



Impact of Early Lifestyle Modification on CKD Progression

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Background:Chronic Kidney Disease (CKD) remains a global health burden, with progression to end-stage renal disease (ESRD) leading to substantial morbidity and healthcare costs. While pharmacologic therapies have advanced, early lifestyle modification is a low-cost, underutilized strategy with growing evidence for delaying CKD progression (1,2).

Aim:To assess the impact of early lifestyle interventions—particularly diet, physical activity, weight management, and smoking cessation—on CKD progression, and evaluate demographic modifiers using both published and local data.

Methods:This observational analysis combines findings from recent clinical trials and meta-analyses (2,4,6,10) with secondary data from a local tertiary hospital (N=312 CKD patients, Stage 2–3a) and a structured patient survey (n=80) assessing adherence and lifestyle behaviors. Variables included eGFR changes, proteinuria, BMI, and BP over 12 months. A subgroup analysis explored the influence of sex, age, and ethnicity.

Results:Patients adhering to ≥ 3 of 5 recommended lifestyle behaviors showed significantly slower eGFR decline (mean 2.1 vs. 4.9 mL/min/1.73 m²/year, $p < 0.01$), reduced albuminuria (27% vs. 11% achieving ACR < 30 mg/g), and improved BP control (8,10). Female and non-smoking patients had greater benefit (11,12). Local hospital data corroborated literature trends, particularly among patients receiving structured counseling. Survey results indicated that over 60% of patients were unaware of the link between lifestyle and kidney health.

Conclusion:Early lifestyle modification plays a critical role in mitigating CKD progression, particularly in early-stage disease. Tailored interventions, public awareness, and integration into nephrology care pathways can enhance long-term outcomes and reduce CKD burden (1,13,15).

Keywords:Chronic kidney disease, lifestyle modification, progression, diet, exercise, demographics, early intervention, kidney function



Introduction:

Chronic Kidney Disease (CKD) is a progressive, noncommunicable condition characterized by gradual loss of kidney function, typically measured by declining estimated glomerular filtration rate (eGFR) and increasing albuminuria. Globally, CKD affects over 850 million people and ranks among the top ten causes of death (14). Its progression to end-stage renal disease (ESRD) results in increased cardiovascular risk, poor quality of life, and significant healthcare costs. Current management primarily focuses on pharmacological interventions and renal replacement therapy, while early lifestyle modification remains underutilized despite growing evidence of its benefits (1,2).

The **Kidney Disease: Improving Global Outcomes (KDIGO)** 2020 guidelines highlight the importance of controlling blood pressure, glycemic levels, and weight to delay CKD progression, yet few clinical settings emphasize structured lifestyle programs for early-stage patients (1). Several systematic reviews and clinical trials have shown that modifications such as sodium restriction, increased physical activity, plant-based diets, smoking cessation, and weight loss can significantly slow kidney function decline and reduce proteinuria (2,4,6,7). Moreover, combining these interventions with pharmacological care enhances long-term outcomes (10). A key limitation in current CKD care is the lack of integration of lifestyle intervention in routine nephrology practice, especially in the earlier stages of disease (3,13). Many patients remain unaware of the impact of modifiable behaviors, and even when informed, adherence rates vary across demographic subgroups. Evidence suggests that gender, ethnicity, socioeconomic status, and baseline comorbidities can influence the effectiveness of lifestyle interventions, indicating a need for more personalized approaches (11,12). In a landmark 2021 trial, structured coaching for early-stage CKD patients led to measurable improvements in eGFR and blood pressure over a five-year period (4). Similarly, meta-analyses have concluded that diet and exercise programs lead to statistically and clinically significant reductions in albuminuria and creatinine levels, particularly when initiated early (6,9,10). However, most of these studies focus on large, often Western, populations with limited applicability to local or resource-constrained settings.

To bridge this gap, the current study investigates both global and local data to evaluate the impact of early lifestyle modification on CKD progression. It integrates published evidence from clinical trials and meta-analyses with secondary data from a local hospital's nephrology department and findings from a structured patient survey. The aim is to assess the real-world applicability of established findings, analyze demographic modifiers, and generate locally



relevant recommendations. This paper focuses specifically on patients in early-stage CKD (Stages 1–3a), when interventions are most likely to influence outcomes. It evaluates the effects of dietary change, physical activity, smoking cessation, and other behaviors on clinical markers such as eGFR, albumin-to-creatinine ratio (ACR), and blood pressure. Through comparative analysis of both global and local datasets, this study aims to reinforce the case for early, personalized lifestyle intervention in CKD and encourage its integration into primary and nephrology care models (8,13,15).

Materials and Methods

Study Design and Setting. This was a mixed-method, observational study combining secondary analysis of clinical trial data and meta-analyses (2,4,6,10) with real-world data from a regional tertiary hospital in South Asia. Additionally, a structured survey was administered to early-stage CKD patients attending outpatient nephrology clinics. The study period covered 12 months (August 2023 – August 2024), with ethical clearance obtained from the institutional review board .

Patient Selection and Inclusion Criteria

Population and Sample Size. Two distinct but complementary data streams were used:

1. Local Hospital Data (n=312):

- Inclusion: Adults (18–75 years) diagnosed with Stage 2–3a CKD (eGFR 45–89 mL/min/1.73 m²), no history of dialysis, and minimum 12 months follow-up.
- Exclusion: Patients with rapidly progressive glomerulonephritis, advanced CKD (Stage 4–5), cancer, or non-adherence to medical therapy.

2. Patient Survey (n=80):

A subset of 80 patients from the same cohort were randomly selected and consented to participate in a structured survey evaluating knowledge, attitudes, and adherence to lifestyle recommendations.

Data Sources and Variables

a) Published Evidence. Quantitative synthesis and narrative summaries were drawn from recent trials and meta-analyses investigating the effects of dietary changes, physical activity, and behavioral interventions on CKD markers (2,4,6,7,8,9,10).

Lifestyle Intervention Definition. Patients were categorized based on adherence to the following five behaviors:



1. Reduced sodium intake (<2g/day)
2. ≥150 minutes/week moderate physical activity
3. Smoking cessation
4. Plant-based or DASH-style dietary pattern
5. ≥5% weight loss (if overweight/obese)

Adherence to ≥3 behaviors over the 12-month period was considered “adequate modification.”

Outcome Measures. Primary outcome: Annual rate of eGFR decline (mL/min/1.73 m²/year) Secondary outcomes: Change in urinary ACR, BP control achievement (≤130/80 mmHg), BMI change and Correlation with demographic factors (age, gender, income level)

Statistical Analysis. Descriptive statistics were used to summarize baseline characteristics. Group differences (adherent vs. non-adherent) were analyzed using:

- Independent *t*-tests for continuous variables (e.g., eGFR decline, BP)
- Chi-square tests for categorical variables (e.g., smoking status, gender)
- Multivariable linear regression for adjusted eGFR decline, controlling for age, gender, comorbidities
- Subgroup analysis by sex and age strata

A *p*-value <0.05 was considered statistically significant. All analyses were performed using SPSS v27.0.

Ethical Considerations. Patient confidentiality was maintained by anonymizing datasets. Survey participation was voluntary, with written informed consent obtained from all participants. The study was conducted in accordance with the Declaration of Helsinki and received ethical clearance from the hospital ethics committee

Results:

1. Baseline Characteristics of the Local CKD Cohort. A total of 312 patients with early-stage CKD (Stage 2–3a) were included in the local hospital cohort. The mean age was 58.3 years (±11.2), and 55.8% were male. The average baseline eGFR was 62.4 mL/min/1.73 m² (±9.1), and the median urinary ACR was 89 mg/g (IQR: 48–135). Hypertension and diabetes were common, present in 67.3% and 50.6% of patients respectively. Notably, only 45.5% had documented receipt of lifestyle counseling, and 30.8% were current smokers (Table 1). These characteristics align closely with populations described in prior cohort studies examining lifestyle interventions in early CKD (2,4,7), supporting the comparability of this sample to existing literature.

Variable	Value
Age (years, mean ± SD)	58.3 ± 11.2



Variable	Value
Male (%)	174 (55.8%)
Female (%)	138 (44.2%)
eGFR (baseline, mL/min/1.73 m ²)	62.4 ± 9.1
Urinary ACR (mg/g, median [IQR])	89 [48–135]
Hypertension (%)	210 (67.3%)
Diabetes (%)	158 (50.6%)
BMI (mean ± SD)	28.4 ± 3.7
Current Smokers (%)	96 (30.8%)
Received Lifestyle Counseling (%)	142 (45.5%)

Table 1: Table 1 shows the **baseline characteristics** of the hospital cohort.

2. Clinical Outcomes by Lifestyle Adherence. Patients were divided into two groups based on adherence to at least three of five key lifestyle behaviors over the 12-month follow-up. Adherence was associated with significantly improved clinical outcomes across all major variables (Table 2).

- **eGFR decline:** Adherent patients experienced a slower annual eGFR decline (−2.1 vs. −4.9 mL/min/1.73 m²/year; $p < 0.001$).
- **Albuminuria:** 27.0% of adherent patients achieved ACR <30 mg/g compared to only 11.0% in the non-adherent group ($p = 0.003$).
- **Blood pressure:** BP control ($\leq 130/80$ mmHg) was achieved by 58.1% of adherent patients versus 31.7% among non-adherents ($p < 0.001$).
- **BMI change:** Adherent individuals had an average BMI reduction of −1.3 kg/m², while non-adherents gained an average of +0.4 kg/m² ($p < 0.01$).

These trends are consistent with findings from Ikizler et al. and Rossi et al., who reported substantial improvements in renal and metabolic outcomes among patients receiving structured exercise and dietary interventions (7,8). Moreover, the local outcomes mirror results from a large-scale randomized trial in Spain, where a 5-year coaching intervention reduced eGFR decline by 35% in adherent patients (4).

Table 2: Table 2 compares clinical outcomes between adherent and non-adherent groups to lifestyle changes.

Parameter	Adherent (n=148)	Non-Adherent (n=164)	p-value
Annual eGFR decline (mL/min/1.73 m ²)	−2.1 ± 1.4	−4.9 ± 2.2	<0.001
Urinary ACR (% achieving <30 mg/g)	40 (27.0%)	18 (11.0%)	0.003
BP control (% achieving $\leq 130/80$ mmHg)	86 (58.1%)	52 (31.7%)	<0.001



Parameter	Adherent (n=148)	Non-Adherent (n=164)	p-value
BMI change (kg/m ²)	-1.3 ± 0.9	+0.4 ± 1.1	<0.01

3. Patient Survey Insights: Knowledge and Behavior Gaps. Among the 80 survey participants, a significant proportion lacked awareness of lifestyle’s role in CKD progression. Only 60% reported understanding that behavior changes could influence kidney outcomes, and fewer than half were adherent to recommended dietary or activity levels (Table 3).

- 43.8% reported engaging in ≥150 minutes of physical activity weekly.
- 52.5% reported understanding dietary guidance.
- 47.5% reported adherence to ≥3 lifestyle changes.
- Among smokers, 73.3% had attempted to quit within the last year.
- Only 37.5% felt confident in sustaining lifestyle changes.

These data reinforce prior reports that knowledge gaps are a major barrier to self-management in CKD (13,15). Despite the presence of comorbidities and risk factors, many patients lack structured support to translate knowledge into action—an issue also documented in the WHO’s 2020 CKD risk factor profiles (14).

Table 3: summarizes key survey responses (n=80).

Survey Item	Yes (%)
Aware of lifestyle's impact on CKD	48 (60%)
Understood dietary recommendations	42 (52.5%)
Reported ≥150 min/week physical activity	35 (43.8%)
Smoking cessation attempts (among smokers)	22 of 30 (73.3%)
Adherent to ≥3 lifestyle changes	38 (47.5%)
Felt confident maintaining changes	30 (37.5%)

4. Subgroup Differences in Renal Decline

Subgroup analysis revealed several demographic patterns in disease progression (Table 4). Female patients had significantly slower eGFR decline than males (-2.6 vs. -4.2 mL/min/year; $p=0.021$). Similarly, non-smokers experienced a more favorable trajectory than smokers (-2.4 vs. -5.0 mL/min/year; $p<0.001$). Age also showed an effect: patients aged <60 declined more slowly than those ≥60 (-3.1 vs. -3.9; $p=0.049$). These findings echo results from Zhou et al., who noted significant interactions between gender, smoking, and CKD progression in a multi-cohort study (11). Additionally, the attenuated benefit among older patients has been observed in previous lifestyle trials, likely due to accumulated comorbid



burden and reduced physiologic reserve (12).

Table 4 :Presents a subgroup analysis of eGFR decline based on demographics (sex, age, smoking).

Subgroup	Mean eGFR Decline (mL/min/year)	p-value
Male	-4.2	0.021
Female	-2.6	—
Age < 60	-3.1	0.049
Age ≥ 60	-3.9	—
Smokers	-5.0	<0.001
Non-Smokers	-2.4	—

Discussion:

This study provides strong, real-world evidence that early lifestyle modification significantly slows the progression of chronic kidney disease (CKD), particularly in patients with Stage 2–3a disease. Patients who adopted three or more recommended behaviors — such as dietary sodium reduction, increased physical activity, smoking cessation, and weight loss — showed marked improvement in kidney function, albuminuria, blood pressure, and body weight over a 12-month period. These findings reinforce and extend observations from controlled trials, underscoring the value of lifestyle interventions in clinical nephrology practice.

Comparison With Prior Research. The local findings are consistent with earlier clinical trials and meta-analyses. For example, in the Lifestyle Intervention Trial (Gomez-Uriza et al.), CKD patients who received structured dietary and exercise coaching showed a 35% slower eGFR decline over five years (4). In a meta-analysis of 11 trials, Navaneethan et al. reported significant reductions in albuminuria and modest improvements in eGFR following behavior-focused interventions (9). Similarly, Kelly et al. concluded that dietary modifications and physical activity reduce the risk of CKD progression by 20–30% (10). Our findings replicate these benefits in a low-resource, real-world hospital setting, which is crucial given the high CKD burden in low- and middle-income countries. Furthermore, the alignment between global and local data reinforces the external validity of lifestyle interventions, suggesting they can be implemented effectively across healthcare systems with minimal infrastructure.

Mechanisms of Benefit. Several biological mechanisms may explain the protective effects of lifestyle modification in CKD. High dietary sodium is associated with glomerular hyperfiltration, increased intraglomerular pressure, and proteinuria — all factors that accelerate kidney damage. Reduction in sodium intake has been shown to enhance the antiproteinuric effects of renin-angiotensin system inhibitors (7). Increased physical activity improves insulin sensitivity, reduces inflammation, lowers blood pressure, and aids in weight



loss, which collectively reduce renal injury. In the trial by Ikizler et al., CKD patients who engaged in regular aerobic exercise had reduced oxidative stress and improved GFR compared to controls (8). Plant-based diets — particularly those aligned with DASH or Mediterranean patterns — reduce acid load and dietary phosphorus, both implicated in CKD progression (6). Smoking cessation mitigates endothelial dysfunction and reduces sympathetic overactivity, key drivers of renal injury (3). The synergy of multiple modest improvements across these pathways likely underlies the cumulative benefit seen in patients adhering to a cluster of healthy behaviors.

Demographic Modifiers and Targeted Interventions. Notably, our study identified important demographic differences in CKD progression and response to lifestyle changes. Female patients had a significantly slower eGFR decline than males, consistent with findings from Zhou et al. who reported gender as a significant modifier in CKD trajectory (11). Non-smokers experienced greater renal preservation than smokers, a trend supported by both observational and interventional studies (12). Older patients (≥ 60 years) showed less benefit than younger counterparts, which may reflect decreased physiological adaptability, polypharmacy, or comorbid burden. These findings support the concept of **targeted lifestyle intervention**, where patient characteristics are used to guide intensity and delivery method. In the future, digital health tools or community health worker models could be leveraged to provide tailored, culturally adapted support — especially in high-risk subgroups. The WHO and KDIGO have called for integrating non-pharmacological care into primary care frameworks to address such gaps (1,14).

Survey Findings and Knowledge Gaps. Our patient survey revealed substantial gaps in awareness, motivation, and confidence regarding lifestyle change. Despite regular clinical follow-ups, fewer than half of the respondents knew that behaviors like diet and exercise could impact CKD outcomes. Less than 40% felt confident in their ability to maintain healthy changes long term. These findings echo results from Beetham et al., who highlighted poor patient education and limited counseling infrastructure as major barriers to lifestyle adherence in CKD populations (13). Moreover, the lack of structured counseling — documented in only 45.5% of patient records — indicates a systemic gap in implementation. Behavioral science research shows that knowledge alone is insufficient to drive change. Interventions must address motivation, environment, and perceived self-efficacy. Techniques such as motivational interviewing, peer support, and feedback-based coaching may improve adherence. A recent study by Singh et al. demonstrated that community-based education significantly improved dietary adherence and slowed CKD progression in a rural population (15).

Clinical Implications. The clinical implications of this study are clear. Early-stage CKD represents a critical window of opportunity for intervention. Patients are often asymptomatic, motivated to avoid dialysis, and physiologically capable of responding to non-pharmacologic therapies. Yet, these interventions are rarely implemented in structured ways. Nephrologists and primary care providers should routinely assess lifestyle behaviors, counsel patients, and refer them to nutritionists, physiotherapists, or structured programs where available. Even



brief interventions — such as 5-minute counseling or printed toolkits — can improve awareness and initiate behavior change (13). Health systems should consider embedding lifestyle services into CKD care pathways, particularly in early stages, before irreversible nephron loss occurs. Implementation models may include:

- Automated referral to dietitians at CKD diagnosis
- Patient education groups
- EMR prompts for lifestyle screening
- Integration with diabetes or hypertension management clinics

Long-term savings from slowing CKD progression could offset program costs, especially given the high burden of dialysis and transplantation.

Strengths and Limitations. Strengths of this study include the use of both published clinical evidence and real-world local data, enhancing both internal and external validity. The inclusion of a structured survey allowed for patient-centered insights, and the subgroup analysis explored population-specific patterns. However, **limitations** include the observational design, which cannot prove causality. Behavioral adherence was self-reported, which may introduce bias. Additionally, the survey sample was relatively small (n=80), and longer-term follow-up beyond one year was not available. The study was conducted in a single hospital, potentially limiting generalizability to other regions. Despite these limitations, the consistency of trends across multiple data sources and alignment with high-quality literature (2,4,6,10) provide strong support for the findings.

Conclusion

This study reinforces the clinical value of early lifestyle modification in slowing the progression of chronic kidney disease. Patients who adopted key behaviors—such as reducing dietary sodium, increasing physical activity, quitting smoking, and managing weight—experienced significantly slower declines in kidney function, improved blood pressure control, and reductions in albuminuria. These findings were consistent across both published trial data and local hospital outcomes, supporting the applicability of lifestyle interventions across diverse healthcare settings. Importantly, adherence to lifestyle recommendations was suboptimal, with fewer than half of patients aware of the link between behavior and kidney outcomes. Women and non-smokers derived greater renal benefit, suggesting the need for personalized approaches. The local survey also revealed significant gaps in knowledge and self-efficacy, indicating that information alone is insufficient to drive behavior change. To achieve meaningful impact, CKD management must move beyond pharmacologic control and incorporate structured, accessible lifestyle support at the earliest stages of disease. This includes routine counseling, patient education, and referral systems embedded into nephrology and primary care pathways. Digital tools and community-based models could help bridge resource gaps, particularly in low- and middle-income regions. In summary, early lifestyle modification is a low-cost, high-impact strategy to delay CKD



progression. Its integration into routine care could improve patient outcomes, reduce dialysis burden, and support long-term health system sustainability. The findings of this study underscore the urgency of making lifestyle support a standard part of early CKD care.

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