2	0.26	64.3
		Male	1.21	1.82	1.4	0.25	
Total protein (g/L)	66 - 81	Female	56	73	64	6.4	50.0
		Male	63	80	68.6	6.8	
Albumins (g/L)	40.6 - 51.4	Female	26	36	30.6	2.83	**0.0**
		Male	30	36	33.4	2.7	
Albumins/ Globulins (g/L)	0.7 – 2.5	Female	0.7	1.4	1.0	0.28	100.0
		Male	0.9	1.3	1.1	0.17	
CRP (mg/L)	0.1 - 0.5	Female	0.5	126	28.7	44.5	**7.1**
		Male	2.5	17.8	8.4	5.88	
Urates (μmol/L)	134 - 337	Female	239	385	312.1	46.78	92.9
	182 - 403	Male	226	354	300.6	47.98	
Creatinine (μmol/L)	79 - 125	Female	449	1223	763.1	215.97	**0.0**
		Male	685	1009	876.8	140.16	

The average serum concentration of phosphorus was within the reference range for 64.3% of patients with males having higher concentrations. Concentration above reference range are common among patients with chronic renal failure and are connected with cardiovascular diseases which are related to higher mortality rates within the population on dialysis (Jiang et al., 2015). Current trend is increasing awareness of patients on phosphorus content in food same as on ways of reducing its intake (Vrdoljak et al., 2015).

Adequate nutrition is important for patients undergoing hemodialysis to prevent numerous complications and to provide higher quality of life. Patients have to take special care on controlled intake of fluids, adequate intake of protein, potassium, sodium, balance between phosphorus and calcium intake as well as adequate energy intake. Tables 3 and 4 along using Fig. 2 represent the average dietary intake of macro- and micro- nutrients for patients measured using 3DD. Only significant difference, according to macro- and micro- nutrients intake, between genders was obtained for water intake (males intake almost twice than females) and for unsaturated fatty acids intake. Recommendation for fluid intake is 1000 mL daily with addition for urine loses and 29% of total patients had fluid intake lower than 1000 mL per day. Average protein intake was adequate only for 14% of patients, and most of them had intake lower than recommended 1.2 to 1.5 g/kg body mass per day. Recent research showed that development of malnutrition could be caused by diet with low protein content (Locatelli et al., 1991; Klahr et al., 1994; Locatelli & Delwecchio, 1999). So, adequate energy and protein intake is very important because it is hard to regain adequate nutrition status and it can take weeks and even months for recovery (Locatelli et al., 2002).

According to conducted regression analysis for estimation of correlation between selected parameters from food and serum only significant correlation was observed between food protein intake and serum albumin concentration ($r=0.70$; $p<0.05$).

Table 3. *Water, energy and macronutrient intakes among hemodialysis patients measured with 3DD (n=14).*

Parameter	Gender	Min	Max	**Average**	**SD**	p [a]
Water (g)	Female	399.7	995.4	692.4	275.4	*0.007**
	Male	872.6	1163.6	1010.8	118.2	
Energy intake (kcal)	Female	810.8	2272.5	1529.4	526.2	*0.160*
	Male	1284.4	2387.9	1902.4	514.4	
Protein (g)	Female	44.64	88.29	58.69	18.24	*0.067*
	Male	57.2	83.44	72.94	10.64	
Fat (g)	Female	32.5	117.75	69.12	27.24	*0.098*
	Male	60.5	115.82	92.78	24.11	
Saturated fatty acids (g)	Female	13.22	31.31	22.33	8.13	*0.061*
	Male	21.69	38.52	29.39	5.80	
Unsaturated fatty acids (g)	Female	14.49	35.27	23.01	11.1	*0.022**
	Male	22.64	48.32	35.44	9.56	
Carbohydrate (g)	Female	85.75	236.36	170.49	59.40	*0.409*
	Male	9.98	20.33	15.68	4.29	
Dietary fibres (g)	Female	10.2	21.9	14.9	4.4	*0.721*
	Male	10.0	20.3	15.8	4.3	

**p<0,05 , [a] student t-test*

Fig. 2 shows compliance of the selected parameters intake to the recommendations. From all nutrients that patients on hemodialysis have to take care of, only calcium intake was adequate in all patients. Potassium and phosphorus intake were adequate for around half of the patients and none had adequate sodium intake. Sodium intake is important as previous studies showed that hemodialysis patients will need to take in approximately 1 l of water for every 8 g of salt consumed. Patients having restricted salt intake to <6 g/day, and drink only when thirsty, should gain no more than 0.8 kg/day (Lindley, 2009).

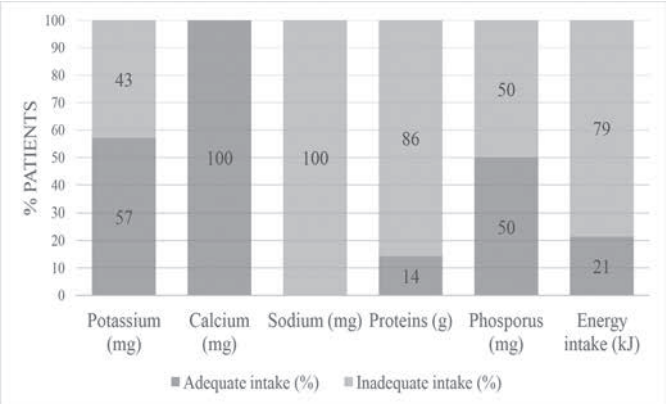

Figure 2. *Compliance of the nutritional intake according to the recommendations for hemodialysis patients, measured with 3DD.*

According to micronutrients intake (table 4) it was observed that there is only a small number of patients that have intake within reference range. Others do not reach recommended intake through nutrition. Reason for that could be avoiding intake of some foods as well as insufficient energy intake what is in accordance with previous research, which showed that macronutrient and micronutrient intakes in hemodialysis and peritoneal dialysis patients are largely inadequate (Bovio et al., 2016).

Table 4. *Vitamin and mineral intake of selected vitamins and minerals for patients according to gender, measured with 3DD (n=14).*

Micronutient	***Reference range****	**Gender**	Min	Max	Average	SD	**Within reference range (% of patients)**
Magnesium (mg)	0.2-0.3 g	Female	103.0	296.7	166.8	74.4	**21.4**
		Male	110.6	225.3	168.9	41.8	
Iron (mg)	Individua-lized	Female	5.7	15.6	8.7	3.1	/
		Male	8.1	11.9	10.2	1.7	
Zinc (mg)	8-11 mg	Female	2.0	8.3	4.2	2.41	**14.3**
		Male	1.9	8.6	4.2	2.6	
Vitamin A (*μg)*	700-900 μg	Female	34.2	331.6	139.5	95.3	**0.0**
		Male	80.0	223.4	141.8	64.0	
Thiamine (mg)	1.1-1.2 mg	Female	0.47	1.5.0	0.84	0.33	**21.4**
		Male	0.64	1.63	1.14	0.43	
Riboflavin (mg)	1.1-1.3 mg	Female	0.64	1.58	1.04	0.30	**42.9**
		Male	1.04	1.77	1.31	0.28	
Vitamin B_6 (mg)	1.3-1.7 mg	Female	0,77	3,05	1,52	0,78	**28.6**
		Male	0,69	2,58	1,61	0,77	
Vitamin C (mg)	75-90 mg	Female	15.44	107.75	66.58	31.14	**35.7**
		Male	47.14	186.58	118.81	62.49	

Conclusions

Hemodialysis patients are a vulnerable population group and their nutritive status is usually quickly manifested at their health status. According to obtained results it can be concluded that more than half of the patients were overweight. Considering nutrient intake there was no observed gender difference. Difference was observed in fluid intake where women intake less and most of the subjects, due to inadequate nutrient intake, should adjust their micro- and macro- nutrients intake to meet the recommendations, with special emphasis on potassium, phosphorus, sodium, protein and total energy intake. The results showed that adequate potassium and phosphorus intake had around half of the patients, only 14% had adequate protein and 21% adequate energy intake. All of the patients had inadequate (excessive) sodium intake and should avoid food high in sodium content. Significant correlation was observed between dietary protein intake and serum albumin concentration.

Further studies should be conducted for better and accurate knowledge about the nutritional status of patients undergoing dialysis in Croatia, taking into account larger sample size along with regional difference due to diversities of nutritional habits across the country.

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