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Effectiveness of Nutritional Education for Hemodialysis Patients with Chronic Kidney Disease: A Systematic Review and Meta-Analysis

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Chronic Kidney Disease, Hemodialysis, Educational Interventions, Nutritional Education, Nutritional Counselling

Disclaimers

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ABSTRACT

Background: Chronic kidney disease (CKD) is an escalating public health issue with increasing incidence and prevalence. This meta-analysis aimed to evaluate the effectiveness of nutritional education interventions for CKD patients undergoing hemodialysis, focusing on renal and nutritional outcomes compared to usual care.

Objective: This meta-analysis evaluates the effectiveness of nutritional education interventions in hemodialysis patients, assessing their impact on renal and nutritional outcomes.

Method: The systematic review with meta-analysis was conducted through literature search was conducted from January 2011 to December 2023 using databases like CINAHL, PubMed, Science Direct, Academia, and Google Scholar. This systematic review and meta-analysis included only randomized controlled trials (RCTs) and quasi-experimental studies (QES) per PRISMA criteria, with the JBI tool used to assess the risk of bias.

Results: Analysis of pooled data from nine RCTs and four QES revealed no statistically significant improvements in key biochemical markers, despite the intervention favoring the experimental group. Changes in serum albumin levels were -0.07 g/L (95% CI: -0.24 to 0.10, p = 0.44), Hb levels changed by 0.22 mg/dl (95% CI: -0.75 to 1.18, p = 0.66), eGFR by -1.47 (95% CI: -4.04 to 1.10, p = 0.26), serum creatinine by 0.00 mg/dl (95% CI: -0.13 to 0.13, p = 0.99), and serum urea levels by -10.49 mg/dl (95% CI: -35.73 to 14.76, p = 0.42). Significant improvement was noted when nurses and nutritionists worked together and involved patients in meal preparation.

Conclusion: Nutritional education interventions favored the experimental group. Nurse-dietitian collaboration, consideration of dietary preferences, and patient involvement in meal preparation improved outcomes. The review highlights the importance of nutritional education for hemodialysis patients and the need for patient-centered, high-quality research.

INTRODUCTION

Chronic Kidney Disease (CKD) is a long-term condition characterized by the gradual loss of kidney function over time, resulting in the accumulation of waste products and an inability to meet the body's requirements (1). CKD is a growing public health problem, as its incidence and prevalence have nearly doubled over the last three decades (2). Patients with CKD receiving hemodialysis (HD) are particularly susceptible to malnutrition, with morbidity and mortality rates ranging from 23% to 76% in this population (3). The progressive decline in kidney function poses significant risks to their health and well-being, disrupting many physiological functions, including nutritional status, electrolyte balance, fluid balance, and acid-base homeostasis (4,5).

The concept of "Food as Medicine" is widely acknowledged for managing clinical conditions, emphasizing the critical role of nutrition in patient care (6). In recent years, nutritional therapy has emerged as a valuable approach to managing various chronic and metabolic conditions, including CKD (7,8). For CKD patients, particularly those undergoing HD, an adequate and well-planned diet is vital to support and maintain the remaining renal function, facilitating the filtration and removal of toxins from the blood (9). Therefore, nutritional therapy can play a crucial role in modifying and potentially improving renal function (10).

However, effective dietary management of CKD requires a robust foundation of data and a clear understanding of pertinent nutritional principles (4). It is essential for CKD patients undergoing HD to comprehend these dietary requirements to prevent and manage potential nutritional deficiencies and imbalances effectively (10,11). Tailored nutritional education interventions have shown promise in improving outcomes such as serum albumin, cholesterol levels, and protein intake, which are critical for delaying muscle wasting and addressing malnutrition in CKD patients receiving HD therapy (3).

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The importance of nutritional education for HD patients cannot be overstated, as it directly impacts their ability to enhance health outcomes through dietary adherence (12). Despite this, many HD patients express concerns over their limited knowledge of dietary and fluid intake, which hinders their ability to adhere to recommended guidelines (13). A narrative review published in 2016 highlighted poor adherence rates, ranging from 20% to 70%, among CKD patients concerning their prescribed diet, medications, and dialysis. The review also noted that adherence to nutritional therapy improved when education plans were customized and adapted over time to reflect changes in lifestyle and CKD symptoms (14).

However, nutritional education remains a complex process, particularly for CKD patients undergoing HD and their caregivers, who may find it challenging and emotionally taxing to grasp renal diet information (12). Often, patients do not receive the necessary nutritional education from dietitians, who are ideally positioned to provide comprehensive dietary guidance (15). Additionally, CKD patients on HD are more likely to be sedentary due to physical issues such as weakness and fatigue, yet physical activity has been shown to improve renal and nutritional outcomes, as well as overall physical and emotional well-being (16-18). Thus, adhering to a renal diet is a multifaceted challenge that requires commitment, motivation, and gradual behavioral changes (19).

To support CKD patients undergoing HD, there is a need for robust scientific evidence on the effectiveness of nutritional education interventions. Previous systematic reviews have examined nutritional education outcomes in patients undergoing peritoneal dialysis or renal transplant (20). However, these reviews highlighted heterogeneity in demographic ranges and outcome assessments, and one review (21) supported dietitian-led nutritional education interventions. A lack of sufficient literature also made it challenging to assess the efficacy of nutritional education interventions in CKD patients during the early stages of their disease.

This systematic review and meta-analysis aimed to evaluate the effectiveness of nutritional education interventions, whether delivered as individualized or group education and counseling, on renal outcomes (eGFR, urea, and creatinine levels) and nutritional outcomes (albumin and hemoglobin levels) in CKD patients undergoing hemodialysis compared to usual care.

MATERIAL AND METHODS

Systematic Review and Meta-Analysis Structure

The systematic review and meta-analysis were structured according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines (22) (Figure 1). The following databases were used: CINAHL, PubMed, and Science Direct. Search terms included combinations of "diet" AND "chronic kidney disease," "dietary education AND "CKD," and "diet or nutrition" OR "nutritional education" AND "renal failure" OR "kidney failure" OR "chronic renal failure," "CKD OR ESRD" AND "dietary education," and "dietary education OR counselling for CKD OR hemodialysis patients" AND "nutritional education and counselling." "CKD OR ESRD OR hemodialysis" AND "nutritional education or nutritional counselling."

Table 1 PICO Framework

Component	Description
Population (P)	Patients with CKD undergoing hemodialysis
Intervention (I)	Nutritional education interventions included nutritional education or nutritional counselling delivered face-to-face, individually or in groups, by a registered dietitian (RD) or registered nurse (RN) in combination with exercise physiologists, cooks, or social workers in a dialysis center for at least eight weeks.
Comparison (C)	Usual education/information
Outcome (O)	Renal outcomes: eGFR, serum urea, and creatinine, Nutritional outcomes: Albumin and hemoglobin.

The PICO question, outlined in Table 1, highlights the critical components of a well-constructed clinical question and helps formulate search strategies by identifying the key concepts that must be present in the articles to address the research question (23,24).

Inclusion Criteria: RCTs and QESs with comparison groups published in English between January 2011 and December 2023 were included. The study population involved patients with CKD undergoing hemodialysis, men and women aged 18 or above, from any geographical location and regardless of specific race/ethnicity.

Exclusion Criteria: Qualitative studies, reviews, protocols, commentaries, single-nutrient studies, and studies that included children, pregnant women, patients with peritoneal dialysis, acute renal failure, renal cancer, kidney transplant, congenital renal disease, or other inflammatory kidney diseases such as nephritis were excluded. The justification for these criteria is based on the need to focus on a homogeneous group that best represents the target population for nutritional interventions in hemodialysis.

Data Extraction and Management

Data were independently extracted by the primary author (TA) using an Excel sheet. Articles were first assessed by title and then by reading the abstract. Articles selected by titles and abstracts underwent full-text review, validated for completeness and accuracy by the second reviewer (AS). Any inconsistencies in the extracted data were discussed, and disagreements were rectified by consensus, including the third reviewer (ESF), who is an expert in reviews and quantitative research methodology. The complete search yielded 436 studies, with 12 duplicates and 331 removed for other reasons. Ninety-three study abstracts and titles were screened; 21 studies were excluded as they did not meet the eligibility criteria, 72 papers were sought for retrieval, 12 papers could not be retrieved. Eventually, 60 full-text articles were screened and 47 were excluded with reasons. Finally, 13 articles were eligible for meta-analysis, including nine RCTs and four QESs. The reasons for exclusion are shown in Figure 1.

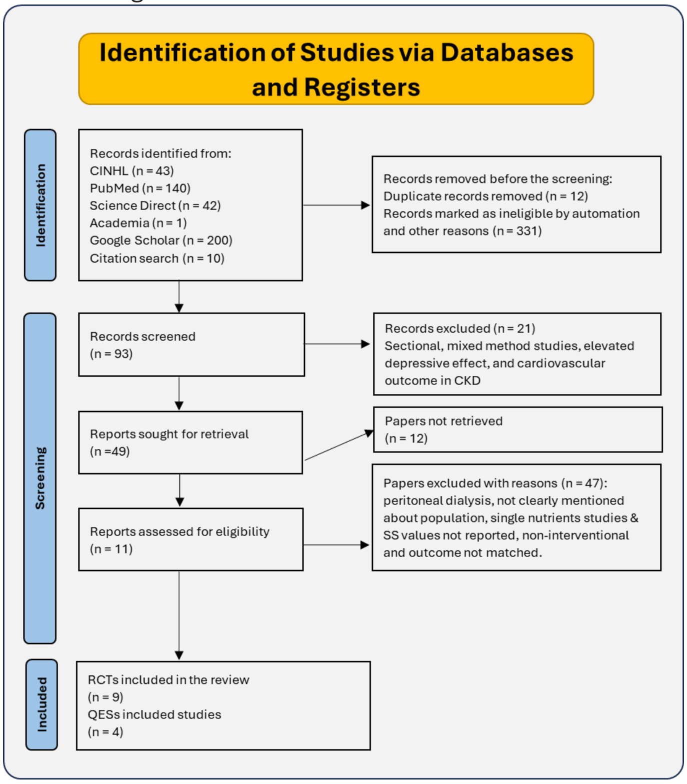

Figure 1 PRISMA Flow Chart

Quality Assessment

The methodological quality of each study was assessed using the Joanna Briggs Institute (JBI) Critical Appraisal Checklist for Randomized Controlled Trials (RCTs) [25] and Quasi-Experimental Studies (QEs) [26]. The RCTs checklist comprises thirteen items, while the QEs checklist includes nine items. Studies achieving a JBI score greater than 70% were deemed to be of good quality, those between 50% and 70% were considered of medium quality, and those less than 50% were classified as low quality. Five out of the nine RCTs were of high quality [27–31], and four were of moderate quality [32–35]. Two QESs were of high quality [36,37], and two of moderate quality [38,39]. A common limitation noted was the absence of participant blinding to treatment assignment and the concealment of allocation to treatment groups.

Statistical Analysis

A meta-analysis was performed using Review Manager (RevMan) 5.4.1 to calculate the magnitude of the pooled effect size for renal and nutritional outcomes. Data from the 13 studies nine RCTs and four QEs—were entered into RevMan [40]. The means and standard deviations were either obtained directly or computed for the QE studies by subtracting the baseline values from the values after interventions using a published equation [41]. Mean differences (MD) with 95% confidence intervals (CIs) were pooled using a random-effects model. Statistical heterogeneity was estimated using the I^2 statistic [42]. Individual outcomes of pooled data were categorized as having low heterogeneity if the I^2 was less than 25%, moderate heterogeneity if between 26% and 75%, and high heterogeneity if greater than 75% [43]. A p-value of <0.05 was considered statistically significant.

RESULTS

Characteristics with outcome variables for the nine RCTs are shown in Table 2. The RCTs were published between January 2011 and December 2023. The studies originated from Italy (32,34), Brazil (27,29), China (30), Australia (33), Taiwan (35), Poland (31), and Iran (28). The combined number of participants in the nine RCTs was 645, with sample sizes ranging from 23 to 134, balanced between the control and intervention groups. Participants' ages ranged from 52 to 66 years. The proportion of men in the RCTs ranged from 51% to 67% in eight studies, whereas one study (28) included only men. The duration of interventions ranged from two months to 24 months. Three studies (27,31,32) reported that interventions lasted three months, three studies (29,30,35) had a six-month intervention duration, two studies (33,34) had 12 and 24-month durations of interventions respectively, and one study (28) had a two-month duration. The duration of the contact sessions of the interventions ranged from 15 minutes to 150 minutes per week. Five studies (27,28,32,34,35) did not report the duration of their intervention sessions.

In seven out of nine RCTs (27–29,31,32,34,35), the intervention was provided by a dietitian. In one study (33), a multidisciplinary team (RD, cook, exercise physiologist (EP), nurse, and social worker) provided the interventions, and in one study (30), the intervention was provided by a nurse.

The study setting was a dialysis unit in all nine studies (27–35).

Two out of nine studies (31,32) provided individualized nutrition education together with cooking classes and exercise, while three studies (29,30,34) used only individualized nutrition education and counselling. Two studies (28,35) combined individualized nutrition education with nutritional supplements. One study (27) employed individualized nutrition education combined with phosphorus-substituting food as an intervention, and one study (33) used a behavioral intervention.

The focus of nutritional education interventions in this review was on individualized nutrition education and counselling. Individualized Nutrition Education and Counselling (INE & C) involves providing patients with CKD undergoing HD with information related to the type of food and the amount of food and fluid they need. The information was presented in face-to-face meetings, mostly at dialysis facilities. Booklets were also provided to enhance patients' understanding and guide the precise amount of fluid and prescribed food.

Table 2 Characteristics of studies; (RCTs 1 – 9; QESs 10 – 13)

Sr. #	Author, Year & Country	Total (T)	Intervention (I)	Control (C)	Age (yrs.)	Male %	HCP	Session Details	Study Duration (months)	Components & MOD	JBI Score
1	Małgorzewicz et al., 2011, Poland	T=52	I=27	C=25	57-63	34.6	RD	Cooking classes/2hrs 4wks, exercise/30min/12wks	03	INE with NS, cooking and exercise training	12/13
2	Molfino et al., 2012, Italy	T=34	I=14	C=20	52	56	RD	NR	24	INE	09/13
3	Wu et al., 2012, Taiwan	T=109	I=55	C=54	54.6	67	RD	NR	06	INC & NPC supplements	09/13
4	Howden et al., 2013, Australia	T=72	I=36	C=36	60-62	62.5	CKD-NP, RD, EP, SW	150 min/week, 8 weeks	12	BI*	09/13
5	Shi et al., 2013, China	T=80	I=40	C=40	23-80 (Mean=53.34)	55	RN	20-30 min/2-3 times/week	06	INE	13/13
6	Paes-Barreto et al., 2013, Brazil	T=89	I=43	C=46	Mean 63.4	51.7	RD	15-20 min	06	INC	12/13
7	Rouhani et al., 2016, Iran	T=52	I=26	C=26	55-66	100	RD	NR	02	INE & NS	12/13
8	de Fornasari et al., 2017, Brazil	T=134	I=67	C=67	56	61	RD	NR	03	INC & Phosphorus substituting foods	12/13
9	Guida et al., 2018, Italy	T=23	I=13	C=10	53	65	RD	NR	03	INE with cooking classes	09/13
10	Bahadori et al., 2014, Iran	T=32	-	-	20-66	53	RN & EP	120 min/week	02	BI* in group	6/9
11	Mersal et al., 2016, Egypt	T=60	I=30	C=30	Mean=43	40	RN	15-20 min, twice a week	02	INE	9/9
12	Jahanpeyma et al., 2017, Iran	T=30	-	-	Mean=40	42	RN	30 min, 4 sessions/wk	03	INE, video & booklets	6/9
13	Düzalan & Pakyüz, 2018, Turkey	T=80	I=40	C=40	Mean=64	53	RN	30-44 min	02	INE	9/9

Abbreviations:
T = Total sample; I = Intervention; C = Control; MOD = Mode of delivery; HCP = Health Care Provider; NR = Not Reported; INE & C = Individualized Nutrition Education & Counseling; BI = Behavioral Interventions; NS = Nutritional Supplements; RD = Registered Dietitian; EP = Exercise Physiologist; RN = Registered Nurse; CKD-NP = CKD Nurse Practitioner. *Behaviors include weight, exercise, and sleep.

The results of the literature search for the four QEs (36–39) are shown in Table 2. The four QE studies were published between November 2014 and November 2018 and originated from Iran (38,39), Egypt (37), and Turkey (36). The total number of participants was 202The sample size ranged from 32 to 80, balanced between control and intervention groups. The age of the participants ranged between 20 to 66 years. The proportion of men in the QEs ranged from 40% to 53% in the four studies (36–39). The duration of the interventions ranged from two (36,37,39) to three (38) months. The duration of the intervention's contact sessions ranged from 15 minutes (37) to 120 minutes (39) per week.
In three studies (36,38,39), the intervention was provided by nurses. In one study, a nurse and an exercise physiologist provided the intervention (39). The study setting was a dialysis unit in all QE studies (36–39). Two out of four studies (36,37) used only individualized nutrition education, whereas one study (39) provided behavioral interventions in eight sessions, each lasting 120 minutes over two months, offered in groups along with a training manual containing information about nutrition, exercise, hemodialysis equipment, and procedure. One study (38) provided individual nutrition education using videos and booklets.
The pooled effect of nutritional education interventions on renal outcomes, including eGFR, creatinine, and urea levels, was calculated. Results indicated no statistically significant improvements in eGFR, with a mean difference of -1.47 (95% CI: -4.04, 1.10, p = 0.26), although this favored the experimental group and showed no heterogeneity (I^2 = 0%) (Fig. 2). Serum creatinine levels remained unchanged at 0.00 mg/dl (95% CI: -0.13, 0.13) with no heterogeneity noted (I^2 = 0%, p = 0.99) (Fig. 3). Similarly, serum urea levels showed no significant improvement, with a mean difference of -10.49 mg/dl (95% CI: -35.73, 14.76), despite very high heterogeneity (I^2 = 80%, p = 0.42), but still favored the experimental group (Fig. 4).

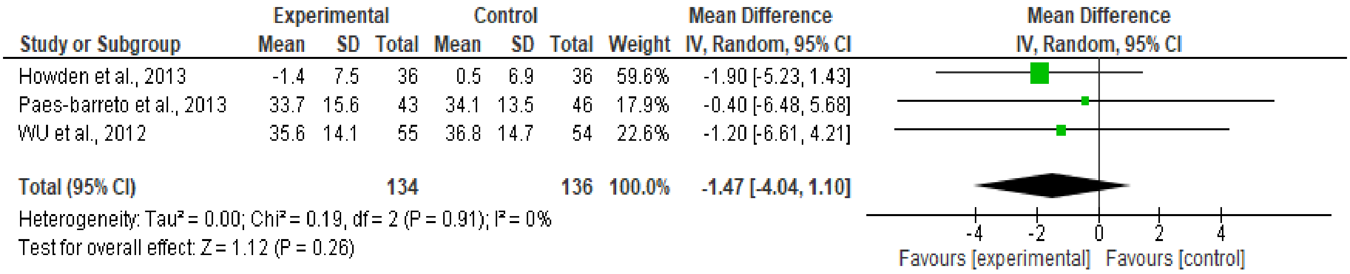

Figure 2 Forest Plot and meta-analysis of eGFR.

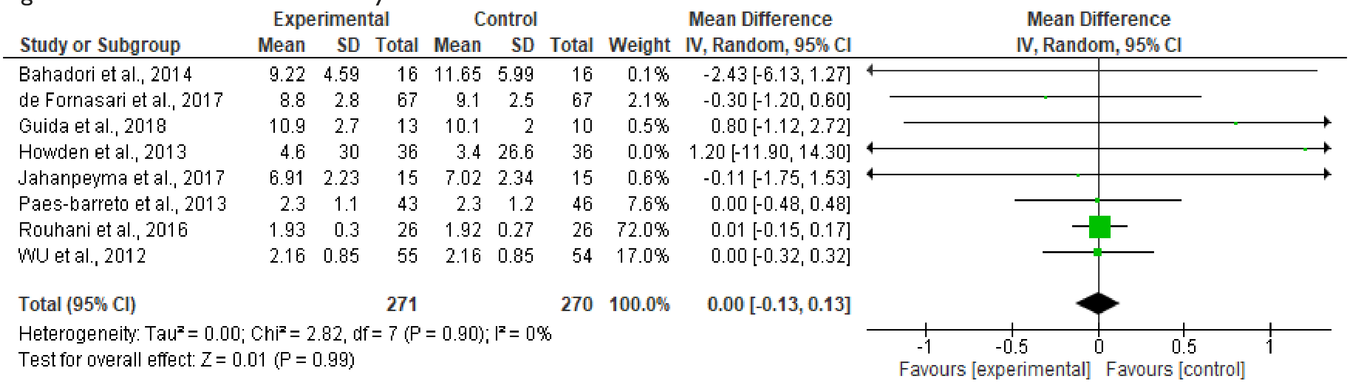

Figure 3 Forest Plot and meta-analysis of creatinine.

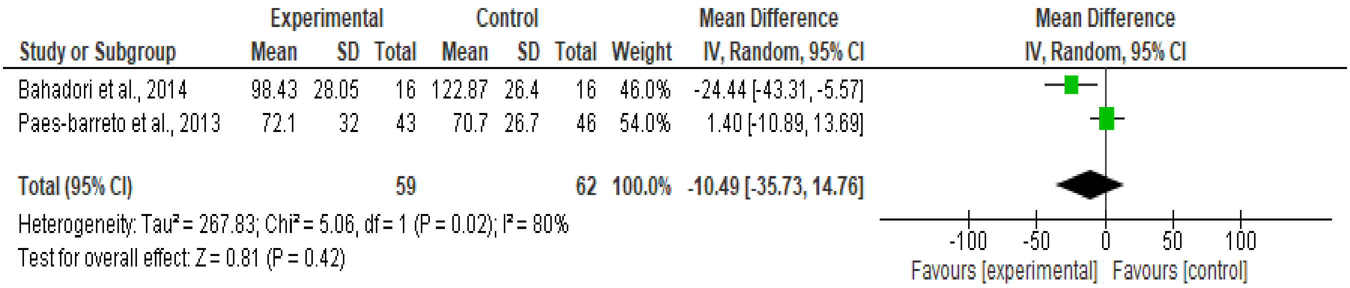

Figure 4 Forest Plot and Meta-Analysis of Urea.

The pooled effect of Individualized Nutrition Education and Counseling (INE&C) on nutritional outcomes, including albumin and hemoglobin levels, was also assessed using a random-effects model. The results demonstrated no significant changes in hemoglobin levels, with a mean difference of 0.22 mg/dl (95% CI: -0.75, 1.18) and high heterogeneity (I^2 = 77%, p = 0.66) (Fig. 5). Although the intervention favored the experimental group, no statistically significant improvement was observed in serum albumin levels, with a mean difference of -0.07 g/L (95% CI: -0.24, 0.10, p = 0.44) and low heterogeneity (I^2 = 23%) (Fig. 6).

Study or Subgroup	Experimental Mean	Experimental SD	Experimental Total	Control Mean	Control SD	Control Total	Weight	Mean Difference IV, Random, 95% CI
Bahadori et al., 2014	11.35	1.42	16	10.13	1.32	16	30.7%	1.22 [0.27, 2.17]
de Fornasari et al., 2017	10.8	1.4	67	11.2	1.5	67	39.2%	-0.40 [-0.89, 0.09]
Guida et al., 2018	11.6	1.3	13	11.6	1.1	10	30.1%	0.00 [-0.98, 0.98]
Total (95% CI)			**96**			**93**	**100.0%**	**0.22 [-0.75, 1.18]**

Heterogeneity: Tau² = 0.56; Chi² = 8.83, df = 2 (P = 0.01); I² = 77%
Test for overall effect: Z = 0.44 (P = 0.66)

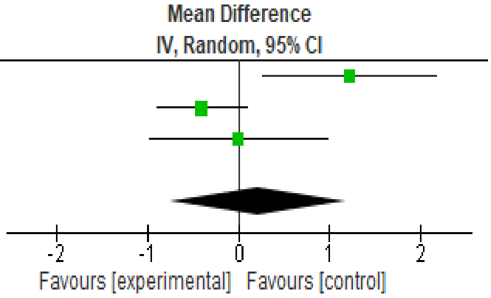

Figure 5 Forest Plot and meta-analysis of Hb.

Study or Subgroup	Experimental Mean	Experimental SD	Experimental Total	Control Mean	Control SD	Control Total	Weight	Std. Mean Difference IV, Random, 95% CI
de Fornasari et al., 2017	4.1	0.5	67	4.1	0.3	67	16.1%	0.00 [-0.34, 0.34]
Düzalan & Pakyüz, 2018	4.1	0.38	40	4.1	0.29	40	11.3%	0.00 [-0.44, 0.44]
Guida et al., 2018	3.9	0.3	13	3.7	0.4	10	3.8%	0.56 [-0.29, 1.40]
Howden et al., 2013	0.7	3.8	36	1	2.4	36	10.4%	-0.09 [-0.56, 0.37]
Małgorzewicz et al., 2011	38.3	4	27	40.8	4	25	7.7%	-0.62 [-1.17, -0.06]
Molfino et al., 2012	3.8	0.4	14	4	0.3	20	5.3%	-0.57 [-1.27, 0.13]
Paes-barreto et al., 2013	4	0.4	43	4.1	0.4	46	12.1%	-0.25 [-0.67, 0.17]
Rouhani et al., 2016	4.22	0.31	26	4.15	0.32	26	8.0%	0.22 [-0.33, 0.76]
Shi et al., 2013	40.7	3.8	40	41.19	3.02	40	11.3%	-0.14 [-0.58, 0.30]
WU et al., 2012	4.33	0.29	55	4.27	0.33	54	14.0%	0.19 [-0.18, 0.57]
Total (95% CI)			**361**			**364**	**100.0%**	**-0.07 [-0.24, 0.10]**

Heterogeneity: Tau² = 0.02; Chi² = 11.74, df = 9 (P = 0.23); I² = 23%
Test for overall effect: Z = 0.78 (P = 0.44)

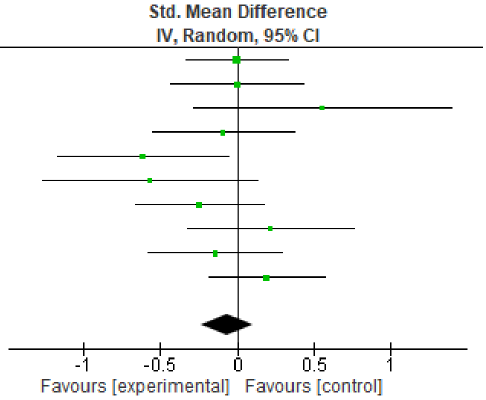

Figure 6 Forest Plot and meta-analysis of albumin.

While statistical significance was not achieved in the primary renal and nutritional outcomes, the direction of effect sizes and the favoring of experimental groups in several metrics suggest potential clinical relevance. These findings underline the importance of considering the real-world implications of nutritional education interventions, particularly as they relate to patient-centered care in hemodialysis settings. Further research should explore the potential benefits of these interventions beyond mere statistical metrics, focusing on patient quality of life, adherence to dietary recommendations, and overall well-being.

DISCUSSION

This systematic review and meta-analysis assessed the effectiveness of nutritional education interventions for patients with CKD undergoing hemodialysis, focusing on renal (eGFR, creatinine, and urea levels) and nutritional (albumin and Hb) outcomes. The content of the nutritional education, whether individualized or group-based, adhered to guidelines recommended by the National Kidney Foundation Kidney Disease Outcomes Quality Initiative (NKFKDOQI) (44) and Modification of Diet in Renal Disease (MDRD) (45). Most common techniques utilized were individualized nutrition education and counseling, which involved behavioral demonstrations and feedback mechanisms (32,39).

Despite employing various behavioral change techniques, the outcomes did not uniformly result in improvement, suggesting that patients with CKD receiving hemodialysis might struggle with information overload and fatigue, which can impede their ability to adhere to complex dietary guidelines. This review found statistically significant improvements in renal and nutritional outcomes in some studies (27,29,30,35), potentially influenced by longer durations and larger sample sizes of interventions. This aligns with other systematic reviews that have highlighted challenges in patient education about CKD and related lifestyle modifications (38).

The approach of individualized nutritional education was predominant, emphasizing patient-specific guidance on dietary management. This is crucial as CKD patients often require tailored advice that considers their cultural values and personal preferences to effectively manage their condition. The integration of behavioral interventions and physical activities in some studies (31,33,39) also highlighted the potential for comprehensive strategies to improve overall health outcomes.

However, the effectiveness of these interventions varied, reflecting the inherent challenges in standardizing educational content across diverse patient populations and settings. Moreover, the didactic methods employed in many studies may not fully address the individual needs and learning styles of patients, underscoring the need for more adaptive and patient-centered educational approaches.

While the quality of most included studies was high, the meta-analysis itself faced several limitations. The exclusion of non-English studies and the small sample sizes in some research may have reduced the generalizability of findings and contributed to insufficient power to detect statistical differences.

Furthermore, the heterogeneity in study designs and the lack of detailed descriptions of interventions in some studies could have impacted the reliability of the pooled results.

CONCLUSION

Nutritional education interventions showed a tendency to favor intervention groups, although statistical significance was not consistently achieved. This lack was mostly attributed to the limited power of studies to detect a difference, highlighting a critical gap in the quantity and quality of experimental research in this area. Clinical outcomes were favorable when nutritional interventions were implemented collaboratively by nurses and dietitians. Despite these positive clinical outcomes, their lack of statistical significance must be acknowledged to avoid misinterpretations. Future research should focus on enhancing methodological robustness and expanding the scope of studies to include diverse populations and intervention models. This review underscores the importance of nutritional education in managing hemodialysis patients, suggesting that tailored, patient-centered interventions could significantly impact their overall health status and renal management.

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