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RESEARCH ARTICLE

Nutritional status of patients receiving maintenance haemodialysis in Bloemfontein, South Africa

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Background: Identifying malnutrition in patients on maintenance haemodialysis (MHD) may be challenging in resource-limited sub-Saharan African settings, as several protein-energy malnutrition markers need to be interpreted in combination.
Methods: An observational cross-sectional study was conducted in 2017 in central South Africa to assess nutritional status based on anthropometry, biochemistry, and dietary intake (24-hour recall of typical intake of a non-dialysis day). Malnutrition was assessed using the 2008 International Society of Renal Nutrition and Metabolism (ISRNM) criteria.
Results: Amongst 75 participants (70.7% men; median age 50.5 [IQR: 41–59.6] years), malnutrition was identified in 20.0%. Median monthly income per person in the household of R2 375 (IQR: R817–R5 375) indicated low economic status. Based on body mass index (BMI), only 5.4% were underweight (< 18.5 kg/m^2), 23.0% overweight (≥ 25.0 kg/m^2) and 33.8% obese (> 30.0 kg/m^2); 58.1% had high waist circumferences, and 66.2% high waist-to-height ratio (WHtR > 0.5), indicating central obesity. Overall, 18.9% simultaneously had a high BMI (≥ 25 kg/m^2) with low arm muscle area (AMA ≤ 15th centile). Moreover, 49.3% had decreased serum albumin levels (< 35.0 g/l); however, C-reactive protein levels were unavailable. Total dietary protein (TDP) intake was estimated low (< 1.0 g/kg) in 32.4% and 50.7% had high carbohydrate intakes (> 60% of total energy).
Conclusions: In this population receiving MHD, with a low economic status and estimated low total dietary protein intake, poor nutritional status was marked by low muscle mass, and was masked by a high BMI and central obesity.

Keywords: body mass index, chronic kidney disease, dietary protein, malnutrition, muscle mass

Introduction

Protein-energy malnutrition (PEM) is common in patients with chronic kidney disease (CKD) and is associated with adverse clinical outcomes, especially in individuals receiving maintenance haemodialysis (MHD) therapy.[1] Protein-energy wasting (PEW) in MHD leads to impaired quality of life, greater morbidity, increased cardiovascular and infection-related mortality, and total mortality.[2] Globally, 43.1–45.3% of dialysis patients present with malnutrition.[3] However, the general rise in abdominal obesity (with low muscle mass), also in the CKD population, is potentially a type of malnutrition (overnutrition) often overlooked that can exacerbate cardiovascular disease (CVD).[4] In sub-Saharan Africa, including South Africa (SA), prevalence and context-specific contributors to malnutrition in MHD have scarcely been reported. The use of different methods to assess nutritional status without consensus on a particular method makes comparisons difficult.[5] Furthermore, in a resource-limited setting, not all biomarkers of malnutrition, such as pre-albumin, total iron-binding capacity (TIBC) and multi-frequency bioelectrical impedance analysis (MF-BIA) are routinely available, complicating the detection and comparison of malnutrition. However, according to the International Society of Renal Nutrition and Metabolism (ISRNM),[6] PEM can be diagnosed if three of the following four characteristics are present: (i) low serum levels of albumin, pre-albumin or cholesterol; (ii) reduced body mass (low or reduced body or fat mass or weight loss with reduced intake of protein and energy); (iii) reduced muscle mass (muscle wasting or sarcopenia, reduced mid-arm muscle circumference); and (iv) low protein (< 0.8 g/kg) and energy intake (< 25 kcal/kg).[6] This method makes use of user-friendly metrics that are more readily available in resource-limited settings. Using this method, Halle et al. (2014) reported a malnutrition rate of 20% amongst MHD patients in Cameroon.[7]

This study addresses the limited availability of South African data on the nutritional status of patients receiving maintenance haemodialysis (MHD), particularly those assessed using a combination of anthropometric measures (body mass index [BMI] and arm muscle area [AMA]), biochemical indicators (serum albumin and cholesterol) and dietary intake (energy and protein intake per kilogram body weight). Furthermore, the study also considered that socioeconomic factors (education, income and employment status) could affect food choices. This study aimed to describe the nutritional status of adults receiving MHD in Bloemfontein, a mid-sized city in the Free State province of central South Africa.

Methodology

A descriptive, cross-sectional study was performed in five of the six dialysis units in Bloemfontein (a mid-sized city in central SA) from January to July 2017. Approval was obtained from the Health Sciences Research Ethics Committee of the Faculty of Health Sciences (HSREC) at the UFS (HSREC142-2016), the Ethics Committee of the Free State Department of Health and dialysis unit managers. Of the total population ($n = 175$), all were approached through convenience sampling, 77 gave voluntary informed consent, with a final sample of 75 with complete datasets: 30 (40%) from tertiary government institutions and 45 (60%) from private institutions. While the projected statistical power indicated a required sample of 121 (Raosoft Inc, Seattle WA, USA), the actual sample size was limited by real-world constraints inherent to the study setting, including voluntary participation and ethical requirements for informed consent. Importantly, all included participants met rigorous eligibility criteria (≥ 18 years, having been diagnosed with end-stage renal disease [ESRD] and having received MHD treatment for at least three months prior to the study) and data collection adhered to standardised, validated methods. Patients were excluded if they had been hospitalised in the three months prior to the study (to exclude acute disease related malnutrition)[8] or were unable to stand unassisted for accurate anthropometric measurement.

Structured interviews were conducted during participants' second or third dialysis session of the week. Socioeconomic data, including age, biological sex and household finances (income per person [pp], per month [pm] in SA Rand [ZAR], and money spent on food in the household), were collected.

At the time of the study, the suggested minimum wage for a household comprising five people was R8 000 pm (R1 600 pp), with 40% (R3 115.26 pm; R623.10 pp) of that to be spent on a minimum nutritional food basket.[9] As the disability grant, at the time of the study, was up to R1 500 pp, ≤ R1 500 pp/pm was used as the minimum income bracket. Household density ratio (HDR) was calculated,[10] as overcrowding may indicate poor household conditions and poverty.

Medical variables collected from the medical file included the time on MHD treatment (in years), the cause of kidney disease and comorbidities.

One 24-hour recall of a typical non-dialysis day was taken, and exact amounts were determined with standardised food models and utensils, with photographs used to illustrate portion sizes when administering the adapted 24-hour recall. One day's food intake can highlight trends and is only an estimation of macronutrient intake[11]. Food Finder® III Software (version 1.1.3, SAFOODS; https://safoods.mrc.ac.za/), which utilises the SA Food Composition Tables, was used to quantify the daily intakes of energy (kcal/kg), total dietary protein (TDP) (g/kg, including animal and plant protein), carbohydrates and fats. The estimated intakes of these were then compared with the National Kidney Foundation Kidney Disease Outcomes Quality Initiative (NKF/KDOQI) recommendations[5,12] for patients receiving MHD, and categorised as inadequate, adequate and above adequate.

As recommended by the NKF, the macronutrient intakes were evaluated based on oedema-free bodyweight (BW_{ef}), which refers to the weight measured immediately post-dialysis. If BW_{ef} was < 95% or > 115% of standard bodyweight (SBW) (derived from the National Health Nutrition Evaluation Survey [NHANES] II data),[11] the adjusted oedema-free bodyweight ($_aBW_{ef}$) was used, calculated with Equation (1):[11]

$$aBWef = BWef + [(SBW - BWef) \times 0.25] \quad (1)$$

Anthropometric variables aimed to measure two types of malnutrition (underfeeding and overfeeding) and included post dialysis/dry BMI, body composition as muscle mass with arm muscle area (AMA) and body fat percentage (BFP). Abdominal obesity was assessed based on waist circumference (WC) and waist-to-height ratio (WHtR). Using standardised anthropometry techniques,[13] the primary researcher performed all anthropometric measurements directly after a dialysis session.

BMI was calculated based on post-dialysis weight (SOEHNLE Professional scale, Mediscale Bluetooth, Model 7841; Soehnle Professional, Backnang, Germany) divided by the square of the height (kg/m^2) (SECA, stadiometer; Seca, Hamburg, Germany) and categorised according to international cutoffs. Due to ascites, one participant's results were omitted for anthropometry, but included for others.

AMA was calculated with mid-upper arm circumference (MUAC) (cm) and triceps skinfold (TSF) (cm), using Equation 2:[14]

$$AMA(cm^2) = \frac{(MUAC - \pi TSF)^2}{4\pi} \quad (2)$$

Classification of AMA and BFP was according to centile categories for age and gender using Frisancho charts:[14] (i) ≤ 5th centile—wasted; (ii) > 5th–≤ 15th centile—below average muscle mass; and (iii) > 15th centile—average muscle mass.[14] The four-site skinfold method (TSF, sub-scapular, supra-iliac and biceps skinfolds measured using a Slimguide Baseline Calliper (Plymouth, MI USA), was used to determine the BFP.[11] Participants' TSF was measured on the arm that was not used for dialysis access.[11] At the time, multi-frequency bioelectrical impedance analysis (MF-BIA) for body composition and handgrip strength was not available within the resource-limited setting.

According to sub-Saharan Africa cutoffs (based on European values due to an absence of regional data), WC ≥ 80 cm for women and ≥ 94 cm for men indicated an increased risk of metabolic complications.[15] Waist-to-height ratio (WHtR), derived from dividing WC (cm) by height (cm), of > 0.5 also indicated increased metabolic risk.[16]

Most recent and routine biomarkers were recorded from the medical files; results older than six months were not considered.

Involvement of a dietitian (visits per year) was categorised as: minimal (0–1 visits/year), average (2–3 visits/year) and sufficient (> 3 visits/year).[5,17]

Diagnosis of malnutrition

According to the study-specific adaptation of the 2008 ISRNM criteria,[6] three or more out of the four diagnostic criteria indicated malnutrition (underfeeding): (i) low AMA (≤ 15th centile; (ii) low BMI (< 18.5 kg/m^2) and/or low BFP (≤ 15th centile); (iii) low energy intake (< 25 kcal/kg) and/or low protein intake (< 1.0 g/kg); (iv) low albumin (< 35 g/l) and/or low cholesterol (< 3.8 mmol/l)[6]. Other nutritional status subgroups included: high risk of malnutrition (2 out of 4 malnutrition criteria), and well-nourished (0–1 out of 4 malnutrition criteria).

Statistical analysis

Statistical analyses were performed with the assistance of the Department of Biostatistics (UFS) on SAS® software (version 9.4, SAS Institute Inc, Cary, NC, USA). Descriptive statistics for categorical data were summarised as frequencies and percentages, and for numerical data as medians and centiles, with distributions that were skewed. Associations were determined by Kruskal–Wallis test for numerical data and Fisher's exact test for categorical data; with a *p*-value < 0.05 considered statistically significant.

Results

Most of the 75 participants were men, 70.7% ($n = 53$), and the median age was 50.5 years (IQR: 41–59.6 years). Median monthly income per person (pp/pm) in the household at R2 375 (IQR: R817–R5 375) indicated a low economic status.[9] The median percentage of income available for food pp/pm

Table 1: Socioeconomic and kidney disease information ($n = 75$)

Variables	n; median	Percentage (%); Interquartile range (IQR)
Biological sex		
Men	53	70.7
Women	22	29.3
Age (median, IQR)	50.5 years	41–59.6 years
Education level		
Primary school (grades 4–7)	5	6.7
Secondary school (grades 8–12)	49	65.3
Tertiary education (diploma, degre and postgraduate degree)	21	28.0
Household finances		
Monthly income per person in the household (median, IQR)	R2 375	R817–R5 375
Percentage of income available for food pp/pm (median, IQR)	27.3	15–37.5
Percentage of income spent on food		
≤ 40% of income	63	84.0
> 40% of income; as recommended	12	16.0
Employment		
Receives a social grant	29	38.7
Employed: full-time	20	26.7
Receives pension (from previous employment)	17	22.7
Employed: part-time/piece jobs	4	5.3
Unemployed	5	6.7
Household density ratio (HDR)		
Ideal	27	36.0
Overcrowded	48	64.0
Dialysis history		
Received continuous ambulatory peritoneal dialysis (CAPD) before being switched to maintenance haemodialysis MHD ($n = 73$)	27	37.0
Number of years on Maintenance Haemodialysis (MHD)		
< 1 year–< 2 years	27	36.0
≥ 2 years–< 5 years	18	24.0
≥ 5 years–< 10 years	19	25.3
≥ 10 years	11	14.7
Aetiology of kidney disease		
Hypertension	36	48.0
Diabetes mellitus	13	17.3
Hypertension and diabetes mellitus	8	10.7
Aetiology not indicated in the file	21	28.0
Other aetiology (glomerular nephritis) ($n = 3$); Tuberculosis (TB) ($n = 1$); human immunodeficiency virus (HIV) ($n = 2$); vesicoureteral reflux ($n = 1$); Polycystic kidneys ($n = 3$); Goodpasture syndrome ($n = 1$); and unknown ($n = 4$)	15	14.7

was 27.3% (IQR: 15–37.5%), and the majority (84.0%) reported spending ≤ 40% on food as recommended in this resource-limited setting. Income was mostly from a social grant (38.7%), being employed full-time (24.0%) or receiving a pension from previous employment (22.7%), while the rest were unemployed (5.3%) or employed only part-time (5.3%). According to the calculated HDR, 64% lived in overcrowded conditions. Hypertension was mostly (37.3%) indicated in the patient files as aetiology of kidney failure, followed by diabetes mellitus (17.3%), and both hypertension and diabetes mellitus (10.7%). Unfortunately, for 28%, the aetiology for kidney failure was missing in the files (Table 1).

Table 2: Anthropometry

Anthropometry	n; median	Percentage (%); Interquartile range (IQR)
Body mass index (BMI) kg/m^2 ($n = 74$)		
Underweight (< 18.5)	4	5.4
Normal (≥ 18.5–< 25.0)	28	37.8
Overweight (≥ 25.0–< 30.0)	17	23.0
Obese class I (≥ 30.0–< 35.0)	14	18.9
Obese class II (≥ 35.0–< 40.0)	6	8.1
Obese class III (≥ 40.0)	5	6.8
BMI kg/m^2 (median, IQR)	26.4	22.2–32.0
Arm muscle area (AMA) centiles for age and gender ($n = 75$)		
AMA ≤ 5th centile (wasted muscle mass)	30	40.0
AMA ≤ 15th centile (low muscle mass)	12	16.0
AMA > 15th centile (normal)	33	44.0
Body fat percentage (BFP) centiles for age and gender ($n = 75$)		
BFP ≤ 5th centile (wasted)	22	29.3
BFP 5th–≤ 15th centile (low body fat)	7	9.3
BFP > 15th–< 85th centile (normal fat)	27	36.0
BFP ≥ 85th–≤ 95th centile (above-average fat)	8	10.7
BFP > 95th centile (excessive fat)	11	14.7
Waist circumference (WC) and waist-to-height (WHtR) ratio associated with increased risk for metabolic complications		
WC Women ($n = 22$)		
Ideal (< 80 cm)	4	18.2
Increased risk (80.0–87.9 cm)	4	18.2
Substantial risk (≥ 88 cm)	14	63.6
WC Men ($n = 52$)		
Ideal (< 94 cm)	27	51.9
Increased risk (94.0–101.9 cm)	6	11.5
Substantial risk (≥ 102 cm)	19	36.5
WHtR ($n = 74$)		
WHtR ≤ 0.5 (ideal)	25	33.8
WHtR > 0.5 (increased risk)	49	66.2

Anthropometry

The median BMI was 26.4 kg/m^2 (IQR: 22.2–32.0 kg/m^2), and more than half (56.8%, $n = 42$) had above-normal BMIs (≥ 25 kg/m^2). Half (56.0%, $n = 42$) had low muscle mass (AMA ≤ 15th centile), 71.4% ($n = 30$) of whom were wasted (AMA ≤ 5th centile). In addition, of those (56%) who had an

AMA ≤ 15th centile, 33.3% ($n = 14$) had a BMI ≥ 25 kg/m^2 indicating being overweight or obese, and 57% had a normal BMI (≥ 18.5 kg/m^2–< 24.9 kg/m^2). Therefore, in total, 18.9% ($n = 14$) simultaneously had a low AMA and a high BMI. A quarter (25.3%) had an above-average BFP (sum of four skinfolds ≥ 85th centile), and contrastingly a low BFP (≤ 15th centile) in 38.7% ($n = 29$). Increased risk of metabolic comorbidities, such as hypertension, diabetes and cardiovascular disease (CVD) was indicated, with android obesity with a high WC in 81.8% ($n = 18$) of women and 48.1% ($n = 25$) of men, and based on WHtR, two-thirds (66.2%, $n = 49$) had a high WHtR (> 0.5) (Table 2).

Dietary intake

Approximately one out of four (28.4%) had an estimated low energy intake < 25 kcal/kg (post-dialysis weight or $_{a}BW_{ef}$)[5] (Table 3). Almost a third (32.4%) had an estimated low TDP intake < 1.0 g/kg[5], and 50.7% had a high CHO intake (Table 3).

Adapted protein-energy malnutrition diagnostic criteria in chronic kidney disease (CKD) stratified according to the International Society of Renal Nutrition and Metabolism (ISRNM) criteria

One out of five (20.0%) was malnourished (underfeeding) according to the adapted ISRNM criteria,[6] where three to four of the proposed malnourished criteria needed to be met (Table 4). Notably, 33.3% had two out of four of the malnutrition criteria and, therefore, were on the verge of malnutrition.

Nutritional status subgroups

Compared with the well-nourished group, the subgroup who were malnourished (Table 5) had significantly lower median BMI (21.8 kg/m^2 vs. 30.1 kg/m^2, $p \leq 0.0003$), median MUAC (25.4 cm vs. 31.0 cm, $p \leq 0.0001$), median triceps skinfold (5.0 mm vs 15.0 mm, $p \leq 0.00001$), and median albumin levels (33 g/l vs. 36 g/l, $p = 0.004$). Furthermore, more had a BMI < 25 kg/m^2 (78.6% vs. 22.9%, $p \leq 0.001$), low AMA (93.4% vs. 25.7%, $p \leq 0.0001$), a low body fat percentage (80.0% vs. 11.4%, $p < 0.0001$), an ideal WHtR (57.1% vs. 17.1%, $p = 0.012$), an ideal WC (75.0% vs. 22.7%, $p = 002$), and more who were in the low albumin category (< 35 g/l) (80.0% vs. 31.4%, $p = 0.005$). There were no significant differences between nutritional status subgroups regarding socioeconomic factors (e.g. education, income and employment status).

Table 3: Estimated energy and macronutrient dietary intakes on a typical non-dialysis day[5,12]

Variables	n; median	Percentage (%); Interquartile range (IQR)
Total energy intake (kcal/ kg) ($n = 74$)		
Inadequate < 25	21	28.4
Adequate 25–35	19	25.7
Above adequate > 35	34	45.9
Total energy intake (kcal/ kg) ($n = 74$) (median, IQR)	32.2	23.6–47.6
Total dietary protein (TDP) intake (g/kg)[#] ($n = 74$)		
Inadequate < 1.0	24	32.4
Adequate 1.0–1.2	12	16.2
Above adequate > 1.2	38	51.4
TDP (g/kg)[#] (median, IQR)	1.2	0.9–1.6
Carbohydrate intake (% of TE[§]) ($n = 75$)		
Inadequate < 50	13	17.3
Adequate 50–60	24	32.0
Above adequate > 60	38	50.7
Fat intake (% of TE[§]) ($n = 75$)		
Inadequate < 25	34	45.4
Adequate 25–35	31	41.3
Above adequate > 35	10	13.3

*Kcal: kilocalorie.
[#]kg: post-dialysis weight or adjusted oedema-free bodyweight.
[§]TE: total energy.

Discussion

In the current study of patients receiving MHD at dialysis centres in central SA (a low- to middle-income country [LMIC]), participants were mostly middle-aged and male, and the aetiology of hypertensive kidney disease and diabetic nephropathy coincides with national data of 39.0% and 12.8%,[18] respectively. In the current study, overcrowding, unemployment rates and reliance on social grants were high, and median pp incomes were low. The median percentage of income available for food pp/pm in the current study was only 27.3%, compared with the recommended 40%.[9] Indeed, evidence from an Australian study indicates that individuals with more advanced stages of CKD are at increased risk of falling into poverty.[19] Therefore, regular evaluation of socioeconomic status and its impact on dietary intake could provide deeper insight into the determinants of nutritional status.

Anthropometry

In the current study, despite the low muscle mass in 56%, the median BMI was relatively high at 26.4 kg/m^2, with 56.8% having a BMI ≥ 25 kg/m^2, indicating overweight or obesity. Indeed, 18.9% had low muscle mass and a high BMI (if muscle function was also assessed it could have been referred to as sarcopenic obesity). The high prevalence of overweight and obesity in the current study seems similar to the general South African population.[20] Interestingly, several epidemiological studies have indicated in patients with ESRD an obesity paradox where a higher BMI (≥ 25 kg/m^2) is associated with significantly better survival (including patients with CVD) in contrast to a higher BMI increasing mortality in the general population.[21] However, in ESRD morbid obesity (BMI > 40 kg/m^2) is still associated with increased CVD mortality, while a BMI < 20 kg/m^2 is associated with an increase in all-cause mortality.[4] A study with 96 MHD Israeli participants showed better nutritional status (greater muscle mass) was found amongst those with an elevated BMI.[22] Furthermore, it seems survival was also better among 261 MHD Israeli patients with higher fat mass, even together with low muscle mass, compared with the non-obese low muscle mass patients.[23] Amongst other theories, it could be that an increased body mass provides resources for responding to inflammation and infection, therefore reducing mortality.[23,24] Thus, the prevalence of a high BMI (even though it can be considered a protective factor), in the presence of low and declining muscle mass or body fat depletion, can possibly mask PEM, resulting in increased morbidity and mortality,[21] and needs consideration.

Dietary intake

In the current study, approximately one out of four (28.4%) on MHD had an estimated low energy intake < 25 kcal/kg (post-dialysis weight or $_{a}BW_{ef}$), although in half, CHO intake was high (> 60% of TE). Furthermore, almost a third (32.4%) had an estimated low total dietary protein intake < 1.0 g/kg (post-dialysis weight or $_{a}BW_{ef}$).[5] This could indicate for some a low-

Table 4: Results of adapted protein energy wasting (PEW)/malnutrition diagnostic criteria in chronic kidney disease (CKD) stratified according to the International Society of Renal Nutrition and Metabolism (ISRNM) criteria ($N = 75$)[5,6]

Low arm muscle area (AMA) (≤15th centile)	Low BMI (<18.5 kg/m²) and/or low body fat% (≤15th centile)	Low protein intake (<1.0 g/kg) and/or low energy intake (<25 kcal/kg)	Low albumin (<35 g/l) and/or low cholesterol (<3.8 mmol/l) levels	*n*	%
Of those who had *four out of four* PEW/malnutrition diagnostic criteria (4.0%, *n* = 3):					
Low AMA	Low BMI and low body fat%	Low energy and protein intake	Low albumin	3	4.0
Of those who had *three out of four* PEW/malnutrition diagnostic criteria (16.0%, *n* = 12):					
Low AMA	Low body fat%		Low albumin	5	6.7
Low AMA		Low energy and protein intake	Low albumin	3	4.0
Low AMA		Low energy and protein intake	Low albumin and cholesterol	1	1.3
Low AMA		Low energy and protein intake	Low albumin and low cholesterol	1	1.3
Low AMA	Low BMI and low body fat%	Low energy and protein intake		1	1.3
	Low body fat%	Low energy and protein intake	Low albumin	1	1.3
Of those who had *two out of four* PEW/malnutrition diagnostic criteria (33.3%, *n* = 25):					
Low AMA			Low albumin	9	12.0
Low AMA	Low body fat%			6	8.0
		Low energy intake	Low albumin	3	4.0
Low AMA		Low energy and protein intake		2	2.7
		Low energy and protein intake	Low albumin and low cholesterol	2	2.7
		Low protein intake	Low albumin	1	1.3
Low AMA			Low cholesterol	1	1.3
Low AMA		Low protein intake		1	1.3
Of those who had *one out of four* PEW/malnutrition diagnostic criteria (38.7%, *n* = 29):					
Low AMA				9	12.0
			Low albumin	8	10.7
		Low energy and protein intake		7	9.3
			Low cholesterol	3	4.0
		Low protein intake		2	2.7
Six participants had *no* malnutrition criteria (8.0%, *n* = 6).					

protein diet with carbohydrates as the main energy source, and CHO replacing protein in the diet. Possibly the dietary intake is context and cultural-specific, as research in the general population of the same province showed that sugar was the most frequently consumed food item.[25] Sugar was eaten at least twice per day by all groups and cooked porridge was the most frequently consumed starchy food (range 47.3–53.2 times a month), followed by bread, consumed at a median frequency of 20 or more pm in all groups.[25] As reflected in the current study, high carbohydrate intake might lead to overweight with correspondingly low muscle mass. When resources are limited, protein intake could be hampered as meat, fish, poultry, and legumes (plant proteins)[26] are more expensive than staple CHO foods like maize porridge and bread.

The four participants (5.4%) with an underweight BMI (< 18.5 kg/m²) all consumed too low amounts of energy and protein. Comparatively, in another African country, low TDP was more frequent in Tanzania, where 84.6% of 39 MHD patients ate less than 1.1 g/kg/day of protein.[27] In the current sample, where half had a high BMI, chronic protein depletion and poor nutritional status can be overlooked if dietary intake (unintentional low energy and protein intake) is not considered simultaneously with other malnutrition markers, such as low muscle mass (AMA), low MUAC, serum albumin and cholesterol levels.[6] Nutrition intervention is vital to track and correct low energy and protein intake, through regular monitoring and evaluation.[5]

Malnutrition

This study found that 20.0% were malnourished according to the ISRNM-adapted diagnostic criteria,[6] which classify individuals as malnourished if more than three of four diagnostic criteria are met.[5,6] Information on malnutrition among MHD patients in developing countries remains limited, partly due to resource constraints, a low nephrology workforce[28] and inconsistent assessment methods. Comparable findings have been reported elsewhere in Africa: a study in Cameroon identified malnutrition in 21% (*n* = 113),[7] while research in the Western Cape province of South Africa by Aziz et al. found 22% (*n* = 116) of MHD patients to be malnourished using an adapted Global Leadership Initiative on Malnutrition (GLIM) approach.[29] Similarly, studies using the Malnutrition Inflammation Score (MIS) reported moderate malnutrition in 24.7% of MHD patients in Egypt (*n* = 174)[30] and PEM in 34% of patients in Iran (*n* = 540).[3] Higher rates were observed in Tanzania, where 61.2% of MHD patients (*n* = 160) were classified as malnourished using the Subjective Global Assessment (SGA).[32] Despite methodological differences across studies, malnutrition consistently emerges as an independent predictor of mortality and is associated with increased hospitalisation.[33]

Interestingly, 93.3% of those classified as malnourished in the current study had a low arm muscle area, while only four had a low BMI, implying that if only BMI were assessed, malnutrition could have been missed. Overall, 56.0% had a low arm muscle area (AMA ≤ 15th centile), of these, 33.3% were overweight or

Table 5: Comparison of variables between subgroups of nutritional status stratified according to the International Society of Renal Nutrition and Metabolism (ISRNM) criteria ($N = 75$)[5,6]

Factor	Malnourished ≥ 3 out of 4 malnutrition criteria		High risk of malnutrition 2 out of 4 malnutrition criteria		Well-nourished 0–1 out of 4 malnutrition criteria		*p*-value
	n	%	*n*	%	*n*	%	
Number of participants	15	20.0	25	33.3	35	46.7	
Biological sex, male	13	86.7	18	72.0	22	62.9	0.234
Age (years) (median with IQR)	44 yrs (33.8–55.8 yrs)		52.3 yrs (43.3–57.2 yrs)		53.2 yrs (43.5–60.9 yrs)		0.123
Education							
Primary (≤ grade 10)	2	13.3	6	24.0	10	28.6	0.324
Secondary (grade 11–12)	8	53.4	15	60.0	13	37.1	
Tertiary	5	33.3	4	16.0	12	34.3	
Income							
Total monthly income per person (R) (median with IQR)	2 667 (533–5 000)		1 900 (760–4400)		3 500 (933–6 667)		0.316
Percentage of income spent on food (median with IQR)	31.3 (18.2–50.0)		27.3 (13.3–40.0)		22.7 (15.0–33.3)		0.352
Percentage of income spent on food							
< 40% (not ideal)	10	66.7	17	73.9	29	87.9	0.196
≥ 40% (ideal)	5	33.3	6	26.1	4	12.1	
Household density ratio (HDR)							
Ideal	5	33.3	9	36.0	13	37.1	0.968
Overcrowded	10	66.7	16	64.0	22	62.9	
Duration on dialysis (years) (median with IQR)	5.1 (1.5–7.1)		4.5 (1.7–7.8)		2.9 (1.3–6.1)		0.591
Co-morbidities							
Hypertension	10	66.7	10	40.0	21	60.0	0.179
Diabetes mellitus	2	13.3	4	16.0	8	22.9	0.796
Complication: anaemia	5	33.3	2	8.0	9	25.7	0.114
BMI kg/m^2 ($n = 74$) (median with IQR)	21.8 (20.3–23.7)		23.5 (20.3–29.5)		30.1 (26.2–34.2)		< 0.0003*
BMI kg/m^2 ($n = 74$)							
< 25	11	78.6	13	52.0	8	22.9	0.001*
≥ 25	3	21.4	12	48.0	27	77.1	
Arm muscle area (AMA)							
≤ 15th centile (low)	14	93.4	19	76.0	9	25.7	< 0.0001*
> 15th centile	1	6.6	6	24.0	26	74.3	
Mid-upper arm circumference (MUAC) (cm) (median with IQR)	25.4 (24.0–28.5)		26.5 (24.5–28.5)		31.0 (29.0–36.0)		< 0.0001*
Triceps skinfold (mm) (median with IQR)	5.0 (4.0–7.0)		9.0 (7.0–16.0)		15.0 (10.0–28.0)		< 0.0001*
Body fat percentage							
≤ 15th centile (low)	12	80.0	13	52.0	4	11.4	< 0.0001*
> 15th centile	3	20.0	12	48.0	31	88.6	
Waist-to-height ratio (WHtR) ($n = 74$)							
≤ 0.5 (ideal)	8	57.1	11	44.0	6	17.1	0.012*
> 0.5	6	42.9	14	56.0	29	82.9	
Waist circumference (WC), men ($n = 52$)							
< 94 cm(ideal)	9	75.0	13	72.2	5	22.7	0.002*
≥ 94 cm	3	25.0	5	27.8	17	77.3	
WC, women ($n = 22$)							
< 80 cm (ideal)	1	50.0	1	14.3	2	15.4	0.502
≥ 80 cm	1	50.0	6	85.7	11	84.6	
Albumin (g/l) (median with IQR)	33 (31–34)		34 (32–36)		36 (34–38)		0.004*
Albumin (g/l)							
< 35 (low)	12	80.0	14	56.0	11	31.4	0.005*
≥ 35	3	20.0	11	44.0	24	68.6	
Cholesterol (mmol/l) (median with IQR)	3.3 (2.0–4.8)		3.5 (2.9–4.0)		4.6 (3.7–5.3)		0.139

(*Continued*)

Table 5: Continued.

Factor	Malnourished ≥ 3 out of 4 malnutrition criteria		High risk of malnutrition 2 out of 4 malnutrition criteria		Well-nourished 0–1 out of 4 malnutrition criteria		*p*-value
	n	%	*n*	%	*n*	%	
Cholesterol (mmol/l) (*n* = 15)							
< 3.8 (low)	2	66.7	3	60.0	3	42.9	1.000
≥ 3.8	1	33.3	2	40.0	4	57.1	
Haemoglobin (g/dl) (median with IQR)	10.6 (9.3–12.4)		11.0 (9.7–11.7)		10.7 (9.9–11.8)		0.953
Haemoglobin (g/dl)							
< 10 (low)	4	26.7	7	28.0	10	28.6	0.991
≥ 10	11	73.3	18	72.0	25	71.4	
Transferrin saturation rate percentage (TSAT) (median with IQR)	26.0 (20.0–34.0)		26.0 (22.7–33.3)		23.7 (22.0–28.0)		0.568
TSAT (*n* = 74)							
< 20% (low)	3	20.0	4	16.7	7	20.0	1.000
≥ 20%	12	80.0	20	83.3	28	80.0	
Serum phosphate (mmol/l) (median with IQR)	1.5 (1.3–2.1)		1.2 (1.1–1.6)		1.6 (1.2–1.9)		0.058
S-phosphate (NKF[§] cutoff) (mmol/l)							
≤ 1.8	10	66.7	21	84.0	25	71.4	0.396
> 1.8 (high)	5	33.3	4	16.0	10	28.6	
S-phosphate (SA[¥] cutoff) (mmol/l)							
≤ 1.42	6	40.0	18	72.0	14	40.0	0.033*
> 1.42 (high)	9	60.0	7	28.0	21	60.0	
Post-dialysis serum urea (mmol/l) (*n* = 47) (median with IQR)	5.5 (4.7–8.5); *n* = 13		5.8 (3.7–7.5); *n* = 13		5.6 (4.9–7.9); *n* = 21		0.866
Pre-dialysis creatinine (µmol/l) (*n* = 65) (median with IQR)	819.5 (691.0–925.0); (*n* = 12)		789.5 (627.5–1 024.0); (*n* = 24)		823.0 (620.0–1 065.0); (*n* = 29)		0.839
Post-dialysis creatinine (µmol/l) (*n* = 10) (median with IQR)	272.0 (249.0–313.0); (*n* = 3)		221.0 (221.0–221.0); (*n* = 1)		326.0 (118.0–414.0); (*n* = 6)		0.683
KtV (median with IQR)	1.4 (1.2–1.5)		1.4 (1.16–1.61)		1.27 (1.19–1.46)		0.292
Energy intake (kcal/kg) (*n* = 74) (median with IQR)	26.3 (20.7–48.9)		36.4 (20.9–44.9)		31.8 (25.8–47.6)		0.803
Energy intake (kcal/kg) (*n* = 74)							
< 25 (low)	7	50.0	7	28.0	7	20.0	0.109
≥ 25	7	50.0	18	72.0	28	80.0	
Total dietary protein intake (g/kg) (median with IQR)	1.0 (0.8–1.6)		1.2 (0.8–1.6)		1.3 (1.0–1.6)		0.615
Total dietary protein intake (g/kg) (*n* = 74)							
< 1.0 (low)	7	50.0	9	36.0	8	22.9	0.167
≥ 1.0	7	50.0	16	64.0	27	77.1	
Consulted a dietitian							
Yes	12	80.0	23	92.0	28	80.0	0.424
No	3	20.0	2	8.0	7	20.0	
Involvement of a dietitian (visits/year)							
Minimal (0−1 visits/year)	12	80.0	21	84.0	25	71.4	0.667
Average (2−3 visits/year)	1	6.7	0	0.0	2	5.7	
Sufficient (> 3 visits/year)	2	13.3	4	16.0	8	22.9	

Associations were determined by Kruskal–Wallis test for numerical data (medians) and Fisher's exact test for categorical data; **p*-value < 0.05 statistically significant.
[§]NKF:National Kidney Foundation.
[¥]SA: South Africa.

obese (≥ 25.0 kg/m^2). However, only two patients (1.7%) with low muscle mass (based on MUAC) reported by Aziz et. al.[29] were found to be obese. This is overshadowed by the 18.9% obese patients we observed with low AMA. Furthermore, only one-fifth (21.2%) in the Cameroon study were overweight (≥ 25 kg/m^2)[7] compared with the current study, where half (56.8%, *n* = 42) had a BMI ≥ 25 kg/m^2. Aziz et al. reported slightly lower rates of overweight or obesity at 46.6%.[29] The methodology to determine muscle mass differs between the two studies, with low muscle mass at 56% (AMA ≤ 15th centile) in the current study and low muscle mass at 23.9% with mid-arm muscle circumference (MAMC) in the Cameroon study,[7] hampering comparison. Recently in Egypt it was found that malnutrition coexisted with a higher BMI distribution of 28.2 ± 6.3 kg/m^2 amongst 71.4% of MHD patients.[34] However, compared with Cameroon, the frequency of low BMIs is lower, as only 8.1% had a low BMI (< 20 kg/m^2), against 28.3% in Cameroon.[7]

Regardless of overall high BMIs compared with the well-nourished group, the malnourished subgroup had a significantly lower median BMI, median MUAC, median triceps skinfold and median albumin levels. Serum albumin is a measure of both visceral and somatic protein status. It can indicate the level of the acute phase inflammatory response, while, in the absence of an inflammatory response, it can indicate chronic malnutrition.[8] In the current study setting, CRP, which can confirm low-grade inflammation due to metabolic stress of the ESRD and MHD procedure, is not routinely measured, but it may be expected that chronic low-grade inflammation, usually indicated by a CRP > 5–10 mg/l, is present[8] and exacerbates the malnutrition.[35] In the Cameroon study, Halle et al. (2014) found that 28% of the patients on MHD had raised CRP (> 6 mg/l).[7] In patients with CKD on dialysis, most studies with high applicability found that elevated CRP levels predicted all-cause mortality.[36] Low serum albumin, regardless of the aetiology, needs attention to decrease mortality and morbidity and dietitian intervention is warranted if it occurs with other markers of malnutrition.[6]

Even though the GLIM criteria have made major strides towards standardising malnutrition diagnosis in other adult populations, there is still no consensus on using the GLIM criteria[37] or any other criteria in the CKD population, even more so in a resource-limited setting. In CKD, the fluid shifts can cause underestimation of the malnutrition rates and overestimation of muscle mass.[37] Furthermore, the unique challenges of a seemingly higher BMI, low muscle mass MHD population with added components of chronic inflammation in an LMIC with limited resources may need an innovative, though simple approach to monitor malnutrition.

Therefore, due to over- and undernutrition, strategic, context-specific nutrition interventions and monitoring are needed. Unfortunately, in the current sample, intervention was inadequate, with 77.3% of participants receiving none to one dietetic consultation per dialysis year.[17] This is concerning, given that bi-annual dietetic monitoring is recommended to support optimal nutritional status in patients receiving MHD.[5] In India, amongst 277 MHD patients, dietetic intervention decreased malnutrition status from 97.2% to 89.8% (assessed by SGA).[38] Limited involvement of dietitians may reflect systemic barriers within the South African health system, such as a shortage of renal-trained dietitians, high clinical workloads and limited posts dedicated to nephrology nutrition services. A recent SA survey of nutrition services found considerable variability in service delivery and capacity, particularly in specialised areas such as renal nutrition.[39] These structural constraints may limit access to consistent dietetic care, even where clinical guidelines support its necessity. In resource-limited settings, low-cost screening tools could assist in triaging patients for prioritised dietetic intervention, particularly where signs of muscle mass loss or dietary inadequacy are present. The coexistence of overweight or obesity with low muscle mass and suboptimal protein intake in this population further underscores the need for targeted, context-specific nutrition counselling.

Limitations

Although the reduced sample size may limit generalisability and statistical power, and the data are dated, the findings remain scientifically valuable and contextually relevant. The study provides valuable and novel data from a severely under-researched region. The findings thus offer a critical contribution to local evidence with regional patterns and resource needs, which can inform future research, clinical practice and policy tailored to the unique context of this population.

Some measurements that may have enhanced the interpretation of the data were not available in the low-resource setting at the time. For body composition, MF-BIA was not readily available, while CRP, TIBC and cholesterol levels were not routinely recorded. Furthermore, muscle function as evaluated with handgrip strength or chair stand was also not assessed and needs to be included in future studies.

Even though dialysis usually corrects metabolic acidosis, it could have been useful in the current study to assess whether metabolic acidosis was present by assessing blood pH and serum bicarbonate, especially in view of the low muscle mass.

Lastly, the typical intake in one non-dialysis day may not accurately represent energy and macronutrient intake, but it can highlight trends that need further research.[11] Contextualised dietary intake data collection techniques relevant to SA are needed to overcome barriers, e.g. language barriers,[17] to measure and report dietary intake consistently.

Conclusions

In central SA, among those receiving maintenance haemodialysis (MHD), poor nutritional status was associated with lower BMI, muscle mass, body fat percentage, serum albumin and reduced abdominal obesity. However, over half were overweight or obese; this likely masked underlying malnutrition when assessed in isolation. Nearly one-third had inadequate estimated protein intake, and while socioeconomic status appeared low, no significant differences were observed between nutritional status subgroups. Accurate malnutrition detection in patients receiving MHD with several biomarkers, which are readily available in resource-limited settings, is needed and needs global standardisation to ensure timely and effective nutrition intervention. Several markers, and specifically muscle mass, need to be routinely assessed as overweight and obesity seem to be more prevalent in this population. In the current study context, low socioeconomic determinants could have resulted in high carbohydrate intake combined with low protein consumption; however, larger in-depth studies are needed to confirm. Ensuring optimal medical nutrition therapy with personalised approaches regarding protein intake is important. Future research needs to address solutions for resource-limited settings to diagnose and curb the adverse effects of malnutrition in the MHD population.

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