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Original article

The relationship between nutritional status, serum folic acid and homocyteine levels in hemodialysis and peritoneal dialysis patients

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Summary. *Background.* Nutritional deficiencies and imbalances may be encountered in hemodialysis (HD) and peritoneal dialysis (PD) patients. The aim of this study is to investigate the relationship between nutritional status, and serum folic acid and homocysteine levels in hemodialysis and peritoneal dialysis patients. *Methods.* Information about demographics and eating habits were recorded using a questionnaire in 30 hemodialysis and 30 peritoneal dialysis patients. The subjective global assessment was used to assess the nutritional status of the patients. Individual food consumption records were taken in three consecutive days. Some routine blood parameters were recorded from the patient files. Folic acid, vitamin B_{12} and homocysteine analysis were also performed from the serum samples from the remaining blood. *Results.* All of the dialysis patients were found malnourished. Body weight, body mass index, waist and hip circumferences values was lower HD patients than PD patients ($p<0.05$). Serum homocysteine levels of PD patients were higher than HD patients ($p<0.05$). A positive correlation was identified between serum homocysteine and BUN levels, whereas there was an inverse relationship between homocysteine and vitamin B_{12} level, total protein, albumin level and malnutrition score ($p<0.05$). In general, no significant difference was found between the nutrients intake of HD and PD patients. *Conclusion.* Nutritional status of patients of HD was found better than PD patients. Assessment of nutritional status periodically is important for the prevention of malnutrition and early intervention in dialysis patients. Dietary folic acid, vitamin B_{12}, vitamin B_6 and protein intake may be improved by foods or supplementation for prevention of hyperhomocysteinemia in dialysis patients.

Key words: nutritional status, dialysis, malnutrition, folic acid, vitamin B_{12}, homocysteine

Background

Renal cachexia, malnutrition and inflammation are the most important risk factors for medical complications, cardiovascular deaths and all-cause morbidity and mortality in dialysis patients (1, 2). The control of blood pressure (3), excessive fluid accumulation (4), pulmonary hypertension (5), fatigue (6), anemia (7), the management of hyperphosphatemia (8, 9) and the effects of inflammation, to prevent and fix the weakening and sarcopenia, reduce costs of medication (1), improve quality of life and survival (2). Course these all are affected by the nutritional status of patients with dialysis.

Assessment and monitoring of nutritional status in dialysis patients is important to determine malnutrition and to make timely nutritional therapy. In this context, to know effect of dialysis types on blood homocysteine, folic acid, vitamin B_{12} levels and association of these molecule levels with nutritional status will affect the medical approach and the prognosis of patients. In other words, to protect dialysis patients from cardiovascular diseases; how much folic acid and vitamin B_{12} supplementation should be given, and what type of food supplements may be used can be deter-

mined by examining the relationship between nutrient intake, folic acid, vitamin B_{12}, and homocysteine levels. The nutritional interventions to be applied without evaluation will lead to nutritional deficiencies and over dosage in the vitamins, or unnecessary costs. As far as we detect in literature, studies on dialysis patients have been based on generally clinical data but limited malnutrition measures (2, 10). Sarcopenic obesity, coagulability, risk of mortality and morbidity from infection and death risk in elderly is higher for patients receiving PD than in those receiving HD (11, 12). Insufficient home-based nutrition therapy, nutritional self-care or nutritional education facilities, consulting with a dietitian may have an additional effect on nutrition status in PD compared with HD. In this study, we evaluated the influence of hemodialysis (HD) and peritoneal dialysis (PD) on nutritional status and patient's plasma levels of homocysteine, folate, and vitamin B_{12}. Also, malnutrition has been evaluated as versatile through food consumption records, clinical examination, anthropometric measurements and biochemical parameters as a different aspect. The hypothesis of this study was hemodialysis is superior in nutritional aspects and B vitamins levels (folate, vitamin B_{12}) and, decreases the plasma level of homocysteine of dialysis patients than peritoneal dialysis.

The Ethics Committee of Medicine Faculty at Atatürk University, Erzurum, Turkey approved the study protocols with the number of 15 on 09.02.2007 and informed consent was obtained from all participants. Study procedures followed were in accordance with the Helsinki Declaration.

Material and methods

Subjects

The study recruited patients from Atatürk University Faculty of Medicine, Yakutiye Research Hospital, and Dialysis Unit in Erzurum province, Turkey. The study design was descriptive, cross-sectional, and single-centered. All dialysis patients who are suitable for the inclusion criteria and are eager to participate in the study were included in the study. Thirty (16 male, 14 female) HD patients and 30 (14 male, 16 female) PD patients were enrolled. Patients with dialysis have osteoporosis (12.5%), rheumatism (4.2%), and hepatitis C (4.2%) diseases. Inclusion criteria included being on maintenance HD and PD patients for >3 months whose age was >18 years, voluntary individuals who were literate. Exclusion criteria included patients exposed to nitric oxide in the last 3 months, life expectancy shorter than 6 months (metastatic cancer, terminal HIV), who have diseases such as stroke, thrombosis, myocardial infarction within the last 3 months, have received vitamin therapy in the last 4 weeks, who use anti-folate and anti-epileptic medication, alcohol, who support enteral and parenteral nutrition, who have kidney transplantation, who have blood transfusion within 30 days. All HD patients were dialyzed for 4 hours and 3 times per week with bicarbonate-buffered dialysate. Patients were dialyzed with the flow rate of blood at 350 mL/min and the flow rate of dialysate at 500mL/min. Polysulfone membranes whose surface area was 1.5-1.8 m^2 with low flow and low heparinization were used in all cases. PD patients perform four exchanges per day. PD was performed with dialysis fluids containing 1.36%, 2.27%, and 3.86% glucose. Bicarbonate was used as a buffer for PD patients.
Sociodemographic characteristics and eating habits of patients were obtained by questionnaire. Subjective Global Assessment Form was used for assessing the malnutrition status of patients (13, 14).

Anthropometric measurements

Anthropometric measurements (body weight, height, mid-arm circumference, waist circumference, and hip circumference) were performed after exiting dialysis session of HD patients and the day when they came to the doctor's control of PD patients. Dry weight was used as the body weight at the end of dialysis in HD patients. For PD patients, weighing was done with the empty abdominal cavity. The evaluation of fluid status is made by clinical observation of body weight change, edema, and blood pressure and checking of biomarkers. Participants were weighed in kilograms using a NAN brand digital weight scale with scale sensitive to 0.1kg. Standing height was measured with a tape measure. All measurements were obtained as described previously (15). Body mass index and mid-arm circumference were compared to clinical references proposed by HEMO study for dialysis patients (16).

Modified Subjective Global Assessment (MSGA)

A screening test used in the evaluation of protein-energy malnutrition. MSGA consists of 2 section and 7 variables. MSGA examines weight change in the preceding 6 months. The history focused on 7 variables, namely: weight change in preceding 6 months, presence of GI symptoms (anorexia, nausea, vomiting, and diarrhea), change in dietary intake and functional capacity, subcutaneous loss of fat, muscle wasting and edema. Variables scores are graded from 1 to 5 such as 1 = Never, 2 = Mild, 3 = Moderate, 4 = Severe 5 = Very seriously. MSGA total score ranges from 7 (normal) to 35 (severe malnutrition). MSGA score; between (7-10) is considered as well-nourished, between 11-22 is considered as having mild to moderate malnutrition, and between 23-35 is considered as severely malnourished in patients on dialysis. Application of MSGA form to dialysis patients is explained in detail in previous studies (13, 14).

Dietary intake

Food consumption record was taken in three consecutive days of all dialysis patients by the researcher. The days for the hemodialysis patients were selected as one day on the weekday, one day on the dialysis day and one day at the weekend; and it was determined as two days on the weekday, and one day on the weekend for the PD patients (17). Dietary energy and other nutrients intake were analyzed by the Food Information System (BEBİS) computer program (18). For PD patients, dialysate calorie added to total calorie intake considering dextrose concentration of dialysate, dialysate volume and dialysis frequency. The mean percentages of meeting energy and other nutrient requirements according to the RDA were determined of all dialysis patients (19-21).

Biochemical Data

Biochemical tests were made following an overnight fast, prior to the midweek dialysis session in HD patients and without interruption of the dialysis schedule in PD patients for some routine analysis With the serum samples from the remaining blood, folic acid, vitamin B_{12} and homocysteine analysis were performed. The blood was placed in EDTA tubes and iced. The plasma was separated in 5000 rpm at 5 minutes within 30 minutes. Plasma samples were stored in Eppendorf tubes at −80°C until analyzed. The iced plasma was thawed at +4 °C after seven days. Homocysteine values were analyzed using the Immuchrom ready commercial kit by means of the Hewlett Packard (HP) 1100 HPLC (high-pressure liquid chromatography) system. The reference value for adult male and female is 5-15 μmol/dL (22). Folic acid and vitamin B_{12} were studied by immunochemistry without electrochemiluminescence by means of Roche Modular Analytical E 170 system. The normal range for adult male and female is 3-17 ng/mL for folic acid and 193-982 pg/mL for B_{12} vitamins (23). All other biochemical tests were taken from patient files.

Statistical Evaluation of Data

Statistical analysis was performed using SPSS 20.0 (SPSS, Inc., IBM, Illinois, USA). Continuous variables were expressed as the mean ± standard deviation and minimum-maximum ranges. Descriptive statistics are used according to the feature of data. Group differences were assessed using the unpaired *t*-test taking into account showing the normal distribution in table. Chi-square test of independent groups (Fisher Chi square or Pearson square) was used for frequency tables. Linear correlation between two variables was assessed by the Pearson test. The coefficient of correlation *r* is given. $P<0.05$ is considered a statistically significant difference (24).

Results

The mean age of HD and PD patients were 48.07±14.62 and 47.70±13.77 years old, respectively. The duration of dialysis was 52.00±44.12 months in HD patients and 27.67±29.31 months in PD patients. Mean duration of education was 6.07±4.78 years of HD patients, and 5.53±4.32 years of PD patients. Malnutrition score according to MSGA was found 17±4.14 and 14.87±4.44 in HD and PD patients, respectively ($p>0.05$). The anthropometric measurements of the patients according to dialysis were given in Table 1. There was a statistically significant difference between the weight, body mass index (BMI), waist circumference, waist/hip

Table 1. Anthropometric measurements of patients according to type of dialysis

	Type of Dialysis					
	Hemodialysis		Peritoneal dialysis			
Anthropometric measurements	**Male (n:16) $\bar{X}$±SD**	**Female (n:14) $\bar{X}$±SD**	**Male (n:14) $\bar{X}$±SD**	**Female (n:16) $\bar{X}$±SD**	**P1**	**P 2**
Body weight (kg)	66.42±7.96	55.99±12.51	73.45±8.35	68.35±19.07	**0.03***	**0.05***
Height (m)	1.69±.06	1.54±0.08	1.70±0.04	1.57±0.06	0.61	0.26
Body mass index (kg/m^2)	23.18±2.55	23.38±4.47	25.32±2.85	27.53±7.27	**0.04***	0.08
Mid arm circumference (cm)	27.12±1.82	27.14±3.82	28.10±2.41	29.81±5.55	0.22	0.14
Waist circumference (cm)	89.68±7.96	92.57±16.56	97.92±7.91	103.87±19.39	**0.02***	0.10
Hip circumference (cm)	99.43±5.25	96.35±11.94	100.57±6.83	108.5±18.39	0.61	**0.04***
Waist/hip ratio	0.90±0.07	0.95±0.10	0.97±0.07	0.95±0.60	**0.01***	0.95

**p<0.05, P1=male; P2=female*

ratio of male patients undergoing peritoneal dialysis and hemodialysis (p<0.05). These measurements of the patients with PD were found higher than HD patients.

Daily intake of energy and nutrients according to dialysis types is given in Table 2. No significant difference was found between the nutrient consumption of patients who underwent HD and PD. The percentages of receiving insufficient energy those are the normal weight were found 53.3% and 80% in HD and PD patients, respectively. 76.7% of patients with hemodialysis and 90% of patients with peritoneal dialysis consume inadequate protein. The daily intake of thiamine, vitamin B_6, folic acid, vitamin C, vitamin D, vitamin E, iron and fiber were found to have lower levels in both dialysis patient groups. Vitamin B_{12} intake was lower in females with PD than the HD patients (p>0.05). Vitamin B_{12} intake is less than RDA levels for female patients with HD and PD. Vitamin A intake is lower than recommended levels in both genders with HD whereas it is normal in PD patients.

Biochemical measurements of patients according to dialysis type are given in Table 3. In general blood parameters for health condition were found higher in PD patients than HD patients (p<0.05). Only, HDL-cholesterol, albumin, calcium, vitamin B_{12}, ferritin, and parathyroid hormone (PTH) levels were found lower in PD patients than HD patients (p<0.05). Serum folic acid level was found to be normal in 63.3% of HD patients and 73.4% of PD patients. There was no low folic acid level in HD patients but, 3.3% of PD patients had low serum folic acid level. The percentages of normal serum B_{12} levels were found 60% of hemodialysis patients and 83.3% of peritoneal dialysis patients. Although no patients with HD lower serum B_{12} levels, 3.3% of patients with PD had lower serum B_{12} levels. Also, serum homocysteine level was found a normal level in 73.3%, mild high level in 26.7% of HD patients. The percentages of mild, moderate, severe high homocysteine levels were found 13.3%, 80%, 6.7% of patients with PD, respectively.

The correlation between some blood nutritional parameters and homocysteine levels in dialysis patients are given in Table 5. A positive correlation was identified between serum homocysteine and BUN levels, whereas there was an inverse relationship between homocysteine and vitamin B_{12} level, total protein, albumin level and malnutrition score (p<0.05).

Discussion

The aim of this study was to evaluation of modality in dialysis (HD versus PD) on nutritional status and patient's plasma level of homocysteine, folate, and vitamin B_{12}. In this study, all of the hemodialysis (HD) and peritoneal dialysis (PD) patients were found to be malnourished by using the MSGA. Anthropometric measurements of PD patients were found higher than HD patients. Both male and female body weights and body mass index, waist/hip ratio were found higher in male PD patients than male HD patients (p<0.05) (Table 1). Therefore, PD patients are more prone to

Table 2 Daily energy and nutrients intake according to types of dialysis

	Type of Dialysis					
	Hemodialysis (n:30)		Peritoneal dialysis (n:30)			
Energy and Nutrients	**Male (n:16) X̄±SD**	**Female (n:14) X̄±SD**	**Male (n:14) X̄±SD**	**Female (n:16) X̄±SD**	**P1**	**P 2**
Energy (kcal)	1594.09±860.48	1200.73±504.08	1655.82±1376.71	1059.99±426.33	0.88	0.41
Protein (g/kg)	1.03±0 .65	0.88±0.47	1.02±0.76	0.60±0.25	0.56	0.25
Lipid (g)	56.47±31.57	52.16±27.56	77.83±84.58	48.67±24.74	0.36	0.72
Cholesterol (mg)	214.41±137.62	172.02±107.38	307.18±307.70	192.43±165.90	0.29	0.70
Saturated fat (g)	23.96±15.35	22.66±14.07	34.47±41.84	21.42±11.49	0.36	0.79
MUFA (g)	18.84±9.93	18.18±9.69	27.49±30.58	17.08±8.53	0.29	0.74
PUFA (g)	9.28±5.94	7.70±3.52	10.29±7.35	7.05±3.52	0.68	0.62
Carbohydrates (g)	201.07±120.89	133.78±63.81	159.41±102.90	113.84±48.78	0.32	0.34
Fibre (g)	17.38±8.94	11.93±5.44	13.75±4.59	10.16±4.39	0.18	0.33
Vitamin A (µg)	643.41±318.18	567.80±327.51	976.72±592.87	694.30±397.81	0.06	0.35
Vitamin B_1 (mg)	0.67±0.36	0.43±0.17	0.62±0.36	0.42±0.13	0.67	0.84
Vitamin B_2 (mg)	1.14±0.62	0.76±0.31	1.20±0.83	0.84±0.24	0.82	0.46
Vitamin B_6 (mg)	1.03±0.58	0.66±0.29	0.98±0.58	0.62±.22	0.83	0.70
Vitamin B_{12} (µg)	3.54±3.88	2.29±1.47	4.01±3.87	1.94±1.58	0.74	0.53
Total Folic Acids (µg)	243.98±138.01	167.73±73.28	213.96±125.31	156.18±61.87	0.54	0.64
Vitamin C (g)	62.61±37.36	42.62±31.86	54.16±31.00	42.47±20.37	0.51	0.97
Sodium (mg)**	3168.72±1570.42	2538.92±1022.87	3474.82±2311.59	2849.77±1503.61	0.67	0.52
Potassium (mg)	1789.11±1017	1101.18±434.30	1680±763.57	1138.02±321.53	0.75	0.79
Calcium (mg)	565.35±356.09	371.65±202.23	590.57±583.20	451.99±129.42	0.89	0.20
Magnesium (mg)	178.80±91.53	124.61±46.88	190.33±112.34	121.79±31.48	0.76	0.85
Phosphorus (mg)	959.95±539.99	654.53±270.99	1036.90±846.97	648.59±192.08	0.77	0.95
Iron (mg)	8.68±4.64	6.33±2.63	9.78±5.49	5.35±2.01	0.56	0.26
Zinc (mg)	8.68±4.77	6.27±2.53	10.38±8.79	5.64±2.45	0.51	0.49

*t-test; *p<0.05, P1=male; P2=female ; ** Sodium from salt wasn't included in calculation; MUFA: Monounsaturated fatty acids, PUFA: Polyunsaturated fatty acids*

chronic diseases. High CRP and blood lipids in PD patients also support this finding. There is a close relationship between body size and composition with physical functions and life quality (25). Mid-Upper Arm Circumference (MUAC) is one of the most important markers that represent the nutritional status and inflammation, also independently increases the survival time in HD patients (4, 26). In this study, when the arm circumference measurements of dialysis patients are compared to standard values, it was shown that male (49%) and female (47%) hemodialysis patients were in the 5^{th}-10^{th} and 10^{th}-25^{th} percentile, and male (47%) and female (49%) PD patients were in the 10^{th}-25^{th} and 25^{th}-50^{th} percentile, respectively. It shows that the protein mass of skeletal muscle of dialysis patients is low. Liman et al. (27) reported that 51% patients with hemodialysis were malnourished according to MUAC. İsoyama et al. (28) found that 20% of dialysis patients had sarcopenia, 24% of them had low muscle mass, and 15% of them had low muscle strength. Also, obese sarcopenia was found higher in the PD group than in the HD group (12). Decreased protein intake, cardiovascular insufficiency, proinflammatory cytokines and changes in DNA methylation decrease the protein synthesis in muscle and increase the muscle destruction. Decreased muscle mass and strength were increased the risk of heart failure, fractures, infections, insulin resistance, weakness, and deaths (29).

Table 3. Biochemical measurements of patients according to type of dialysis

	Type of Dialysis §		
Nutritional blood parameters	**Hemodialysis (n:30) $\bar{X}$±SD**	**Peritoneal dialysis (n:30) $\bar{X}$±SD**	**P values**
High-density lipoprotein cholesterol (mg/dl)	46.86±9.59	40.46±7.48	**0.006***
Low-density lipoprotein cholesterol (mg/dL)	121.06±37.20	146.96±45.17	**0.018***
Triglyceride (mg/dL)	169.26±98.43	213.96±138.28	0.155
Total cholesterol (mg/dL)	181.36±45.31	207.60±54.17	**0.046***
Blood urea nitrogen (mg/dL)	19.90±11.87	45.30±15.57	**0.000***
Creatinine (mg/dL)	2.95±1.40	10.85±15.51	**0.007***
Albumin (g/dL)	4.21±0.74	3.24±0.58	**0.000***
Sodium (mmol/L)	140.16±3.72	138.30±4.44	0.083
Potassium (mmol/L)	3.36±0.55	4.30±0.82	**0.000***
Calcium (mg/dL)	10.13±0.88	8.92±1.29	**0.000***
Phosphorus (mg/dL)	2.49±0.67	4.57±1.18	**0.000***
C-reactive protein (mg/dL)	0.58±0.47	2.84±4.42	**0.007***
Hemoglobin (g/dL)	11.30±1.79	10.22±3.22	0.112
Hematocrit (%)	35.13±6.09	30.32±9.58	**0.024***
Folic Acid (ng/ mL)	12.63±6.27	13.74±22.13	0.792
Homocysteine (μmol/L)	13.53±4.03	53.44±38.05	**0.000***
Vitamin B_{12} (pmol/L)	899.64±412.16	592.13±354.91	**0.014***
Alkaline phosphatase (U/L)	197.68±152.23	120.46±67.45	0.490
Lactate dehydrogenase (U/L)	248.30±95.83	265.53±96.25	**0.000***
Total Protein (g/dL)	7.90±1.19	6.41±1.01	0.340
Glucose (mg/dL)	100.93±31.80	111.33±49.91	**0.019***
Ferritin (ng/mL)	585.96±335.22	384.92±307.02	**0.000***
Parathyroid hormone (pg/mL)	723.76±627.12	256.41±226.32	**0.006***

*t-test, *p<0.05; § Dialysis output values were taken into account for HD and PD patients*

It has been found that %52-85.4 of HD patients (10, 30-32) and %40.6-74.8 of PD patients (33) were malnourished in these previous studies. It has been indicated that malnutrition increases the risk of infection in dialysis patients (34), triggers arterial calcification in HD patients, and has an important role in cardiovascular deaths (2). In this study, it was found that albumin level of PD patients was significantly lower than the HD patients (p<0.05). Similarly, Mathew et al. specified that the albumin level of PD patients was lower than the HD patients. Low albumin levels can be explained with loss of high-molecular protein during the PD and inflammation in PD patients. Low albumin levels in dialysis patients cause impairment of the Ca, P, cholesterol, and triglyceride transportation (10). Also, low levels of albumin led to impairment in total cholesterol and LDL cholesterol transport in PD patients. In this study, C-reactive protein, which is a marker of inflammation, total and LDL-cholesterol levels were found higher of PD patients than HD patients (p>0.05) (Table 3).

Various studies have shown that serum and red blood cell folic acid levels of PD patients are higher than HD patients (35, 36). However the difference was not statistically significant, it was also found that HD patients had lower serum folic acid levels than PD patients, in this study (Table 3). Presence of low folic acid level might be explained by folic acid is a small molecule and it loses during the HD process and it can also interact with other medications in HD patients (37, 38). Also, vitamin B_{12} level was found higher in HD patients than PD patients (p>0.05). Similar re-

Table 4 Correlation between some nutritional blood parameters and homocysteine levels in dialysis patients

Nutritional blood parameters	Homocysteine levels	
	Pearson Correlation	p
Triglyceride (mg/dL)	0.023	0.860
Cholesterol (mg/dL)	0.113	0.391
Blood urea nitrogen (mg/dL)	0.549	**0.000****
Creatinine (mg/dL)	0.108	0.413
Albumin (g/dL)	-0.369	**0.004****
C-reactive protein (mg/dL)	0.04	0.761
Hemoglobin (g/dL)	-0.019	0.883
Folic acid (ng/mL)	-0.147	0.262
Vitamin B_{12} (pmol/L)	-0.316	**0.014***
Lactate dehydrogenase (U/L)	-0.011	0.936
Total protein (g/dL)	-0.315	**0.014***
Body mass index (kg/ m^2)	0.163	0.212
Malnutrition score	-0.389	**0.020***
Calcium (mg/dL)	-0.315	**0.014***
Phosphorus (mg/dL)	0.380	**0.003****
Parathyroid hormone (pg/mL)	-0.256	**0.048***

**p<0.05, **p<0.01*

sults have shown in the literature (39). Vitamin B_{12} is a large molecule and its binds to haptocorrin (big non-glycoprotein) at 80-90%, thus the loss of vitamin B_{12} is less due to hemodialysis (40). Homocysteine and methylmalonic acid (MMA) are novel markers which are used to determine the functional status of vitamin B_{12} and folate in tissues. High levels of homocysteine and normal levels of MMA show the folate deficiency. On the other hand, high levels of homocysteine and MMA show vitamin B_{12} deficiency (41). Vitamin B_{12} serves as a vehicle molecule in the transfer of the methyl groups from 5-methyltetrahydrofolate to homocysteine. Therefore, even though folic acid levels are normal, vitamin B_{12} deficiency cannot ensure the methionine remethylation from homocysteine. Furthermore, adenosyl-cobalamin, as one form of vitamin B_{12}, ensures the transformation of methylmalonic acid to succinyl CoA. This reaction has an important role in the metabolism of fatty acids and aliphatic amino acids. Vitamin B_{12} deficiency causes abnormal lipid accumulation (42, 43). In this study, abnormal lipid levels of PD patients could be correlated with the functional vitamin B_{12} deficiency. Normal blood vitamin B_{12} level is associated with the late emptying of vitamin B_{12} stores in the body. Vitamin B_{12} is stored in the body for 3-5 years, folic acid is stored in the body for 1-1.5 years, and vitamin B_6 is stored in the body for 3-4 months (40). Also, it has been found that 80% of the PD patients have moderate levels of homocysteine and 73.3% of the HD patients have normal levels of homocysteine in this study. It is shown that homocysteine levels were higher than the cutoff value (13.5μmol/L) in both dialysis modality (HD and PD) (44). Decrease of cystathionine synthase activity occurs due to PEM, decreases the synthesis of cytosine and cysteine from methionine and it leads to hyperhomocysteinemia (45). In this study, dietary protein intake of PD patients was found lower than HD patients ($p>0.05$) (Table 2). Furthermore, there is a positive relationship between serum homocysteine and BUN levels and there is an inverse relationship between vitamin B_{12} levels, total protein levels, albumin levels, and malnutrition scores in this study ($p<0.05$) (Table 4). Despite normal vitamin B_{12} and folate levels, high homocysteine levels may show the decrease in the function of vitamin B_{12} receptors dependent on uremia. The decrease in transcobalamin II level may lead to the reduction of vitamin B_{12} intake from peripheral tissues in inflammation prone HD patients. This mechanism may occur in order to remove the vitamin B_{12} from pathogenic microorganisms which lead to inflammation and infection in peripheral tissues. High serum vitamin B_{12} concentrations in case of inflammatory conditions such as HD, lead to functional vitamin B_{12} deficiency in peripheral tissues and thus hyperhomocysteinemia occurs (37). Saifan et al, there was a 58% prevalence of vitamin B_{12} deficiency as defined by high MMA level in HD patients (46). This hypothesis is supported by vitamin B_{12} level and the relationship between CRP and ferritin levels. Hyperhomocysteinemia could be impaired vitamin B_{12} metabolism (38). Despite normal vitamin B_{12} and folate levels, one reason for high levels of homocysteine can be explained vitamin B6 deficiency. Even though vitamin B_{12} and folate levels are normal in hemodialysis patients, it was previously shown in other studies that dialysis patients had a vitamin B_6 deficiency (41). Vitamin B_6 deficiency is observed in 24-56% of hemodialysis patients. Also, observing more

common compared to other vitamin B deficiencies because the molecular size of vitamin B_6 (MW 245) is smaller than the molecular sizes of folate (MW 441) and vitamin B_{12} (MW 1355). Therefore, the loss of vitamin B_6 is more during dialysis. Furthermore, vitamin B_6 stores in the body are limited and this also increases the deficiency risk (40). Thus, hyperhomocysteinemia can occur because of malnutrition, vitamin B_{12} functional deficiency, vitamin B_6 deficiency and uremia. In present study; the dietary consumption of vitamin B_6 is found 1.03 ± 0.58 mg and 0.66 ± 0.29 mg in male and female patients with hemodialysis, respectively. Vitamin B_6 intakes were 0.98 ± 0.58 mg and 0.62 ± 0.22 mg in the male and female patients with peritoneal dialysis patients, respectively. Although pyridoxine is recommended 1.3-1.7 mg in diet of healthy adults (47) , this daily intake of pyridoxine does not meet requirements of hemodialysis and peritoneal dialysis patients. It is proposed that dialysis patient should consume more vitamin B_6 than RDA (20, 48).

Strengths of the study are as follows; measurements were performed in only one laboratory and subjective global assessments and anthropometric measurements were performed by one dietitian. These strengths ensure the minimum measurement bias. In this study, there were an equal number of patients from each group, age characteristics of the two groups are similar, and both genders were well represented. These strengths decreased the error dependent on confounding factors. This study is a single-centered study. Vitamin B_6 levels were not measured, functional indexes/biomarkers were not used in the determination of the vitamin B_{12} and folate levels, and only static indexes were used. These are the important limitations of this study. MMA level was not measured whereas only homocysteine levels were measured. This prevented to determine whether or not hyperhomocysteinemia occurs due to the functional deficiency of vitamin B_{12} or folate.

Conclusion

This study was conducted to compare nutritional status, serum folic acid and homocysteine levels of hemodialysis and peritoneal dialysis patients. Malnutrition is identified in both dialysis modalities. Body mass indexes (BMI), waist circumference, waist/hip ratio of male PD patients were found higher than male HD patients. PD patients had a higher level of homocysteinemia than HD patients. Hyperhomocysteinemia can be affected by malnutrition, functional deficiency of vitamin B_{12}, vitamin B_6 deficiency and uremia. These findings suggest that when anthropometric measurements are assessed in patients on dialysis, a health professional should be considered to use with body composition methods. While making a decision about dialysis modality in renal units, it should be also considered that the types of dialysis which could effect on nutritional status and homocysteine, folic acid, vitamin B_{12} levels of patients. Further analysis of data after longer follow-up is needed to suggest a nutritional status benefit for a particular dialysis modality. Also, further studies are required for the determination of well and malnutrition nutritional status at the beginning of dialysis in patients. In addition, change of nutritional status with dialysis modality in the long term should be detected.

Supplementary Data

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Conflict of interest statement

None declared.

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