Original article

Effect of a dietary education intervention on biochemical markers in hemodialysis patients with chronic kidney disease: A study in Udupi and Mangalore regions of Karnataka, India

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Abstract. *Background and aim:* Nutritional health is one of the most critical aspects of overall health for chronic kidney disease (CKD) sufferers, particularly those on hemodialysis. In CKD, advanced kidney disease and renal replacement treatment cause protein-energy wasting, leading to various metabolic and nutritional abnormalities. Despite the importance of diet for hemodialysis patients, investigations have revealed that many individuals need more knowledge about optimal nutrition. As a result, inadequate nutrition reduces life quality and increases hemodialysis complications and mortality in these patients. This study aimed to evaluate the impact of a dietary education intervention on biochemical markers in hemodialysis patients with CKD in the Udupi and Mangalore regions of Karnataka, India. *Materials and Methods:* This is a multicentric and randomised control trial was conducted among 250 hemodialysis patients with CKD at KMC Hospital, Manipal, Dr TMA Pai Hospital Udupi, and Father Muller Medical College Hospital (FMMCH) Mangalore from April 5, 2022, to April 5, 2023. The participants were randomly assigned to either the intervention or control groups. The intervention group received a comprehensive dietary education program, including personalised dietary plans, nutritional counselling, and monitoring, while the control group received standard care without any specific nutritional intervention. The statistical analysis was carried out using the EZR software. *Results:* The results demonstrated a significant improvement in biochemical markers among participants in the intervention group compared to the control group. Specifically, there was a notable reduction in sodium ($p < 0.001$), haemoglobin ($p < 0.001$), and potassium ($p = 0.009$) levels in the intervention group. *Conclusions:* The findings of this study highlight the positive impact of a dietary education intervention on improving biochemical markers in hemodialysis patients with CKD.

Key words: nutrition education program, biochemical parameters, patient education, end-stage renal disease, hemodialysis, adherence to fluid limitations, Udupi region

Introduction

Hemodialysis (HD) or kidney transplantation is necessary for individuals with end-stage kidney disease (ESKD) to remove waste products and excess fluids from the bloodstream while regulating salts and minerals. Hemodialysis is the primary treatment method for 93% of hospital patients with impaired renal function. This typically involves a four-hour session connected to a dialysis machine thrice weekly. However, hemodialysis is associated with a restricted diet, fluid intake, fatigue, and other symptoms that impede daily activities (1). ESKD is a significant public health concern, and epidemiological data indicate an increasing prevalence of the condition globally (2). In India, studies have reported an incidence rate of 229 cases per million people for ESKD, with over 100,000 new patients requiring renal replacement therapy (RRT) annually (3).

HD is a highly effective therapeutic option, and maintaining adherence to dialysis treatment can be challenging for individuals. Nutrition is crucial in mitigating complications and improving the quality of life for individuals with HD. CKD individuals undergoing dialysis must adhere to a stringent dietary regimen as part of their treatment. Patients undergoing hemodialysis frequently require accurate information about their nutritional regimen (4). Malnutrition is highly prevalent among HD patients and is associated with increased mortality and morbidity rates. Therefore, in routine nephrology practice, dietary assessment and providing adequate care for dialysis patients are paramount (5).

Maintaining a well-balanced diet is crucial for promoting overall health. It is integral to treating chronic renal disease, often leading to biochemical abnormalities. One benefit of a balanced diet is achieving and maintaining a healthy body weight (6). In individuals with chronic renal disease, diet is an essential element of prevention for CKD. As a result, inadequate nutrition reduces life quality and increases hemodialysis complications and mortality in these sufferers. One of hemodialysis patients' most essential health goals is to reduce undernutrition, ensure appropriate nutrition, and avoid skeletal symptoms and biochemical problems by controlling serum phosphorus and calcium levels and encouraging patients to eat a balanced diet. As a result, specific and continuous education is required for these patients. Patients educated about their disease save time and energy and are more likely to eat a diet that decreases hospital visits. In addition to improving the quality of health treatment, education can help patients recover (7).

Sodium is a vital extracellular fluid component and crucial in maintaining serum osmolality. Individuals with chronic kidney disease (CKD) who have impaired sodium excretion are at risk of developing hypertension. The sodium balance in hemodialysis patients is influenced by sodium intake and dialysis removal. Despite the significance of dietary considerations for hemodialysis patients, studies have indicated a need for more knowledge among many individuals regarding optimal nutrition (8).

Dietary adherence among patients with ESKD can significantly impact blood calcium and phosphorus levels, potentially leading to bone abnormalities associated with ESKD. Therefore, healthcare professionals should prioritise maintaining control over these factors. Both the International Society of Renal Nutrition and Metabolism (ISRNM) and the National Kidney Foundation (NKF) Kidney Disease Outcomes Quality Initiative (KDOQI) guidelines advisory committee strongly recommend nutritional management as an integral part of the treatment approach for predialysis patients (9). Protein-energy wasting (PEW) is a prevalent condition associated with malnutrition among hemodialysis individuals (10). Adherence to appropriate dietary guidelines, ensuring sufficient food intake, and receiving nutritional support can help prevent malnutrition (11).

Nutrition is a critical part of treatment for those with chronic renal impairment. Hence, poor nutrition significantly affects these patients' mortality, quality of life, and hemodialysis complications. Dietary and lifestyle modifications must be implemented to treat chronic renal disease (12). The risk of malnutrition is estimated to be 40% greater for people with CKD (13). The most important health concerns for hemodialysis patients are preventing starvation, providing enough food, preventing renal osteodystrophy

by managing calcium and phosphate levels, and encouraging patients to take the right foods (14,15). Thus, these patients need specialised and ongoing nutrition instruction (16). Education can help people become more intelligent, pragmatic, and psychologically aware (17). Knowledge is increased because of effective patient education on treatments for chronic illnesses. People can be persuaded to modify their behaviour by making them aware of their lifestyle and how it affects their health since knowledge is a prerequisite for change (18). Teaching patients about their condition might help them save unnecessary time and effort spent on medical visits by motivating them to maintain a healthy diet (19). Education may enhance a patient's symptoms, self-control, and independence, in addition to raising the standard of healthcare (20, 21). Evaluating the outcomes of a nutrition programme using laboratory standards is one way to assess the effectiveness of education.

Uric acid, blood urea nitrogen, total protein, and creatinine are critical markers of renal function and must be periodically checked among these parameters (22). Even though dialysis reduces mortality among CKD sufferers due to mineral metabolism, it raises the chance of developing cardiac issues (23). For instance, the mineral phosphorous is naturally found as phosphorus and is essential for bone metabolism. Patients with CKD who experience mineral and bone abnormalities should focus on preventing and treating hyperphosphatemia. According to studies, individuals receiving hemodialysis are more likely to die because of hyperphosphatemia. Receiving proper nutrition is one of the key strategies for achieving this objective (24).

Clinical pharmacists and nurses play a unique and crucial role among hemodialysis professionals due to their frequent patient interactions, enabling them to be more attuned to patients' needs and capable of providing relevant comments and recommendations (25). Research has shown that patient education by nurses contributes to increased patient knowledge and better adherence to treatment plans (26). Furthermore, nurses are actively involved in independent activities, such as educating patients about self-care, which is invaluable.

In India, CKD is a significant public health concern, and the Udupi and Mangalore regions of Karnataka have reported a high prevalence of CKD cases. Despite the high majority, limited research has focused on the impact of dietary education interventions tailored explicitly for hemodialysis patients in this region. Understanding the effectiveness of dietary education interventions in this population is essential for developing evidence-based strategies to improve the management of CKD and enhance patient outcomes. It is expected that the provision of personalised diet planning, nutritional advice, and ongoing monitoring through this intervention will positively impact the biochemical markers and overall nutritional status of hemodialysis patients in these regions.

Material and methods

Study setting, design, and patient characteristics

This study was designed as a randomised control trial (RCT) and multi-centric setting investigation from April 5, 2022, to April 5, 2023. Responses were collected from 250 patients undergoing treatment at KMC Hospital, Manipal, Dr TMA Pai Hospital, Udupi, and FMMCH, Mangalore, India. Two hundred fifty patients (183, 73.2%) were male, and (67, 26.8%) were female. A total of 250 patients (198, 79.2%) were undergoing dialysis in the general dialysis unit, (24, 9.6%) were in the special dialysis unit (SDU), and (28, 11.2%) were in the isolation room. The questions were framed and multiplied by the total sample size (intervention 125 and control 125) at our hospitals for effective nutrition education for hemodialysis patients and validated with the help of three nephrologists and two renal dieticians. Patients' dietary regimen consisted of 54 items, including information on the significance of eating a balanced diet, proteins, calories, potassium, phosphorus, calcium, salt, fluids and vitamins, and dietary supplements. Of a total of 54 questions, 6, 7, 7, 5, 7, 4, 5, and 13 questions were related to knowledge and awareness about potassium, phosphorus and calcium, salt, proteins & iron, fluids, calories, vitamins and nutritional supplements, kidney and hemodialysis respectively were framed in the questionnaire.

Inclusion criteria

1. Only outpatient department haemodialysis Patients
2. Treatment on End Stage Renal Disease
3. At least three months of haemodialysis therapy.
4. Patients who could complete questionnaires in Kannada and English during a direct interview.
5. Patients must be at least 18 years old.
6. Patients who agree to take part in the investigation.
7. Ability to speak as well as understand English or Kannada language.
8. Being conscious and cooperative
9. Haemodialysis sufferers with co-infections of HIV, Hepatitis B, and Hepatitis C

Exclusion criteria

1. Individuals receiving hemodialysis for acute kidney injury and chronic kidney disease.
2. Patients are not willing to give consent.
3. Patients who were pregnant and lactating
4. Patients undergoing renal transplantation evaluation.
5. All paediatric patients
6. Any tumours or trauma patients
7. Patients who do not often undergo maintenance haemodialysis but occasionally require it because of severe conditions.
8. Any surgical complications such as kidney stones
9. Patients on peritoneal dialysis
10. ICU Patients
11. The study did not include participants undergoing therapy on the day of the visit and refusing to give permission.
12. Severe physical or mental impairment conditions

Two hundred fifty patients with HD were recruited as participants from three hospitals, and a selection was made randomly for either the intervention (n=125) or control (n=125) groups. Patients were interviewed while receiving outpatient HD treatment and routine dialysis unit follow-up visits. Participants were instructed in individualised sessions during the health education programs. The researchers gave the educational instructions; each session lasted 20 minutes and was done twice weekly for 24 weeks. The pedagogical presentation began with an overview of renal impairment and a summary of what HD is, how it works, and why it is essential to use and maintain it. Dietary counselling was given to participants individually in a verbal and written manner in collaboration with a dietician, emphasising the appropriate number of phosphorus, potassium, sodium, calcium, calories, protein, and portions to consider. For HD patients, a nutritional pamphlet was designed to explain and demonstrate the permitted number of fruits, proteins, and vegetables, as well as junk foods' salt and sugar content and the repercussions of these components. This research was separated into two sections: pre-nutrition education program and post-nutrition education program. During the pre-nutrition education phase, a systematic survey was done to analyse the haemodialysis patient's dietary status and highlight the educational program's priorities. The post-education phase included implementing an education program to evaluate its impact on renal disease, anthropometric measurements, and haemodialysis patient lifestyle.

In a pre-educational program to collect data, direct interviews with HD patients were conducted during dialysis. Interviews, flyers, and posters were used as educational materials. Six months after the education, the same questionnaire was administered to collect the data.

There are three sections to the questionnaire. The first section includes socio-demographic data such as age, gender, educational achievement, and medical information. The second section covers biochemical evaluation such as creatinine, calcium, potassium, phosphorous, sodium, vitamin B12, folic acid, bicarbonate, haemoglobin, red blood cells, iron, serum ferritin, total protein, albumin, uric acid, and PTH. These details were obtained from the patient's file, and section three covers anthropometric measurements, the patient's height, weight, and body mass index (BMI). Dietary assessment is essential

to nutritional assessment and part of any effective healthcare system. We have used the following approaches to evaluate the type and quantity of food consumed by the sample. For three days, the patient kept track of their food intake. Sufferers were asked to give a detailed description of their meal consumed, including the brand name, if feasible and an estimate of the amount consumed in grams. Three days of daily nutrient consumption were documented for food analysis.

The nutrition teaching programs were established to improve the nutritional status and dietary consumption of ESRD patients. Five nutrition and kidney disease specialists examined the programs for content consistency, objective consistency, and language compatibility. After a 12-hour fast, blood samples were collected in the morning to determine Vitamin B12, Folic acid, and Bicarbonate. These laboratory studies were conducted at the Manipal Academy of Higher Education hospital, employing standard laboratory protocols. Data collection tracked the patient's total nutritional intake, including everything the patient ate, using a three-day food intake diary. NutritionIx is an indigo company software that calculates food calories and nutritional composition. The results were compared to the existing Quality of Kidney Disease Outcomes Initiative guidelines.

Statistical analysis

All statistical analyses were carried out with the EZR software (Model 1.41, Rterm (64-Bit) R commander, (Mac et al., USA and Microsoft Corporation, USA). When describing nutrition parameters, questions and an overall score, Frequency, and Percentage were used in the general HD patients. After education, the interventional group obtained the highest percentage of calories (81.6%), whereas the control group obtained the highest rate of knowledge related to vitamins and nutritional supplements (76.8%).

Ethical approval

Ethical approval was obtained from the Institutional Ethics Committee before commencing the study. Informed consent was obtained from all participants, ensuring their privacy, confidentiality, and voluntary participation. Measures were taken to maintain data security and protect participant identities throughout the study. The research was given ethical clearance by the Institutional Committees (IEC: 471/2019 from KMC Manipal, held valid for KMC Manipal and Dr TMA Pai Hospital Udupi, FMIEC/CCM/294/2021 from FMMCH, Mangalore). Clinical Trial Registration-India (CTRI) registration number was CTRI/2019/08/020874.

Results

The level of knowledge related to nutritional parameters and kidney-related questions among patients undergoing hemodialysis before and after education is shown in Table 1. The level of Knowledge and overall scores before and after the education of HD patients are shown in Table 2.

The overall score shows that in a sample size of 250 people, inadequate knowledge was identified in both the interventional and control groups (42, 33.6 %) before education, (6, 4.8%) after education, and (36, 28.8 %) before teaching, (15, 12 %) after schooling. Moderate knowledge was identified in both the interventional and control groups (49, 39.2 %) before teaching (58, 46.4%) after education, and (40, 32 %) before conducting 57, 45.6 %) after schooling. Adequate knowledge was identified in both the interventional and control groups (34, 27.2 %) before eduteaching61, 48.8%) after education, and (49, 39.2 %) before eduteaching (53, 42.4 %) after education. Knowledge of the patients regarding dietary regimen has improved after implementing the intervention program in the interventional group as precise, as noted in the after-education results in all domains. Table 3 shows the impact of a dietary education program on hemodialysis patients' overall BMI and weight measures.

The patients had normal BMI levels compared to the before and after education in the interventional and control groups. Compared to before and after education, weight measurements were reduced in the intervention group but increased in the control group. Table 4 shows the impact of a biochemical assessment education program on overall hemodialysis patients.

Table 1. Level of knowledge related to nutritional parameters and kidney-related questions among patients undergoing hemodialysis patients before and after nutritional education.

Nutrition and Kidney related knowledge	Interventional Group (N=125)				Control Group (N= 125)			
	Before education	%	After education	%	Before education	%	After education	%
Knowledge related to potassium	419	55.86	585	78	399	53.2	345	46
Knowledge related to phosphorus and calcium	436	49.82	644	73.6	419	47.88	413	47.2
Knowledge related to salt	457	52.22	603	68.91	425	48.57	432	49.37
Knowledge related to proteins and Iron	321	51.36	467	74.72	296	47.36	340	54.4
Knowledge related to fluid	535	61.14	685	78.28	459	52.45	602	68.8
Knowledge related to calories	250	50	408	81.6	295	59	377	75.4
Knowledge related to Vitamins and nutritional supplements	280	44.8	428	68.48	396	63.36	480	76.8
Knowledge related to kidney and hemodialysis questions	835	51.38	1071	65.90	735	45.23	943	58.03

Table 2. Level of Knowledge and overall scores before and after the education of HD Patients.

Nutrition and Kidney related knowledge	Scores	Interventional Group				Control Group			
		Before education	%	After education	%	Before education	%	After education	%
Adequate knowledge	37-54	34	27.2	61	48.8	49	39.2	53	42.4
Moderate knowledge	19-36	49	39.2	58	46.4	40	32	57	45.6
Inadequate knowledge	0-18	42	33.6	6	4.8	36	28.8	15	12
Total	54	125	100	125	100	125	100	125	100

Table 3. The impact of a dietary education program on hemodialysis patients' overall BMI and weight measures.

Parameters	Normal range		Interventional Group				P. Value	Control group				P. Value
Underweight	<18.5		Pretest		Post-test			Pretest		Post-test		
Normal	18.5-24.9	Parameters	Mean	S. D	Mean	S. D		Mean	S. D	Mean	S. D	
Overweight	25-29.9	BMI measurements	22.24	4.62	22.13	4.49	0.097	21.79	3.60	21.94	3.68	0.056
Obesity	>30	Weight measurements	59.62	14.19	58.68	13.66	0.013	57.75	11.17	59.11	13.94	1.174

According to the effect of nutritional education in interventional studies, the biochemical parameters were improved and highly significant before and after instruction. Sodium (150.08 ± 9.46 mmol/L vs 140.78 ± 4.66), Potassium (5.38 mmol/L ± 1.07 vs 4.83 ± 0.98), Phosphorus (5.94 mg/dl ± 2.55 vs 4.26 ± 1.71), Albumin (3.31 g/dl ± 0.71 vs 3.90 ± 0.78), Haemoglobin (9.80 g/dl ± 1.93 vs 13.60 ± 0.67), Red blood cells (4.14 ×10^ 6/μL ± 0.72 vs 4.68 ± 1.30), Iron (31. 76 ± 14.24 vs 106.60 vs 127.75) and Bicarbonate (19.41 ± 2.90 vs 22.47 ± 2.81). According to the effect of nutritional education in interventional studies, the biochemical parameters were non-significant before and after instruction. Serum ferritin (933.83

Table 4. The impact of a biochemical assessment education program on overall hemodialysis patients.

		Interventional Group				P.Value	Control group				P. Value
		Pretest		Post-test			Pretest		Post-test		
Parameters	Normal range	Mean	S. D	Mean	S. D		Mean	S. D	Mean	S. D	
Na	136-145 mmol/L	150.08	9.46	140.78	4.66	1.62e-16 ($P<0.01$)^{S}	137.08	7.91	133.44	7.69	0.095^{NS}
K	3.5-5.1 mmol/L	5.38	1.07	4.83	0.98	0.009^{S}	5.29	0.92	5.51	2.82	0.388^{NS}
Iron	33-193 µg/dl	31.76	14.24	106.40	127.75	0.000^{S}	70.52	164.42	83.30	63.34	0.317^{N}
S.ferritin	20.0-250ng/dl	933.83	705.60	798.25	637.55	0.041^{NS}	837.32	655.75	864.27	657.07	0.679^{NS}
Creatinine	0.7-1.2mg/dl	9.36	4.05	6.69	3.63	0.028^{NS}	9.01	3.85	7.69	4.87	0.095^{NS}
Uric acid	Male:4.4 -7.6 mg/dl Female: 2.3-6.6 mg/dl	7.28	2.69	6.19	2.23	0.013^{N}	6.26	2.56	5.53	2.84	0.021^{N}
ALB	3.5-5.2g/dl	3.31	0.71	3.90	0.78	0.015^{S}	3.75	0.70	4.02	0.89	0.036^{N}
T. protein	0-2 Yrs. 5.6-7.5g/dl Above 3 Yrs.8.40 g/dl	6.90	1.06	6.53	1.00	0.002^{N}	5.91	1.96	6.87	1.04	0.004^{N}
PTH	15-65 pg/ml	429.60	444.17	349.02	271.61	0.077^{NS}	439.43	425.18	502.40	404.86	0.089^{NS}
Ph	2.5-4.5mg/dl	5.94	2.55	4.26	1.71	0.001^{S}	5.58	1.92	5.34	2.29	0.324^{NS}
Ca	8.6-10.0 mg/dl	9.00	1.65	9.34	1.82	0.134^{N}	8.14	1.25	8.38	1.32	0.125^{NS}
HBG	13.0-17.0g/dl	9.80	1.93	13.60	0.67	3.79e-35 ($p < 0.05$)^{S}	9.55	1.53	9.40	2.08	0.458^{NS}
RBCs	4.5-5.5 ×10^ 6/µL	4.14	0.72	4.68	1.30	0.037^{S}	3.26	0.59	3.40	0.72	0.044 ^{NS}
Bicarbonate	22-29 mmol/L	19.41	2.90	22.47	2.81	1.03^{e-13S}	18.44	3.31	20.48	3.99	0.062^{NS}
Folate	Males: 4.5-32.2 ng/ml Females: 4.8-37.3 ng/ml	12.04	6.20	11.91	5.96	0.777^{N}	10.92	5.81	12.34	5.83	0.004^{N}
Vitamin B12	Normal: 197-771pg/ml Intermediate: 145-190pg/ml Deficient: <145pg/ml	580.22	548.07	642.21	617.78	0.090^{N}	537.313	546.33	641.16	630.52	0.025^{N}

Note: N: Normal; S: Significance; NS: Non-significant.

ng/dl ± 705.60 vs 798.25 ± 637.55), Creatinine (9.36 mg/dl ± 4.05 vs 6.69 ± 3.63), and Parathyroid Hormone (429.60 pg/ml ± 444.17 vs 349.02 ± 271.61). According to the effect of nutritional education in interventional studies, the biochemical parameters were normal before and after instruction. Uric acid (7.28 mg/dl ± 2.69 vs 6.19 ± 2.23), T. protein (6.90g/dl ± 1.06 vs 6.53 ± 1.00), Calcium (9.00 mg/dl ± 1.65 vs 9.34 ± 1.82), Folic acid (12.04 ng/ml ± 6.20 vs 11.91 ± 5.96) Vitamin B12 (580.22 ± 548.07 vs 642.21 ± 617.78). Table 5 shows the impact of a nutritional assessment education program on hemodialysis patients.

The intervention group's nutrition parameters were reduced compared to the before and after education. Total food amount in grams, plant protein, animal protein, plant fat, animal fat, plant carbohydrate, animal carbohydrate, and cholesterol. The fibre diet significantly increased in the interventional group

Table 5. The impact of a nutritional assessment education program on hemodialysis patients.

	Interventional Group				P.Value	Control group				P. Value
	Pretest		Post-test			Pretest		Post-test		
Parameters	Mean	S. D	Mean	S. D		Mean	S. D	Mean	S. D	
Patients take the total food amount	1956.31	531.18	1915.96	507.20	0.155	1868.60	520.79	1979.78	712.18	0.695
Plant Proteins	38.04	18.04	37.63	16.77	0.773	40.06	16.58	46.58	80.80	0.361
Animal Proteins	30.12	20.07	25.27	19.19	0.006	28.34	23.00	29.83	24.02	0.751
Plant Fat	39.15	25.61	38.03	25.59	0.598	40.18	21.94	40.11	21.71	0.969
Animal Fat	23.35	15.39	20.68	15.06	0.051	23.31	18.76	23.64	19.05	0.823
Plant carbohydrate	219.51	109.30	216.56	99.34	0.691	211.80	104.05	207.31	103.58	0.456
Animal Carbohydrate	65.32	59.62	60.86	53.72	0.382	63.29	55.20	65.21	56.66	0.716
Fibre	28.05	15.43	32.72	17.81	0.005	32.13	14.62	29.21	13.93	0.003
Cholesterol	0.28	1.87	0.15	0.18	0.422	0.21	0.28	0.40	1.36	0.138

compared to before and after education. Compared to the before and after education, these nutrition parameters were raised in the control group. Total food amount in grams, plant protein, animal protein, animal fat, plant carbohydrate, animal carbohydrate, and cholesterol. When compared to the before and after education, plant fat and fibre diet was reduced in the control group. All nutritional metrics improved in interventional groups when compared to the control group. Indian Food Composition Tables (IFCT) 2017 and the Indian food composition database assessed the dietary characteristics of plant and animal proteins, plant and animal fat, plant and animal carbohydrates, fibre, and cholesterol. ICMR-National Institute of Nutrition (NIN) Hyderabad Dept. of Health Research, Ministry of Health and Family Welfare, Government of India created this database. Nutrition education information for hemodialysis patients' theory, as well as pictorial examples, was prepared. Nutritional knowledge related to potassium, phosphorus, calcium, salt, proteins, and fluids is explained with visual examples.

Discussion

Studies have shown that patients with renal disease need to make dietary changes to prevent malnutrition (27-30). End-stage renal illness is frequently the result of CKD. This is a devastating side effect that causes significant morbidity and mortality worldwide. CKD is a universal health problem that affects millions of citizens (31, 32). HD patients have a variety of difficulties that affect many aspects of their lives (33).

No previous research has been done in India on the correlation between nutrition education (NE) programs and biochemical and nutritional characteristics in HD sufferers. This is also the first study to investigate the impact of NE and how it influences HD sufferers' lifestyle decisions. In addition, our study used many hospital participants, allowing for a more precise analysis of the findings. It is challenging to measure the nutritional status of hemodialysis patients. According to several authors, undernutrition is more common in people under the age of 30 than in people over the age of 60, and it was also established that there is a link between malnutrition and the ageing process. Undernutrition was more common among illiterates, or persons with no education than among those with a higher level of education. A lack of education and information in this group frequently causes malnutrition. According to this study, being underweight is one of the risk factors for starvation in HD sufferers, consistent with previous findings. Albumin levels in hemodialysis patients are dropping, according to various studies. According to several conclusions, patients on dialysis for more than four years had a higher risk of

malnutrition than those on dialysis for less than one year (34).

One of the most essential things CKD patients can do to control their blood pressure is to reduce their sodium intake. According to the National Kidney Disease Education Program, controlling blood pressure lowers protein urea levels and reduces the risk of developing cardiovascular disease (35). After participating in a dietary education program, hemodialysis patients' serum RBC and HBG levels increased significantly.

Our findings demonstrated that hemodialysis patients were in a healthy weight range as measured by BMI and that weight and BMI changes following a nutrition education program were substantial. Anthropometric measurements are used to assess a person's nutritional state. Anthropometry is a simple and accurate method for determining changes in nutritional status (36). Hemodialysis patients should pay attention to their mineral intake and limit their salt, phosphate, and potassium consumption. The results demonstrate that after participating in a nutrition education program, Na, Ph, and K consumption reduced significantly ($P<.01$). Hemodialysis patients must typically limit their daily potassium consumption to (2–3 g/day) and their daily phosphorus intake to 0.6–1.2 g/day. These findings are consistent with those of Cukor et al., who discovered that dietary guidelines are strict (fluid, potassium, phosphorus, and low sodium) and that the decrease in Na, Ph, and K consumption after a nutrition education program is due to patients improving adherence to a suitable diet and food items (37). Hemodialysis patients are more likely to suffer from malnutrition because of a lack of protein in the diet. Prescription medications, along with food, can trigger stomach upset, which can lead to a reduction in appetite and food consumption. As a result, it could be the cause of malnutrition. According to various studies, other factors probably interfere with this survey's results. Anaemia, gastroenteritis, prolonged kidney diseases, and dermatitis can all increase malnutrition (38).

Dieticians and clinical pharmacists play a vital role in assisting patients in improving their nutritional intake and offering advice on nutrient restrictions such as potassium, sodium, phosphorus, and fluid intake (39). One of the most common ways of nutrition education patients receive is one-on-one and face-to-face teaching. Patient-centred education is vital in improving the sufferer's knowledge of the disease (40). Sufferers of hemodialysis would benefit from a health education program that would help them better understand their renal disease, learn self-management skills, and actively participate in their hemodialysis treatment, enhancing adherence and quality of life (41). Moreover, this is consistent with the current nutritional health education program that positively impacts patient knowledge and performance regarding chronic disease patient care. A statistically significant difference in HD patients' outcomes was demonstrated when comparing pre- and post-educational interventions. This considerable difference is due to the clarity of the program material, which is written in simple english, kannada as well as the relevance and applicability of the program's contents, as well as the clinical pharmacist's presence on the field for the majority of the time to answer any questions. Patients' high reactivity, curiosity, and desire to increase their understanding and capacities to control their sickness all played a role in their adjustment.

Conclusions

Malnutrition is connected to more significant morbidity and mortality rates in persons with chronic renal disease. As a result, it is vital to identify, treat, and prevent disorders related to poor clinical outcomes. According to the results of this study, a nutrition education program improved hemodialysis patients' nutrition status, dietary consumption, and biochemical markers. As a result, well-designed, regular, and diverse educational programs may help patients improve their knowledge, self-management, and therapeutic outcomes. The patients' understanding of dietary regimens improved after the study group program was implemented in the education program group, as evidenced by the post-test results in all domains.

Limitations

The study did not include a long-term follow-up to assess the sustained effects of the dietary education

intervention. Long-term monitoring would provide valuable insights into the durability of the observed improvements in biochemical markers and overall patient outcomes. Considering these limitations, further research with larger sample sizes, more extended follow-up periods, and control for confounding factors is needed to validate the findings of this study and provide a more comprehensive understanding of the impact of dietary education interventions on hemodialysis patients with CKD.

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