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# Nutritional deficiencies in hemodialysis patients with sarcopenia and frailty: A comparative analysis

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## ABSTRACT

Chronic kidney disease (CKD) is associated with significant metabolic alterations, leading to muscle wasting, frailty, and nutritional deficiencies. Hemodialysis patients are particularly vulnerable to malnutrition due to increased catabolism, dietary restrictions, and systemic inflammation. Sarcopenia, characterized by the loss of muscle mass and function, and frailty, a condition of increased vulnerability to adverse health outcomes, are prevalent in this population and contribute to higher morbidity and mortality. This review explores the nutritional deficiencies commonly observed in haemodialysis patients with sarcopenia and frailty, comparing their dietary intake, biochemical markers, and clinical outcomes. The impact of protein-energy wasting, micronutrient deficiencies, and dietary interventions on muscle health and functional status is examined. Understanding the nutritional challenges in this population is essential for developing targeted dietary and therapeutic strategies to improve patient outcomes and quality of life.

## KEYWORDS

Hemodialysis; Chronic kidney disease; Sarcopenia; Frailty; Nutritional deficiencies; Protein-Energy wasting; Micronutrient deficiencies

## ARTICLE HISTORY

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## Introduction

Haemodialysis is the most common renal replacement therapy for patients with end-stage renal disease (ESRD), providing life-sustaining filtration of metabolic waste and excess fluids. Despite its benefits, patients undergoing haemodialysis often face a decline in overall health due to complications such as protein-energy wasting (PEW), micronutrient deficiencies, and progressive muscle loss. Sarcopenia and frailty are highly prevalent in this population, resulting in decreased physical function, poor quality of life, and an increased risk of hospitalization and mortality. Sarcopenia is characterized by a progressive loss of skeletal muscle mass and strength, while frailty encompasses a broader range of physiological decline, including weakness, fatigue, and reduced resilience to stressors. Multiple factors, such as chronic inflammation, oxidative stress, uremic toxicity, and inadequate nutrient intake, influence both conditions [1]. Understanding the nutritional aspects of sarcopenia and frailty in haemodialysis patients is essential for developing effective dietary and clinical interventions to enhance patient health longevity.

## Overview of Nutritional Deficiencies in Haemodialysis Patients

Haemodialysis patients frequently face considerable nutritional challenges stemming from metabolic disturbances, dietary restrictions, and enhanced protein breakdown. Malnutrition within this group is multifaceted, with insufficient dietary intake, inflammation, hormonal imbalances, and nutrient losses related to dialysis all contributing to a high incidence of nutritional deficiencies.

## Protein-Energy Wasting (PEW) in haemodialysis patients

Protein-energy wasting is a common complication in haemodialysis patients, characterized by decreased protein and energy intake, increased muscle protein breakdown, and metabolic imbalances [2]. The catabolic nature of dialysis, coupled with dietary restrictions, worsens muscle wasting and energy deficits. Understanding the mechanisms of PEW, including hormonal changes, systemic inflammation, and decreased appetite, is vital for developing targeted nutritional interventions.

## Micronutrient deficiencies and their impact on muscle health

Haemodialysis patients frequently experience deficiencies in essential vitamins and minerals, such as vitamin D, B-complex vitamins, iron, and antioxidants. Vitamin D deficiency, due to impaired renal activation, leads to muscle weakness and increased fracture risk. B-complex vitamins, particularly vitamin B12 and folate, play crucial roles in energy metabolism and neurological function [3]. Low antioxidant levels contribute to oxidative stress, accelerating muscle degradation. Addressing these deficiencies through dietary modifications and supplementation is crucial for improving muscle function and overall health.

## Electrolyte imbalances and neuromuscular function

Maintaining electrolyte balance is a challenge in haemodialysis patients, as fluctuations in potassium, magnesium, and phosphorus levels can have profound effects on muscle function and cardiovascular health. Hyperkalaemia and hypokalaemia can lead to muscle weakness and arrhythmias, while phosphorus imbalances contribute to bone demineralization and cardiovascular complications [4]. Managing electrolyte levels through dietary strategies while ensuring adequate nutrient intake is a key aspect of patient care.

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## Inflammation and oxidative stress as drivers of sarcopenia and frailty

Chronic inflammation is a major contributor to muscle loss in haemodialysis patients, as inflammatory cytokines promote protein breakdown and inhibit muscle synthesis. Oxidative stress, resulting from an imbalance between free radicals and antioxidants, further exacerbates muscle degradation and aging-related decline. Strategies to reduce inflammation and oxidative damage, such as antioxidant-rich diets and anti-inflammatory therapies, are crucial for preserving muscle mass and preventing frailty.

## Dietary intake differences between frail and non-frail haemodialysis patients

Frail haemodialysis patients tend to have lower protein and caloric intake compared to their non-frail counterparts. Factors such as anorexia, gastrointestinal symptoms, depression, and altered taste perception contribute to reduced food consumption, worsening malnutrition [5]. Identifying dietary patterns and developing tailored nutritional interventions can help bridge the gap between dietary intake and nutritional requirements.

## The role of dietary interventions in managing sarcopenia and frailty

Optimizing nutrition through individualized dietary counselling and supplementation plays a critical role in mitigating sarcopenia and frailty. High-protein diets, essential amino acid supplementation, and omega-3 fatty acids have shown promise in preserving muscle mass and improving physical function. Nutritional interventions should be personalized based on patient-specific needs and biochemical markers [6].

## Exercise and physical activity as adjuncts to nutritional strategies

While dietary interventions are essential, incorporating resistance training and physical activity can enhance muscle strength and functional outcomes in haemodialysis patients. Exercise programs tailored to the patient's physical condition can complement nutritional strategies, helping to counteract muscle loss and improve overall health.

## Comparative Analysis of Nutritional Intake in Sarcopenic and Frail Haemodialysis Patients

Sarcopenic and frail haemodialysis patients exhibit distinct nutritional deficiencies compared to those without these conditions. Studies indicate that protein and energy intake is significantly lower in frail and sarcopenic patients, contributing to a more rapid decline in muscle mass and strength. These patients often have reduced appetite and altered taste perception, which can lead to insufficient dietary intake. Chronic inflammation further exacerbates this issue by promoting catabolic pathways and suppressing protein synthesis [7].

Protein intake is a key determinant of muscle preservation in haemodialysis patients, yet many fails to meet the recommended daily protein intake of 1.2-1.4 g/kg of body weight. Sarcopenic patients, in particular, tend to have lower protein consumption, leading to a greater decline in muscle mass and functional impairment. Adequate protein intake is essential for preventing muscle wasting, and its deficiency has been strongly correlated with increased mortality risk in haemodialysis patients.

Energy intake is another critical factor in preventing malnutrition and maintaining muscle mass. Frail haemodialysis patients often experience reduced energy intake due to anorexia, gastrointestinal symptoms, and depression. Studies suggest that a daily caloric intake of at least 30-35 kcal/kg is necessary to maintain energy balance and prevent progressive weight loss. However, many patients fail to meet this target, resulting in energy deficits that contribute to muscle loss and increased frailty risk.

Micronutrient intake also differs between sarcopenic, frail, and non-frail haemodialysis patients. Vitamin D levels tend to be lower in sarcopenic patients, potentially exacerbating muscle weakness and functional decline. B-complex vitamins, particularly vitamin B12 and folate, are essential for red blood cell production and neurological function [8]. Deficiencies in these vitamins are more common in frail patients, leading to anaemia, cognitive decline, and increased fatigue. Antioxidant deficiencies, including low levels of vitamin C and E, have been associated with higher oxidative stress and muscle degradation in sarcopenic patients.

Dietary phosphorus and potassium intake are carefully regulated in haemodialysis patients to prevent hyperphosphatemia and hyperkalaemia. However, this restriction often leads to inadequate intake of nutrient-rich foods, further contributing to deficiencies in essential vitamins and minerals. The challenge lies in achieving a balance between meeting nutritional requirements while avoiding complications associated with electrolyte imbalances.

## Role of Dietary Interventions in Managing Nutritional Deficiencies

Optimizing dietary intake is crucial for preventing and managing sarcopenia and frailty in haemodialysis patients. Nutritional counselling and individualized dietary plans can help ensure that patients meet their protein and energy requirements. High-quality protein sources such as eggs, fish, poultry, and plant-based proteins should be prioritized to enhance muscle protein synthesis while maintaining renal safety. In cases where dietary intake is insufficient, oral nutritional supplements containing essential amino acids, omega-3 fatty acids, and micronutrients may be recommended to improve nutritional status [9].

Vitamin D supplementation is widely recommended for haemodialysis patients to improve muscle function and bone health. Correcting deficiencies in iron, vitamin B12, and folate is also essential for managing anaemia and reducing fatigue. Antioxidant-rich diets, including foods high in vitamins C and E, may help mitigate oxidative stress and muscle degeneration. Additionally, ensuring adequate electrolyte balance through dietary modifications can enhance muscle function and reduce complications associated with deficiencies.

Protein-energy wasting is a significant concern in haemodialysis patients, and strategies to increase protein intake



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should be individualized [10]. Intradialytic parenteral nutrition (IDPN) may be considered for patients with severe malnutrition who cannot meet their nutritional needs through oral intake. Physical exercise interventions combined with dietary modifications have shown promise in improving muscle strength and physical performance in frail and sarcopenic patients.

## Conclusions

Nutritional deficiencies in haemodialysis patients with sarcopenia and frailty present a complex challenge that requires a multifaceted approach. Protein-energy wasting, micronutrient deficiencies, and electrolyte imbalances contribute to the progression of muscle loss and functional decline, significantly impacting patient outcomes. Comparative analysis suggests that sarcopenic and frail patients have lower dietary intake and higher nutritional deficiencies than their non-frail counterparts. Addressing these deficiencies through dietary interventions, supplementation, and tailored nutritional strategies is essential for improving muscle health, reducing frailty risk, and enhancing overall quality of life in haemodialysis patients. Further research is needed to refine dietary recommendations and develop effective interventions tailored to the unique needs of this population.

## Disclosure statement

No potential conflict of interest was reported by the author.

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