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Dietary intake and nutritional status of Moroccan hemodialysis patients: Sidi Bennour case-study

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Abstract. Introduction: Poor nutritional status (NS) of patients with end-stage renal disease (ESRD) is considered the main cause of poor clinical prognosis and mortality. Objective: This study aims to evaluate NS and analyze daily intakes and the prevalence of protein-energy malnutrition in hemodialysis (HD) patients with ESRD in comparison with control subjects without kidney disease. Subjects and Methods: The study included 156 ESRD patients as the case group and 210 apparently healthy subjects without chronic kidney disease as the control group. Clinical data, anthropometric measurements and two 24-hour dietary recalls were collected to assess nutritional status and dietary intake. Results: The mean energy intake (EI) among the cases was 1905.68 ± 594.36 kcal per day with only 36.1% of them found to meet the current recommended intake for energy density and 6% having met the recommended minimum of 1.1 to 1.2 g/kg of protein per day. Total dietary intakes of calories, protein, fat, and carbohydrates were significantly lower in HD patients compared to the control group. Likewise, the results showed low intakes of minerals and vitamins in HD patients compared to control subjects. Protein and dietary energy density were negatively correlated with age, body mass index (BMI), waist circumference (WC), and waist-to-hip ratio (WHR). Conclusion: The study reveals the crucial importance of assessing and monitoring the diet and nutritional status of hemodialysis patients which could potentially help provide information on irregularities to be corrected and thus contribute to improved health and quality of life during treatment of HD patients.

1 Introduction

Over the past decades, the Moroccan population has recognized a rapid changes in diet and lifestyle. Parallel to these changes that accompany the ongoing nutritional transition in the country, there is an increase in serious nutritional disorders, an increased prevalence of non-

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communicable diseases (NCDs) and therefore an increased risk of morbidity and mortality [1, 2].

Chronic kidney disease (CKD), one of these disorders, is a real public health problem representing a high economic and social burden associated with high cardiovascular morbidity, mortality and low quality of life [3]. Furthermore, several metabolic and cardiovascular risk factors, including obesity, diabetes, hypertension and metabolic syndrome and determining factors of CKD are also in continuous increase both in Morocco and in the world [4] besides to the major role of nutrition and diet in the development of these diseases. Thus, CKD is associated with numerous alterations that can lead to many metabolic and nutrional disorders which contribute to the loss of body protein and energy reserves [3].

An increasing incidence of CKD has been perceived worldwide in recent years, associated with a rise of the patients number that require renal replacement therapy (RRT) [3]. In Morocco, the first annual report of the Magredial Registry estimated the prevalence of end-stage renal disease (ESRD) at 267.1 per million population (pmp) in four regions of Morocco while the incidence was between 100 and 150 pmp in 2010 [3].

Altered nutritional status is significantly common in hemodialysis patients with an occurrence rate of more than 20% of dialysis patients. Protein-energy malnutrition (PEM) is the major macronutrient disorder affecting dialysis patients. This malnutrition is considered among the most serious complications of chronic kidney failure, particularly in patients undergoing hemodialysis. Numerous studies evaluating the nutritional status of hemodialysis patients highlight a high prevalence of PEM ranging from 18% to 75% [4-6]. Indeed, low intake of protein and energy, is the main factor of malnutrition in CKD [7]. Additionally, PEM is an eovator of morbidity and mortality in the dialysis population.

A link between protein-energy malnutrition and increased morbidity and mortality in dialysis patients has been reported by several research studies conducted over the last decade [8]. However, the mechanism of malnutrition in chronic kidney disease is complex and poor nutritional status can be attributed to several factors. These include dietary restrictions during the pre-dialysis period, poor appetite and increased catabolism during the dialysis period [3]. Failure to follow dietary recommendations contributes to low intake of nutrients, including vitamins, mineral compound, and energy.

Dietary advice and nutrition education play a crucial role for a good health and are important elements involved in the treatment of CKD which causes many metabolic disorders. One of the benefits of a good balanced diet is to maintain optimal body weight. According to the Kidney Disease Outcome Quality Initiative (K/DOQI) of the National Kidney Foundation, the recommended dietary intake for protein is between 1.1 and 1.2 g/kg/day and for energy between 25 and 35 kcal /kg/day for dialysis patients [9].

This study therefore aimed to evaluate the nutritional status and analyze daily food rations and determine the prevalence of protein-energy malnutrition in hemodialysis patients with end-stage renal failure in comparison with healthy control subjects.

2 Subjects and methods

2.1 Study sample

The present study (case-control) was carried out in the province of Sidi Bennour belonging to the Casa - Settat Region, between January 2017 and January 2018. The study sample involved two groups of individuals:

• A group of 156 patients with end-stage renal disease (ESRD) undergoing regular hemodialysis aged 17 or over, recruited from two dialysis units (Provincial hospital center and community hospital of Sidi bennour and Zemamra) in the province of Sidi Bennour. All participating patients were dialyzed two or three times per week (each session lasting 3 to 5 hours).

• A second control group is made up of 210 subjects without kidney disease, recruited from all the primary care centers in the province of Sidi Bennour.

All subjects were informed about the study' objectives and provided informed consent to participate in the study.

2.2 Data gathering

Information was collected using structured questionnaires to collect data on demographic characteristics (age, gender, area of residence, education level), socio-economic status (SES) (monthly income, occupation, etc.), physical activity, personal history of hypertension, diabetes, chronic kidney disease and treatment. Blood pressure and anthropometric parameters (weight, height, waist and hip circumference) were also carefully measured.

2.3 Anthropometric measurements

Weight was measured to the nearest 0.1 kg, in light clothing and without shoes using a mechanical scale and, height to the nearest 0.1 cm with a stadiometer with the subjects in a standing position, not wearing shoes and shoulders in normal position. Body mass index (BMI) was calculated by dividing weight (kg) by the square of height (m^2). Underweight was defined as BMI < 18 Kg/m^2, normal weight as $18 \leq BMI \leq 24.9$ Kg/m^2, overweight $25 \leq BMI \leq 29.9$ Kg/m^2 and overall obesity were was defined as a $BMI \geq 30$ Kg/m^2 according to the criteria of the World Health Organization (WHO). Waist circumference (WC) was measured midway between the lowest rib and iliac crest and hip circumference (HC) at the greater trochanter using a flexible tape and both expressed in (cm) and the waist-to-hip ratio (WHR) is calculated by dividing WC by the hip circumference (HC). Waist circumference (WC) is a marker of body fat distribution, according to the NCEP-ATP III reference values, a WC greater than 88 cm for women and 102 for men is considered high. For the patients' group, all anthropometric measurements were performed after the dialysis sessions and were taken by the same trained person to reduce subjective errors.

2.4 Blood pressure measurement

Systolic and diastolic blood pressures were measured twice in a sitting position, after a 10-minute rest period, using an OMRON M2 type electronic radial blood pressure monitor and the average of the two separate measurements was considered as the patient's final blood pressure. Hypertension is defined according to WHO criteria as blood pressure equal to or more than 140 mmHg (systolic)/90 mmHg (diastolic) or current use of antihypertensive medications.

2.5 Exercise assessment

Physical activity was assessed using the self-reported number of exercise sessions, of any type, that participants completed each week. This number was then multiplied by the number of minutes per session and used as an indicator of routine exercise level [10].

2.6 Biochemical measurements

All the blood samples were collected by venipuncture after an overnight fast of at least 12 hours. Sample analysis was performed using a BTS 350 semi-automatic spectrophotometer. All analyzes were carried out on the day of blood sampling. Fasting plasma glucose (FPG) was measured by an enzymatic method using glucose oxidase. Triglycerides (TG) and total cholesterol (TC) were measured using an enzymatic method with glycerol phosphate oxidase, cholesterol esterase, and cholesterol oxidase, respectively. Serum creatinine was measured by the standard Jaffe-Kinetic colorimetric reaction method, while urea was measured by an enzymatic colorimetric method with urease glutamate dehydrogenase (GLDH).

2.7 Dietary recall

The nutritional status of the study patients' group was assessed using body mass index (BMI), two 24-hour dietary recalls recorded on two separate days, one dialysis day and one non-dialysis day, were collected. Each subject was asked about the types and quantities of foods and drinks consumed during the 24 hours preceding the interview. The consumed foods were converted into various nutrients using BILNUT 2.01 software (S.C.D.A. NUTRISOFT-BILNUT) adapted to Moroccan foods, the average of the two 24-hour dietary recalls was used to reflect usual intakes for each nutrient.

Current guidelines from the Kidney Disease Outcomes Quality Initiative (K/DOQI) Clinical Practice Guidelines for Nutrition in Chronic Kidney Disease, recommend that the optimal goal of dietary protein intake is between 1.1 and 1.2 g/kg/day in the hemodialysis patient and between 25 and 35 kcal/kg/day for energy intake. Patients who consumed less than this threshold were classified as having insufficient dietary protein and energy intake, respectively.

For the control group, the dietary assessment was established for each subject completing two separate, non-consecutive 24-hour dietary recalls.

2.8 Statistical analysis

Data analyses were performed using the statistical program SPSS version 24.0. Continuous variables were expressed as mean ± standard deviation and categorical variables as frequencies and percentages. The Student's t-test was used to compare differences between means, and the Chi-square test was used to compare category differences. For all statistical tests, the significance level was set at a p-value less than 0.05 ($p \leq 0.05$).

3 Results

3.1 Demographic and socioeconomic characteristics

The study included 157 patients with ESRD on maintenance hemodialysis and 210 controls (Table 1). The two groups had differences in terms of age, gender, education level and employment status, while the comparison of the other sociodemographic characteristicsthe showed no significant differences in the two groups.

Table 1. Demographic and socio-economic characteristics of ESRD patient and control groups.

Characteristics	Control group (n=210)	ESRD patients (n=157)	P- value
Age (years)	54.18±13.45	49.34±14.99	0.001
Gender, n (%)			0.001
Male	58 (27.6)	86 (54.8)	
Femele	152 (72.4)	71 (45.2)	
Marital Status, n(%)			0.867
Married	136 (64.8)	103 (65.6)	
No	74 (35.2)	54 (34.4)	
Education attainement, n(%)			0.000
Illiterate	169 (80.5)	90 (57.3)	
Educated	41 (19.5)	67 (42.7)	
SES, n (%)			0.477
Low	122 (58.1)	82 (52.2)	
Medium	64 (30.5)	57 (36.3)	
High	24 (11.4)	18 (11.5)	
Area of residence, n (%)			0.733
Urbain	65 (31)	46 (29.3)	
Rural	145 (69)	111 (70.7)	
Employment status, n (%)			0.013
Unemployed	149 (71)	129 (82.2)	
Employed	61 (29)	28 (17.8)	
Type of family, n (%)			0.119
Nuclear	114 (54.3)	98 (62.4)	
Extended	96 (45.7)	59 (37.6)	
Medical coverage, n (%)			0.972
Without	16 (7.6)	11 (7)	
Mutual assisstance	7 (3.3)	5 (3.2)	
RAMED	187 (89)	141 (89.8)	

Data are expressed as n (%). ESRD : End stage renal disease ; SES : Socioecnomic status ; RAMED : Régime d'assistance médicale (Medical assistance plan).

3.2 Anthropometric and biochemical characteristics

The main anthropomeric and biochemical data of the study participants are presented in Table 2. The table shows significant differences between the two groups regarding weight, waist and hip circumference, WHR and BMI. The data also show that the prevalence of overweight, general obesity and abdominal obesity were significantly lower in the ESRD patient group than the control group. The results of the data analysis concerning biochemical characteristics also show that there is a significant difference of all biochemical parameters between the two groups.

Table 2. Anthropometric and biochemical of ESRD patient and control groups.

Characteristics	Control group (n=210)	ESRD patients (n=157)	P-value
Weight, (Kg)	76.15±14.55	62.27±12.80	0.000
Height, (cm)	163.25±8.32	162.65±9.26	0.521
WC (cm)	98.84±12.38	86.99±13.57	0.000
HC (cm)	104.80±9.72	93.87±8.72	0.000
WHR	0.94±0.07	0.92±0.08	0.031
BMI, (kg/m²)	28.69±5.67	23.48±4.18	0.000
BMI categories, n(%)			0.000
Underweight	3 (1.4)	12 (7.7)	
Normal weight	54 (25.7)	96 (61.5)	
Overweight	75 (35.7)	34 (21.8)	
Obesity	78 (37.1)	14 (9.0)	
WC categories, n (%)			0.000
Normal	61 (29.0)	118 (75.2)	
High	149 (71.0)	39 (24.8)	
WHR categories, n (%)			0.005
Normal	38 (18.1)	48 (30.6)	
High	172 (81.9)	109 (69.4)	
Glucose, g/l	1.25±0.61	1.06±0.57	0.004
Urea, g/l	0.30±0.09	1.49±0.57	0.000
Creatinin, mg/l	9.31±2.13	100.55±37.88	0.000
Total Cholesterol, g/l	1.85±0.38	1.60±0.41	0.000
Triacylglycerol, g/l	1.25±0.63	1.51±0.71	0.001

Data are expressed as mean ± standard error for Continuous and n (%) for categorical variables. WC : Waist circumference ; HC : Hip circumference ; BMI : body mass index ; WHR : waist to hip ratio.

3.3 Clinical and lifestyle factors

Table 3 presents information regarding the lifestyle and clinical profile of the participants. Mean SBP and DBP as well as the prevalence of hypertension were higher in the hemodialysis patient group than in the control group. There is also a significant difference between the two groups regarding tobacco and alcohol consumption. In contrast, physical activity (PA) results show higher PA levels in the control group than in ESRD patients and this difference is statistically significant (p = 0.000).

Table 3 . Comparison of Lifestyle factors and clinical data in the ESRD patients and control group.

Characteristics	Control group (n=210)	ESRD patients (n=157)	P-value
SBP, (mmHg)	132.40±19.29	133.96±22.92	0.481
DBP, (mmHg)	76.44±10.66	78.66±12.67	0.07
Hypertension, n (%)			0.016
No	136 (64.8)	82 (52.2)	
Yes	74 (35.2)	75 (47.8)	
Diabetes, n (%)			0.595
No	182 (86.7)	133 (84.7)	
Yes	28 (13.3)	24 (15.3)	
Smoking, n (%)			0.000
Never	170 (81.0)	100 (63.7)	
Current	9 (4.3)	7 (4.5)	
Past	31 (14.8)	50 (31.8)	
Alcohol consumption, n (%)			0.000
Never	194 (92.4)	121 (77.1)	
Current	1 (0.5)	0 (0.0)	
Past	15 (7.1)	36 (22.9)	
Physique activity, n (%)			0.028
Low PA	111 (52.9)	101 (64.3)	
High PA	99 (47.1)	56 (35.7)	
Etiology, n (%)			_
Unknown	_	112 (71.8)	
Hypertensive nephropathy	_	12 (7.7)	
Diabetec nephropathy	_	15 (9.7)	
Kidney polykystosis	_	8 (5.1)	
Others		9 (5.8)	

Data are expressed as mean ± standard error for Continuous variables and n (%) for categorical variables. SBP : Systolic blood pressure ; DBP : Diastolic blood pressure ; PA : Physical activity.

3.4 Dietary intake

The average dietary intakes determined in all ESRD patients and 160 controls are shown in Table 4. Energy intake was lower in ESRD patients compared to the control group while energy intake normalized to actual body weight tended to be higher in these ESRD patients, with no significant difference (P = 0.063).

Higher dietary macronutrient intakes were found in controls than in ESRD patients for carbohydrates (P = 0.012), protein (P = 0.001), and total fat (P = 0.002). Furthermore, SFA intake was higher in the ESRD patient group than in the control group (P = 0.000). Regarding micronutrients, dietary intakes of sodium (P = 0.000), potassium (p = 0.000), calcium (p = 0.000) and phosphorus (p = 0.000) were higher in the control group than in the patients suffering from ESRD. However, no difference was observed between ESRD patients and the control group regarding the percentage of proteins contribution to energy intake (p=0.285).

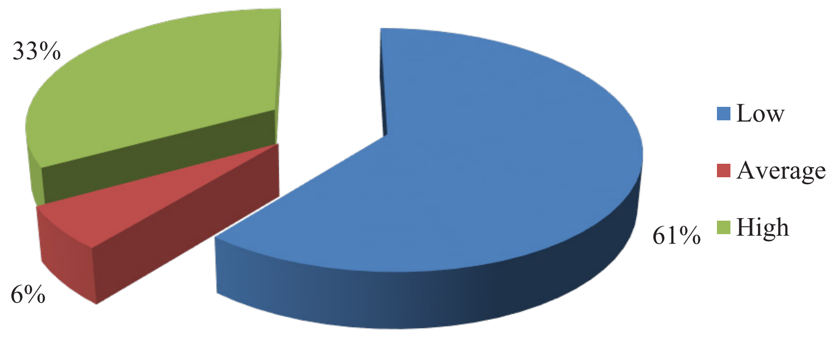
In addition, a negative and highly significant correlation was noted between protein and energy intake and age (p = 0.000), BMI (p = 0.000), WC (p = 0.000) and WHR (p = 0.000).

Table 4. Energy and nutrients intakes in the ESRD patients and control group.

Energy/Nutrients	Control group (n=160)	ESRD patients (n=157)	P- value
Energy			
Energy, kcal/day Energy, kcal/kg/day	2156.24±696.48 29.19±10.60	1904.98±592.50 31.37±10.19	0.001 0.063
Macronutrients			
Carbohydrates, g/day % from energy intake	325.29±102.23 61.21%	297.86±89.02 63.85%	0.012 0.013
Protein, g/day % from energy intake	75.24±37.13 13.85%	63.40±24.94 13.38%	0.001 0.285
Protein, g/kg/day	1.02±0.53	1.05±0.43	0.609
Total fat, g/day % from energy intake	61.62±32.31 24.94	50.59±31.62 22.79	0.002 0.037
SFA, g/day	30.55±6.33	35.83±8.61	0.000
MUFA, g/day	46.21±9.06	46.57±8.56	0.713
PUFA, g/day	23.23±7.84	17.51±6.65	0.000
Dietary fiber, g/day	29.90±13.02	19.03±10.65	0.000
Micronutrients			
Calcium, mg/day	529.39±286.23	390.65±199.57	0.000
Phosphorus, mg/day	1384.49±475.50	1038.44±378.31	0.000
Sodium, mg/day	2835.20±1159.48	1971.42±1082.15	0.000
Potassium, mg/day	2621.59±945.32	2030.97±720.76	0.000
Vitamin E, mg/day	4.63±4.58	3.36±3.01	0.004
Vitamin B1, mg/day	1.10±1.55	0.68±0.28	0.001
Vitamin C, mg/day	91.11±63.32	61.23±49.08	0.000
Folates, mg/day	320.74±120.60	211.26±99.70	0.000

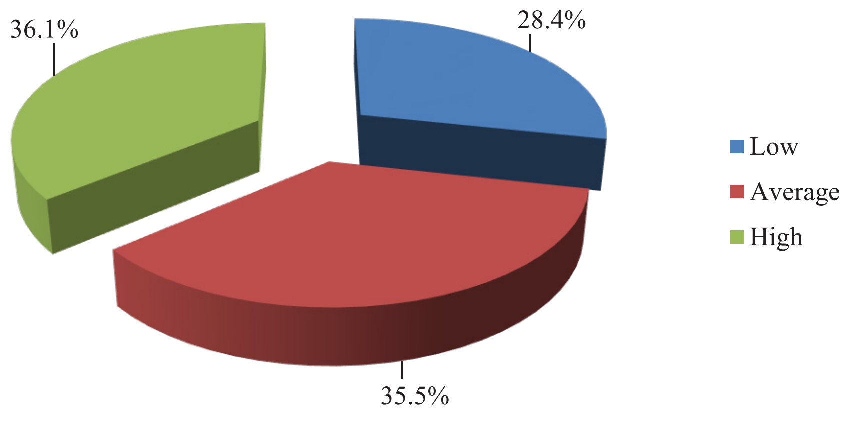
Data are expressed as mean ± standard error.

Figures 1 and 2 displays the results of protein and energy intakes in hemodialysis patients, respectively. The figures have revealed that only 6% of participants met the recommended intake of protein intake and 36.1% met the recommended intake of energy.



Legends: Low: Below the recommended level; Average: On the recommended level; High : Above the recommended level

Fig. 1. Distribution of ESRD patients according to the recommended level of protein intake.



Legends: Low: Below the recommended level; Average: On the recommended level; High: Above the recommended level.

Fig. 2. Distribution of ESRD patients according to the recommended level of energy intake.

4 Discussion

This study is the first to present data on the nutritional status and food intake of hemodialysis patients in Morocco. It aimed to assess nutritional status and analyze daily food intakes as well as the prevalence of protein-energy malnutrition in ESRD compared to control subjects. To our knowledge, this is also the first study to jointly explore the characteristics of patients with ESRD and their early dietary intake of energy and macronutrients and compare them with control subjects residing in the province of Sidi Bennour.

Study data indicated that among the causes of ESRD, unknown etiology was the most common cause of ESRD (71.8%), followed by diabetic nephropathy (9.6%), and then hypertensive nephropathy (7.7%). These results are consistent with those reported by previous studies conducted in Mexico and Egypt [11] which highlight that public health awareness, early diagnosis and management of diabetes and hypertension should include the most important steps for the prevention of ESRD.

The present results showed that 35.7% and 37.1% of the control group were overweight and obese, respectively, compared to 21.8% and 9.0% of ESRD patients with overweight and obesity. These prevalences of excessive weight appear high compared to those reported in a previous survey published by Balbino et al, 2017 [12] and lower than another study published by Racic et al, 2015 and Boaz et al, 2021 [13, 14].

The dietary intake of hemodialysis patients was significantly lower than that of control subjects and did not meet daily calorie or protein requirements. Indeed, the intakes of most nutrients were lower in dialysis patients, particularly those of minerals and vitamins. This difference could be explained by the symptoms often associated with advanced chronic kidney disease, in this case anorexia, nausea, vomiting, psychosocial factors, depression and poverty [15, 16]. Furthermore, patients with ESRD are subject to certain dietary restrictions such as reducing the intake of phosphorus, an important component of protein foods, as well as reducing fruits and vegetables. As a result, patients' overall diet often does not meet daily calorie and protein requirements. Additionally, the risk of increased potassium and fluid overload contribute to serious cardiovascular complications and increased mortality in hemodialysis patients [17, 18]. On the other hand, although ESRD patients have lower intakes of macro- and micronutrients, they have a higher intake of saturated fatty acids. Thus, based on the results of this study and given the implication of saturated fat consumption in atherosclerosis and cardiovascular problems, one can say that dialysis patients have an atherogenic diet. This finding appears to be in agreement with other studies undertaken by Maraj et al, 2019 [17] and Kalantar Zadeh et al, 2002 [9] who reported that patients with ESRD seem to have a dietary composition rich on meat and fats exposing these patients to a more atherosclerosis disease.

In order to maintain adequate nutritional status, kidney current guidelines recommend for ESRD patients undergoing maintenance hemodialysis to have a protein intake of 1.1 to 1.2 g/kg/day and an energy intake of 25 to 35 kcal/kg/day [19]. However, in this study, patients did not meet these current recommendations and only 6% and 36.1% of these HD patients achieved the recommendations for protein intake and energy intake respectively. These results were in line with those of several studies carried out by Luis et al, 2016, Kalantar Zadeh et al, 2002 and Emara et al, 2022 [9, 16, 20].

This study has several limitations that should be considered. The survey was carried out on a population from a low socio-economic area of Morocco which could affect the diet of hemodialysis patients from the study region but may not be extrapolated to ESRD patients in other areas centers or regions of Morocco. Nevertheless, the results found strongly agree with reports from other parts of the world.

Dietary records are carried out over two days only which can be a source of errors inherent in dietary assessment and can also be affected by under- or over-reporting. However, an effort was made to minimize them, through additional concise interviews with patients to determine more precisely the quantity of food portions ingested. Furthermore, as participants were recruited from only two HD centers, the results cannot be generalized to all patients undergoing renal replacement therapy in Morocco.

Another limitation is that the study design does not allow the causality of the observed associations to be assessed.

5 Conclusion

In conclusion, the results of this study highlighted the importance of dietary management of chronic renal failure. Patients must eat an adequate and balanced diet to maintain good nutritional status. It is therefore imperative to increase overall energy intake as well as protein intake, provided that 70% of protein intake is of animal origin [18, 21, 22]. Indeed, nutritional education and counseling of patients with ESRD have a major role to play in the preservation of renal functions and the prevention of morbidity. The ultimate goal is to improve quality of life for maintaining an optimal nutritional state and thus improve the quality of life of hemodialysis patients.

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References

1. R. Belahsen, Proceedings of the Nutrition Society **73(3)**, 385-388 (2014)
2. R. Moustakim, M. El Ayachi, M. Mziwira, et al., Nephrol Ther. **16**, 147-152 (2020) DOI: https://doi.org/10.1016/j.nephro.2019.12.003
3. R. Moustakim, M. Mziwira, M. El Ayachi, et al., GSC Advanced Research and Reviews **3(2)**, 09-19 (2020)
4. R. Moustakim, M. Mziwira, M. El Ayachi, R. Belahsen, Metab Syndr Relat Disord. **19(8)**, 460-468 (2021) DOI: 10.1089/met.2020.0117
5. M. Skouroliakou, M. Stathopoulou, A. Koulouri, et al., Journal of Renal Nutrition **19(4)**, 283 – 290 (2009)
6. J. J. Carrero, F. Thomas, K. Nagy, et al., Journal of Renal Nutrition **28(6)**, 380 – 392 (2018)
7. H. Tabibi, A. As’habi, B. N. Heshmati, et al., Renal Failure **34(10)**, 1200–1205 (2012)
8. A. M. Omari, L. S. Omari, H. H. Dagash, et al., BMC Nephrology **20**, 92 (2019) DOI : https://doi.org/10.1186/s12882-019-1288-z
9. K. Kalantar-Zadeh, J. D. Kopple, S. Deepak, et al., Journal of Renal Nutrition **12(1)**, 17-31(2002)
10. L. Funderburk, M. Peterson, K. Beretich, et al., PloS One **13(12)**, e0209514 (2018)
11. A. H. Mohamed, M. O. Omar Jeele, International Journal of General Medicine **15**, 6259–6267 (2022)
12. K. P. Balbino, A. P. S. Epifanio, S. M. R. Ribeiro, et al., Comparison between direct and indirect methods to diagnosis of malnutrition and cardiometabolic risk in haemodialysis patients. J Hum Nutr Diet (2017)
13. M. Racic, N. Petkovic, K. Bogicevic, et al., Ren Fail. **37(7)**, 1126–1131 (2015)
14. M. Boaz, Kaufman-Shriqui, O. Azoulay, T. Weinstein, Life **11**, 166 (2021) DOI: https://doi.org/10.3390/life11020166
15. H. Lee, H. Kim, T. Y. Kim, et al., J Korean Med Sci. **35(23)**, e181 (2020) DOI: https://doi.org/10.3346/jkms.2020.35.e181

16. R. H. Emara, D. M. Abo Zahra, JHIPH **52(1)**, 8-16 (2022)
17. M. Maraj, B. Kuśnierz-Cabala, P. Dumnicka, et al., Oxidative Medicine and Cellular Longevity, Article ID 6309465, 10 pages (2019) DOI: https://doi.org/10.1155/2019/6309465
18. K. Mekki, M. Bouchenak, M. Remaoun, J. Belleville, Cah. Nutr. Diét. **39(3)**, 211 – 216 (2004)
19. T. A. Ikizler, J. D. Burrowes, L. D. Byham-Gray, et al., Am J Kidney Dis. **76 (3 Suppl 1)**, S1-s107 (2020) DOI: 10.1053/j.ajkd.2020.05.006.
20. D. Luis, K. Zlatkis, B. Comenge, et al., J. Ren. Nutr. **26**, 190–195 (2016)
21. Ikizler and Hakim, Kidney International **50**, 343 – 357(1996)
22. C. O. Oladele, E. Unuigbe, I. I. Chukwuonye, et al., Saudi J Kidney Dis Transpl. **32(2)**, 445-454 (2021)