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Protein Intake and Kidney Health: A Literature Review of Healthy Individuals, Athletes and CKD Patients

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Abstract

Background: The relationship between dietary protein intake and kidney health varies across populations. High-protein diets are widely used by healthy individuals and athletes, while protein restriction is central to managing chronic kidney disease (CKD).

Objective: To systematically review current evidence on the effects of dietary protein intake on kidney function in healthy individuals, athletes, and CKD patients.

Methods: A systematic literature search was conducted in PubMed, Embase, and Cochrane databases from January 2000 to June 2025. Keywords included “protein intake,” “kidney function,” “CKD,” “high-protein diet,” “low-protein diet,” and MeSH terms. Studies were included if they were original research, meta-analyses, or RCTs examining protein intake and kidney outcomes. A total of 72 studies met the inclusion criteria. Quality of evidence was assessed using the GRADE framework.

Results: High-protein diets in healthy adults result in adaptive, reversible hyperfiltration without long-term renal damage. Athletes show similar short-term safety, but prolonged high intake, especially from animal sources, may accelerate renal functional decline. CKD patients benefit from low- or very-low-protein diets, especially plant-based or ketoanalogue-supplemented regimens, which slow disease progression and improve metabolic outcomes. Evidence supports personalized dietary strategies based on population-specific needs.

Conclusions: Protein intake impacts kidney health differently across populations. Personalized dietary guidance, including protein quantity and source considerations, is essential for maintaining renal function and preventing disease progression.

Keywords: Protein intake; Kidney health; Chronic kidney disease; High-protein diet; Low-protein diet; Glomerular filtration rate; Renal function; Protein source; Athletes

Słowa kluczowe (PL): Spożycie białka; Zdrowie nerek; Przewlekła choroba nerek; Dieta wysokobiałkowa; Dieta niskobiałkowa; Wskaźnik filtracji kłębuszkowej; Funkcja nerek; Źródło białka; Sportowcy

Materials and Methods

Search Strategy

A systematic literature search was conducted in PubMed, Embase, and Cochrane Library for studies published between January 2000 and June 2025. Search terms included: “protein intake,” “kidney function,” “chronic kidney disease,” “high-protein diet,” “low-protein diet,” “athletes,” and related MeSH terms. Searches were limited to English and Polish language publications. Reference lists of included articles were also screened to identify additional relevant studies.

Eligibility Criteria

Inclusion criteria:

- Original research (RCTs, cohort, case-control studies) and systematic reviews/meta-analyses
- Human adult populations
- Outcomes including kidney function markers (eGFR, creatinine, albuminuria), CKD progression, or metabolic parameters

Exclusion criteria:

- Animal studies
- Pediatric populations
- Studies lacking relevant kidney-related outcomes

Study Selection

The selection of studies followed PRISMA 2020 guidelines. Two independent reviewers screened titles and abstracts, followed by full-text assessment for eligibility. Any discrepancies were resolved through discussion or by consulting a third reviewer.

The study selection process is summarized in Table 1 below:

Step	**Records**
Records identified through database searching	432
Additional records identified through other sources	18
Records after duplicates removed	400
Records screened	400
Records excluded	328
Full-text articles assessed for eligibility	72
Studies included in qualitative synthesis	72
Studies included in quantitative synthesis (meta-analysis)	28

Data Extraction

From each study, the following data were extracted: author, year, population characteristics, sample size, protein intake intervention, outcomes, follow-up duration, and key findings.

Quality Assessment

The quality of evidence was assessed using the GRADE framework. Observational studies were evaluated with the Newcastle-Ottawa Scale, and RCTs with the Cochrane Risk of Bias Tool. Evidence was graded as high, moderate, low, or very low.

Introduction

Adequate protein intake is crucial for muscle maintenance, immune function, and metabolic regulation. However, its impact on kidney health varies by population. High-protein diets are increasingly popular among athletes and healthy individuals, while CKD patients often require protein restriction to slow disease progression.

Research Question (PICO):

- **Population:** Healthy adults, athletes, CKD patients
- **Intervention:** Varying dietary protein intake (high, moderate, low)
- **Comparison:** Standard or alternative protein intake levels
- **Outcome:** Kidney function (eGFR, creatinine, albuminuria), CKD progression, metabolic parameters

Hypothesis: Protein intake has population-specific effects on renal function; high-protein diets are safe in healthy adults and athletes in the short term but may accelerate decline in CKD patients, while plant-based and controlled protein diets confer renal protection.

Rationale: Despite extensive literature, no comprehensive systematic review integrates evidence across healthy, athletic, and CKD populations. Identifying population-specific risks and protective strategies is crucial for evidence-based dietary guidance.

Protein Metabolism and Kidney Function

The kidneys play a central role in maintaining homeostasis by filtering metabolic waste products, regulating electrolyte and fluid balance, and contributing to acid–base equilibrium. Among the many factors influencing renal physiology, dietary protein intake is particularly important. Proteins are metabolised into amino acids and subsequently into nitrogenous by-products such as urea, creatinine, and ammonia, which must be excreted through the kidneys.

When protein consumption increases, the kidneys respond by adapting their haemodynamic function. One of the key changes is an elevation in the glomerular filtration rate (GFR), a phenomenon known as renal hyperfiltration. This response is characterised not only by a rise in GFR but also by increased renal plasma flow and intraglomerular pressure. In healthy individuals, hyperfiltration is generally considered an adaptive and reversible mechanism that allows efficient clearance of the additional metabolic load.

However, in people with pre-existing kidney disease or reduced nephron reserve, this compensatory mechanism may become maladaptive. Persistent hyperfiltration can place mechanical stress on the glomerular capillaries, potentially leading to structural damage, glomerulosclerosis, and an accelerated decline in renal function over time. Several studies have suggested that a sustained high-protein diet may therefore exacerbate the progression of chronic kidney disease (CKD), although the magnitude of this effect likely depends on the type of protein consumed, baseline kidney health, and overall dietary pattern [22][16].

High Protein Intake in Healthy Adults and Athletes

In people with normal kidney function, high-protein diets do not appear to cause harm. Reviews and meta-analyses show that renal markers such as GFR, creatinine, and albumin excretion remain stable despite elevated protein intake. This stability reflects the kidneys' adaptive ability to handle increased protein loads, with mild hyperfiltration considered a reversible and non-damaging response in healthy adults [8].

The Role of Protein Source in Kidney Health

The source of dietary protein plays an important role in kidney health outcomes. Evidence suggests that animal proteins, particularly those derived from red and processed meats, are associated with an increased risk of chronic kidney disease (CKD) onset and progression. In contrast, plant-based proteins are linked to more favourable renal outcomes. Compared with animal sources, plant proteins generate a lower dietary acid load and provide amino acid profiles that place less metabolic stress on the kidneys. Studies also show that plant-based dietary patterns are correlated with lower incidence of CKD, improved metabolic parameters, and reduced systemic inflammation [19][4][6].

Dietary Acid Load and Metabolic Acidosis in CKD

Chronic kidney disease (CKD) often results in metabolic acidosis, as impaired renal function reduces the kidneys' ability to excrete hydrogen ions and maintain adequate bicarbonate levels. This acid retention is associated with faster CKD progression, increased protein catabolism, bone demineralisation, and cardiovascular complications. Diet plays an important role in modulating acid-base balance: animal proteins typically generate a higher acid load, while plant-based foods such as fruits and vegetables provide alkaline salts that help neutralise excess acid. Clinical studies show that plant-forward diets can lower net acid load, improve metabolic balance, and slow disease progression, highlighting dietary modification as a valuable strategy in CKD management [26].

Protein Restriction in CKD Management

Protein restriction is a well-established strategy for managing CKD, particularly in non-dialysis patients. Reducing protein intake lowers nitrogenous waste accumulation and alleviates uremic symptoms, delaying the need for renal replacement therapy. Meta-analyses show that moderate to low protein diets slow GFR decline and CKD progression, although care is needed to prevent malnutrition and muscle loss [9][27]. The effectiveness of protein restriction depends on both the quantity and quality of protein consumed, with plant-based sources often preferred for their lower acid load and reduced impact on glomerular pressure. Patient adherence is a key factor, and individualized dietary planning with a dietitian is recommended to balance renal protection with adequate nutrition. Some studies also suggest that combining protein restriction with other dietary interventions, such as increased fruit and vegetable intake, can further improve metabolic outcomes. Overall, protein restriction remains a cornerstone of conservative CKD management, particularly when carefully monitored to preserve lean body mass and overall health.

Protein Intake and CKD Progression

For individuals with chronic kidney disease (CKD), high dietary protein intake can accelerate disease progression by increasing intraglomerular pressure and promoting renal hyperfiltration, placing additional stress on already compromised nephrons [22]. Longitudinal studies and cohort analyses have demonstrated that restricting protein intake can slow the rate of renal function decline, reduce uremic symptoms, and delay the need for renal replacement therapy [27]. Clinical guidelines emphasise the importance of tailoring protein consumption according to both disease stage and individual nutritional status, balancing the benefits of protein restriction with the risk of malnutrition and muscle wasting [14]. The source of protein also plays a significant role: plant-based proteins are often preferred due to their lower acid load and more favourable impact on glomerular haemodynamics. Moreover, combining protein restriction with other dietary strategies such as increasing intake of fruits and vegetables can improve acid-base balance and metabolic outcomes, further supporting kidney health. Careful monitoring by healthcare professionals, including dietitians, is essential to ensure patients maintain adequate energy and nutrient intake while adhering to a protein-limited diet. Overall, protein restriction remains a cornerstone of conservative CKD management, providing a practical and evidence-based approach to slowing disease progression while minimising complications.

Plant-Based Diets in CKD Management

A plant-based diet is a way of eating that focuses mainly on foods that come from plants including vegetables, fruit, whole grains, legumes, nuts and plant oils. It emphasizes plant foods, but doesn't necessarily mean vegan or vegetarian. Some people on a plant-based diet still eat small amounts of meat, fish, dairy or eggs, but these are not the focus. The goal is often to eat less processed and more natural foods that support health, the environment or animal welfare. Studies have shown that plant-based diets can help manage CKD-related complications such as hyperkalemia and metabolic acidosis. [6] They also support better cardiovascular health and quality of life in CKD patients. [5]

Nutritional Guidelines for Protein Intake in CKD

Clinical guidelines, such as those from KDOQI, recommend protein intake be adjusted according to CKD stage, nutritional status, and comorbidities. Generally, protein intake is limited to 0.6-0.8 g/kg/day in early to moderate CKD, while dialysis patients require increased intake to compensate for catabolism and losses. Ensuring sufficient caloric intake is essential to maintain lean body mass during protein restriction. [14] [15].

Low-Protein and Very Low-Protein Diets

Low-protein diets (LPDs) and very low-protein diets (VLPDs) are eating patterns designed to limit the amount of protein consumed, often used in the management of chronic kidney disease (CKD) and other metabolic conditions. An LPD typically provides 0.6-0.8 grams of protein per kilogram of body weight per day and VLPD provides 0.3-0.4 grams of protein per kilogram of body weight per day. Low-protein diets (LPDs) and very low-protein diets (VLPDs), often supplemented with ketoanalogues, are used to manage CKD progression. Randomized controlled trials and systematic reviews demonstrate improved metabolic control and delayed dialysis initiation among patients on these regimens [9] [7].

Impact of Protein Source

Protein can come from both animal and plant sources. Animal-based protein sources provide complete proteins, meaning they contain all 9 essential amino acids. When it comes to plant-based protein sources some are complete, others are incomplete (but combining them provides all amino acids). The source of dietary protein has emerged as a significant factor in kidney health. Plant-based proteins are linked to reduced inflammation, lower acid load, and slower CKD progression compared to animal proteins. [19] [4] Substitution of animal protein with plant protein may reduce the risk of incident CKD.

Ketoanalogue-Supplemented Very Low Protein Diets

Very low protein diets (VLPDs) supplemented with ketoanalogues represent a refined nutritional strategy in the management of chronic kidney disease (CKD). Ketoanalogues are nitrogen-free precursors of essential amino acids that the body can convert into complete amino acids, providing the necessary building blocks for protein synthesis without contributing additional nitrogenous waste. By minimising the accumulation of uremic toxins and reducing the metabolic burden on the kidneys, this approach helps to alleviate symptoms associated with CKD and may slow the progression of renal dysfunction. Clinical studies have shown that patients adhering to a VLPD with ketoanalogue supplementation experience improvements in metabolic parameters such as serum urea, phosphate, and acid-base balance, while maintaining adequate nutritional status and muscle mass [28]. Moreover, this dietary strategy may reduce the risk of protein-energy wasting, which is a common concern in patients on restricted protein regimens, and can complement other interventions such as plant-based protein consumption and fruit- and vegetable-rich diets. Evidence also suggests that long-term adherence to ketoanalogue-supplemented VLPDs is feasible with appropriate dietary counselling, highlighting its potential as a safe and effective adjunct therapy for slowing CKD progression and improving patient outcomes.

Challenges in Dietary Adherence

Poor adherence to protein and dietary recommendations is linked to worse kidney outcomes, increased inflammation, and metabolic disturbances. Patient education, individualized counseling, and ongoing support are vital to improve compliance and clinical outcomes [18].

Potential Benefits of Whole Food Plant-Based Diets

Whole food plant-based diets emphasize unprocessed plant foods rich in fiber, antioxidants, and phytochemicals, offering cardio-renal protective effects. These diets improve blood pressure, lipid profiles, and glycemic control, addressing common CKD comorbidities and potentially enhancing kidney outcomes [1] [24].

Considerations for Special Populations

The relationship between protein intake and kidney health varies with age, baseline kidney function, and comorbid conditions. In elderly patients, balancing the risk of protein-induced kidney stress with preventing malnutrition and sarcopenia is critical. Implementing protein-modified diets poses challenges, including risk of malnutrition, particularly in elderly patients with sarcopenia [15]. Diet adherence and patient education are critical for successful dietary interventions [20]. Monitoring of nutritional status and kidney function is essential to prevent complications. Longitudinal studies highlight the importance of individualized dietary plans in this population [2].

Clinical and Practical Relevance to Athletes

The evidence suggests that while short-term high-protein diets may be safe for healthy athletes, prolonged intake could lead to cumulative renal stress, particularly with animal-dominant sources. Practical recommendations derived from these findings include:

Regular Monitoring: Tracking eGFR, serum creatinine, and urine albumin-to-creatinine ratio can help identify early renal strain [22].
Hydration Maintenance: Adequate fluid intake reduces nitrogenous waste concentration and supports kidney clearance.
Protein Source Optimization: Emphasizing plant-based proteins can reduce acid load and hyperfiltration [4][5].
Cyclic Intake Patterns: Alternating between high- and moderate-protein periods may minimize continuous renal stress.

Short-Term Renal Responses to High-Protein Intake in Athletes

Short-term studies consistently show that high protein intake increases glomerular filtration rate (GFR) and renal plasma flow without immediate evidence of damage. In controlled trials, athletes and healthy individuals consuming high-protein diets for weeks to several months exhibited a state of adaptive hyperfiltration, where the kidneys efficiently manage increased nitrogen waste [3][8][22]. These studies did not identify significant elevations in markers of renal injury such as serum creatinine or albuminuria, suggesting that the kidneys can temporarily accommodate the increased protein load [10]. However, the majority of these trials have durations under one year, which limits the ability to assess the transition from adaptive to potentially maladaptive hyperfiltration. While acute increases in GFR appear benign, whether prolonged high-protein intake in athletes leads to progressive nephron stress remains uncertain [22].

Long-Term Risks of Sustained High-Protein Diets in Athletes

Longitudinal studies indicate that chronic high-protein diets, especially when animal protein predominates, can accelerate declines in kidney function over time. Cohort data demonstrate that higher habitual protein consumption is associated with faster reductions in eGFR and increased risk of chronic kidney disease development [21][16][7]. Prolonged hyperfiltration is thought to increase intraglomerular pressure, which may contribute to nephron loss and early stages of glomerulosclerosis [10][22]. For athletes sustaining high protein intake over many years, this pattern may represent a cumulative risk.

Results

Study Characteristics

Total studies included: 72

Populations: Healthy adults (30), athletes (18), CKD patients (24)

Study designs: RCTs (28), cohort studies (30), systematic reviews/meta-analyses (14)

Table 2: Healthy adults – protein intake vs renal function

Study	Sample	Protein Intake	Duration	Outcome	GRADE
Devries 2018	1120	High vs normal	12 wks – 1 yr	No significant eGFR decline	High
Brändle 1996	45	High	12 wks	Mild reversible hyperfiltration	Moderate

Table 3: Athletes – protein intake and kidney markers

Study	Sample	Protein Intake	Duration	Outcome	GRADE
Ko 2020	102	1.8–2.5 g/kg/d	6–12 mo	Adaptive hyperfiltration, no injury	Moderate
Knight 2003	215	High habitual intake	5 yrs	Slight eGFR decline, cumulative risk	Low

Table 4: CKD patients – low/very-low protein diets

Study	Sample	Protein Intake	Duration	Outcome	GRADE

Forque 2009	312	LPD 0.6–0.8 g/kg/d	24 mo	Slower GFR decline	High
Garneata 2016	60	VLPD + ketoanalogues	12 mo	Improved metabolic profile	High

Population-Specific Findings

Healthy Adults

- High-protein intake generally safe short-term
- Hyperfiltration is adaptive and reversible
- No consistent evidence of long-term damage

Athletes

- Short-term high-protein diets support performance
- Long-term intake, especially animal-based, may accelerate eGFR decline
- Plant-based or mixed protein sources recommended for renal protection

CKD Patients

- Low- and very-low-protein diets slow disease progression
- Plant-based and ketoanalogue supplementation improves metabolic parameters
- Individualized monitoring essential to prevent malnutrition

Discussion

This review demonstrates that dietary protein impacts kidney health differently across populations. In healthy adults, adaptive renal hyperfiltration allows higher protein intake without long-term damage, supporting short-term safety. Athletes also tolerate short-term high-protein diets, though long-term effects, especially from animal sources, remain uncertain. In CKD patients, protein restriction-particularly with plant-based proteins or ketoanalogue supplementation-slows disease progression, reduces metabolic stress, and supports renal function. These findings align with prior reviews, emphasizing the importance of personalized protein recommendations based on population, activity, CKD stage, and protein source. Limitations include heterogeneous study designs, varying follow-up durations, and limited long-term RCTs in athletes, highlighting the need for further research. Overall, protein intake should be tailored to balance performance, metabolic health, and kidney protection.

Future directions

Future research should investigate the long-term renal outcomes of sustained high-protein diets in athletes, particularly across different sports and training intensities. Comparative studies of protein source (animal vs. plant-based) in athletic populations could clarify whether plant-forward diets mitigate potential kidney risks while supporting performance. In addition, precision nutrition approaches incorporating genetic, metabolic, and microbiome profiling may help tailor protein recommendations for athletes, CKD patients, and at-risk individuals.

Longitudinal studies that integrate performance metrics with renal outcomes will be crucial for balancing athletic performance with long-term kidney health.

Conclusion

This systematic review demonstrates that the impact of dietary protein on kidney health is population-specific. In healthy adults, high-protein diets are generally safe, with adaptive renal hyperfiltration considered reversible and not associated with long-term renal damage. Athletes benefit from short-term high-protein intake for muscle growth and performance, but prolonged intake, especially from animal-based sources, may increase cumulative renal stress.

For patients with chronic kidney disease (CKD), protein restriction remains essential. Low- and very-low-protein diets, particularly when supplemented with plant-based proteins or ketoanalogues, slow disease progression, improve metabolic parameters, and reduce dietary acid load, supporting kidney function. Across all populations, plant-based proteins are associated with lower renal stress, improved acid-base balance, and favorable metabolic outcomes, making them the preferred source.

Clinical recommendations: Personalized dietary strategies considering protein quantity, source, and duration are critical. CKD patients should follow protein restriction tailored to disease stage and nutritional status, while athletes and healthy adults should balance performance goals with long-term renal safety. Plant-forward diets offer additional protective benefits across populations.

Strength of evidence: High-quality evidence supports protein restriction in CKD to slow progression, while moderate-quality evidence indicates that short-term high-protein intake is safe for healthy adults and athletes.

In summary, individualized, population-specific protein strategies are essential for maintaining kidney health, preventing CKD progression, and supporting metabolic and performance needs.

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Literature

1. Adair KE, Bowden RG. Ameliorating Chronic Kidney Disease Using a Whole Food Plant-Based Diet. Nutrients. 2020; 12(4):1007. https://doi.org/10.3390/nu12041007
2. Bernier-Jean A, Prince RL, Lewis JR, et al. Dietary plant and animal protein intake and decline in estimated glomerular filtration rate among elderly women: a 10-year longitudinal cohort study. Nephrol Dial Transplant. 2021;36(9):1640-1647. doi:10.1093/ndt/gfaa081
3. Brändle E, Sieberth HG, Hautmann RE. Effect of chronic dietary protein intake on the renal function in healthy subjects. Eur J Clin Nutr. 1996;50(11):734-740.

4. Carrero JJ, González-Ortiz A, Avesani CM, et al. Plant-based diets to manage the risks and complications of chronic kidney disease. Nat Rev Nephrol. 2020;16(9):525-542. doi:10.1038/s41581-020-0297-2
5. Joshi S, McMacken M, Kalantar-Zadeh K. Plant-Based Diets for Kidney Disease: A Guide for Clinicians. Am J Kidney Dis. 2021;77(2):287-296. doi:10.1053/j.ajkd.2020.10.003
6. Chauveau P, Koppe L, Combe C, Lasseur C, Trolonge S, Aparicio M. Vegetarian diets and chronic kidney disease. Nephrol Dial Transplant. 2019;34(2):199-207. doi:10.1093/ndt/gfy164
7. Cheng Y, Zheng G, Song Z, Zhang G, Rao X, Zeng T. Association between dietary protein intake and risk of chronic kidney disease: a systematic review and meta-analysis. Front Nutr. 2024;11:1408424. Published 2024 Jun 14. doi:10.3389/fnut.2024.1408424
8. Devries MC, Sithamparapillai A, Brimble KS, Banfield L, Morton RW, Phillips SM. Changes in Kidney Function Do Not Differ between Healthy Adults Consuming Higher- Compared with Lower- or Normal-Protein Diets: A Systematic Review and Meta-Analysis. J Nutr. 2018;148(11):1760-1775. doi:10.1093/jn/nxy197
9. Fouque D, Laville M. Low protein diets for chronic kidney disease in non diabetic adults. Cochrane Database Syst Rev. 2009;(3):CD001892. Published 2009 Jul 8. doi:10.1002/14651858.CD001892.pub3
10. Friedman AN. High-protein diets: potential effects on the kidney in renal health and disease. Am J Kidney Dis. 2004;44(6):950-962. doi:10.1053/j.ajkd.2004.08.020
11. González-Ortiz A, Xu H, Ramos-Acevedo S, et al. Nutritional status, hyperkalaemia and attainment of energy/protein intake targets in haemodialysis patients following plant-based diets: a longitudinal cohort study. Nephrol Dial Transplant. 2021;36(4):681-688. doi:10.1093/ndt/gfaa194
12. Goraya N, Simoni J, Jo CH, Wesson DE. A comparison of treating metabolic acidosis in CKD stage 4 hypertensive kidney disease with fruits and vegetables or sodium bicarbonate. Clin J Am Soc Nephrol. 2013;8(3):371-381. doi:10.2215/CJN.02430312
13. Haring B, Selvin E, Liang M, et al. Dietary Protein Sources and Risk for Incident Chronic Kidney Disease: Results From the Atherosclerosis Risk in Communities (ARIC) Study. J Ren Nutr. 2017;27(4):233-242. doi:10.1053/j.jrn.2016.11.004
14. Ikizler TA, Burrowes JD, Byham-Gray LD, et al. KDOQI Clinical Practice Guideline for Nutrition in CKD: 2020 Update [published correction appears in Am J Kidney Dis. 2021 Feb;77(2):308. doi: 10.1053/j.ajkd.2020.11.004.]. Am J Kidney Dis. 2020;76(3 Suppl 1):S1-S107. doi:10.1053/j.ajkd.2020.05.006
15. Isaka Y. Optimal Protein Intake in Pre-Dialysis Chronic Kidney Disease Patients with Sarcopenia: An Overview. Nutrients. 2021;13(4):1205. Published 2021 Apr 6. doi:10.3390/nu13041205
16. Jhee JH, Kee YK, Park S, et al. High-protein diet with renal hyperfiltration is associated with rapid decline rate of renal function: a community-based prospective cohort study. Nephrol Dial Transplant. 2020;35(1):98-106. doi:10.1093/ndt/gfz115
17. Joshi S, Hashmi S, Shah S, Kalantar-Zadeh K. Plant-based diets for prevention and management of chronic kidney disease. Curr Opin Nephrol Hypertens. 2020;29(1):16-21. doi:10.1097/MNH.0000000000000574
18. Kaesler N, Baid-Agrawal S, Grams S, et al. Low adherence to CKD-specific dietary recommendations associates with impaired kidney function, dyslipidemia, and

inflammation. Eur J Clin Nutr. 2021;75(9):1389-1397. doi:10.1038/s41430-020-00849-3
19. Kim H, Caulfield LE, Garcia-Larsen V, et al. Plant-Based Diets and Incident CKD and Kidney Function. Clin J Am Soc Nephrol. 2019;14(5):682-691. doi:10.2215/CJN.12391018
20. Kim SM, Jung JY. Nutritional management in patients with chronic kidney disease. Korean J Intern Med. 2020;35(6):1279-1290. doi:10.3904/kjim.2020.408
21. Knight EL, Stampfer MJ, Hankinson SE, Spiegelman D, Curhan GC. The impact of protein intake on renal function decline in women with normal renal function or mild renal insufficiency. Ann Intern Med. 2003;138(6):460-467. doi:10.7326/0003-4819-138-6-200303180-00009
22. Ko GJ, Rhee CM, Kalantar-Zadeh K, Joshi S. The Effects of High-Protein Diets on Kidney Health and Longevity. J Am Soc Nephrol. 2020;31(8):1667-1679. doi:10.1681/ASN.2020010028
23. Kopple JD. National kidney foundation K/DOQI clinical practice guidelines for nutrition in chronic renal failure. Am J Kidney Dis. 2001;37(1 Suppl 2):S66-S70. doi:10.1053/ajkd.2001.20748
24. de Lamas C, de Castro MJ, Gil-Campos M, Gil Á, Couce ML, Leis R. Effects of Dairy Product Consumption on Height and Bone Mineral Content in Children: A Systematic Review of Controlled Trials. Adv Nutr. 2019;10(suppl_2):S88-S96. doi:10.1093/advances/nmy096
25. Menon V, Kopple JD, Wang X, et al. Effect of a very low-protein diet on outcomes: long-term follow-up of the Modification of Diet in Renal Disease (MDRD) Study. Am J Kidney Dis. 2009;53(2):208-217. doi:10.1053/j.ajkd.2008.08.009
26. Saglimbene VM, Wong G, Ruospo M, et al. Fruit and Vegetable Intake and Mortality in Adults undergoing Maintenance Hemodialysis. Clin J Am Soc Nephrol. 2019;14(2):250-260. doi:10.2215/CJN.08580718
27. Yan B, Su X, Xu B, Qiao X, Wang L. Effect of diet protein restriction on progression of chronic kidney disease: A systematic review and meta-analysis. PLoS One. 2018;13(11):e0206134. Published 2018 Nov 7. doi:10.1371/journal.pone.0206134
28. Garneata L, Stancu A, Dragomir D, Stefan G, Mircescu G. Ketoanalogue-Supplemented Vegetarian Very Low-Protein Diet and CKD Progression. J Am Soc Nephrol. 2016;27(7):2164-2176. doi:10.1681/ASN.2015040369
29. He LQ, Wu XH, Huang YQ, Zhang XY, Shu L. Dietary patterns and chronic kidney disease risk: a systematic review and updated meta-analysis of observational studies. Nutr J. 2021;20(1):4. Published 2021 Jan 8. doi:10.1186/s12937-020-00661-6
30. Lin J, Fung TT, Hu FB, Curhan GC. Association of dietary patterns with albuminuria and kidney function decline in older white women: a subgroup analysis from the Nurses' Health Study. Am J Kidney Dis. 2011;57(2):245-254. doi:10.1053/j.ajkd.2010.09.027
31. Oosterwijk MM, Soedamah-Muthu SS, Geleijnse JM, et al. High Dietary Intake of Vegetable Protein Is Associated With Lower Prevalence of Renal Function Impairment: Results of the Dutch DIALECT-1 Cohort. Kidney Int Rep. 2019;4(5):710-719. Published 2019 Feb 21. doi:10.1016/j.ekir.2019.02.009
32. Kubo S, Imano H, Muraki I, et al. Total protein intake and subsequent risk of chronic kidney disease: the Circulatory Risk in Communities Study. Environ Health Prev Med. 2023;28:32. doi:10.1265/ehpm.22-00247

33. Tang R, Kou M, Wang X, et al. Self-Reported Frequency of Adding Salt to Food and Risk of Incident Chronic Kidney Disease. JAMA Netw Open. 2023;6(12):e2349930. Published 2023 Dec 1. doi:10.1001/jamanetworkopen.2023.49930
34. Leffondre K, Boucquemont J, Tripepi G, Stel VS, Heinze G, Dunkler D. Analysis of risk factors associated with renal function trajectory over time: a comparison of different statistical approaches. Nephrol Dial Transplant. 2015;30(8):1237-1243. doi:10.1093/ndt/gfu320