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ORIGINAL ARTICLE

Dietary intake and factors associated with malnutrition among chronic kidney disease patients: insights from a hospital based cross-sectional study

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ABSTRACT

Background: Chronic kidney disease (CKD) is a global health concern in both developed and developing countries. However, there is limited evidence on dietary intake and factors associated with malnutrition among CKD patients in our context. Therefore, this study determined dietary intake and predictors of malnutrition in CKD patients.

Methods: In a cross-sectional study in adult CKD patients' (n = 189; aged: 44.8 ± 10.09 years; stage 1-5) data on demographic factors, medical history and dietary intake was collected using multiple pass method. Anthropometric measurements including Mid upper arm circumference (MUAC), Body mass index (BMI), and Waist to Hip ratio (WHR) were used to assess nutritional status using CKD-specific cut-offs.

Results: Malnutrition was present in 83.4% of patients. The average intake of energy and essential macronutrients and micronutrients were significantly ($p < 0.05$) lower than recommended intake. Factors significantly associated with malnutrition included gender ($p = 0.01$), low dietary intake of fibre ($p = 0.03$), calcium ($p = 0.03$), iron ($p = 0.04$) and zinc ($p = 0.03$). Furthermore, presence of oedema ($p = 0.05$), high serum creatinine ($p = 0.03$), low serum albumin ($p = 0.02$), presence of kidney stones ($p = 0.05$) and co-morbidities ($p = 0.05$) show significant association with malnutrition.

Conclusion: The study highlights high burden of malnutrition among CKD patients, with dietary intake falling far below the recommended levels. There is a need for individualized dietary interventions, particularly in advanced CKD stages, to improve nutritional status and patient outcomes.

Keywords: BMI, Chronic Kidney Disease, Dietary Intake, Malnutrition, MUAC

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Introduction

Chronic kidney disease (CKD) a chronic progressive loss of kidney function affects 10% of the adult population globally and is associated with higher mortality and morbidity (1). The burden of CKD is rising in developing countries, with a reported prevalence of 7-34.3% in South-East Asia (2).

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In Pakistan, the reported prevalence is between 12.5% to 29.9% (3-5). Various factors contribute to the development of CKD including reduced numbers of nephrons at birth, aging, diabetes, hypertension, ischemic heart diseases (IHD), exposure to toxins and genetic predisposition (6).

The progressive decline in kidney function is associated with significant metabolic and physiological alterations, including accumulation of uremic toxins, chronic inflammation, hormonal imbalances, and disturbances in appetite regulation. These changes directly impact dietary intake, nutrient metabolism, and overall nutritional status, making malnutrition a common and clinically significant consequence of CKD (7). Nutritional status deterioration begins early in the disease course, particularly when the glomerular filtration rate (GFR) falls below 60 mL/min/1.73 m^2, emphasizing early nutrition assessment and intervention (8). CKD patients with reductions in GFR should aim to maintain a body mass index (BMI) of around 23.6 to 24.0 kg/m^2 for both genders (9). Disease-related malnutrition (DRM), particularly protein energy wasting, is highly prevalent in CKD, affecting approximately 20% to 50% of patients (8). DRM is driven by several factors including decreased nutrient and energy intake due to anorexia, hormonal imbalances, chronic inflammation, increased catabolism, and nutrient losses during dialysis particularly protein and water-soluble nutrients (10, 11).

In addition to macronutrients deficiencies, CKD patients are also prone to multiple micronutrient deficiencies including vitamins and trace minerals, which further increases the risk of complications such as anaemia, cardiovascular diseases, and impaired immune function (10). Haemodialysis further aggravates these deficiencies through loss of water-soluble nutrients.

Lifestyle modification, particularly adherence to CKD-specific dietary and fluid recommendations, plays a critical role in improving clinical outcomes. However, poor dietary compliance remains a major challenge and associated with poor nutritional status (12). Current dietary recommendations mainly focus on selected nutrients like protein, sodium and potassium, while limited evidence exists regarding overall dietary pattern and adherence in CKD populations, particularly in low- and middle-income settings (13).

While several studies have explored the nutritional status and dietary pattern of CKD patients worldwide, most of these originates from developed countries, limiting its applicability to low- and middle-income settings (7, 10). In contrast, evidence from Pakistan is limited and mostly focused on CKD prevalence and its outcomes rather than detailed assessment of dietary intake and factors associated with nutritional status (3, 4). In Khyber Pakhtunkhwa, where cultural dietary habits, food accessibility, and health literacy differ from other regions of Pakistan, there is a notable lack of context-specific data on dietary intake and factors associated with malnutrition among CKD patients.

Therefore, this study aims to assess dietary intake among CKD patients in relation to CKD-specific dietary recommendations, and identify factors associated with malnutrition in this patient population.

Methods

This hospital based cross-sectional study was conducted at Institute of Kidney Disease, Peshawar. Data was collected from

189 CKD patients of all stages (I-V) including hemodialysis and patients on conservative management. Sample size was calculated using 12% expected prevalence of CKD (4) in Pakistani population, at confidence level of 95% and 5% margin of error, the calculated sample size was 140. To make up for that incomplete data, an additional 20% was added so the calculated sample size was 168. The real sample size of 189 falls within ± 5% of the measured or surveyed value. Participants were recruited using a consecutive sampling technique. Data was collected from patients during their hospital admission or visit for follow-up. All the patients provided informed consent.

Ethicalapproval(301/Chairman/R&E/Committee/IKD) was sought from the institution ethical committee of Institute of Kidney Diseases, Peshawar via letter number 301/Chairman/ R &E/IKD dated 17.04.2023.

Patients aged 18 years and above with eGFR less than 60 ml/min/1.73m² (CKD stage I-V) of both genders vising the nephrology department for admission or follow-up were included in the study.

CKD patients in critical condition, unable to take food orally, dependent on others for self-care and unable to communicate were excluded from study. Patient unwilling to participants were also excluded.

A predesigned questionnaire was used to gather demographic data on age, gender, education, family size, occupation, income, medical history and co-morbidities. Anthropometric measurements including weight, height and mid upper arm circumference (MUAC) were obtained from patients using standard procedures (14). All measurements were made on the participants wearing minimum clothing. Weight and height measurements were converted to body mass index (BMI) and patients were classified as underweight (BMI < 18.5), normal (BMI = 18.5- 24.9) and overweight (BMI >25) using WHO classification for BMI (WHO, 1995). According to KDOQI nutrition guidelines, CKD patients with significantly reduced GFR should maintain a BMI of at least 23.6 to 24.0 kg/m² for both men and women (9). Patients were also categorized into two groups based on their MUAC (males; Undernourished <23 cm, Normal MUAC > 23 cm and females; Undernourished <22 cm, Normal MUAC >22 cm) (15).

Dietary intake data was obtained using 24-hour dietary recalls. To improve accuracy, a multiple-pass approach was employed, and interviews were conducted by trained nutritionists. For this purpose, three days 24-hour diet recalls were conducted on non-consecutive days: a dialysis day, a non-dialysis day, and a weekend day (not on dialysis), to best approximate the patient's usual intake during their weekly cycle. The estimated dietary intakes were calculated as the average of these three recalls. Portion sizes were estimated using standardized household measures (cups, spoons, bowls) along with the aid of food portion size charts/pictures and visual aids to assist participants in recalling quantities consumed. The intake of macronutrients and micronutrients from dietary intake data were estimated using the Food composition table for Pakistan (16) and Nutri Survey software. Dietary nutrient and energy intake were compared with recommendations for CKD patients or recommendations for healthy adults where not established.

Data were analyzed using SPSS version 20. Continuous variables were presented as mean ± SD, while categorical variables were expressed as frequencies and percentages. Anthropometric indices (MUAC and BMI) were categorized using standard cut-offs, and CKD stages were classified according to KDOQI guidelines (17). Mean macro- and micronutrient intakes were compared with recommended values using one-sample t-test. Chi-square tests assessed differences in proportions of underweight (BMI < 23.6) vs. normal/obese (> 23.6) and MUAC categories across CKD stages. Correlation coefficients were calculated between anthropometric indicators and nutrient intake. Unpaired t-tests compared mean nutrient intake across BMI and MUAC groups. Determinants of nutritional status were examined using binary logistic regression, with patients categorized as nourished or under-nourished based on BMI and MUAC cut-offs. Variables were analysed using univariate and multivariate models, with significance set at $p \leq 0.05$.

Results

A total of 189 CKD patients were included, with a mean age of 44.78 ± 10.09 years (Table 1). The majority were male (72.2%) and married (98.4%), with 65.2% employed and only 37.4% having more than five years of formal education. Patients exhibited elevated blood pressure (mean systolic: 140.37 ± 23.48 mmHg; diastolic: 82.01 ± 12.11 mmHg), with a high frequency of comorbid conditions including hypertension (72%) and diabetes (52.4%). Anthropometric assessment indicated generally low nutritional status, with a mean BMI of 20.46 ± 2.60 kg/m² and MUAC of 21.30 ± 2.06 cm.

Table 1: General characteristics of study patients (n = 189)

Characteristics	Mean ± SD/ N (%)
Age (years)	44.8 ± 10.1
Gender (Male)	135 (72.2)
Marital Status (Married)	184 (98.4)
Family Size	6.2 ± 2.2
Family income	23310.2 ± 7538.4
Employment status (Yes)	122 (65.2)
Education (yes)*	70 (37.4)
Pulse Rate	83.8 ± 8.6
Systolic Blood Pressure (mmHg)	140.4 ± 23.5
Diastolic Blood Pressure (mmHg)	82.0 ± 12.1
Medical History	
Hypertension (yes)	135 (72.2)
Diabetes Mellitus	98 (52.4)
Cardiovascular Disease (Yes)	24 (12.8)
Kidney Stone (Yes)	85 (45.5)
Family History of CKD (yes)	39 (20.9)
Other Disease (Yes)	46 (24.6)
Anthropometric Measurements	
Weight (Kg)	56.1 ± 6.7
Height (cm)	165.6 ± 6.6
MUAC (cm)	21.3 ± 2.1
BMI (kg/m²)	20.5 ± 2.6

**No. of years of education > 5 years*

A high prevalence of malnutrition was observed among CKD patients (Supplementary Table 1 at the end of article). Based on KDOQI criteria, 83.4% of patients had a BMI below 23.6 kg/m², indicating poor nutritional status. Similarly, MUAC-based assessment showed that 85.2% of males and 51.9% of females were malnourished. Overall dietary intake was markedly inadequate, particularly for energy and protein. The mean energy intake was 881.95 ± 514.97 kcal/day, with low protein intake (26.02 ± 17.38 g/day). Micronutrient intake was also suboptimal across most nutrients, including calcium, iron, zinc, and B-vitamins (Table 2).

Table 2: Comparison of Nutrient and Energy Intake to Recommended Intake in Chronic Kidney Disease

Daily dietary intake	Actual Intake	Recommended intake	% of Recommended Intake
Energy (Kcal/day)	882.0 ± 515.0	1962.3 ± 227.6	44.9**
Protein (gm/day)	26.0 ± 17.4	44.5 ± 9.0	58.5**
Lipid (gm/day)	19.8 ± 14.2	64.55 ± 17.06	30.8**
Carbohydrates (gm/day)	147.4 ± 87.3	267.2 ± 35.6	55.2**
Fiber (gm/day)	4.0 ± 2.4	25.2 ± 3.1	15.7**
Potassium (mg/day)	273.5 ± 182.5	2000.0 ± 0.0	13.7**
Sodium (mg/day)	221.7 ± 135.4	1500.0 ± 0.0	14.8**
Calcium (mg/day)	159.6 ± 74.2	1054.6 ± 89.3	15.1**
Phosphorus (mg/day)	383.8 ± 208.8	872.0 ± 65.6	44.0**
Iron (mg/day)	9.7 ± 6.3	15.3 ± 1.6	63.3**
Zinc (mg/day)	5.4 ± 4.1	9.4 ± 1.2	57.3**
Thiamine (mg/day)	0.7 ± 0.5	1.2 ± 0.0	55.8**
Riboflavin (mg/day)	0.4 ± 0.2	1.3 ± 0.0	26.9**
Niacin (mg/day)	5.4 ± 4.6	16.0 ± 0.0	34.0**
Vitamin C (mg/day)	47.3 ± 38.9	77.0 ± 10.7	61.4**
Vitamin A (mcg/day)	43.7 ± 29.1	864.9 ± 65.6	5.1**
Cholesterol (mg/day)	25.3 ± 29.2	32.4 ± 5.6	8.0**

Average daily dietary intake of energy, macro- and micronutrients in CKD patients, expressed as percentage of recommendations. One sample t-test: **p<0.001.

Malnutrition increased with disease progression. A significant association was observed between CKD stage and both BMI (p = 0.004) and MUAC (p = 0.03). Lower BMI and MUAC values were more prevalent in advanced stages (stages III-V), indicating worsening nutritional status with declining kidney function (Supplementary Table 2).

Table 3: Comparison of Dietary Intake between malnourished and well-nourished patients

Dietary Intake	BMI < 23.6 (n = 156)	BMI ≥ 23.6 (n = 31)	*P*	MUAC < Reference range for gender (n = 142)	MUAC ≥ Reference range for gender (n = 45)	*P*
Total Energy (Kcal/day)	870.1 ± 507.1	941.4 ± 553.6	0.48	828.7 ± 445.3	1050.0 ± 668.9	0.01*
Carbohydrate (g/day)	144.7 ± 867.0	161.1 ± 88.8	0.34	137.9 ± 80.5	177.5 ± 101.1	0.01*
Protein (g/day)	25.8 ± 17.1	27.2 ± 19.0	0.67	24.9 ± 668.9	29.6 ± 21.5	0.12
Lipid (g/day)	19.9 ± 14.5	19.5 ±14.4	0.88	20.2 ± 14.4	18.8 ± 13.5	0.57
Fiber (g/day)	4.0 ± 2.4	3.8 ± 2.1	0.77	3.8 ± 2.1	4.5 ± 3.1	0.09
Potassium (mg/day)	270.1 ± 186.8	290.4 ±160.7	0.57	273.1 ± 190.3	274.9 ± 157.3	0.95
Sodium (mg/day)	230.2 ± 352.9	179.3 ± 227.8	0.44	246.7 ± 362.5	142.9 ± 214.8	0.07
Calcium (mg/day)	155.0 ± 73.3	182.8 ±75.7	0.057*	148.2 ± 65.1	195.6 ± 89.0	0.00*
Phosphorus (mg/day)	380.1 ± 205.5	402.8 ± 227.3	0.58	364.5 ± 186.7	444.8 ± 259.9	0.02*
Iron (mg/day)	9.6 ± 6.2	10.0 ± 6.6	0.73	9.2 ± 5.6	11.1 ± 7.8	0.07
Zinc (mg/day)	5.4 ± 4.2	5.5 ± 4.1	0.92	5.1 ± 3.8	6.3 ± 5.0	0.11
Thiamine(mg/day)	0.5 ± 0.5	0.7 ± .5	0.39	0.6 ± 0.5	0.8 ± 0.5	0.02

Riboflavin(mg/day)	0.4 ± 0.2	0.4 ± 0.2	0.44	0.3 ± 0.2	0.4 ± 0.2	0.05*
Niacin (mg/day)	5.5 ± 4.6	5.3 ± 4.4	0.90	5.5 ± 4.7	5.2 ± 4.2	0.72
Vitamin C (mg/day)	47.4 ± 69.5	46.9 ± 67.2	0.98	47.0 ± 65.4	48.3 ± 79.8	0.91
Vitamin A (mcg/day)	41.6 ± 28.0	54.5 ± 32.5	**0.02***	42.1 ± 29.6	48.7 ± 27.4	0.19
Cholesterol (mg/day)	25.5 ± 29.4	23.8 ± 28.7	0.76	**27.7 ± 31.1**	**17.6 ± 20.6**	**0.04***

*Values are mean ± SD. Independent sample t-test; *p<0.05.*

Patients classified as well-nourished based on MUAC had significantly higher intake of energy, carbohydrates, calcium, phosphorus, riboflavin, and cholesterol ($p < 0.05$) (Table 3). When categorized by BMI, only calcium and vitamin A intake differed significantly between groups, indicating that MUAC may be a more sensitive indicator of dietary differences compared to BMI. Gender-based analysis further showed that male patients were more likely to be malnourished compared to females (Supplementary Table 3). MUAC showed significant positive correlations with energy, protein, carbohydrate, fiber, and multiple micronutrients ($p < 0.05$), suggesting that better dietary intake is associated with improved nutritional status (Supplementary table 4). In contrast, no significant associations were observed between dietary intake and BMI.

Table 4 represent the factors associated with malnutrition in CKD patients based on BMI and MUAC. Patients were classified as malnourished (BMI < 23.6 kg/m^2) or well-nourished (≥ 23.6 kg/m^2). In univariate analysis, male gender (UOR: 3.0; p = 0.01), lower vitamin A intake (UOR: 1.2; p = 0.05), low MUAC (UOR: 2.0; p = 0.00), high urea levels (UOR: 1.0; p = 0.05), low eGFR (UOR: 1.0; p = 0.00), and presence of oedema (UOR: 0.2; p = 0.05) were associated with low BMI. In multivariate analysis, low intake of dietary fibre (AOR: 0.1; p = 0.03), calcium (AOR: 1.0; p = 0.03), iron (AOR: 20.1; p = 0.04) and zinc (AOR: 0.0; p = 0.03), along with low MUAC (AOR: 17.0; p = 0.01), and presence of oedema (AOR: 0.2; p = 0.05) remained significant predictors of low BMI, while most co-morbidities such as diabetes, hypertension, heart disease, and kidney stones showed no association.

Factors associated with low MUAC in univariate analysis included male gender (UOR: 0.2; p = 0.00), low intake of energy (UOR: 1.0; p = 0.02), carbohydrate (UOR: 1.0; p = 0.01), sodium (UOR: 1.0; p = 0.04), calcium (UOR: 1.01; p = 0.00), phosphorus (UOR: 1.0; p = 0.03), thiamine (UOR: 2.2; p = 0.02), and cholesterol (UOR: 2.0; p = 0.05) along with low eGFR (UOR: 1.0; p = 0.02) and oedema (UOR: 0.5; p = 0.03). In the multivariate analysis predictors of low MUAC were male gender (AOR: 0.04; p = 0.01), low BMI (AOR: 3.25; p = 0.00), high serum creatinine (AOR: 2.87; p = 0.03) and low serum albumin (AOR: 0.27; p = 0.02). Among the co-morbidities, only kidney stones (AOR: 12.01; p = 0.05) showed significant association with low MUAC.

Table 4: Factors associated with nutritional status with CKD patients' stage 1-5

Indicators	Predictors of Malnutrition in Chronic Kidney Disease by Body Mass Index				Predictors of Malnutrition in Chronic Kidney Disease by MUAC			
	Unadjusted OR (95% CI)	*P*	Adjusted OR (95% CI)	*P*	Unadjusted OR (95% CI)	*P*	Adjusted OR (95% CI)	*P*
Sociodemographic status								
Age (≥ 60 years)[1]	0.5 (0.13; 1.65)	0.24			0.5 (0.192; 1.48)	0.23		
Gender[2]	3.0 (1.36; 6.68)	**0.01**			0.2 (0.09; 0.39)	**0.00**	0.04 (0.01; 0.41)	**0.01**
Patient Education (No)	0.7 (0.31; 1.48)	0.33			1.3 (0.62; 2.56)	0.52		
Family Income (low)*	0.4 (0.15; 1.05)	0.06			0.6 (0.22; 1.39)	0.20		
Daily dietary intake**								
Energy (Kcal/day)	1.0 (1.00; 1.00)	0.48			1.0 (1.00; 1.00)	**0.02**		
Protein (gm/day)	1.0 (0.98; 1.03)	0.67			1.0 (0.996; 1.03)	0.12		
Lipid (gm/day)	1.0 (0.97; 1.03)	0.88			1.0 (0.97; 1.02)	0.57		
Carbohydrates (gm/day)	1.0 (0.99; 1.01)	0.34			1.0 (1.00; 1.01)	**0.01**		
Fiber (gm/day)	1.0 (0.82; 1.15)	0.77	0.1 (0.00; 0.77)	**0.03**	1.1 (0.980; 1.28)	0.10		
Potassium (mg/day)	1.0 (0.99; 1.00)	0.57			1.0 (0.99; 1.00)	0.95		
Sodium (mg/day)	2.0 (0.99; 1.00)	0.45			1.0 (0.99; 1.00)	**0.04**		
Calcium (mg/day)	1.0 (1.00; 1.01)	0.06	1.0 (0.87; 0.99)	**0.03**	1.01 (1.00; 1.01)	**0.00**	1.03 (1.00; 1.06)	**0.03**
Phosphorous (mg/day)	1.0 (0.99; 1.00)	0.58			1.0 (1.00; 1.03)	**0.03**		
Iron (mg/day)	1.0 (0.95; 1.07)	0.73	20.1 (1.19; 341.30)	**0.04**	1.1 (0.99; 1.10)	0.08		
Zinc (mg/day)	1.0 (0.92; 1.10)	0.92	0.0 (0.00; 0.40)	**0.03**	1.1 (0.99; 1.15)	0.11		
Thiamine (mg/day)	1.4 (0.65; 3.07)	0.39			2.2 (1.13; 4.41)	**0.02**		
Riboflavin (mg/day)	2.3 (0.27; 19.62)	0.44			6.2 (0.96; 39.91)	**0.06**		
Niacin (mg/day)	1.0 (0.91; 1.08)	0.90			1.0 (0.92; 1.06)	0.72		
Ascorbic Acid (mg/day)	1.0 (0.99; 1.01)	0.98			1.0 (0.99; 1.01)	0.91		
Vitamin A (mcg/day)	1.0 (1.00; 1.03)	**0.03**	1.2 (1.00; 1.52)	**0.05**	1.0 (0.99; 1.02)	0.19		
Cholesterol (mg/day)	1.0 (0.98; 1.01)	0.76			1.0 (0.97; 1.00)	**0.05**		
MUAC (low) ***/BMI (low)***	2.0 (1.57; 2.57)	**0.00**	17.0 (2.24; 128.23)	**0.01**	2.0 (1.60; 2.52)	**0.00**	3.25 (1.75; 6.07)	**0.00**
Urea (high) ***	1.0 (0.99; 1.00)	**0.05**			1.0 (0.99; 1.00)	0.07		
Creatinine (high) ***	0.8 (0.61; 1.04)	0.09			1.0 (0.76; 1.16)	0.54	2.87 (1.13; 7.27)	**0.03**
eGFR (low) ***	1.0 (1.01; 1.04)	**0.00**			1.0 (1.00; 1.04)	**0.02**		
S. Albumin (low) ***	1.0 (0.66; 1.44)	0.90			0.8 (0.53; 1.08)	0.13	0.27 (0.09; 0.79)	**0.02**
Haemoglobin (low)***	0.9 (0.79; 1.10)	0.41			1.0 (0.87; 1.14)	0.88		
Oedema (yes)	3.4 (1.45; 8.17)	**0.01**	0.2 (0.04;0 .99)	**0.05**	0.5 (0.23; 0.93)	**0.03**		
Presence of comorbidities								
Diabetes (Yes)	1.0 (0.45; 2.08)	0.92			1.2 (0.69; 2.65)	0.38		
Hypertension (Yes)	1.0 (0.40; 2.18)	0.87			1.1 (0.51; 2.25)	0.85		
Heart disease (Yes)	1.0 (0.32; 3.18)	0.99			1.2 (0.43; 3.52)	0.69		
Kidney Stones (Yes)	1.4 (0.62; 2.91)	0.45			0.7 (0.38; 1.45)	0.38	12.01 (1.00; 143.85)	**0.05**
Others[3] (yes)	1.1 (0.45; 2.61)	0.86	0.1 (0.00; 1.03)	**0.05**	1.0 (0.46; 2.21)	0.98		

[1]Reference to ≥ 60 years; [2] Reference to male; *family income below the median; **lower than recommended intake; * below or above the reference values;**
[3]Chronic glomerulonephritis/acute on chronic renal failure etc.

Discussion

The present study identified a substantial burden of malnutrition, with gender differences and multiple contributing socio-demographic, clinical, and dietary factors, emphasizing individualized nutritional care in CKD patients.

The study patients predominantly comprised middle-aged, married males with low educational status, which may partly explain the observed nutritional vulnerabilities. Previous studies have also reported a higher burden of CKD among men and individuals with lower educational attainment, likely due to limited health awareness and access to health care (18-20).

In the present study, hypertension emerged as the leading contributor to CKD, followed by diabetes and nephrolithiasis, consistent with previous studies from Pakistan indicating hypertension as both a cause and consequence of CKD progression and cardiovascular risk (17,21). The coexistence of these conditions further exacerbates disease progression through vascular and metabolic damage to renal tissues and vasculature (22-25).

Most of our patients had BMI below the recommended thresholds for CKD, and with MUAC identified even a greater proportion of undernourished individuals, particularly among males. These findings emphasize MUAC as a sensitive indicator of nutritional status, especially in chronic disease settings where BMI alone may underestimate malnutrition. Previous studies also reported high rates of BMI-based malnutrition (26) and high MUAC-defined malnutrition comparable to our results (27). CKD has been shown profound impact on nutritional status leading to increase nutritional risk when GFR start declining below 60 mL/min/1.73 m². Therefore, guidelines recommend that dialysis and late-stage CKD patients should maintain BMI within the upper normal range, ideally not below 23.6-24.0 kg/m² for both genders (7, 9).

In the present study, dietary assessment revealed markedly inadequate intake of energy, macronutrients, and micronutrients, with energy intake meeting less than half of recommended levels. Significant deficiencies were observed in protein, carbohydrates, fats, fibre, calcium, potassium, and vitamin A, highlighting widespread nutritional inadequacies. These findings are consistent with previous studies reporting poor dietary intake among CKD patients, often attributed to reduced appetite, dietary restrictions, and disease-related metabolic changes commonly seen in CKD (28, 29). In patient with CKD adequate carbohydrate intake is required to provide majority of daily calories and spare protein (30). Moreover, sufficient protein intake is recommended with around half of the protein intake should come from high-biological-value protein sources with a low phosphorus-to-protein ratio to support muscles and iron absorption (31). In addition, adequate consumption of healthy fats especially polyunsaturated fatty acids is suggested to reduce kidney damage, improve renal function, and limit vascular complications (32). Likewise, adequate fibre intake (25-38 g/day) in CKD is recommended to support gut microbiota, reduce inflammation and uremic toxins, lower cardiovascular risk, and decrease overall mortality (33).

The present study demonstrated that nutritional status deteriorates with advancing CKD stage, as reflected by declining BMI and MUAC with lower eGFR levels. This agrees with existing literature showing progressive nutritional decline in later stages of CKD (34, 35). Furthermore, dietary factors such as low intake of fibre, calcium, iron, and zinc were identified as significant predictors of malnutrition, emphasizing the critical role of diet quality in maintaining nutritional status. In addition, MUAC showed significant associations with dietary intake and clinical parameters, including serum creatinine and albumin levels, suggesting that MUAC may also help capture the relationship between dietary intake and nutritional status compared to BMI. The association of malnutrition with oedema and kidney stones further highlights the multifactorial nature of nutritional decline in CKD patients.

Conclusion

This study highlights the need for regular nutritional screening and assessment in CKD patients using simple tools like BMI and MUAC. Socio-demographic and clinical factors, including age, gender, education, poor dietary intake, hypertension, and diabetes, were significantly associated with poor nutritional status. It emphasizes the need for early nutritional intervention, improving diet quality including both macro- and micro-nutrients. The findings also support the importance of early, stage-specific nutritional comprehensive and individualize nutritional care into routine CKD management to improve patient outcomes.

Limitations of study:

This study has several limitations. First, non-random sampling was used due to the hospital-based setting, which may introduce selection bias. Second, the cross-sectional nature of the study prevents the establishment of cause-effect relationships between dietary intake, nutritional status, and clinical outcomes. Third, dietary recalls may not accurately estimate energy and nutrient intake because of difficulties in recalling food portions and quantities. Additionally, the small sample size and predominance of male participants may limit the strength of statistical associations.

Strength of the study:

Despite these limitations, the study provides important insights into the nutritional challenges of CKD patients in a developing-country context. It provides a comprehensive evaluation of nutritional status in CKD patients by integrating both dietary assessment and anthropometric measures, including BMI and MUAC. The use of MUAC alongside BMI enhances the detection of malnutrition, particularly in chronic disease settings. Additionally, the study identifies key dietary and clinical predictors of malnutrition, offering valuable analytical insights. Importantly, it contributes region-specific evidence from Khyber Pakhtunkhwa, addressing a significant gap in the existing literature.

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All the authors agree to take responsibility for every facet of the work, making sure that any concerns about its integrity or veracity are thoroughly examined and addressed.

Supplementary data

Table 1

Indicators	Categories		N (%)
Body Mass Index (kg/m^2) WHO Criteria	Underweight (<18.5)		45 (24.1)
	Normal (18.5-24.9)		131 (70.1)
	Overweight (25-29.9)		11(5.9)
National Kidney Foundation (NKF) Criteria	BMI < 23.6		156 (83.4)
	BMI > 23.6		31 (16.6)
Mid Upper Arm Circumference (MUAC)	Male	< 23 cm	115 (85.2)
		> 23 cm	20 (14.8)
	Female	< 22 cm	27 (51.9)
		> 22 cm	25 (48.1)

Supplementary Table 2: Malnutrition by Stage of Chronic Kidney Disease based on Body Mass Index and Mid Upper Arm Circumference

Stage of CKD	BMI < 23.6 (n = 156)	BMI ≥ 23.6 (n = 31)	*P*	MUAC < Reference range for gender** (n = 142)	MUAC ≥ Reference range for gender** (n = 45)	*P*
Stage 1(GFR > 90 mL/min/1.73m^2)	2 (50)	2 (50)	**0.00***	1 (25)	3 (75)	**0.03***
Stage 2(GFR = 60-89 mL/min/1.73m^2)	2 (33.3)	4 (66.7)		3 (50)	3 (50)	
Stage 3(GFR = 30-59 mL/min/1.73m^2)	27 (87.1)	4 (12.9)		23 (74.2)	8 (28.5)	
Stage 4 (GFR = 15-29 mL/min/1.73m^2)	75 (87.4)	11 (12.6)		72 (82.8)	8 (25.8)	
Stage 5(GFR <15 mL/min/1.73m^2)	49 (83.1)	10 (16.9)		43 (72.9)	16 (27.1)	

***For Male < 23 cm and for female < 22 cm was considered as malnutrition. Chi-square test; *p<0.05.*

Supplementary Table 3: Gender Based Distribution of Malnutrition in Chronic Kidney Disease

Malnutrition in CKD	Patient Gender		*P*
	Male (n = 135)	Female (n = 52)	
BMI < 23.6	119 (88.1)	37 (71.2)	**0.01****
BMI ≥ 23.6	16 (11.9)	15 (28.8)	
MUAC < Reference range for gender*	115 (85.2)	27 (51.9)	**0.00****
MUAC ≥ Reference range for gender*	20 (14.8)	25 (48.1)	

**For Male < 23 cm and for female < 22 cm was considered as malnutrition; Chi-square test; **p<0.005*

Supplementary table 4: Correlation between dietary intake and anthropometric measurements

Variables	Weight (Kg)	Height (cm)	BMI (kg/m^2)	MUAC (cm)
Energy (Kcal/day)	-0.039	-0.069	0.051	**0.234****
Protein (gm/day)	-0.046	-0.040	0.024	**0.183***
Lipids (gm/day)	-0.079	-0.033	-0.052	-0.057
Carbohydrate (gm/day)	-0.018	-0.066	0.074	**0.215****
Fiber (gm/day)	-0.083	-0.136	0.033	**0.194****
Potassium (mg)	0.048	0.007	0.016	0.070
Sodium (mg/day)	-0.084	-0.012	-0.060	-0.124
Calcium (mg/day)	-0.003	-0.101	0.101	**0.306****
Phosphorous (mg/day)	-0.034	-0.139	0.087	**0.221****
Iron (mg/day)	-0.035	-0.063	0.047	**0.190****
Zinc (mg/day)	-0.048	-0.005	0.003	**0.180***
Thiamine (mg/day)	-0.010	-0.017	0.043	**0.200****
Riboflavin (mg/day)	-0.010	-0.091	0.089	**0.169***
Niacin (mg/day)	-0.054	0.025	-0.031	0.027
Vitamin C (mg/day)	-0.064	-0.099	0.013	0.040
Vitamin A (mcg/day)	0.036	-0.015	0.058	0.080

Values are correlation coefficients. $*p < 0.05$; $**p < 0.01$