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THE RELATIONSHIP BETWEEN CHRONIC KIDNEY DISEASE AND SARCOPENIA: A SYSTEMATIC REVIEW

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ABSTRACT
Chronic kidney disease (CKD) is a growing global health problem and is associated with multiple systemic complications. One important but often underrecognized complication is sarcopenia, characterized by progressive loss of muscle mass, strength, and physical performance. Sarcopenia is highly prevalent in patients with advanced CKD and those undergoing hemodialysis and is associated with poor clinical outcomes, including increased hospitalization, functional decline, and mortality. This literature review aimed to synthesize recent evidence on the relationship between CKD and sarcopenia, including prevalence, contributing factors, pathophysiological mechanisms, and clinical implications. This review followed the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines. Literature searches were conducted in PubMed, ScienceDirect, Google Scholar, and Semantic Scholar for English-language articles published between 2020 and 2025. Study selection was guided by the PICOS framework. Methodological quality was assessed using the Joanna Briggs Institute (JBI) Critical Appraisal Checklist. A total of 15 studies meeting the inclusion criteria were included in the final synthesis. The included studies reported a high prevalence of sarcopenia among CKD patients, ranging from 15.9% to 64.1%, with higher rates observed in advanced CKD stages and hemodialysis populations. Sarcopenia was consistently associated with older age, malnutrition, protein–energy wasting, chronic inflammation, reduced physical activity, and metabolic disturbances. Clinically, sarcopenia was linked to increased mortality, hospitalization, reduced physical function, and poorer quality of life. Sarcopenia is a prevalent and clinically significant complication of CKD. Early detection and integrated interventions combining nutritional optimization, resistance exercise, and metabolic management are essential to improve patient outcomes. Further longitudinal studies are needed to strengthen preventive and therapeutic strategies.

Keywords: chronic inflammation; chronic kidney disease; hemodialysis; muscle mass; physical function; sarcopenia

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INTRODUCTION
Chronic kidney disease (CKD) is a major global health problem with a prevalence that continues to increase worldwide. This condition is characterized by a progressive and irreversible decline in kidney function lasting more than three months. According to reports from international health organizations, CKD is currently among the top ten leading causes of death globally. In Indonesia, the prevalence of CKD has also increased in recent years based on national health surveys, placing an additional burden on the healthcare system and negatively affecting population quality of life. CKD not only impairs renal filtration and excretory functions but also triggers a wide range of systemic complications, including metabolic, cardiovascular, hematological, and musculoskeletal disorders. One important complication that is often underrecognized yet has a substantial impact on patient outcomes is sarcopenia (Jiang et al., 2025).

Sarcopenia is a syndrome characterized by progressive loss of skeletal muscle mass, muscle strength, and physical performance. Although initially associated with aging, recent studies indicate that sarcopenia can develop earlier and more severely in individuals with chronic diseases, including CKD. In CKD patients, sarcopenia arises not only from degenerative processes but also from complex pathophysiological interactions involving chronic low-grade inflammation, hormonal disturbances, nutritional imbalance, oxidative stress, and reduced physical activity. Patients with CKD, particularly those undergoing hemodialysis, frequently experience muscle weakness, fatigue, and progressive functional decline (Rakhima et al., 2025).

The close relationship between CKD and sarcopenia can be explained by the concept of protein energy wasting (PEW), a condition characterized by malnutrition and loss of lean body mass commonly observed in CKD patients. PEW results from decreased appetite, dietary restrictions, increased catabolic activity, and impaired protein synthesis. Chronic inflammation further accelerates muscle protein degradation through activation of the ubiquitin–proteasome pathway. In addition, metabolic acidosis a common condition in CKD promotes muscle protein breakdown and inhibits muscle regeneration, while the accumulation of uremic toxins disrupts muscle cell function and repair processes. Consequently, CKD patients are at a significantly higher risk of muscle mass and strength loss compared with age-matched healthy individuals (Ben Othman et al., 2025).

Beyond physiological mechanisms, clinical and lifestyle factors also contribute to the development of sarcopenia in CKD. Low levels of physical activity are common due to fatigue, dyspnea, and physical limitations, while dietary restrictions related to protein and fluid intake may compromise adequate nutritional support for muscle health. Psychosocial factors, including depression and sleep disturbances, further exacerbate the risk of sarcopenia. As such, a holistic approach is required to fully understand the complex interplay between CKD and sarcopenia.

The impact of sarcopenia in CKD patients is substantial. Declines in muscle strength and physical performance reduce independence in daily activities and increase the risk of falls, recurrent hospitalization, and mortality. Several studies have demonstrated that CKD patients with sarcopenia have a poorer prognosis than those without sarcopenia, and muscle deterioration may also compromise treatment outcomes, including the effectiveness of hemodialysis. Therefore, sarcopenia represents a critical clinical issue in the comprehensive management of CKD.

Given the high prevalence and serious consequences of sarcopenia in CKD, a deeper understanding of their relationship is essential. Early detection of sarcopenia in CKD patients may enable timely and effective interventions, such as nutritional optimization, structured exercise programs, and improved management of comorbid conditions. Although numerous studies have explored the biological mechanisms and clinical implications of sarcopenia in CKD, a comprehensive synthesis of recent findings remains necessary. Accordingly, this literature review aims to provide an integrated understanding of the relationship between CKD and sarcopenia, the contributing factors, and the clinical implications for healthcare practice.

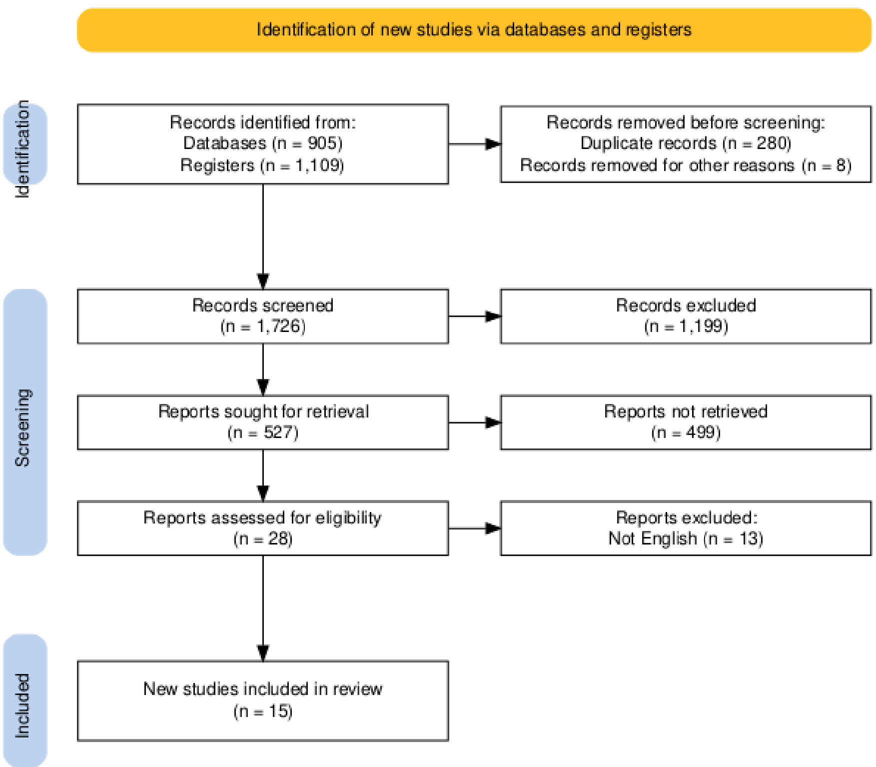
METHOD

This literature review was conducted in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines. A research protocol was developed prior to the literature search to ensure transparency and methodological consistency throughout the review process, although the protocol was not registered in PROSPERO due to the small-scale nature of the study. A comprehensive literature search was performed across several international scientific databases, including PubMed, ScienceDirect, Google Scholar, and Semantic Scholar. The search strategy employed combinations of relevant keywords using Boolean operators (AND, OR) to refine and optimize retrieval, including *"Chronic Kidney Disease," "CKD," "Sarcopenia," "Muscle mass," "Dialysis,"* and *"Protein-energy wasting."* An example of the search formula used was *("Chronic Kidney Disease" AND "Sarcopenia") OR ("CKD" AND "Muscle Loss").* A total of 15 studies meeting the inclusion criteria were included in the final synthesis. Study selection was guided by predefined inclusion and exclusion criteria based on the PICOS framework, and all stages of article identification, screening, data extraction, and quality appraisal were conducted systematically following standardized literature review principles.

Tabel 1.
Format PICOS

Komponen	Kriteria
P (Population)	Pasien dewasa dengan penyakit ginjal kronis (stadium 3–5) atau pasien yang menjalani hemodialisis.
I (Intervention/Exposure)	Kondisi terkait inflamasi, malnutrisi, PEW, aktivitas fisik rendah, atau faktor lain yang memengaruhi sarkopenia.
C (Comparison)	Pasien CKD tanpa sarkopenia atau populasi kontrol sehat bila tersedia.
O (Outcome)	Massa otot, kekuatan otot, performa fisik, prevalensi sarkopenia, faktor risiko.
S (Study design)	Artikel penelitian asli (cross-sectional, cohort, case-control), systematic review, atau meta-analisis.

The inclusion criteria for this literature review were articles published in English between 2020 and 2025, availability of full-text manuscripts, and studies that analyzed the relationship between chronic kidney disease (CKD) and sarcopenia. Exclusion criteria included animal or laboratory-based studies and articles for which the full-text version was not accessible. Study selection and quality assessment were conducted systematically following the PRISMA framework. Literature searches were performed using ScienceDirect and the Publish or Perish application across three databases: Google Scholar, PubMed, and Semantic Scholar. The search strategy incorporated combinations of keywords including *Chronic Kidney Disease*, *CKD*, *Sarcopenia*, *Muscle mass*, *Dialysis*, and *Protein–energy wasting*. The initial search yielded 1,109 records from ScienceDirect, 322 from Google Scholar, 72 from Semantic Scholar, and 511 from PubMed. All retrieved records were imported into Mendeley and Rayyan AI to identify and remove duplicate articles. This process identified 489 duplicate records, and 8 additional records were excluded due to missing titles, resulting in the removal of 288 duplicated articles. Subsequently, 1,726 articles underwent title and abstract screening, during which 1,199 articles were excluded based on the predefined criteria. A total of 527 articles were assessed for full-text eligibility, of which 28 met the inclusion criteria. Thirteen articles were further excluded due to non-English language, resulting in 15 studies included in the final review. The entire study selection process was conducted through four sequential stages in accordance with the PRISMA flow diagram.



Gambar 1. Prisma Flow Diagram

The analysis process was conducted to assess the methodological quality of the included studies using the JBI Critical Appraisal Checklist as the evaluation instrument. Each appraisal item was rated as "yes," "no," "unclear," or "not applicable." A score of 1 was assigned to each "yes" response, while all other responses received a score of 0. The scores for all items in each study were summed to obtain a total quality score. Studies that achieved at least 50% of the maximum possible score, based on a predetermined threshold agreed upon by the researchers, were classified as meeting the inclusion criteria. Studies of low methodological quality were excluded to minimize potential bias and ensure the validity of the review findings. At the final stage of quality screening, 15 studies achieved a score of ≥50% and were deemed eligible for synthesis. Overall, quality appraisal was performed on 15 studies that formed the basis of this literature review.

RESULT

The study selection process yielded 15 articles that met the inclusion criteria and were assessed as having adequate methodological quality based on the JBI appraisal instrument. These studies comprised cross-sectional and prospective cohort designs investigating the prevalence, risk factors, pathophysiological mechanisms, and intervention effects (nutritional or exercise-based) related to sarcopenia in patients with chronic kidney disease (CKD), including both pre-dialysis patients and those undergoing hemodialysis. Overall, the main findings of the included studies can be categorized into several key aspects: the prevalence of sarcopenia in CKD, contributing pathogenic factors, clinical correlations with health outcomes (such as mortality, hospitalization, and quality of life), and the effects of nutritional and exercise interventions.

Most studies reported a high prevalence of sarcopenia among CKD populations, with prevalence rates varying depending on the definition of sarcopenia used, measurement methods (DXA, BIA, handgrip strength), and disease stage. The majority of studies demonstrated a higher prevalence in patients with advanced-stage CKD and in those receiving hemodialysis. Beyond prevalence, the studies consistently showed that sarcopenia was associated with adverse clinical outcomes, including increased mortality, higher hospitalization rates, reduced physical function, and an elevated risk of falls. The following section presents a summary of the characteristics and main findings of the 15 selected studies.

Tabel 2.
Ringkasan 15 Studi Terpilih mengenai CKD dan Sarkopenia

No	Judul, Penulis, Tahun	DSVIA	Hasil/Temuan
1	Kakita D. et al.,2022— *Simplified discriminant parameters for sarcopenia among patients undergoing haemodialysis*	D: Cross-sectional. S: 356 pasien HD. V: MCI, calf circ., SARC-F, SARC-CalF → sarcopenia AWGS2. I: Kreatinin serum, calf, SARC-F. A: ROC, logistic regression.	Prevalensi 39.9%. MCI AUC 0.77. Calf circ terbaik. MCI signifikan.
2	Zhao et al., 2024 — *Prevalence and risk factors of sarcopenia in maintenance hemodialysis*	D: Retrospective. S: 165 pasien HD. V: BMI, waist, HGS, BIA muscle. I: BIA, HGS. A: Logistic regression.	Prevalensi 21.82%. Faktor: aktivitas rendah, BMI rendah, fosfat rendah.
3	Yang et al., 2024 — *Prevalence and severity of sarcopenia in MHD*	D: Cross-sectional. S: 220 pasien HD. V: Aktivitas fisik, BMI, fosfat. I: BIA, HGS. A: Logistic regression.	Prevalensi probable + confirmed sarcopenia 64.1%. Faktor yang meurunkan risiko sarcopenia: aktivitas fisik tinggi, BMI tinggi, kadar fosfat tinggi.
4	Li et al., 2025 — *Stage-specific prevalence and progression of sarcopenia in aging HD patients*	D: Multicenter cross-sectional. S: 448 lansia HD. V: Stage AWGS, nutrisi, aktivitas. I: BIA, IPAQ. A: Logistic regression.	Prevalensi 54%. Risiko: aktivitas rendah, DM, lama HD, malnutrisi.

No	Judul, Penulis, Tahun	DSVIA	Hasil/Temuan
5	Lu et al., 2025 — *Predictive model for sarcopenia in CKD*	D: Predictive modeling. S: 1092 CKD. V: 49 prediktor klinis. I: CHARLS biomarkers. A: LASSO, ML, ROC.	Prevalensi 21.2%. Nomogram memiliki akurasi tinggi (AUC 0.886-0.859). Prediktor utama: usia, linkar pinggang, LDL-C, HDL-C, Trigliserida, tekanan darah diastolik.
6	Martino et al., 2024 — *Low-Protein Diet in Elderly CKD*	D: Prospective. S: 45 CKD4–5. V: Low-protein diet → massa otot. I: Diet recall, body comp. A: Paired tests.	Diet rendah protein aman jangka pendek dan tidak memperburuk sarcopenia bila diawasi nutrisionis.
7	De La Flor et al., 2025 — *Morphofunctional Assessment Using Nutritional* Ultrasonography	D: Cross-sectional. S: 74 HD. V: NUS, BIA, HGS. I: US quadriceps. A: Korelasi, AUC.	Sarcopenia risk 24.3%, confirmed 40.5% and severe 20.3%. NUS korelasi baik dgn ASMI & HGS. Ultrasonografi otot merupakan alat praktis dan akurat untuk deteksi sarcopenia pada pasien HD
8	Nagy et al., 2024 — *Concordance between BIA & Muscle Ultrasound*	D: Cross-sectional. S: 41 HD. V: CSA US, BIA mass, HGS. I: US quadriceps. A: ROC, korelasi.	Prevalensi 58.5%. Cut-off CSA ~2.9 cm² for female, and 2.96 cm² for male. US valid sebagai screening alternatif.
9	Yogesh et al., 2025 — *Prevalance and Predictors of Sarcopenia, PEW & Sarcopenic Obesity in CKD*	D: Cross-sectional. S: 442 CKD. V: Sarcopenia, PEW, SO. I: BIA, HGS, gait. A: Logistic regression.	Sarcopenia 29.9%. Prediktor: usia↑, male, BMI↓, eGFR↓, CVD.
10	Kovačević Totić P. et al., 2025 — *Correlation Between Sarcopenia and Oral Health in Patients on Chronic Hemodialysis*	D: Cross-sectional / S: n=100 HD pts / V: oral health measures, CRP, albumin, BIA, HGS / I: OHIP-14, SarQoL, dental exam / A: Fisher exact, Mann–Whitney U	Prevalensi sarcopenia 28%. Kurang gigi & premolar berhubungan dengan sarcopenia (p=0.035). CRP↑ dan albumin↓ pada sarcopenia.
11	Inoshita H. et al., 2023 — *Dietary Patterns and Sarcopenia in Elderly CKD (Conservative)*	D: Cross-sectional / S: n=441 CKD konservatif / V: dietary variety, veg intake, BMI, grip, ASM / I: dietary variety score, BIA, HGS / A: logistic regression	Prevalensi (varies by stage); Almost-daily konsumsi sayur hijau/kuning terkait rendah odds sarcopenia (CKD G3 OR 0.35). BMI↑ protektif.
12	Rakhima F. et al., 2025 — *Prevalence & Factors Associated with Sarcopenia in Dialysis (InaKidney)*	D: Cross-sectional single center / S: n=132 CKD 5D / V: SCI, physical activity, nutrition, phosphate, calcium / I: HGS, BIS, 6-m walk, AWGS2019 / A: logistic regression	Prevalensi sarcopenia 15.9%. Phosphate & calcium serum lebih tinggi protektif; underweight & malnutrisi terkait lebih tinggi risiko.
13	Bacci M. et al., 2025 — *Impact of Sarcopenia, Dynapenia, Obesity on Muscle Strength in CKD (Healthcare)*	D: Cross-sectional sex-specific study / S: n=78 CKD5 HD (44M/34F) / V: sarcopenia, dynapenia, obesity, MQI / I: DXA, HGS, IL-6, TUG / A: comparative analyses	Men showed higher dynapenia & sarcopenia burden; obesity inversely related to muscle quality. MQI lower in men; adiposity linked to poorer muscle quality.
14	Ben Othman R. et al., 2025 — *Sarcopenia in Hemodialysis Patients: Multicenter Cross-Sectional (J Clin Med)*	D: Multicenter cross-sectional / S: n=118 HD pts / V: HGS, muscle mass, performance, nutrition, QoL / I: HGS, circumference, SPPB, TUG / A: logistic regression	Prevalensi sarcopenia 42.4%. Independent predictors: diabetes mellitus and longer HD duration; sarcopenia associated with worse performance & QoL.
15	Yu M.-D. et al., 2021 — *Relationship between CKD and Sarcopenia (Scientific Reports)*	D: Prospective observational / S: 123 hospitalized CKD pts vs 57 controls / V: RASMI (DXA), HGS, gait speed / I: DXA, dynamometer / A: multivariate logistic regression	Sarcopenia more common in CKD vs controls; CKD progression independently associated with higher sarcopenia risk.

After integrating the findings from the 15 included studies, consistent patterns emerged indicating that the prevalence of sarcopenia in patients with chronic kidney disease (CKD) varies widely but is consistently higher in advanced stages of CKD and among patients undergoing hemodialysis.

Reported prevalence ranged from 15.9% to 64.1%, as documented by Rakhima et al. (2025) and Yang et al. (2024), with intermediate prevalence reported in other studies such as Kakita et al. (2022), Zhao et al. (2024), and Li et al. (2025). This variability is largely attributable to differences in sample characteristics, assessment methods for muscle mass and strength (DXA, BIA, handgrip strength), and the diagnostic criteria applied, including AWGS and SARC-F. Nevertheless, all studies consistently identified sarcopenia as a significant clinical problem in both CKD and hemodialysis populations.

From a pathophysiological perspective, advanced age emerged as the dominant risk factor for sarcopenia, followed by sex, nutritional status, and systemic inflammation. Several studies reported a higher burden of sarcopenia and dynapenia among male patients, while nutritional factors particularly low body mass index, malnutrition, and inadequate protein intake were consistently associated with an increased risk of muscle mass and strength loss. Biomarkers such as low serum albumin levels and elevated C-reactive protein further underscore the central role of chronic inflammation and protein–energy wasting in the pathogenesis of sarcopenia in CKD. These factors act synergistically with CKD-related metabolic disturbances, including metabolic acidosis and reduced physical activity, thereby accelerating muscle degradation.

Clinically, sarcopenia was strongly associated with adverse health outcomes, including increased mortality, higher hospitalization rates, reduced physical function, increased risk of falls, and poorer quality of life. Handgrip strength was consistently identified as a key indicator of muscle strength, while assessment of muscle mass using BIA, DXA, and muscle ultrasonography demonstrated good validity. Simple screening tools such as SARC-F, SARC-CalF, and calf circumference were shown to be effective, particularly in resource-limited clinical settings. Overall, this review highlights the multifactorial nature of sarcopenia in CKD and its substantial impact on patient prognosis. Although preliminary evidence suggests that integrated interventions combining nutritional support and resistance exercise may mitigate the effects of sarcopenia, large-scale prospective studies with long-term follow-up are still required to strengthen clinical practice recommendations.

DISCUSSION

The relationship between chronic kidney disease (CKD) and sarcopenia is a complex phenomenon involving interactions among physiological, inflammatory, metabolic, and hormonal processes. CKD, as a progressive condition, leads to the accumulation of uremic toxins that directly impair skeletal muscle structure and function. Uremic toxins such as indoxyl sulfate and p-cresyl sulfate are known to disrupt mitochondrial function, reduce energy production capacity, and increase oxidative stress, thereby accelerating muscle tissue damage. In addition, CKD causes fluid retention and electrolyte imbalances, which further impair muscle contractility and muscle cell regeneration. The cumulative effects of these factors make patients with CKD highly vulnerable to progressive loss of muscle mass and physical strength (S. Li et al., 2025).

Chronic inflammation represents another key mechanism linking CKD and sarcopenia. In CKD, inflammatory markers such as C-reactive protein (CRP), interleukin-6 (IL-6), and tumor necrosis factor-alpha (TNF-α) are significantly elevated as a result of persistent renal injury. This systemic inflammatory state promotes muscle protein breakdown through activation of the ubiquitin–proteasome pathway, thereby accelerating muscle proteolysis. Chronic inflammation also reduces sensitivity to anabolic signals such as insulin and insulin-like growth factor-1 (IGF-1), leading to impaired muscle protein synthesis. Furthermore, inflammation is closely associated with uremic anorexia, which exacerbates poor nutritional intake. Prolonged deficiencies in protein and energy intake further accelerate the development of sarcopenia in patients with CKD (Inoshita et al., 2023). Metabolic acidosis, which is common in CKD, also plays a substantial role in disrupting protein balance. Acid accumulation activates muscle proteolysis and suppresses protein synthesis, thereby accelerating muscle loss. Evidence indicates that greater severity of metabolic acidosis is associated with a higher risk of sarcopenia. Hormonal dysregulation further contributes to this process, as patients with CKD frequently exhibit reduced levels of anabolic hormones such as testosterone, vitamin D, and growth hormone. These imbalances impair the body's ability to maintain muscle mass. In addition, CKD is associated with reduced physical activity due to chronic fatigue, anemia, and functional limitations, resulting in insufficient mechanical stimulation necessary to preserve muscle strength and volume. Physical inactivity therefore represents a critical contributor to sarcopenia progression in CKD (J. W. Kim & Yang, 2025).

In many studies, malnutrition or protein–energy wasting (PEW) has emerged as a dominant factor strengthening the association between CKD and sarcopenia. PEW encompasses reduced protein intake, increased metabolic demands, and excessive protein degradation. Patients undergoing hemodialysis are particularly susceptible to PEW due to the loss of amino acids and proteins during dialysis procedures. The combination of increased nutritional requirements, impaired nutrient absorption, and protein losses during dialysis creates a highly catabolic state that facilitates the development of sarcopenia. Thus, muscle loss in CKD is driven not only by the disease itself but also by the effects of renal replacement therapy (Bakinowska et al., 2024; Tsai et al., 2025).

Age is another important contributor to sarcopenia in CKD. Older patients are already predisposed to age-related muscle loss, and the presence of CKD accelerates this process. The synergistic effects of biological aging, chronic inflammation, physical inactivity, and metabolic disturbances create a state of extreme vulnerability to severe sarcopenia. This explains why sarcopenia prevalence is substantially higher among elderly CKD patients compared with younger adults. Overall, the mechanisms linking CKD and sarcopenia are multifactorial and interrelated, underscoring sarcopenia as a systemic complication that is largely unavoidable in CKD patients without comprehensive management.

The association between CKD and sarcopenia has profound clinical implications for quality of life, functional capacity, and long-term outcomes. Sarcopenia significantly impairs physical function, including gait speed, handgrip strength, and the ability to perform activities of daily living, thereby increasing dependence on external assistance and the risk of falls and injuries. In patients undergoing hemodialysis, reduced mobility often complicates access to healthcare facilities and negatively affects treatment adherence. Moreover, sarcopenia is associated with increased hospitalization rates, longer hospital stays, and higher mortality, particularly due to cardiovascular complications and infections (Kovačević et al., 2021).

From a clinical perspective, sarcopenia has emerged as an important prognostic indicator in CKD. Several studies have demonstrated that reduced muscle strength is a strong predictor of mortality, in some cases exceeding the prognostic value of laboratory parameters such as serum albumin or hemoglobin. Consequently, routine assessment of muscle mass and physical performance is increasingly recognized as an essential component of CKD management. Simple tools such as handgrip strength or gait speed can be used for early detection, allowing timely intervention before severe functional decline occurs. Given the high prevalence of sarcopenia, screening should be incorporated into standard clinical evaluations, particularly for older patients and those receiving long-term hemodialysis.

In terms of intervention, evidence suggests that effective management of sarcopenia in CKD requires a multidisciplinary approach integrating nutritional modification, physical exercise, and correction of metabolic abnormalities. Nutritional intervention is a cornerstone strategy aimed at optimizing protein and energy intake based on individual needs. Protein supplementation, essential amino acids such as leucine, and vitamin D supplementation have been shown to enhance muscle protein synthesis. In hemodialysis patients, intradialytic nutritional support has demonstrated benefits in improving nutritional status and muscle mass. However, the success of nutritional interventions is often limited by poor appetite, nausea, and strict dietary restrictions commonly experienced by CKD patients.

Resistance exercise represents another key component in the management of sarcopenia in CKD. Numerous studies have shown that progressive resistance training involving repeated muscle contractions can significantly improve muscle strength and functional performance. Resistance training performed two to three times per week has been shown to be safe for hemodialysis patients when supervised appropriately. Positive effects include improvements in muscle mass, walking speed, and daily functional capacity. Combining resistance training with light aerobic exercise further enhances physical capacity and reduces fatigue, making structured exercise programs strongly recommended (S. Kim et al., 2025).

Addressing metabolic factors such as acidosis, inflammation, and hormonal imbalance is also critical in sarcopenia management. Correction of metabolic acidosis through bicarbonate supplementation can reduce muscle proteolysis and improve protein synthesis efficiency. Controlling inflammation through optimal management of comorbidities and dialysis adequacy also supports muscle preservation. In addition, vitamin D deficiency, which is highly prevalent in CKD, should be corrected due to its role in muscle strength and neuromuscular function. Comprehensive metabolic management enhances the effectiveness of nutritional and exercise interventions.

Daily physical activity outside of formal exercise programs should also be emphasized. CKD patients often exhibit low activity levels due to chronic fatigue, anemia, and mobility limitations. Encouraging simple activities, such as walking for 15–30 minutes per day, can provide meaningful benefits in preserving muscle mass and preventing functional decline. The use of pedometers or activity-tracking applications may further improve motivation and adherence (Bacci et al., 2025).

Overall, interventions targeting sarcopenia in CKD require an integrated approach. A combination of early detection, nutritional support, resistance exercise, metabolic control, and promotion of daily physical activity provides the most effective strategy to slow or reverse muscle loss. Successful implementation depends on close collaboration among physicians, dietitians, physiotherapists, and nurses. With an appropriate multidisciplinary approach, the burden of sarcopenia can be reduced, leading to meaningful improvements in physical function, quality of life, and prognosis among patients with CKD.

CONCLUSION

This study demonstrates a strong and multifactorial association between chronic kidney disease (CKD) and the development of sarcopenia in adult patients, particularly those in advanced stages or undergoing hemodialysis. Based on a review of 15 international studies, the link between CKD and sarcopenia is driven by complex interactions among chronic inflammation, oxidative stress, acid–base imbalance, hormonal dysregulation, reduced physical activity, and malnutrition such as protein energy wasting, which collectively accelerate muscle mass loss, reduce muscle strength, and impair physical performance, ultimately diminishing quality of life. These findings highlight the importance of early, multidimensional interventions including nutritional monitoring, optimization of protein intake, structured resistance exercise, inflammation control, and optimized dialysis management as integral components of comprehensive CKD care, while further large-scale longitudinal studies are needed to strengthen evidence on underlying mechanisms and effective preventive strategies.

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