Does Dietary Intake Differ in Kidney Failure Patients With Sarcopenia and Frailty Treated by Hemodialysis

Haalah Shaaker, MSc[1,2] and Andrew Davenport, MD[1] (iD)

Abstract

Background: Inadequate nutrition is common for both sarcopenia and frailty. We investigated whether hemodialysis patients with sarcopenia and frailty have reduced dietary intakes. **Methods:** Dietary intake, and physical activity were analyzed, along with body composition and relevant clinical data. **Results:** We studied 51 hemodialysis patients; 52.9% male, age 60 ± 15 years; 33.3% sarcopenic, and 72.5% frail. Dietary protein and calories were similar for sarcopenic and non-sarcopenic patients 0.68 (0.38–3.5) vs. 0.68 (0.18–2.9) g protein/kg/day and 19.2 (8.2–77.5) vs. 15.2 (6.2–38.5) kcal/kg/day. More sarcopenic patients had low physical activity (88.2% vs. 58.8%, X^2 4.6, $p = .03$). Frail and non-frail patients had similar intakes 0.67 (0.28–3.5) versus 0.83 (0.18–1.6) g protein/kg/day and 15.5 (8.1–77.5) vs. 18.8 (6.2–45.4) kcal/kg/day. Sarcopenia was associated with age [Odds ratio (OR) 1.09, 95% confidence interval (CI) [1.02, 1.18], $p = .017$], body mass index [OR 0.84, 95% CI [0.71, 0.99], $p = .042$] and lack of exercise [OR 7.62, 95% CI [1.16, 50.29], $p = .035$]. Frailty was associated with female gender [OR 17.79, 95% CI [2.09, 151.59], $p = .008$], age [OR 1.13, 95% CI [1.04, 1.22], $p = .006$], and dialysis vintage [OR 1.55, 95% CI [1.06, 2.26], $p = .024$]. **Conclusion:** Hemodialysis patients with sarcopenia and frailty did not have lower dietary protein and calorie intake. Frailty was associated with age and sarcopenia with a sedentary lifestyle.

Introduction

In the United Kingdom (UK), more older patients with progressive chronic kidney disease (CKD) are now being offered treatment with dialysis. As such, the demographics of the dialysis population have changed over recent years, with growing numbers of not only older patients, but also those with greater co-morbidity and increased dependency (Hounkpatin et al., 2020). Therefore, more patients with sarcopenia and frailty are now being treated with dialysis (Umakanthan et al., 2021; Yoowannakul et al., 2018). Sarcopenia, being defined as a loss of muscle mass greater than that expected for normal age-related physiological muscle loss, and consensus cut-offs from the European Working Group on Sarcopenia in Older People (EWGSOP) (Cruz-Jentoft et al., 2019) and the Asian Working Group for Sarcopenia (AWGS) (Chen et al., 2020). Frailty is a condition that renders an individual more prone to dependency on others and a higher risk of mortality when confronted with various stressors. Those suffering from frailty are at a greater risk of deterioration

compared to individuals of similar age (Pulok et al., 2020), and in the UK National Health Service (NHS) frailty assessments are classified using the clinical frailty score (CFS) (Rockwood et al., 2005).

Both frailty and sarcopenia have been shown to be linked to an increased risk of death. In a recent systematic review, the prevalence of frailty was reported to range from 7% in patients with CKD stages 1 to 4 up to 73% in those treated with hemodialysis (HD) and associated with increased risk of mortality and hospitalization (Chen et al., 2020; Chowdhury et al., 2017). Other observational studies reported that frailty was associated with a 2.6-fold increase in the risk of death, and an even greater chance of hospitalization (Church et al., 2020;

[1]University College London, UK
[2]King Abdulaziz University, Jeddah, Saudi Arabia

Corresponding Author:
Haalah Shaaker, Division of Medicine, University College London, London WC1E 6BT, UK.
Email: haalah.shaaker.21@ucl.ac.uk

McAdams-DeMarco et al., 2013). Similarly, sarcopenia is also associated with both an increased mortality risk and hospitalization (Chen et al., 2020; Shu et al., 2022).

Patients with frailty and sarcopenia have been reported to have reduced nutritional intake (Ligthart-Melis et al., 2020), and a recent review highlighted that an inadequate dietary energy and protein intake along with other factors contributed to the development of sarcopenia in HD patients (Sabatino et al., 2021). In 2020, the Kidney Disease Outcomes Quality Initiative (KDOQI) consensus meeting published nutritional target guidelines for HD patients to sustain dietary adequacy and prevent muscle wasting related conditions such as sarcopenia and frailty. KDOQI recommended a daily protein and calorie intake between 1.0 and 1.2 g/kg/day with 25 and 30 kcal/kg/day, along with periodic assessment of vitamin and mineral intake (Ikizler et al., 2020). Although numerous studies have established the increasing prevalence of sarcopenia and frailty in individuals undergoing hemodialysis (HD), none of these studies have investigated the influence of nutrition (Lee et al., 2020; Takeuchi et al., 2018). Whereas studies in non-dialysis patients have demonstrated that a diet low in protein and vitamins contributes to frailty (Bartali et al., 2006), studies in dialysis patients have reported the HD patients may have inadequate energy and protein consumption, this has not been shown to be associated with sarcopenia (Garcia-Torres et al., 2020). Similarly reduced vitamin D intake has not been reported to increase the incidence of sarcopenia in chronic kidney disease (CKD) patients (Noor et al., 2021). Again, studies in non-dialysis sarcopenic patients have observed a positive effect of Omega 3 supplements in reducing muscle degradation (Buoite Stella et al., 2018), whereas there is limited data on the potential effects of Omega 3 supplements to mitigate frailty and sarcopenia in HD subjects (Lalia et al., 2017), and the benefits of antioxidant supplements to prevent and manage sarcopenia remain controversial (Cerullo et al., 2012). As such, we wished to determine whether dietary intake differed between HD patients with and without both sarcopenia and frailty in terms of specific trace elements, vitamin D and Omega-3-fatty acids, and also to determine whether overall nutritional intake was inadequate by comparison with the consensus KDOQI recommended targets.

Methods

Study Design

We undertook a cross-sectional comparative audit of nutritional intake in adult patients with established kidney failure attending for routine outpatient HD in dialysis centers under the supervision of a UK university hospital between May and July 2022.

Setting

This study targeted adult renal patients treated with HD at two hemodialysis units in London under the care of a tertiary university hospital. The data was collected by a single highly qualified dietitian investigator over 3 months (May to July 2022). To reduce bias, the same dietitian investigator made all hand grip strength measurements and bioimpedance measurements.

Participants

All dialysis patients attending two kidney dialysis centers were invited to participate provided that they had been established on regular hemodialysis for 12 weeks or more. Dialysis treatments used high-flux dialyzers and dialysis machines fitted with ultrafilters (Fresenius FX series, Fresenius 5008H dialysis machines, Fresenius medical company, Bad Homberg, Germany), with ultrapure water and bicarbonate dialyzate, containing 5.5 mmol/L glucose, targeting a sessional on-line clearance (Kt/V) of ≥ 1.4 (Tangvoraphonkchai et al., 2018). Single bolus low molecular weight heparin (Tinzaparin, Leo Pharmaceuticals, Lutterworth, UK) was used for anticoagulation (Davenport, 2013). Patients with visual or physical disability, mental health, or language barriers who were unable to provide written 48-hr diet histories were excluded. Similarly, patients who had been discharged within 6 weeks from hospital following an emergency admission and those with untreated cancer or undergoing chemotherapy were excluded from study.

Variables/Data Sources/Measurement

Patients were provided with written instructions on how to complete the 48-hr food diaries and shown a visual hand guide of portion sizes along with an example of a completed food record to assist them in completing their food diaries. The 2-day nutritional records were pooled and analyzed using "Nutritics" software (Nutritics, Swords, Dublin, Ireland) (O'Kelly, 2022) to obtain numerical data for each nutrient and then directly exported to a spreadsheet in Microsoft Excel (Microsoft Office 365, 2019). Patients were also asked to complete a physical activity diary for both (occupational and exercise activity levels) and then were classified according to the Nutritics software program. Occupational levels were classified as sedentary, lightly active, moderately active, very active, and extremely active. Exercise levels were categorized as none (little or no regular exercise), light (walking, e.g., 1–3 days per week), moderate (hard exercise for 3 days per week, or light exercise for 5 days per week), very active (hard exercise for 6 days per week), and ultra-active (training twice daily).

Body composition, including appendicular lean mass (ALM), fat mass, the ratio of extracellular water to total body water (ECW/TBW), and body cell mass (BCM) were measured using multi-frequency

bioelectrical impedance (InBody 720, Seoul, South Korea) following a standardized protocol (Oliveira et al., 2018; Panorchan et al., 2015), with all measurements standardized to post- the mid-week dialysis session. ALM was indexed to height (ALMI). Height, weight, and body mass index (BMI) were routinely checked by the registered nurses. Weighing scales, stadiometer and bioimpedance equipment were regularly serviced and calibrated. Patients with limb amputations and those with limb paralysis were excluded. Patient demographics, dialysis mode, months of dialysis treatment (vintage), comorbidities, Clinical Frailty Score (CFS), and results of routine laboratory investigations were obtained from hospital computerized data bases. All blood test results were obtained from the same mid-week dialysis session at which the BIA measurements were made. Normalized nitrogen appearance (nPNA) and creatinine generation rates were calculated by standard methods (Daugirdas, 2021; Salame et al., 2018). Basal metabolic rate was estimated using the Harris-Benedict equation (Aleksandra Zając, 1918).

We used the Stoke-Davies co-morbidity grading system (Davies et al., 2002) and frailty was assessed using the Canadian Society of Gerontology score (Rockwood et al., 2005). Following the manufacturer's guidelines hand grip strength (HGS) was measured using the grip-D strength dynamometer (Takei Scientific Instruments Co, Nigata, Japan), with the maximum value of three maximal voluntary exertions with the dominant (stronger) arm recorded (El-Katab et al., 2016). Measurements were contemporaneous with BIA body composition measurements. Sarcopenia was determined using the consensus EWGSOP (Cruz-Jentoft et al., 2019) and AWGS (Chen et al., 2020) criteria.

Study Size

Out of 224 potential patients with kidney failure established on regular hemodialysis, 97 agreed to participate, while 127 either met exclusion criteria or declined to participate. Research questionnaires were administered to consenting participants, but only 56 responses were received. Subsequently, five participants were excluded from the data analysis: two due to incomplete nutritional records and three for missing bioelectrical impedance analysis (BIA) results and declining the test. As such we studied the 51 participants who completed the dietary questionnaires and who had corresponding BIA and HGS results.

Ethical Approval

Our comparative audit of nutritional intake was checked with and complied with the UK National Health Service Health Research Authority guidelines for clinical audit and service development (https://www.hra.nhs.ukhttps://researchsupport.admin.ox.ac.uk/sites/default/files/researchsupport/documents/media/defining-research.

pdf) and registered with the Hospital. All patient data was appropriately anonymized.

Statistical Analysis

Results are expressed as mean ± standard deviation, or median and interquartile range, or percentage. Data was analyzed using the D'Agostino and Pearson normality test, and numerical data analyzed by t-test if normally distributed and by Mann Whitney U test if non-parametric. Categorical data was analyzed using the Chi square test (χ^2). Cohen's kappa statistic was used to compare frailty and sarcopenia groupings and Bland Altman for comparing estimates of calorie intake. Appropriate corrections for small numbers and multiple testing were applied. Univariate analysis was by Pearson and Spearman analysis, respectively. Logistic step-backward models for both frailty and sarcopenia were developed and included all variables with univariate association $p < .1$. If necessary, non-parametric numerical variables were log transformed to improve data distribution Variables were then retained if statistically significant, or improved model fit. Statistical analysis was performed using Graph Pad Prism (version 9.0, Graph Pad, San Diego, CA, USA), Statistical Package for Social Science version 28.0 (IBM Corporation, Armonk, New York, USA), and Analyse-It (version 4.0, Leeds, UK). Statistical significance was taken at or below the 5% level.

Results

Study Participants and Main Characteristics

Initially 97 of a potential 224 (43.3%) HD patients agreed to take part in our cross-sectional audit. However, only 54 (55.7%) returned completed 48-hr food intake questionnaires, and three other patients were excluded due to missing bioimpedance measurements. We studied 51 patients. 52.9% male, mean age 60 ± 15 years, median dialysis treatment (vintage) 36 (24–72) months, median body mass index (BMI) 26.3 (22.3–30.8), percentage body fat (%BF) 33 ± 14.1%, appendicular lean mass index (ALMI) 9.4 (7.9–11.2) kg/m^2, and basal metabolic rate (BMR) 1,466 ± 315 kcal, respectively. Forty-three patients were treated with haemodiafiltration (HDF) (84.3%), and only 8 (15.7%) by hemodialysis (HD).

One third met the criteria for sarcopenia, and 72.5% were classified as frail (CFS score ≥ 4), 82% of the sarcopenic group were also frail, and 38%% of those with frailty had sarcopenia. As expected sarcopenic patients had lower ALMI and lower HGS. However, sarcopenic patients were also older, with a greater proportion of Asian ethnicity, and lower BMR and serum phosphate (Tables 1 and 2). More patients with sarcopenia had a history of cancer ($\chi^2 = 5.43$, $p = .02$). Just over half the sarcopenic patients (52.9%) were classified as

Table 1. Bivariate Analysis of Participants With and Without Sarcopenia and Frailty.

	Sarcopenic n = 17 (33.3%)	Not sarcopenic n = 34 (66.7%)	p-Value	Vulnerable/Frail n = 37 (72.5%)	Not frail n = 14 (27.5%)	p-Value
Demographics						
Age (years)	68.8 (±12.3)	55.6 (±14.4)	**.002**	63.5 (±12.8)	50.7 (±16.5)	**.005**
Males, n (%)	9 (53)	18 (53)	1.00	16 (43)	11 (78.5)	**.024**
Ethnicity groups						
White, n (%)	3 (18)	9 (26)	**.004**	10 (27)	2 (14)	.445
Black, n (%)	2 (12)	13 (38)		9 (24)	6 (43)	
Asian, n (%)	12 (70)	7 (20.5)		15 (40.5)	4 (29)	
Others, n (%)	0	5 (15)		3 (8)	2 (14)	
Comorbidities						
Diabetes, n (%)	9 (53)	17 (50)	.843	19 (51)	7 (50)	.931
Hypertension, n (%)	8 (47)	25 (73.5)	.062	24 (65)	9 (64)	.969
Cancer, n (%)	4 (23.5)	1 (3)	**.02**	4 (11)	1 (7)	.694
Anthropometry and body composition						
Height (cm)	1.57 (±0.08)	1.68 (±0.11)	<**.001**	1.6 [1.535–1.69]	1.7 [1.685–1.8]	**.002**
Weight (kg)	62 [50.9–71.8]	79 [63.3–94.6]	**.001**	70.5 [60.25–80.25]	73.75 [59–95.85]	**.002**
BMI (kg/m^2)	24.37 [21.2–28.2]	27.64 [23.4–33.9]	.097	26.23 [22.4–31.5]	25.7 [20.7–30.6]	.520
HGS (kg)	15.04 (±5.28)	20.10 (±9.71)	.051	15 [10.1–20.7]	23.7 [19.2–30.7]	.658
Fat (%)	36.54 (±11.71)	31.30 (±15.04)	.215	36 (±13)	25 (±14.1)	.123
ALMI (kg/m^2)	7.9 [6.4–16.8]	9.9 [6.9–20.6]	<**.001**	8.82 [6.3–20.6]	9.9 [7.68–14.6]	**.047**
ECW/TBW	0.395 [0.391–0.399]	0.40 [0.387–0.407]	.582	0.398 [0.391–0.406]	0.393 [0.381–0.398]	**.008**
BCM (kg)	24.31 (±3.67)	34.47 (±8.45)	<**.001**	26.9 [24.0–34.2]	35.05 [31.2–42.6]	.099
BMR (kcal/day)	1,218 (±146)	1,591 ± (304)	<**.001**	1,333 [834–2449]	1,609 [1105–2111]	**.055**

Note. Normality testing was performed by using Microsoft Excel (Microsoft Office 365, 2019). Data shown are (mean ± SD) for normally distributed data, median [range] for non-parametric data, or (%) for percentages as convenient. Comparisons were carried out by independent *t*-test, Mann-Whitney *U* test or Chi-squared test with appropriate correction for multiple testing and small numbers with (IBM SPSS Statistics Version 27, 2021).
n = number of subjects; m = meter; kg = kilograms; BMI = body mass index; kg/m^2 = kilograms per meter squared; HGS = hand grip strength; SSM = skeletal muscle mass; FFM = fat-free mass; ASM = appendicular skeletal muscle mass; ECW/TBW = extracellular water/total body water ratio; BCM = body cell mass; RMR = resting metabolic rate; HD = hemodialysis; HDF = haemodiafiltration.
The bold *p*-values represent a statistical significance (*p* < .05).

Table 2. Comparison of Laboratory Values and Dialysis Treatment Between Participants Living With and Without Sarcopenia and Frailty.

	Laboratory values all n = 51	Sarcopenic n = 17 (33.3%)	Not sarcopenic n = 34 (66.7%)	p-Value	Vulnerable/Frail n = 37 (72.5%)	Not frail n = 14 (27.5%)	p-Value
Hb (g/L)	109 (±12.4)	112 (±12.57)	107.32 (±12.13)	.159	109 (±11.97)	107 (±13.81)	.511
Albumin (g/L)	39 [36–41]	40 [36.5–41]	38 (±5.6)	.446	39 [36–41]	39.5 [36.75–42.5]	.751
CRP (mg/L)	5 [2–19]	6 [3.5–20.5]	5 [1.75–16.25]	.202	8 [3–20.5]	2 [1.75–5]	**.022**
HbA1c (mmol/mol)	39 [34–51.75]	46 [35–54]	38 [34–50]	.327	39 [34.25–53.25]	40.9 [34–53]	.874
Phos (mmol/L)	1.8 (±0.5)	1.5 [1.3–1.7]	1.87 [1.7–2.2]	**.004**	1.7 (±0.46)	2.05 (±0.53)	**.026**
K (mmol/L)	4.9 (±0.96)	5.15 (±0.98)	4.86 (±0.96)	.872	4.97 (±0.86)	4.9 (±1.23)	.910
Na (mmol/L)	137 (±2.93)	137.12 (±2.55)	137.21 (±3.15)	.921	137 (±2.79)	137 (±3.4)	.877
Ca (mmol/L)	2.22 (±0.22)	2.25 [2.1–2.4]	2.21 [2.10–2.40]	.960	2.24 (±0.19)	2.17 (±0.29)	.342
Dialysis modality							
Months dialysis	36 [24–72]	48 [24–84]	36 [24–72]	.278	48 [24 – 78]	30 [20.4–72]	.244
HDF, n (%)	43 (84.3)	16 (94)	27 (79.5)	.173	34 (92)	9 (64)	**.016**
nPCR	1.69 [1.29–2.19]	1.56 [1.25–1.97]	1.83 [1.34–2.22]	.165	1.69 [1.32–2.20]	1.77 [1.26–2.14]	.752
URR (%)	70.48 (±8.96)	73.45 (±8.66)	69 (±8.86)	.095	71.98 (±8.64)	66.51 (±8.88)	.051

Note. Normality testing was performed by using Microsoft Excel (Microsoft Office 365, 2019). Data shown are (mean ± SD) for normally distributed data or median [range] for non-parametric data. Comparisons Were Carried out by independent *t*-test or Mann-Whitney *U* test as appropriate with (IBM SPSS Statistics Version 27, 2021).
nPCR = normalized protein catabolic rate; g/L = gram per liter; CRP = C-reactive protein; mg/L = milligram per liter; HbA1c = hemoglobin A1c; Phos = phosphorus; mmol/L = millimole per liter; K = potassium; Na = sodium; Ca = calcium; Hb = hemoglobin; URR = urea reduction ratio.
*p < .05 was considered significant. The bold *p*-values represent a statistical significance (*p* < .05).

Table 3. Comparison of Nutritional Intake Between Participants Living With and Without Sarcopenia and Frailty.

	Sarcopenic n = 17 (33.3%)	Not sarcopenic n = 34 (66.7%)	p-Value	Vulnerable/Frail n = 37 (72.5%)	Not frail n = 14 (27.5%)	p-Value
Energy (kcal)	1,146 [890–1,632]	1,300 [942–1,676]	.536	1,182 [901–1677]	1,389 [1,051–1,641]	.535
Carbohydrate (g)	127 [86–186]	145.5 [118–185]	.905	136.4 107 - 185]	154.5 [118–189]	.399
Protein (g)	48.6 [33–65]	58.8 [37–81]	.358	49.6 [34–78]	59 [37–69]	.752
Energy (kcal/kg)	19.2 [13.2–26.8]	15.2 [11.5–23.9]	.181	15.5 [12–24.4]	18.8 [12.6–26.3]	.627
Protein (g/kg)	0.68 [0.53–1.15]	0.68 [0.44–0.99]	.413	0.67 [0.48–0.99]	0.83 [0.42–1.03]	.866
Fat (g)	49.4 [35–80]	52.2 [33–69]	.497	47.5 [33–74]	55.3 [41–70]	.736
Fluid (ml)	1,033 (±337)	1,128 (±469)	.461	1,052 (±388)	1,212 (±516)	.238
Fluid from drinks (ml)	529 [376–843]	615 [370–614]	.960	586 (±253)	797 (±523)	.263
Fiber (g)	12.3 [8.6–15.5]	10.8 [8.1–14.2]	.749	10.7 [8.6–13.9]	12 [8.1–15.3]	.598
Sugars (g)	41.6 [24.6–53.1]	39 [27.7–59.8]	.826	41.6 [28.3–58.9]	37.9 [25.4–55.8]	.642
Free sugars (g)	16.4 [8.1–24.1]	14.92 [4.9–23.7]	.632	15.3 [6.4–24.3]	17.8 [4.8–25]	.736
Saturated fat (g)	15.45 [9.6–24.1]	17.33 [11.2–24.4]	.603	15.4 [10.5–24.0]	19.7 [14.0–28.5]	.342
MUFA (g)	14.75 [5.8–22.9]	11.8 [7.9–16.9]	.448	12 [7–17]	15.2 [9–21]	.399
PUFA (g)	5.4 [1.7–14.3]	4.25 [2.9–6.7]	.549	4.4 [2.8–8.2]	5.3 [3.1–9.2]	.473
Omega3 (n-3) (g)	0.18 [0.10–1.10]	0.24 [0.16–0.50]	.889	0.17 [0.11–0.44]	0.35 [0.24–0.95]	**.015**
Trans-fatty acids (g)	0.51 (±0.44)	0.56 (±0.3)	.296	0.53 (±0.34)	0.57 (±0.39)	.711
Sodium (mg)	1,474 [876–1855]	1,334 [1010–1880]	.704	1,506 (±846)	1,658 (±689)	.552
Potassium (mg)	1,334 [1027–1638]	1,297 [891–1583]	.590	1,403 (±596)	1,311 (±488)	.612
Chloride (mg)	2,156 [1546–2831]	2,162 [1577–2946]	.920	2,143 [1422–2947]	2,339 [1749–2810]	.423
Calcium (mg)	545 (±235)	497 (±187)	.433	512 (±202)	514.4 (±215)	.979
Phosphorus (mg)	638 [480–838]	653 [503–827]	.764	636 [480–823]	690 [532–849]	.673
Magnesium (mg)	142 [102–172]	123.2 [102–169]	.646	120 [102–165]	153.6 [99–172]	.555
Iron (mg)	5.5 [4.9–9.1]	5.4 [3.9–8.1]	.472	5.2 [4.5–8.2]	5.5 [4.6–8.1]	.899
Zinc (mg)	4.7 [3.2–7.2]	5.05 [3.7–7.4]	.811	5.6 (±2.95)	4.9 (±2.13)	.372
Selenium (µg)	25.4 [15.7–34.3]	24.4 [18.5–39.9]	.448	24.5 [16.5–39.2]	24.4 [19.3–36.5]	.883
Vitamin A (µg)	305 [232–487]	396 [242–552]	.523	401 [237–516]	291 [112–581]	.473
Vitamin D (µg)	1.16 (±1.15)	2.18 (±1.81)	**.039**	1.74 [0.36–3.41]	1.05 [0.14–2.07]	.311
Vitamin E (mg)	7.19 (±5.76)	5.72 (±3.80)	.280	6.5 (±4.9)	5.2 (±3.3)	.372
Vitamin K (µg)	7.68 [2.6–18.0]	7.75 [2.5–25.4]	.905	9.3 [3.1–23.5]	5 [2.0–31.6]	.342
Folates (µg)	131 [104–146]	133 [97–201]	.576	131 [100–188]	141 [77–180]	.704
Vitamin C (mg)	50.67 [14.5–75]	50.89 [21.4–85.9]	.308	52.6 [19.9–79.7]	46.8 [17.0–71.5]	.720

Note. Normality testing was performed by using Microsoft Excel (Microsoft Office 365, 2019). Data shown are (mean ± SD) for normally distributed data or median [range] for non-parametric data. Comparisons were carried out by independent *t*-test or Mann-Whitney *U* test as appropriate with (IBM SPSS Statistics Version 27, 2021).
Kcal = kilo calorie; g = gram; ml = milliliter; mg = milligram; µg = microgram; MUFA = monounsaturated fatty acid; PUFA = polyunsaturated fatty acid.
The bold *p*-values represent a statistical significance (*p* < .05).

sedentary, compared to 37.5% in the non-sarcopenic group (χ^2 3.5, *p* = .06), and took no exercise (82.4% vs. 44.1%, χ^2 3.5, *p* = .06), and only 11.8% took part in moderate or active exercise (χ^2 4.6, *p* = .03).

The majority of patients were frail, although not statistically greater than those with sarcopenia (χ^2 3.7, *p* = .056). As with sarcopenia, patients classified as vulnerable or suffering from frailty were older, and more were female, with lower weight and ALMI, and serum phosphate gender, but with a higher C reactive protein (CRP), and proportionately more treated by HDF (Tables 1 and 2). Less than half the frail patients (40.5% vs. non-frail 21.4%) were classified as sedentary, and 67.6% took no exercise (vs. non-frail 57.1%, χ^2 1.6, *p* = .2). Only a minority of frail (5.4%) and non-frail (35.7%) patients performed any moderate or active exercise (χ^2 0.17, *p* = .68).

Dietary Intake

We compared dietary intake between patients with and without sarcopenia (Table 3). We found no significant

differences in energy or protein intake, either as absolute values, or adjusted for body weight. Similarly there were no differences in dietary electrolyte, trace elements and vitamin intake, apart from Vitamin D. Likewise there were no differences in protein and calorie consumption between frail and non-frail patients (Table 3). Comparing electrolytes, trace elements and vitamins, then only the absolute amount of omega 3 fatty acids was lower in those with frailty.

KDOQI published a series of dietary recommendations for dialysis patients, so we compared dietary intakes with these recommendations. We found that there was no significant difference between groups with or without sarcopenia or frailty and achieving these KDOQI targets (>25 kcal/kg/day of calorie and >1.0 g/kg/day of protein). Regardless, on average 75% of our study population failed to achieve the calorie and protein targets recommended (failing to achieve protein target: sarcopenic 70.5%, non-sarcopenic 76.5%, frail 75.6%, non-frail 71.4%) and calorie targets: sarcopenic 70.5%, non-sarcopenic 76.5%, frail 75.6%, non-frail 71.4%, respectively).

Table 4. Multivariate Analysis of Risk Factors for Sarcopenia and Frailty in the Study Population.

Variables	Risk factors for sarcopenia				Risk factors for frailty			
	β	OR	95% CI	*p*-Value	β	OR	95% CI	*p*-Value
Gender (Female)	−0.660	0.517	0.087, 3.079	.469	2.878	17.787	2.087–151.594	**.008**
Age (years)	.090	1.094	1.016, 1.178	**.017**	.118	1.126	1.035–1.224	**.006**
BMI (kg/m²)	−0.174	0.840	0.711, 0.993	**.042**	.009	1.010	0.927–1.099	.827
No exercise	2.031	7.624	1.156, 50.288	**.035**	−0.133	0.875	0.150–5.104	.882
Dialysis length (years)	−0.212	0.809	0.541, 1.210	.302	.436	1.547	1.059–2.259	**.024**

Note. The multivariate analysis was done by binary logistic regression analysis with (IBM SPSS Statistics Version 27, 2021).
OR = odds ratio; CI = confidence interval; BMI = body mass index; kg/m² = kilograms per meter squared.
The bold *p*-values represent a statistical significance ($p < .05$).

Basal Metabolic Rate and Actual Energy Intake. As most of our patients took no exercise and were sedentary, we compared their basal energy requirements and daily dietary calorie intake. We found no significant correlation between BMR and 48-hr averaged calorie consumption ($r = −.07$, $p = .91$). On Bland Altman analysis BMR using the Harris Benedict equation over estimated average daily calorie intake by 102.6 kcal, with 95% limits of agreement from −1,416 to 1,212 kcal.

Risk Factors Associated With Sarcopenia and Frailty. Multivariate step-backward logistic models were generated to determine which factors were independently associated with sarcopenia and frailty. Sarcopenia was associated with older age, lower BMI, and taking no exercise (Table 4). Whereas frailty was associated with increasing age, along with female gender, and longer dialysis vintage (Table 4).

Dialysis Duration and Fall in Intake. When we tested the correlation between dialysis vintage and nutrient intake, we found that longer dialysis vintage is associated with lower protein, calorie, and phosphate consumptions ($r = −.450$, $p = .001$), ($r = −.375$, $p = .007$), and ($r = −.387$, $p = .005$). Where no significant correlations were found between (Phosphate levels vs. dialysis vintage) and (Phosphate levels vs. phosphate intake).

Discussion

Frailty and sarcopenia are established risk factors for HD patients, both for mortality and hospitalization [6,9]. Previous reports have highlighted that both patients with sarcopenia and frailty have inadequate dietary energy and protein intake (Sabatino et al., 2021), and randomized controlled trials appear to suggest a critical role for dietary protein intake in preventing sarcopenia and muscle loss (Ganapathy & Nieves, 2020). However, we found that there was no difference in self-reported 48-hour dietary intake between those patients with and without sarcopenia, and also those with and without frailty. Only serum phosphate was lower in both patients with sarcopenic and frailty, whereas serum albumin did not differ, in keeping with an earlier report (Umakanthan

et al., 2021). However, around 75% of all our patients, with and without sarcopenia and with or without frailty failed to achieve the KDOQI recommended daily protein or calorie intake (Ikizler et al., 2020). Taste is reduced in patients with advanced CKD, and as HD patients are advised to restrict dietary sodium intake, along with phosphate, which is now a common ingredient in sauces and seasonings, used in processed foods, these limitations may reduce overall dietary intake (Noce et al., 2021).

In keeping with the consensus definitions of sarcopenia we found that sarcopenic patients had reduced ALMI and muscle strength (Chen et al., 2020; Cruz-Jentoft et al., 2019). Although no patient had an active cancer, we noted that sarcopenic patients were more likely to have a previous history of cancer, in keeping with previous reports of the effects of cancers (Bossi et al., 2021). Earlier studies noted differences in body composition between White Europeans and Asian dialysis patients (Davenport et al., 2011), but even allowing for the differences between EWSGOP and AWGS definitions of sarcopenia (Chen et al., 2020; Cruz-Jentoft et al., 2019), more Asian patients had sarcopenia, which is in keeping with earlier reports (Yoowannakul et al., 2018). Although dialysis treatment with hemodiafiltration has been reported to improve nutritional status, in terms of body composition, compared to standard hemodialysis, most of our patients with sarcopenia had been treated with hemodiafiltration (Molina et al., 2018). More patients with sarcopenia took no exercise and were rated as having a sedentary lifestyle, and several studies have reported that dialysis patients have lower active energy expenditure (Hendra et al., 2022). Although some studies have reported that nutritional supplements can prevent or reverse sarcopenia (Davenport, 2013; Ganapathy & Nieves, 2020), this has not been universal, with other studies showing no benefit from improved nutrition alone, or reversal only when an exercise program was additional to nutritional support (Ganapathy & Nieves, 2020; Isaka, 2021).

The majority of our patients were classified as vulnerable or suffering from frailty. As frailty was most closely associated with age, this is in keeping with the changing demographics of the hemodialysis population, with

increasing numbers of elderly patients with CKD and additional co-morbidities now being offered dialysis treatment. Relatively more female patients were classified as frail, and these differences in the prevalence of frailty are thought likely due to a combined effect of biological, psychosocial and behavioral differences between women and men (Park & Ko, 2021). Frail patients were also more likely to have been treated for longer by dialysis, and as bone loss has been reported to increase with the duration of dialysis treatment, then this may be a risk factor for increasing frailty (Yoneki et al., 2019). Although previous studies have reported poor nutritional intake as a risk factor for frailty (Ligthart-Melis et al., 2020), we found no difference in daily protein or energy intake, or for micronutrients, apart from omega-3 fatty acids, although as with sarcopenia the lower serum phosphate levels would suggest reduced dietary intake.

Although we found no reduction in dietary intake of protein or calories in those patients with sarcopenia and frailty, we noted that longer dialysis vintage was associated with lower calorie, protein and phosphate consumption. This could be due to suppressed appetite consequent on the accumulation of uremic toxins and loss of urinary output overtime, as dialysis treatments do not clear all uremic toxins (Borek et al., 2017). In addition, we found that serum phosphate levels were not strongly associated with dietary phosphate intake, which may reflect that certain foodstuffs naturally bind dietary phosphate and the prescription of phosphate binders (Coladonato, 2005).

Strength and Limitations

We approached 97 dialysis patients, but only 54 (55.7%) completed their 48-hr dietary diaries. As we found that patients found that accurately recording their dietary intake was burdensome, and this highlights some of the inherent difficulties in performing studies in an elderly multi-ethnic dialysis population, with increasing numbers of patients affected by declining cognitive function, increasing physical incapacity and dependency, along with language barriers (Iyasere et al., 2019). Although the study population was limited, we present very granular data, due to the time spent educating patients on portion sizes and completing dietary diaries, and then directly exporting data into the Nutrics software program. As with any cross-sectional study we can only report associations and not causality, as longitudinal studies are required to determine whether protein and calorie intake below the KDOQI targets leads to progressive changes in body composition, or whether in an elderly sedentary population body composition is maintained.

Conclusion

We performed a cross-sectional audit to compare nutritional intake with the KDOQI recommendations for dialysis patients (Ikizler et al., 2020). Although most of our patients failed to achieve KDOQI targets, we do not have longitudinal body composition data to determine whether failure to achieve these targets led to loss of body fat or lean tissue, or equally whether patients were eating enough protein and calories to maintain body tissue stores. However, there were no differences in the prevalence of either frailty or sarcopenia as to whether patients achieved or did not achieve KDOQI targets.

Although previous reports highlighted poor nutritional intake as a risk factor for both sarcopenia and frailty, we found no difference in protein or calorie intake between those with and without sarcopenia or frailty. Similarly, there were no differences in the intake of most fats, sugars, minerals, or micronutrients, although serum phosphate levels were lower. Our study only identified a decreased intake of vitamin D and omega-3 in patients with sarcopenia and frailty, respectively. In addition, we noted that dietary intake was lower in those patients who had been treated by dialysis for a longer time. However, most patients failed to achieve the KDOQI daily recommended protein and calorie targets. As such, we would recommend providing oral nutritional supplements for those showing signs of poor intake and declining nutritional status. In addition to nutritional support, as physical inactivity was prevalent in both groups, we would also recommend motivational exercise approaches.

Key Messages

(1) Hemodialysis patients with sarcopenia and frailty did not have lower dietary protein and calorie intake.
(2) Three-quarters of our patients did not achieve the dietary protein or calorie targets recommended by KDOQI.
(3) The majority of our patients were classified as leading a sedentary life-style, and did not take part in any physical exercise or activity program.
(4) In our study patients classified as frail were more likely to be older, female and have been treated by hemodialysis for longer, whereas although patients classified as having sarcopenic were also more likely to be older, sarcopenia was associated with lower BMI and taking no exercise.
(5) Nutritional intake was lower in patients who had been treated by hemodialysis for longer.

Author Contribution

HS collected and analyzed data and wrote 1st draft. AD obtained institutional approvals and edited manuscript. Both authors approved final version.

Ethical Approval

Our comparative audit of nutritional intake was checked with and complied with the UK National Health Service Health Research Authority guidelines for clinical audit and service development (https://www.hra.nhs.ukhttps://researchsupport. admin.ox.ac.uk/sites/default/files/researchsupport/documents/ media/defining-research.pdf) and registered with the Hospital. All patient data was appropriately anonymized.

ORCID iD

Andrew Davenport [iD] https://orcid.org/0000-0002-4467 -6833

Data Availability

Data is retained and may be available on reasonable request with all identifiers removed in keeping with current UK NHS guidelines.

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