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Integrated Lifestyle Interventions for Early-Stage Chronic Kidney Disease: A Public Health Framework Combining Renal Nutrition and Therapeutic Yoga

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ABSTRACT: Chronic kidney disease (CKD) is prevalent in people worldwide, impacting over 10% of adults, and is a major contributor to cardiovascular morbidity, premature mortality, and health system costs. Pharmacological approaches in the standard of care (so far) are drugs that reduce hemodynamic and metabolic stress on the nephron, with little attention to dietary protein overload, the generation of uremic toxins from the gut, and dysautonomia. This study brings together the published evidence on two non-pharmacological interventions that have recently been proposed for use alongside guideline-based medical therapy in early-stage (Stage 2-3) CKD: the plant-dominant low-protein diet (PLADO) and structured therapeutic yoga. Low-protein diets containing plant proteins (PVs) are associated with slower progression of GFR loss, decreased proteinuria, and improved acid-base and mineral parameters. If properly managed, they do not result in protein-energy wasting. Randomized and observational studies on yoga-based interventions for CKD and dialysis populations separately have shown benefits such as blood pressure, heart rate variability, quality of life, and select inflammatory markers, seemingly mediated by vagally mediated autonomic rebalancing. There is a lack of literature testing these two interventions together as a protocol, with adequate power. This paper illustrates the mechanistic framework of the combined renal nutrition therapy and therapeutic yoga approach, critically reviews the current evidence base for each intervention independently, provides comparative analytical syntheses, suggests an integrated approach in delivering the combined therapy, and outlines a public health approach for implementing it in community-based primary care and nephrology clinics.

1. INTRODUCTION

Chronic kidney disease (CKD) is becoming a serious health issue and is yet to be fully recognized. According to population-based estimates from the Global Burden of Disease (GBD) Study, the prevalence of chronic kidney disease (CKD) in the world is estimated to be more than 9–10% of all adults, or several hundred million people, with a disproportionate and rising prevalence in low- and middle-income sub-Saharan Africa and South Asia [1,2]. In contrast to mortality and disability adjusted life years (DALYs) for many non-communicable diseases that have reached a plateau or even started to decline, the burden of mortality and DALYs attributable to CKD has been steadily increasing, leading to speculation that it is likely to become one of the biggest killers worldwide over the next few decades if the current trends continue [1,3]. CKD is an abnormality of kidney structure or function observed for more than three months with health implications. It is staged from 1 (normal or high eGFR with evidence of kidney damage) to 5 (kidney failure), based on eGFR and albuminuria categories [4,5]. The twin epidemics of

type 2 diabetes mellitus and systemic hypertension, along with obesity, metabolic syndrome, and environmental nephrotoxin exposure, are overwhelmingly responsible for the disease [2,3].

In the early stages (Stages 1-3, with an eGFR>about 30 mL/min/1.73 m2), CKD often has no symptoms. The slow, progressive, and silent nephron attrition, intraglomerular hypertension, and tubulointerstitial fibrosis have already occurred but are generally not recognized by the patient. If left untreated, this course will end in the progressive hyperfiltration injury of the remaining nephrons, which leads to further increases in proteinuria and ultimately results in end-stage kidney disease (ESKD) with renal replacement therapy (dialysis or renal transplantation) as the only viable option. Given that early-stage CKD is "silent" and that there is a relatively short window for intervention at any point in the disease course to meaningfully reduce progression, the early stage of the disease represents the point of maximal leverage for public health intervention.

There has been considerable change over the past decade in the "pharmacological standard of care. In the long term, renin-angiotensin-aldosterone system inhibitors (RAASi), angiotensin-converting enzyme inhibitors (ACEI), and angiotensin receptor blockers (ARB) have been the first-line treatment for lowering intraglomerular pressure and proteinuria in patients with hypertension and/or albuminuria. The use of sodium-glucose cotransporter-2 inhibitors (SGLT2i) has been shown in large outcome trials to lower the composite outcome of kidney failure, sustained eGFR decline and cardiovascular death, and are now recommended by the various kidney disorders: Improving Global Outcomes (KDIGO) 2024 clinical practice guideline for use in most adults with CKD, with or without diabetes, if eGFR and albuminuria criteria are met [4–7]. Nonsteroidal mineralocorticoid receptor antagonists and glucagon-like peptide-1 receptor agonists have added to the armamentarium of useful drugs [4,7]. They are a true, evidence-based breakthrough, and no lifestyle program should replace guideline-based medical therapy.

Even with the best pharmacotherapy, there is still a significant risk. Current outcome trials of SGLT2 inhibitors show relative risk reductions for composite renal outcomes of 28–39%, leaving most of the risk unabated [7]. However, glomerular-acting agents fail to address two upstream factors that accelerate the process of CKD: (i) metabolic and hemodynamic effects of chronic consumption of animal protein in the diet, and (ii) chronic activation of the renal SNS. These are all non-pharmacological interventions – medical nutrition therapy through structured intervention and mind-body autonomic interventions.

There are two lifestyle interventions with an ever-growing body of evidence: a plant-dominant, low-protein diet (PLADO) and therapeutic yoga. PLADO limits total protein to 0.6–0.8 g/kg/day, with at least 50%–70% coming from minimally processed whole-plant foods [8,9]. It improves on past limitations of low-protein diets that were not selective and associated with poor palatability and protein-energy wasting [10,11]. Therapeutic yoga is a medically oriented yoga program that uses gentle postures (asanas), controlled breathing (pranayama), and relaxation techniques. Several clinical trials in patients with CKD and dialysis have reported beneficial effects on blood pressure, HRV, and quality of life [12–18].

Though PLADO and therapeutic yoga are seemingly complementary, the two have rarely been assessed in an integrated trial design. This narrative review outlines the pathophysiological rationale for introducing Lifestyle medicine in the pre-emptive management of early-stage CKD, appraises the evidence base for PLADO and therapeutic yoga, and examines the integrated public health model for primary care delivery.

2. MATERIALS AND METHODS

2.1 Literature Search and Evidence Synthesis

The study material comprised peer-reviewed clinical literature, epidemiological databases, and guidelines for clinical practice on non-pharmacological interventions in adults with CKD Stages [1-4]. Major international nephrology trial reports, systematic reviews/meta-analyses, and observational cohort studies were searched in PubMed, Medline, PubMed Central (PMC), and the Cochrane Library.

2.2 Literature Search Strategy

The literature collection and sampling process were done according to the biomedical and integrative health search queries. The following search strings were used: ("chronic kidney disease" OR "CKD") AND ("plant-dominant low-protein diet" OR "PLADO" OR "dietary protein restriction" OR "plant-based nutrition") AND ("therapeutic yoga" OR "pranayama" OR "autonomic nervous system" OR "heart rate variability" OR "HRV"). Specific retrieval was conducted for publications

assessing reductions in renal function, proteinuria, and blood pressure, modulation of autonomic function, and patient quality of life.

2.3 Extracting and Synthesizing Evidence

The data from the studies were systematically retrieved: textual, physiological, and quantitative clinical. The data fields included sample size, baseline CKD stage, various dietary compositions (target protein intake (g/kg/day); plant-animal ratio); therapeutic yoga program (frequency, specific asana, specific pranayama protocol), measured hemodynamic and autonomic parameters, and safety parameters (hyperkalemia, protein-energy wasting risk, musculoskeletal strain, etc.).

2.4 Analytical Methods

Data synthesis was conducted using narrative and comparative analytical approaches. Based on this synthesized evidence, two analytical matrices were developed: (i) Analytical synthesis of clinical efficacy, physiological targets, effect sizes, and safety of PLADO and therapeutic yoga, and (ii) An operational protocol and multi-domain monitoring framework for primary care implementation of PLADO and therapeutic yoga. All the formulas (including Maroni's formula for protein-equivalent nitrogen appearance and the race-free 2021 CKD-EPI equation) were tested during these studies [19,20].

2.5 Comparative Evidence Synthesis

Effect data from published meta-analyses, RCTs, and clinical studies were collected and qualitatively tabulated to show similarities and differences in therapeutic effects across trial arms for categorical outcomes (RR or OR) and for mean differences in eGFR slope, blood pressure, and heart rate variability measures.

3. RESULTS AND DISCUSSION

3.1 Preliminary Analysis

The Global Burden of Disease (GBD) CKD Collaboration landmark analysis in 2020 estimated the global prevalence of CKD in 2017 at 9.1% (697.5 million people) and identified it as the twelfth leading cause of death globally [1,3]. Another GBD study up to 2021 estimated that there were 674 million people with CKD, with high prevalence in low- and middle-income countries [2]. An unfair burden of disability adjusted life years attributable to CKD is found in countries of South Asia and sub-Saharan Africa, where the combination of infectious insults, poor access to early detection, and high prevalence of diabetes and hypertension has been identified as the cause of the burden [1,2]. Both high BMI and low physical activity are directly related to the global burden of CKD [2].

The common pathway of CKD progression is the glomerular hyperfiltration, podocyte injury, and tubulointerstitial fibrosis. Increased intraglomerular capillary hydrostatic pressure (P_g) leads to compensatory hyperfiltration, which leads to glomerulosclerosis. This hyperfiltration can be reproduced by an acute increase in renal plasma flow and GFR, induced by high animal protein intake, which causes glucagon-mediated afferent arteriolar vasodilation [8–10]. At the same time, continued renal afferent and efferent sympathetic nerve activity increases systemic vascular resistance, negates the dip in blood pressure seen during the night, and causes renin release. Besides this, colonic bacterial fermentation of aromatic amino acids in animal protein produces protein-bound uremic toxins, indoxyl sulfate and p-cresyl sulfate, which are associated with faster progression of tubular damage and a faster decline in eGFR [21–25]. Observational and clinical nutrition studies in Southeast Asian and Indian populations show that unmonitored nutritional practices may directly affect metabolic and renal profiles and, consequently, the dynamics of creatinine and bone-mineral metabolism if protein quality and caloric requirements are not properly balanced [26,27]. Using race-free 2021 CKD-EPI creatinine and cystatin C equations enables accurate staging and identification of CKD in the critical window for lifestyle intervention: Stages 2–3, defined by the combination of eGFR and urine albumin-to-creatinine ratio (uACR) [4,5,20].

3.2 Instrumental Analysis

Table 1 presents a comparative analysis of PLADO and therapeutic yoga, based on extracted trial findings and physiological mechanisms.

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Table 1. Comparative Analytical Matrix of Clinical Efficacy, Mechanisms, and Safety of PLADO and Therapeutic Yoga in CKD

Intervention Domain	Primary Physiological Target	Clinical Endpoints & Observed Effects	Quantified Effect Sizes / Clinical Trends	Safety Profile & Key Precautions	Key References
Plant-Dominant Low-Protein Diet (PLADO)	Intraglomerular hemodynamics; net endogenous acid production; gut uremic toxin synthesis	Slower rate of eGFR loss; reduction in proteinuria; maintenance of serum bicarbonate; lower serum phosphorus; decreased indoxyl sulfate	Significant reduction in ESRD risk (RR 0.60–0.70 across meta-analyses); preserved eGFR slope (–1.0 to –1.5 mL/min/1.73m²/yr)	The risk of protein-energy wasting (PEW) is avoided when caloric intake is maintained at 25–35 kcal/kg/day; periodic monitoring using the Maroni formula is required.	[4–10,12,14,35,36]
Therapeutic Yoga	Cardiac autonomic tone; sympathetic overactivity; baroreflex sensitivity; neuroendocrine stress axis	Reduction in resting clinic and ambulatory blood pressure; elevation in time/frequency-domain HRV; improvement in KDQOL physical/mental scores	Systolic BP reduction (–3 to –8 mmHg); significant increase in RMSSD and HF power; reduction in LF/HF ratio; KDQOL subscale increases	Inversions, heavy abdominal compression, and Valsalva maneuvers are contraindicated; protocol must be gentle, restorative, and breath-centered	[12–18,31–35]
Combined Integrative Model (Proposed)	Convergent dual targeting: intraglomerular hemodynamics + autonomic neurovascular tone	Hypothesized synergistic reduction in intraglomerular pressure, ambulatory blood pressure, systemic inflammation, and uremic symptoms	Unproven empirically; hypothesized additive preservation of eGFR and enhanced long-term patient-reported wellness	Multidisciplinary oversight required: concurrent monitoring of renal biochemistry, dietary nitrogen balance, and postural tolerance	[4,7–9,12,34]

Slow (regulated) breathing of the diaphragm (pranayama) is the physiological basis of yoga's autonomic effects. Experimental physiology shows that slow breathing increases vagal tone and shifts cardiac autonomic balance away from sympathetic predominance, as indicated by increases in HRV parameters SDNN, RMSSD, and HF power, and a decrease in the LF/HF ratio [31–33,36]. In addition, component-isolation studies have shown that slowed breathing per se is sufficient to increase vagus-mediated HRV parameters, and this is not a nonspecific placebo effect [33]. However, there is a consistent reduction in the LF/HF ratio and systolic blood pressure, and an increase in HF power, in the acute studies of Bhramari and Nadi Shuddhi pranayama [37,38]. At the same time, yoga interventions delivered alongside structured diet programs have been found to achieve significant changes in metabolic parameters and body composition in related endocrine and metabolic disorders [34,39]. On the other hand, intense vinyasa yoga temporarily disrupts HRV parameters; therefore, the beneficial effects in clinical groups are limited to gentle, restorative yoga protocols [33].

3.3 Biological Activity and Integrated Operational Framework

Table 2 details the structural protocol synthesis and unified monitoring framework for implementing combined PLADO and therapeutic yoga in primary and community care settings.

Table 2. Structural Protocol Synthesis and Monitoring Framework for Combined PLADO and Therapeutic Yoga

Protocol Dimension	Plant-Dominant Nutrition Component (PLADO)	Mind-Body Therapeutic Yoga Component	Integrated Delivery Matrix
Core Components	• Protein: 0.6–0.8 g/kg IBW/day • ≥50–70% plant-based protein • Energy: 25–35 kcal/kg/day • High soluble/insoluble dietary fiber	• Diaphragmatic breathing (Nadi Shuddhi, Bhramari) • Gentle mobilizations (Sukshma Vyayama) • Modified restorative asanas • Guided relaxation (Yoganidra)	Co-delivered community/clinic model; dietitian-led group cooking/nutrition sessions plus certified yoga therapy sessions
Dosing & Frequency	Continuous daily dietary pattern; monthly or bi-monthly dietitian follow-up	45–60 minutes per session; 3–5 days per week (minimum 2 supervised, remaining home-based)	Parallel 12-to-24-week initial induction phase followed by monthly maintenance support
Clinical Contraindications & Adaptations	Severe uncorrected malnutrition; uncontrolled severe hyperkalemia; catabolic intercurrent illness	Full inversions (Sirsasana); rapid hyperventilation (Kapalabhati); deep abdominal twists; extreme holding; active graft-site strain	Tailored for CKD Stage 2–3; physical adaptations for frail, hypertensive, or mobility-impaired patients.
Objective Monitoring Parameters	• Serum creatinine/cystatin C (race-free eGFR) • uACR • Serum bicarbonate, K+, PO4–, albumin • Maroni urinary nitrogen appearance	• Ambulatory blood pressure & nocturnal dipping • Resting short-term ECG HRV (RMSSD, LF/HF) • KDQOL-SF domain scores • Functional assessment	Unified quarterly monitoring battery combining clinical nephrology laboratories and physiological autonomic testing

Figure 1 presents the operational flowchart that illustrates the clinical entry point, twin therapeutic pillars, convergent biological mechanisms, unified monitoring battery, and target public health outcomes for this integrated model.

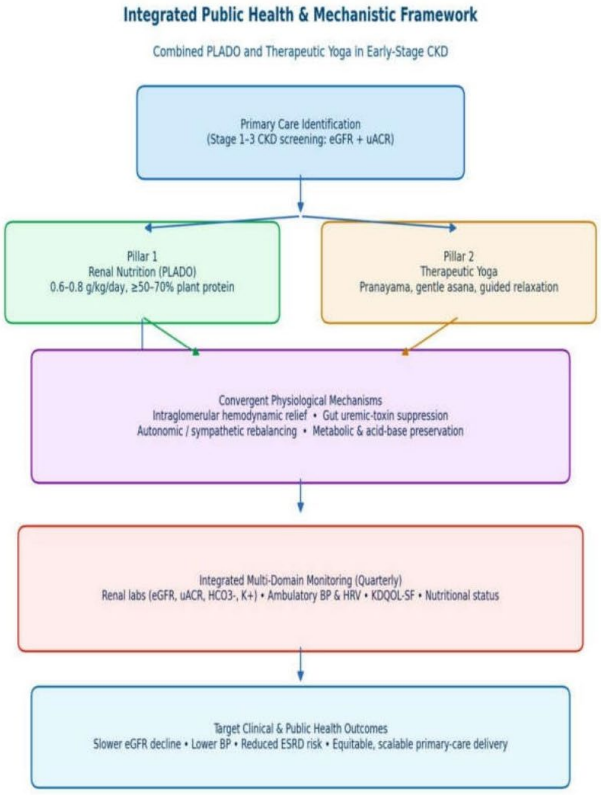

Figure 1. Operational Public Health and Mechanistic Framework for Combined PLADO and Therapeutic Yoga in Early-Stage Chronic Kidney Disease.

Patient access was also outlined in Figure 1, including the steps of primary care identification, dual-pillar lifestyle intervention prescription, convergent physiological mechanisms (intraglomerular hemodynamic relief, gut uremic toxin suppression, autonomic balancing, and metabolic preservation), multi-domain quarterly surveillance, and final clinical and health-system outcomes.

Clinical trials of yoga interventions in the CKD population support these physiological patterns. Pandey et al. randomly allocated 54 patients with CKD to a 6-month yoga intervention, in addition to usual treatment, to assess physical quality of life. They demonstrated a significant increase in physical QoL scores, with no significant changes in renal parameters and no adverse events [12]. Yurtkuran et al. found beneficial effects on functional and quality of life in HD patients following a modified yoga program [13]. Guided meditation (Yoganidra) is beneficial for ESRD patients, leading to significant improvements in Kidney Disease Quality of Life scores, sleep, and anxiety [14]. There have been a few recent systematic reviews on yoga and meditation for people with CKD, which have shown that both practices have positive effects on blood pressure, oxidative stress markers, and quality-of-life scores. Still, the studies were small and methodological differences remained [16–18,20].

The results of this review indicate that PLADO and therapeutic yoga are two non-overlapping physiological mechanisms. PLADO works upstream of nutrient delivery by decreasing dietary acid load and binding phosphorus to phytate, reducing the production of uremic toxins in the colon, and decreasing intraglomerular hyperfiltration [8–11,21,22,28–30]. Goraya et al. showed that alkali-inducing fruits and vegetables were able to correct metabolic acidosis to a degree similar to that of oral sodium bicarbonate in Stage 4 CKD without providing excessive sodium [30]. Meta-analysis studies by Rhee et al. (2018) and Yan et al. (2018) mentioned that protein-restricted diets slow down the process of CKD, reduce excess protein in urine, and decrease the risk of ESRD without compromising nutritional status[10,11]. Furthermore, dietary fiber provides co-benefits for cardiometabolic outcomes, including lipid fractions and glycemic control [28,29]. In the clinical context, it appears that individual plant-based nutrition and frequent assessment of dietary intake are necessary to maintain nitrogen balance and avoid undesirable metabolic changes [26,27].

For patients with chronic sympathetic hyperactivity, however, therapeutic yoga may be beneficial, since it does not have a target in traditional drug therapy. Sympathetic hypertonicity is associated with non-dipping nocturnal blood pressure, increased systemic vascular resistance, and renin hypersecretion. Slow breathing during therapeutic yoga and baroreflex modulation can recruit vagal tone, resulting in lower blood pressure and rebalancing of cardiac autonomic tone [31–33,36,37,39,40]. Both interventions aim to address downstream effects of microvascular shear stress and inflammation, and a mechanism-based approach to both is a reasonable approach to additive or synergistic renoprotection.

The integrated model could be useful in healthcare and its industry, focusing on a primary care framework, and including routine testing for eGFR and uACR, PLADO counseling by dietitians, and proper yoga training [4,5]. This lifestyle strategy would be especially beneficial in low- and middle-income areas where access to new drugs such as SGLT2 inhibitors and mineralocorticoid receptor antagonists is limited by their high cost [2,4,7]. Furthermore, indigenous knowledge about healthy eating, Ayurvedic principles, and yoga practice are inextricable from the health culture of the people in South Asia, providing a favorable context for community acceptance, trust, and adherence. Future studies are required that include multi-center, factorial, randomized controlled trials (RCTs) comparing eGFR slopes versus Standard Care versus PLADO versus Yoga versus PLADO+Yoga over 12–24 months, as well as health-economic and implementation studies [20].

4. CONCLUSION

Despite the advent of modern pharmacology, chronic kidney disease is an increasing burden worldwide, and the current gold standard of treatments fails to address all the issues associated with the disease. The plant-dominant, low-protein diet and therapeutic yoga have complementary, non-pharmacological mechanisms of action: metabolic-hemodynamic stress and uremic toxin production due to PLADO; sympathetic overactivity due to therapeutic yoga. While the current literature has shown the effectiveness and safety of each of these interventions alone, research integrating their effects within an integrated public health approach is an important avenue for future research in nephrology. Primary care may be a venue for using such low-cost, scalable, lifestyle-based approaches to facilitate the spread of equitable control of chronic disease worldwide.

Author Contributions

Author1: Conceptualization, Methodology

Author2: Visualization.

Author3: Investigation, Data Curation, Writing - Review & Editing, Supervision.

Author4: Writing - Original Draft,

Author 5: Editing and other technical assistance

Conflict of Interest

The authors declare that there is no conflict of interest.

Ethics Statement

As a review analyzing published scientific literature, formal ethical approval was not required for this study.

Data Availability Statement

No original datasets were generated during this review. All synthesized literature is publicly accessible via the cited primary sources.

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