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ROLE OF PHYSICAL ACTIVITY, DIET AND LIFESTYLE-ASSOCIATED DETERMINANTS IN THE CLINICAL MANAGEMENT AND PROGRESSION OF CHRONIC KIDNEY DISEASE

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ABSTRACT

Chronic kidney disease (CKD) is a major global health burden associated with increased morbidity, mortality, and reduced quality of life. In addition to pharmacological treatment, lifestyle-related factors such as physical activity, dietary habits, smoking, alcohol consumption, sleep quality and psychosocial health play a crucial role in the clinical management and progression of CKD. This review aimed to summarize current evidence regarding the impact of physical activity, diet and lifestyle-associated determinants on CKD progression and patient outcomes. A narrative review of recent clinical guidelines, observational studies, and interventional research was conducted, focusing on nutritional management, plant-based dietary patterns, obesity, mental health, sleep disturbances, smoking, alcohol use and multidisciplinary care approaches in CKD.
The evidence indicates that regular physical activity improves cardiovascular and metabolic health, enhances functional capacity and can slow renal function decline. Dietary interventions, particularly plant-dominant patterns and structured approaches such as DASH and Mediterranean diets, are associated with improved blood pressure control, reduced proteinuria and better cardiometabolic outcomes. Key nutritional factors, including protein, sodium, potassium, phosphorus and fiber intake, play critical roles in disease progression and require individualized management. Additional lifestyle factors such as smoking cessation, weight management, sleep quality and mental health support further contribute to improved outcomes. Multidisciplinary care and patient education are essential for effective long-term management. Integrating lifestyle modification with standard medical therapy should therefore be considered a key component of comprehensive CKD care.

KEYWORDS

Chronic Kidney Disease, Diet, Physical Activity, Lifestyle Modification, Disease Progression

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Introduction

Chronic kidney disease (CKD) represents a growing global health issue, affecting over 10% of the adult population and contributing considerably to morbidity, mortality, and healthcare expenditures worldwide [1–3]. The increasing prevalence of CKD is largely associated with population aging and the rising incidence of conditions such as diabetes mellitus, hypertension, obesity and other metabolic disorders [2,3,6]. Progressive deterioration of kidney function in CKD is linked to numerous complications, including cardiovascular disease, reduced functional capacity, impaired quality of life and eventual kidney failure requiring dialysis or transplantation [1,4].

In recent years, increasing attention was brought toward the influence of modifiable lifestyle factors on CKD prevention and progression. Elements such as physical activity, nutritional habits, body weight management, smoking, sleep disturbances and psychological well-being appear to significantly affect disease outcomes [1,8,20,21]. Research indicates that regular exercise may improve cardiovascular performance, physical functioning, inflammatory status and metabolic control, while individualized dietary strategies may help reduce proteinuria, blood pressure and metabolic complications associated with CKD [1,8–15,22,23]. Lifestyle-oriented interventions may additionally contribute to better treatment adherence and improved overall quality of life among CKD patients [20,50,58–63].

Despite increasing recognition of these benefits in contemporary guidelines, lifestyle-based management remains insufficiently implemented in everyday nephrology practice [1,11,15]. Therefore, an updated overview of current evidence regarding non-pharmacological strategies in CKD care is warranted.

The aim of this review is to summarize current knowledge regarding the role of physical activity, dietary patterns and lifestyle-associated determinants in the management and progression of chronic kidney disease, with particular focus on their clinical relevance, therapeutic potential and implications for comprehensive patient care.

Methodology

This narrative review was based on a literature search conducted using publicly available scientific databases, including PubMed, nephrology focused journals and guidelines. Publications released between 2010 and May 2026 were identified using combinations of the following keywords: “chronic kidney disease,” “physical activity”, “exercise”, “diet”, “nutrition”, “lifestyle”, “disease management” and “disease progression”. Relevant clinical guidelines, systematic reviews, meta-analyses and original research articles were included. Studies were selected according to their relevance to lifestyle-related interventions and CKD outcomes. The retrieved literature was subsequently reviewed and qualitatively synthesized to evaluate the impact of physical activity, dietary approaches and other lifestyle-associated factors on CKD management and progression.

Results

The reviewed evidence indicates that lifestyle-related interventions play a major role in CKD management and progression. Regular physical activity was associated with improved cardiovascular health, physical functioning, quality of life and beneficial effects on renal outcomes [8–15]. Dietary approaches, particularly plant-based, Mediterranean and DASH-style diets, were linked to better blood pressure control, reduced proteinuria, improved metabolic balance and lower cardiovascular risk [1,22,23,46–49]. Sodium restriction and individualized protein intake were also associated with slower disease progression [1,20,26,30]. Additional factors, including obesity management, smoking cessation, mental health support, sleep optimization and patient education, may further improve treatment adherence and clinical outcomes in CKD patients [50,58–68]. Overall, the findings support the integration of lifestyle-focused interventions into routine CKD management.

1. Pathophysiology and progression of CKD

1.1 Definition and classification

Chronic kidney disease (CKD) is defined as the presence of structural or functional kidney abnormalities persisting for at least three months, accompanied by markers of kidney damage or a reduced estimated glomerular filtration rate (eGFR <60 mL/min/1.73 m²), regardless of the underlying cause [1,4].

CKD is classified using three key components: underlying etiology, level of kidney function using glomerular filtration rate (GFR) and degree of albuminuria. GFR categories are divided into six stages: G1 (≥90 mL/min/1.73 m², with evidence of kidney damage), G2 (60–89), G3a (45–59), G3b (30–44), G4 (15–29), and G5 (<15 or kidney failure requiring dialysis) [1,4]. Albuminuria is further stratified into three categories: A1 (<30 mg/g), A2 (30–299 mg/g) and A3 (≥300 mg/g), which reflect increasing severity of kidney damage and risk of progression [1,4].

1.2 Etiology

The progression of CKD is driven by a combination of systemic and renal mechanisms. The most common underlying causes worldwide are diabetes mellitus, particularly type 2 diabetes and arterial hypertension [1,2,4]. Kidney damage may develop through different pathways, including prerenal hypoperfusion, postrenal obstruction or intrinsic renal injury.

Prerenal and postrenal causes are mainly related to reduced renal perfusion or impaired urinary outflow. Intrinsic renal disease represents the most frequent category, which includes vascular damage (e.g. nephrosclerosis), glomerular diseases (e.g. IgA nephropathy, lupus nephritis, diabetic nephropathy) and tubulointerstitial disorders (e.g. polycystic kidney disease and inflammatory or reflux-associated nephropathies). These mechanisms often coexist, sharing overlapping risk factors and biological pathways that collectively contribute to progressive loss of renal function [4,7].

1.3 Risk factors

CKD progression is also strongly influenced by non-modifiable and modifiable risk factors. The rising prevalence of CKD is strongly influenced by age-related decline in kidney function, which may result in reduced eGFR and CKD classification even without underlying kidney pathology [5]. After the age of 40–50 years, GFR decreases at an average rate of approximately 0.75–1.0 mL/min/1.73 m² per year, which may lead to CKD classification even in the absence of overt disease [5,7].

In addition, sex and racial differences contribute to variability in disease prevalence and outcomes, reflecting both biological factors and differences in comorbidities, genetics, lifestyle and socioeconomic conditions [6]. Among modifiable risks, hypertension, proteinuria, metabolic disturbances, obesity and diabetes remain central drivers of disease progression [7].

2. Physical activity and CKD

2.1 Benefits

Regular physical activity provides multiple systemic and renal benefits in patients with chronic kidney disease. Exercise has been shown to improve blood pressure control, muscular strength, physical performance, lipid metabolism and dialysis efficiency, while also reducing hospitalization rates [9,10,12,14,15]. In addition, physical activity is effective in alleviating depressive symptoms and addressing reduced exercise capacity and functional limitations commonly observed in CKD populations [9,10].

From a physiological perspective, exercise influences key regulatory systems involved in CKD progression, including vascular function, hemodynamic stability and metabolic homeostasis. In patients with CKD, consistent activity is associated with improved insulin sensitivity, reduced inflammation, leading to better cardiovascular outcomes. These effects are mediated through modulation of intraglomerular pressure and neurohormonal pathways, including the sympathetic nervous system and renin–angiotensin–aldosterone system. Enhanced antioxidant capacity further contributes to renal protection [8].

2.2 Types of exercise

Current recommendations suggest that individuals with CKD, including kidney transplant recipients, should engage in at least 150 minutes of moderate-intensity aerobic activity per week, combined with resistance training on at least two days weekly [8,12,15,17]. For those already physically active, equivalent benefits may be achieved with approximately 75 minutes of vigorous-intensity exercise or a mixed-intensity approach [12].

Activity monitoring through step counting has also been highlighted, with around 4500 steps daily linked to improved quality of life, while 10000 steps per day may support weight maintenance. Wearable devices such as pedometers and smartwatches can facilitate long-term adherence and motivation [12,15,17,19].

2.3 Impact on progression and quality of life

Evidence from a meta-analysis of randomized controlled trials indicates that exercise interventions may lead to statistically significant improvement in eGFR (+2.16 mL/min/1.73 m^2) compared with non-exercising controls [11]. Furthermore, physical training improves functional capacity, particularly in dialysis patients [10].

In both CKD and kidney transplant populations, low levels of physical activity are associated with poorer quality of life, faster renal function decline and increased mortality risk [14].

2.4 Limitations and contraindications

Despite its benefits, implementation of exercise programs in CKD remains limited due to patient-related and healthcare system barriers, highlighting the need for multidisciplinary involvement, including nephrologists, nurses, dietitians and exercise specialists [15,19]. Although concerns exist regarding safety in dialysis patients, current evidence suggests that appropriately supervised exercise carries a low risk of adverse events and can be performed on both dialysis and non-dialysis days [15,16,19].

Contraindications and precautions include unstable clinical conditions such as recent initiation of hemodialysis, intradialytic hypotension, uncontrolled or severe hypertension (≥180/110 mmHg or persistently >160/100 mmHg), acute metabolic disturbances (e.g. hypo- or hyperglycaemia), peritonitis, catheter dysfunction, significant fluid overload and unstable serum potassium levels [17,18,19]. Exercise involving dialysis access points should also be restrained and properly controlled [17,18].

2.5 Clinical implications

Beyond kidney-specific outcomes, regular physical activity also reduces the risk of comorbid conditions such as type 2 diabetes, stroke and certain cancers, including colorectal and breast cancer [13]. Despite robust evidence supporting its benefits across CKD stages, physical activity remains underutilized in routine clinical practice [11].

Combining exercise with adequate nutritional support may help prevent muscle wasting and sarcopenia, even with protein restriction diets [15,19]. However, excessive or poorly controlled physical exertion may lead to transient albuminuria or acute kidney injury due to increased glomerular stress [8].

Overall, structured and individualized exercise programs improve physical, metabolic and cognitive outcomes, as well as overall quality of life in CKD patients. When appropriately prescribed and tailored to patient capacity, exercise is safe and should be integrated as a key component of comprehensive CKD management [15].

3. Diet in CKD management

3.1 Benefits and limitations

Dietary modification represents a key component in the management of chronic kidney disease (CKD). Nutritional interventions aimed at controlling obesity, hypertension, diabetes mellitus, dyslipidemia and hyperuricemia have been associated with improved renal outcomes [20,35]. In contrast, unhealthy dietary patterns combined with physical inactivity characterized by high consumption of sodium, red and processed meats, high glycaemic index foods and sugar-sweetened beverages are linked to an increased risk of CKD, particularly in populations affected by rising obesity rates [21,25].

Progressive renal dysfunction leads to the accumulation of protein-derived metabolites and uremic toxins, which contribute to both renal and cardiovascular injury. However, excessive dietary protein restriction may result in loss of muscle mass and worsening clinical outcomes, highlighting the need for balanced nutritional strategies [24,26]. According to the most recent Kidney Disease: Improving Global Outcomes (KDIGO) guidelines, patients with CKD are encouraged to follow diversified dietary patterns rich in plant-based foods while limiting intake of animal-based and processed products [1,22,23].

3.2 Protein

Dietary protein intake plays a central role in regulating renal hemodynamics and influencing CKD progression [20]. The kidneys are essential for protein metabolism and excretion of nitrogenous waste products. While high-protein diets are generally well tolerated in individuals with normal kidney function, patients with reduced glomerular filtration rate or high-risk conditions such as diabetes, hypertension and obesity are more susceptible to the adverse renal effects of increased protein intake [25,26].

Reduced protein intake has been shown to decrease intraglomerular pressure, limit afferent arteriolar dilation and reduce hyperfiltration, thereby improving blood pressure control and proteinuria, as demonstrated in multiple meta-analyses [20,26]. In contrast, long-term high protein intake particularly from animal sources may accelerate CKD progression through sustained hyperfiltration, elevated intraglomerular pressure and structural renal damage [23,25].

KDIGO guidelines recommend a protein intake of approximately 0.8 g/kg/day for adults with CKD stages G3–G5, while avoiding excessive intake above 1.3 g/kg/day due to the risk of disease progression [1,26]. In some stable patients without diabetes, slightly lower intake may be considered. The average physiological requirement is approximately 0.5–0.6 g/kg/day, sufficient to maintain nitrogen balance, indicating that appropriately supervised protein restriction does not necessarily lead to malnutrition [1]. Protein restriction is not recommended in children due to growth requirements, whereas older adults especially those with frailty or sarcopenia may require higher intake to preserve functional status [1].

3.3 Sodium

Sodium intake is a major modifiable factor influencing both CKD progression and cardiovascular risk. Excess sodium contributes to fluid overload, hypertension and structural renal and cardiovascular damage [20,28]. In CKD, hypertension is often salt-sensitive due to reduced nephron mass and impaired sodium excretion, leading to sodium retention, increased pressure natriuresis, and worsening proteinuria, which can also reduce the effectiveness of antihypertensive therapy [27,29]. This salt sensitivity is driven by dysregulation of renal, neurohormonal, and vascular systems, including activation of the renin–angiotensin–aldosterone system and sympathetic nervous system, with additional contributions from aging, obesity and altered renal hemodynamics [28,29].

Meta-analyses confirm that sodium restriction reduces both systolic and diastolic blood pressure and decreases albuminuria in CKD populations, including those on dialysis or after transplantation [30]. KDIGO recommends limiting sodium intake to <2 g/day (equivalent to <5 g sodium chloride/day) to support blood pressure control, reduce proteinuria, and slow CKD progression [1]. It should also be noted that some low-sodium salt substitutes contain potassium, which may be hazardous in patients with impaired potassium excretion and require careful monitoring [31].

3.4 Potassium and phosphorus

Dietary potassium is present in a wide range of foods, including fruits, vegetables, legumes, nuts, dairy products and meat. Highly processed foods and potassium-based additives often contain more readily absorbable potassium forms than whole plant foods [1,32]. Hyperkalaemia is common in CKD due to impaired renal excretion and is clinically significant as it may limit the use of renoprotective therapies such as renin–angiotensin–aldosterone system inhibitors [31]. Although low-potassium diets are often defined as 2–3 g/day (50–77 mmol/day), strict restriction is increasingly questioned, and intake should be individualized based on serum potassium levels and clinical status [32].

Disturbances in phosphorus metabolism are also common in CKD due to reduced renal excretion, leading to hyperphosphatemia, vascular calcification, cardiovascular disease, renal osteodystrophy and increased mortality [22]. While phosphorus restriction has traditionally been recommended, it may unnecessarily limit nutrient-dense plant-based foods. Emerging evidence suggests that plant-derived phosphorus is less bioavailable than animal-based sources, allowing better phosphorus control within plant-focused diets [33,39].

3.5 Fluid intake

Current guidelines do not provide clear recommendations regarding fluid intake in CKD [1,34]. In the general population, higher water intake has been associated with a lower risk of CKD and slower decline in renal function [34]. However, findings in CKD populations are inconsistent.

Data from the Modification of Diet in Renal Disease study suggest that higher urine output and lower urine osmolality may be associated with faster CKD progression [36]. Similarly, the CKD-REIN study cohort demonstrated a U-shaped relationship between fluid intake and progression to kidney failure, indicating potential risks at both low and high intake levels [34]. Overall, current evidence suggests that a moderate fluid intake of approximately 1–2 L/day may be appropriate in CKD, adjusted according to individual urine output and clinical status in pre-dialysis patients [34].

3.6 Vitamin supplementation

As kidney function declines, the ability to activate vitamin D decreases, increasing the risk of deficiency. Vitamin D deficiency in CKD is associated with secondary hyperparathyroidism, bone fragility, muscle weakness, increased fall risk, vascular stiffness and higher mortality [37]. Deficiencies of vitamin D and folic acid are particularly common in CKD populations [38].

Altered vitamin D metabolism contributes to chronic kidney disease–mineral and bone disorder (CKD-MBD), affecting both skeletal integrity and cardiovascular health. While vitamin D deficiency and elevated parathyroid hormone levels impair bone quality and increase fracture risk, excessive supplementation with active vitamin D analogues may lead to low bone turnover, highlighting the need for individualized therapy based on calcium, phosphate and parathyroid hormone levels [39].

Evidence does not support routine supplementation of vitamins A, E, or K, nor folic acid, even in patients treated with erythropoiesis-stimulating agents [37]. However, emerging data suggest potential benefits from supplementing vitamin D, calcitriol, pyridoxine (vitamin B6) and omega-3 fatty acids [20,37].

3.7 Dietary fiber

Dietary fiber, found in plant-based foods such as fruits, vegetables, whole grains, legumes, nuts and seeds, plays an important role in CKD management [23,40]. Higher fiber intake is associated with improved blood pressure, glycemic control, lipid profile, body weight and gastrointestinal function, as well as beneficial modulation of gut microbiota [23,43].

Patients with CKD are at increased risk of low fiber intake due to dietary restrictions, medication use, fluid limitation, reduced physical activity, altered gut microbiota and impaired gastrointestinal motility, all contributing to a high prevalence of constipation [40]. CKD is associated with disruption of the kidney–gut axis, where impaired renal function leads to accumulation of uremic toxins and gut dysbiosis, promoting systemic inflammation and oxidative stress that further accelerate kidney damage in a self-perpetuating cycle [44].

Dietary fiber influences these pathophysiological effects by modulating the gut microbiota, decreasing the generation of uremic toxins, attenuating systemic inflammation and oxidative stress, thereby preserving renal function and slowing CKD progression [41,43]. In patients with CKD, higher dietary fiber intake has been associated with reduced inflammatory burden, delayed disease progression and decreased mortality risk [23,42].

4. Diet examples and recommendations

4.1 Plant-dominant diets

Plant-based dietary patterns are characterized by a high content of dietary fiber, phytochemicals and anti-inflammatory compounds. These diets have been associated with improved clinical outcomes in CKD, including reductions in proteinuria, metabolic acidosis, and cardiometabolic risk factors such as hypertension, diabetes, cardiovascular disease and obesity [1,23,45].

In addition, plant-oriented low-protein dietary approaches, such as the plant-dominant low-protein diet (PLADO) and the plant-focused low-protein diet for chronic kidney disease in diabetes (PLAFOND), have been proposed as strategies to slow CKD progression. Evidence suggests that these diets may reduce the risk of kidney failure without increasing hyperkalaemia in advanced CKD and may also improve phosphorus metabolism [32,39,46].

The PLADO model is a structured and patient-centered dietary approach that typically includes a protein intake of 0.6–0.8 g/kg/day, with at least half derived from plant sources, fiber intake above 25 g/day, sodium restriction to <4 g/day (or <3 g/day in the presence of edema or hypertension) with adequate energy intake of 30–35 kcal/kg/day.

4.2 DASH and Mediterranean diet

Dietary patterns emphasizing minimally processed plant foods, such as the Dietary Approaches to Stop Hypertension (DASH) and Mediterranean diets, have been associated with slower decline in kidney function, reduced risk of kidney failure, reduced mortality rates and improved quality of life in CKD populations [1].

The DASH diet was originally developed for hypertension management, a major driver of CKD progression. It is characterized by high intake of fruits, vegetables, whole grains and low-fat dairy products, alongside reduced consumption of sodium, red meat, added fats and sugar-sweetened foods [23,48]. Its beneficial effects on blood pressure are linked to sodium restriction and increased intake of key nutrients such as calcium, contributing to both cardiovascular and renal protection [48].

Similarly, the Mediterranean diet is based on high consumption of plant-based foods, whole grains, legumes, nuts, and fish, with moderate intake of olive oil, dairy, meat, and eggs. It is widely recommended for cardiovascular risk reduction and lipid management [1]. This dietary pattern has also been associated with reduced risks of cardiovascular disease, cancer and obesity. It benefits CKD patients through improvements in endothelial function, inflammation, lipid metabolism and blood pressure regulation [49,51].

Overall, both DASH and Mediterranean diets support cardiometabolic health and may help slow CKD progression. Importantly, they can be adapted across different stages of CKD through individualized nutritional planning [1,48,49].

4.3 Renal-specific diets

Although evidence for dietary interventions in the primary prevention of CKD remains limited, nutritional strategies targeting major risk factors such as obesity, hypertension, diabetes, dyslipidemia and hyperuricemia may improve renal outcomes [20]. In this context, renal-specific dietary models, including plant-focused low-protein approaches such as PLADO and PLAFOND, are increasingly considered, particularly in patients with CKD and diabetes [23].

Encouraging home-prepared meals, reducing processed food intake, and increasing consumption of diverse plant-based foods may improve overall diet quality, enhance fiber intake and support a healthier gut microbiome [50]. Dietary modification is also essential in managing CKD-related metabolic disturbances. Increasing intake of alkaline-forming foods while reducing acid-producing foods may help lower net endogenous acid production and improve metabolic acidosis [1]. In this regard, fruits and vegetables may serve as an alternative to sodium bicarbonate therapy, as they may also provide additional blood pressure benefits due to lower sodium content [46].

However, restrictive or plant-based diets may carry potential risks, including vitamin B12 deficiency and protein–energy wasting in CKD patients. Therefore, careful monitoring and supplementation may be required when necessary [50]. Overall, dietary decisions should be based on an individualized risk–benefit assessment supported by ongoing nutritional evaluation [23].

4.4 Individualized diet management

Patients with CKD are at risk of multiple nutritional complications, including undernutrition, protein–energy wasting (PEW), electrolyte imbalances and obesity-related metabolic disturbances, all of which complicate disease management [35,50]. As CKD progresses, metabolic changes such as uremia, chronic inflammation, hormonal imbalance, metabolic acidosis and gastrointestinal dysfunction may reduce appetite and food intake, leading to gradual loss of energy and protein storages [50].

Excessive dietary restriction, particularly inadequate protein intake without sufficient caloric support, may further worsen malnutrition and should be avoided, especially in patients with sarcopenia, cachexia or metabolic instability [1]. For this reason, dietary management in CKD must be individualized and patient-centered. Collaboration with renal dietitians and nutrition specialists is essential to tailor recommendations regarding protein, sodium, potassium, and phosphorus intake according to CKD stage, comorbidities and patient-specific needs [1,46,47].

Ultimately, adherence to personalized dietary interventions is crucial for slowing CKD progression, managing symptoms and preventing complications such as electrolyte imbalance and cardiovascular disease [50]. This approach should incorporate patient education, shared decision-making and culturally appropriate guidance to improve long-term adherence and address misconceptions about diet [1,50].

5. Lifestyle interventions

5.1 Obesity

Obesity is a well-established contributor to the development and progression of CKD. It promotes renal damage both directly and indirectly through its association with hypertension, type 2 diabetes mellitus, dyslipidemia and hyperuricemia. It is also linked to proteinuria, acute kidney injury and progression to kidney failure [1,20]. In particular, visceral adiposity is strongly associated with increased cardiometabolic risk and mortality, emphasizing the importance of early weight management for renal protection [20].

In patients with CKD, obesity further complicates clinical management by reducing eligibility for kidney transplantation, negatively influencing dialysis outcomes and increasing overall morbidity and functional impairment [50]. Weight reduction achieved through dietary energy restriction and increased physical activity may reduce systemic inflammation, oxidative stress, and obesity-related glomerular hyperfiltration. However, sustained weight loss through lifestyle modification alone is achieved in only a limited proportion of patients [20,50].

Available management strategies include lifestyle interventions, pharmacological therapy and bariatric surgery. Emerging evidence suggests that metabolic surgery may slow CKD progression and reduce mortality in selected individuals, although results in advanced CKD remain inconsistent [50,52]. Management should therefore be individualized, with particular caution in frail or older patients where higher energy and protein intake may be necessary to prevent sarcopenia, while weight reduction strategies should be carefully monitored in obese patients [1].

5.2 Smoking and alcohol consumption

Cigarette smoking is an independent and modifiable risk factor for both cardiovascular disease and CKD. It is associated with an increased risk of incident CKD, end-stage renal disease and kidney failure, independent of traditional risk factors such as age, diabetes, hypertension, and body mass index [58,59]. The harmful effects of smoking on kidney function are cumulative and involve multiple mechanisms, including endothelial dysfunction, oxidative stress, chronic inflammation, glomerulosclerosis and tubular injury [58].

Current smokers have a markedly higher risk of kidney failure compared with never-smokers, while former smokers remain at elevated risk for years after cessation, although risk declines significantly over time following quitting [58,59]. Therefore, smoking cessation is strongly recommended for all patients with CKD, as it reduces progression of renal disease as well as cardiovascular, respiratory and oncological complications. Behavioral and pharmacological support should be offered when applicable [1,59].

The relationship between alcohol consumption and CKD is more complex. Observational data suggest a possible U-shaped association between alcohol intake and CKD risk [53,56]. Approximately 20–37% of CKD patients report alcohol consumption, with about 10% classified as heavy drinkers [54–57]. Some studies indicate that light-to-moderate alcohol intake may be associated with a lower prevalence of CKD compared with both abstinence and heavy consumption, particularly in older populations [56,57].

Proposed protective mechanisms include improvements in lipid metabolism, antioxidant effects and healthier lifestyle patterns often observed in moderate drinkers [53,57]. However, these findings should not be

interpreted as evidence to encourage alcohol consumption, as alcohol is also associated with hypertension, stroke, addiction, mental health disorders, electrolyte imbalance and increased mortality risk, particularly in patients with comorbid diabetes or cardiovascular disease [53].

5.3 Sleep disturbances

Sleep disorders are highly prevalent but frequently underdiagnosed in patients with CKD. Common conditions include insomnia, obstructive sleep apnea, restless legs syndrome and periodic limb movement disorder [60,61]. These disturbances significantly worsen quality of life and contribute to fatigue, cognitive impairment, increased morbidity and higher mortality risk [60].

Diagnosis can be challenging because symptoms such as fatigue, poor concentration, and daytime sleepiness often overlap with manifestations of CKD itself [61]. For this reason, systematic screening and early identification of sleep disturbances should be integrated into routine CKD care. Management strategies may include treatment of underlying causes, behavioral and sleep hygiene interventions, as well as pharmacological therapy when necessary [60,61].

5.4 Mental health

Mental health disorders are common in CKD, with depression and anxiety affecting a significant proportion of patients [62,63]. The prevalence of depressive symptoms increases with CKD severity and is associated with poorer treatment adherence, reduced quality of life, higher hospitalization rates and increased mortality [63].

Patients with severe psychiatric conditions, such as schizophrenia or bipolar disorder, are also at higher risk of developing CKD and may experience reduced access to optimal nephrology care, including transplantation [62]. Additionally, the chronic burden of CKD management including dietary restrictions, medication regimens and frequent clinical visits further contribute to psychological distress [63].

Non-pharmacological approaches such as physical activity, psychological counseling, internet-based cognitive behavioral therapy and dietary patterns like the Mediterranean diet may help reduce depressive symptoms and systemic inflammation associated with both CKD and mental illness [63]. Overall, integrated multidisciplinary care involving nephrologists and mental health professionals, along with routine screening and timely intervention, is essential for comprehensive CKD management [62,63].

6. Integrated clinical management approaches

6.1 Multidisciplinary care

Modern CKD management increasingly relies on a patient-centered multidisciplinary approach that integrates nephrology care with dietary counseling, pharmacological management, education on kidney replacement therapy and transplantation, as well as psychological and social support [1]. This model is particularly important because many patients have limited understanding of CKD and require structured education and continuous support to improve self-management and adherence to therapy [64].

Evidence shows that comprehensive multidisciplinary care is associated with slower decline in eGFR, reduced hospitalization and mortality rates, improved preparation for dialysis and better survival after dialysis initiation [65]. Since CKD is strongly linked to both kidney failure and cardiovascular mortality, effective management must address multiple domains simultaneously, including blood pressure control, glycaemic regulation, anemia, mineral and bone disorders, dyslipidemia, lifestyle modification and psychosocial health [65].

Overall, coordinated care with shared decision-making and patient-centered goals can improve both clinical outcomes and quality of life in individuals with CKD [64,65].

6.2 Digital health and monitoring tools

Digital health technologies are becoming increasingly important in CKD care, supporting remote monitoring, patient engagement and continuity of care. These include telemedicine consultations, mobile health applications, wearable devices and online platforms that allow patients to track parameters such as blood pressure, body weight, symptoms and dietary adherence at home [1].

Such tools can enhance self-management, improve health literacy, support physical activity, dietary behaviors and increase adherence to treatment through reminders, virtual follow-up and peer support systems [50,66]. They may also positively influence psychological well-being, particularly in early stages of CKD [66].

However, access to digital health is not equal across populations. Older adults, individuals with lower socioeconomic status, minority groups and those affected by digital exclusion may benefit less from these

interventions [66,67]. Therefore, digital health should be considered a complementary component of CKD care that supports but does not replace traditional multidisciplinary management, and must be implemented in an equitable and patient-centered manner [1,50,66,67].

6.3 Patient education

Patient education is a core pillar of CKD management, as it supports self-care, improves adherence, facilitates shared decision-making and enables early recognition of disease complications [1,67,68]. Early and structured educational interventions have been associated with improved disease knowledge, better self-management behaviors, fewer hospitalizations and emergency visits and delayed initiation of kidney replacement therapy [68].

Effective education should be individualized and tailored to patient literacy level, language and cultural background, providing clear information about disease progression, treatment options, medication safety and renal replacement therapies [1,68]. Delivery methods may include multidisciplinary team-based programs, group education sessions, community health workers, caregivers, digital platforms and one-to-one counseling [1,67].

Continuous and accessible education is therefore an essential element of comprehensive CKD care and should be maintained throughout all stages of disease [1,67,68].

6.4 Challenges and limitations

CKD remains a major global health burden, with persistently high prevalence and mortality, particularly in regions with a high incidence of diabetes and cardiovascular disease [3]. Effective management is limited by barriers at multiple levels, including healthcare systems, providers and patients [1,69].

System-level challenges include limited access to nephrology services, diagnostic tools, medications and cost-effective treatments, particularly in resource-constrained settings. Additional issues such as delayed referral, financial limitations and political instability further contribute to disease progression and poorer outcomes [3,69].

At the patient level, low disease awareness, limited health literacy and difficulties adhering to dietary and pharmacological recommendations significantly affect outcomes [67,69]. Healthcare providers also face constraints such as time pressure, limited CKD-specific training and challenges in communicating complex medical information [67]. Furthermore, older adults represent a particularly vulnerable population requiring individualized, often multidisciplinary care due to multimorbidity, frailty and therapeutic goals [1].

Improving early detection, strengthening patient education, expanding access to care along with integrating multidisciplinary and technology-supported approaches are essential strategies to improve CKD outcomes globally [1,69].

Conclusions

Chronic kidney disease is a complex, progressive condition driven by both medical and lifestyle-related factors. Its development is strongly influenced by modifiable risks such as hypertension, diabetes, obesity, diet, physical inactivity and smoking, making lifestyle intervention a key part of management alongside medical therapy.

Evidence supports the benefits of physical activity, balanced dietary patterns and careful regulation of nutrients such as sodium, protein and others in slowing disease progression and improving quality of life. However, these strategies must be individualized to avoid malnutrition or other complications.

Overall, optimal CKD care requires a multidisciplinary, patient-centered approach that combines medical treatment with education, psychological support and modern digital tools. Addressing broader barriers to care remains essential for improving long-term outcomes.

Author's contribution statement
Conceptualization: [KN], [AS]
Methodology: [BZ], [KB], [ZW], [AG]
Software: [BZ], [MR], [TS]
Check: [MR], [OM], [ZW], [TZ]
Formal analysis: [KN], [NK], [OM], [AS]
Investigation: [OM], [ZW], [KB],[MR]
Resources: [KN], [BZ], [MR], [TS]
Data curation: [NK], [AG]
Writing- draft preparation: [TS], [AS]
Writing- review and editing: [KN], [OM], [NK]
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