ISSN: 0975-3583, 0976-2833 VOL15, ISSUE9, 2024

Original Research Article

The Impact of Dietary Sodium Restriction on Cardiovascular Outcomes in Patients with Stage 3-4 Chronic Kidney Disease: An Observational Analysis

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Abstract

Background:

Patients with stage 3-4 chronic kidney disease (CKD) are at high risk for cardiovascular complications. Sodium restriction is commonly recommended for blood pressure control and reducing cardiovascular events, but its broader effects on other outcomes in CKD are not well studied.

Objective:

This study aims to evaluate the impact of dietary sodium restriction on cardiovascular outcomes, including blood pressure, left ventricular hypertrophy (LVH), hospitalizations due to heart failure, kidney function, and quality of life in patients with stage 3-4 CKD.

Methods:

A total of 150 patients with stage 3-4 CKD were enrolled in this 12-month observational study. Seventy-five patients followed a sodium-restricted diet (≤ 2.3 g/day), while 75 patients adhered to a standard diet (> 2.3 g/day). Key outcomes measured included changes in blood pressure, LVH regression, hospitalization rates

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due to heart failure, estimated glomerular filtration rate (eGFR), electrolyte levels, and quality of life (QoL).

Results:

Patients on the sodium-restricted diet had significant reductions in systolic (12 mmHg) and diastolic (8 mmHg) blood pressure compared to the standard diet group ($p < 0.001$ and $p < 0.01$, respectively). LVH regression was more prevalent in the sodium-restricted group (20% vs. 8%, $p = 0.02$). Hospitalization rates for heart failure were significantly lower in the sodium-restricted group (6.7% vs. 20%, $p = 0.004$), with shorter hospital stays (4 vs. 7 days, $p = 0.03$). Kidney function declined more slowly in the sodium-restricted group (eGFR: 4.5 vs. 6.8 mL/min/1.73 m², $p = 0.03$). QoL scores improved by 15% in the sodium-restricted group ($p < 0.01$).

Conclusion:

Sodium restriction in CKD patients significantly improves cardiovascular outcomes, slows kidney function decline, and enhances quality of life.

Keywords:

Chronic kidney disease, sodium restriction, blood pressure, left ventricular hypertrophy, heart failure, eGFR, quality of life

Introduction

Chronic kidney disease (CKD) is a progressive condition that significantly increases the risk of cardiovascular complications, particularly in patients with stage 3-4 CKD[1]. These patients commonly experience hypertension, left ventricular hypertrophy (LVH), and heart failure, which contribute to high morbidity and mortality rates. Managing cardiovascular risk in CKD is crucial to improving patient outcomes, and dietary modifications, such as sodium restriction, are often recommended as a non-pharmacological intervention to achieve this goal[2,3].

Excessive sodium intake is well-known to exacerbate hypertension, fluid retention, and cardiovascular strain, leading to adverse outcomes such as heart failure and LVH[4].

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Current guidelines recommend sodium restriction (≤ 2.3 g/day) for patients with CKD to manage blood pressure and prevent cardiovascular events[5,6]. However, the evidence supporting the long-term benefits of sodium restriction in this patient population, particularly on outcomes such as LVH regression, hospitalization rates, kidney function, and quality of life, remains limited[7].

This observational study aims to evaluate the impact of sodium restriction on key cardiovascular and renal outcomes in patients with stage 3-4 CKD over a 12-month period. Specifically, the study examines the effects of a sodium-restricted diet on blood pressure control, LVH, hospitalization due to heart failure, estimated glomerular filtration rate (eGFR), electrolyte balance, and quality of life. By providing further insight into the potential benefits of sodium restriction in this high-risk population, this study seeks to contribute to the development of more effective dietary interventions for managing CKD-related complications.

Methodology

Study Design:

This observational study was conducted at the National Institute of Medical Science & Research, Jaipur, from July 2023 to June 2024. The study aimed to assess the impact of dietary sodium restriction on cardiovascular and renal outcomes in patients with stage 3-4 chronic kidney disease (CKD). A total of 150 patients diagnosed with stage 3-4 CKD were enrolled and followed for 12 months. The study included patients who met specific inclusion and exclusion criteria, and data were collected at baseline, every three months, and at the end of the study.

Study Population:

Patients were eligible for inclusion if they were:

- Aged 18 years or older,
- Diagnosed with stage 3-4 CKD (estimated glomerular filtration rate [eGFR] between 15 and 59 mL/min/1.73 m^2),
- Had stable kidney function for at least three months prior to enrollment.

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Exclusion criteria included patients:

- On dialysis or scheduled for kidney transplantation,
- With heart failure requiring hospitalization within the last three months,
- With active infections, malignancies, or other serious comorbid conditions.

Intervention:

Participants were divided into two groups:

1. **Sodium-Restricted Group**: 75 patients followed a sodium-restricted diet, limiting sodium intake to ≤ 2.3 g/day.
2. **Standard Diet Group**: 75 patients followed a standard diet with sodium intake > 2.3 g/day.

Both groups received dietary counseling at the beginning of the study and were monitored regularly for adherence to their respective diets.

Data Collection:

Data were collected at baseline, every three months, and at the end of the 12-month study. The following parameters were measured:

- **Blood Pressure**: Systolic and diastolic blood pressure were recorded using automated sphygmomanometers.
- **Echocardiograms**: Performed at baseline and the end of the study to assess left ventricular hypertrophy (LVH) and left ventricular mass index (LVMI).
- **Hospitalizations**: Records of hospital admissions due to heart failure were documented.
- **Kidney Function**: eGFR was measured at baseline and every three months.
- **Electrolyte Levels**: Serum sodium and potassium levels were assessed regularly.
- **Quality of Life**: Assessed using the Kidney Disease Quality of Life (KDQoL) instrument.

Statistical Analysis:

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Continuous variables such as blood pressure, LVMI, eGFR, and electrolyte levels were expressed as mean ± standard deviation (SD) and compared between groups using independent t-tests or Mann-Whitney U tests for non-parametric data. Categorical variables such as hospitalization rates and LVH regression were analyzed using Chi-square tests. A p-value of less than 0.05 was considered statistically significant for all analyses.

Ethical Considerations:

The study protocol was approved by the Institutional Ethics Committee of the National Institute of Medical Science & Research, Jaipur. Informed consent was obtained from all participants before enrollment in the study. The study adhered to the principles of the Declaration of Helsinki.

Results

Our study revealed significant differences between the sodium-restricted group and the standard diet group across several cardiovascular and renal parameters.

Blood Pressure Control

Patients in the sodium-restricted group experienced more substantial reductions in blood pressure compared to those in the standard diet group (Table 1). The sodium-restricted group showed a mean systolic blood pressure decrease of 12 mmHg, compared to only 4 mmHg in the standard diet group ($p < 0.001$). Similarly, diastolic blood pressure decreased by 8 mmHg in the sodium-restricted group versus 2 mmHg in the standard diet group ($p < 0.01$). Pulse pressure reduction was also more pronounced in the sodium-restricted group (4 mmHg vs. 0 mmHg, $p < 0.01$).

Cardiac Structure and Function

The sodium-restricted diet was associated with more favorable changes in cardiac structure (Table 2). The prevalence of left ventricular hypertrophy (LVH) regression was significantly higher in the sodium-restricted group (20% vs. 8%, $p = 0.02$). Moreover, the reduction in left ventricular mass index (LVMI) was more substantial in the sodium-restricted group (10 g/m² vs. 3 g/m², $p = 0.04$).

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Heart Failure Outcomes

Patients on the sodium-restricted diet demonstrated better outcomes related to heart failure (Table 3). The hospitalization rate for heart failure was significantly lower in the sodium-restricted group (6.7% vs. 20%, $p = 0.004$). When hospitalization did occur, the average length of stay was shorter for the sodium-restricted group (4 days vs. 7 days, $p = 0.03$).

Kidney Function

The sodium-restricted diet appeared to have a protective effect on kidney function (Table 4). The decline in estimated glomerular filtration rate (eGFR) was less pronounced in the sodium-restricted group compared to the standard diet group (4.5 mL/min/1.73 m^2 vs. 6.8 mL/min/1.73 m^2, $p = 0.03$).

Electrolyte Balance

Despite the dietary sodium restriction, there were no significant differences in serum electrolyte levels between the two groups (Table 5). Serum sodium levels (138 mEq/L vs. 139 mEq/L, $p = 0.08$) and potassium levels (4.3 mEq/L vs. 4.4 mEq/L, $p = 0.11$) remained within normal ranges and did not differ significantly between the groups.

Quality of Life

Patients in the sodium-restricted group reported a greater improvement in quality of life compared to those in the standard diet group (Table 6). The percentage of patients reporting quality of life improvement was significantly higher in the sodium-restricted group (15% vs. 8%, $p < 0.01$).

Discussion

This observational study demonstrates the significant impact of dietary sodium restriction on cardiovascular outcomes, kidney function, and quality of life in patients with stage 3-4 chronic kidney disease (CKD). Over the 12-month period, patients who adhered to a sodium-restricted diet ($\leq$ 2.3 g/day) showed notable improvements in blood pressure control, left ventricular hypertrophy (LVH) regression, hospitalization

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rates due to heart failure, and a slower decline in kidney function compared to those on a standard diet. These findings underscore the potential of sodium restriction as an essential non-pharmacological strategy for managing CKD-related complications.

Cardiovascular Outcomes

The reduction in systolic and diastolic blood pressure in the sodium-restricted group was significant compared to the standard diet group. This result is consistent with existing studies, such as those conducted by Kang et al[7]. (2023), which showed that reduced sodium excretion is associated with better cardiovascular outcomes in CKD patients. In our study, the sodium-restricted group exhibited a 12 mmHg reduction in systolic and an 8 mmHg reduction in diastolic blood pressure, compared to 4 mmHg and 2 mmHg, respectively, in the standard diet group. This blood pressure reduction likely contributed to the observed LVH regression in 20% of the sodium-restricted group compared to 8% in the standard diet group. Given that LVH is a key predictor of cardiovascular mortality in CKD, our findings are in line with other research highlighting sodium reduction's role in improving cardiovascular health in CKD patients (Garofalo et al[8]., 2018).

The significantly lower hospitalization rates due to heart failure (6.7% in the sodium-restricted group vs. 20% in the standard diet group) further emphasize the cardioprotective effects of sodium restriction. These findings are consistent with those of Doukky et al[9]. (2016), who observed that dietary sodium restriction was associated with a reduction in heart failure-related hospitalizations. Moreover, the shorter average length of hospital stay (4 days in the sodium-restricted group vs. 7 days in the standard diet group) supports previous studies that show patients on low-sodium diets experience fewer heart failure episodes and recover more quickly when hospitalized (Shi et al[10]., 2022).

Kidney Function

The slower decline in estimated glomerular filtration rate (eGFR) in the sodium-restricted group compared to the standard diet group (4.5 vs. 6.8 mL/min/1.73 m^2) suggests that sodium restriction may have a renoprotective effect. This aligns with studies by Borrelli et al[11]. (2020) and Saran et al[12]. (2017), which reported that

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sodium restriction slows CKD progression by lowering blood pressure and reducing cardiovascular strain. Although the primary mechanism is likely related to blood pressure control, reduced fluid retention and lower cardiovascular strain may also contribute to the slower decline in kidney function. This is particularly relevant, as CKD patients have limited treatment options to slow disease progression, especially in the later stages.

Electrolyte Balance and Quality of Life

No significant differences in serum sodium or potassium levels were observed between the groups, indicating that sodium restriction did not lead to adverse electrolyte imbalances. This supports the safety of sodium restriction in CKD patients, which aligns with findings from McMahon et al[13]. (2021), who reported that altered salt intake does not significantly affect serum electrolytes.

In terms of quality of life (QoL), patients on the sodium-restricted diet reported a 15% improvement in QoL scores, compared to 8% in the standard diet group. This improvement can be attributed to better cardiovascular health, fewer hospitalizations, and enhanced control of fluid retention. Similar results were found in a meta-analysis by Garofalo et al[8]. (2018), which suggested that sodium restriction improves overall well-being in CKD patients by alleviating the burden of cardiovascular symptoms and hospital admissions.

Clinical Implications

The findings from this study suggest that sodium restriction should be strongly recommended for patients with stage 3-4 CKD as part of a comprehensive management strategy. The improvements in cardiovascular outcomes, reduced hospitalizations, and slower decline in kidney function highlight the significant clinical benefits of sodium restriction. This intervention is safe, does not adversely affect electrolyte balance, and enhances patients' quality of life. Jaques et al[14]. (2021) also emphasized the importance of managing sodium intake to reduce cardiovascular risk, which is consistent with the conclusions drawn from our study.

Limitations

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This study is not without limitations. First, as an observational study, it cannot establish causality between sodium restriction and the observed outcomes. Second, adherence to the sodium-restricted diet was based on self-reported intake and may not have been fully accurate. Finally, the relatively small sample size and single-center design may limit the generalizability of the results. Future randomized controlled trials with larger cohorts and more rigorous dietary monitoring are needed to confirm these findings.

Conclusion

This study demonstrates that dietary sodium restriction in patients with stage 3-4 chronic kidney disease (CKD) leads to significant improvements in cardiovascular and renal outcomes. Patients on a sodium-restricted diet showed a substantial reduction in both systolic (12 mmHg) and diastolic (8 mmHg) blood pressure, along with a higher prevalence of left ventricular hypertrophy (LVH) regression (20% vs. 8%). The sodium-restricted group also experienced significantly fewer hospitalizations due to heart failure (6.7% vs. 20%) and a shorter average hospital stay (4 vs. 7 days). Moreover, the decline in kidney function, as measured by estimated glomerular filtration rate (eGFR), was slower in the sodium-restricted group (4.5 vs. 6.8 mL/min/1.73 m^2), suggesting a renoprotective effect. Importantly, the sodium-restricted diet did not result in significant electrolyte imbalances, and patients reported a marked improvement in their quality of life (15% vs. 8%).

These findings highlights the potential benefits of sodium restriction as a key dietary intervention for improving cardiovascular outcomes, preserving kidney function, and enhancing quality of life in patients with stage 3-4 CKD. Implementing sodium restriction as part of a comprehensive CKD management strategy could significantly reduce cardiovascular risks and hospitalizations, ultimately improving patient outcomes.

References

1.Kim SM, Jung JY. Nutritional management in patients with chronic kidney disease. Korean J Intern Med. 2020 Nov;35(6):1279-1290. doi: 10.3904/kjim.2020.408. Epub 2020 Sep 23. PMID: 32872726; PMCID: PMC7652660.

2.Doukky R, Avery E, Mangla A, Collado FM, Ibrahim Z, Poulin MF, Richardson D, Powell LH. Impact of Dietary Sodium Restriction on Heart Failure Outcomes. JACC Heart Fail. 2016 Jan;4(1):24-35. doi: 10.1016/j.jchf.2015.08.007. PMID: 26738949; PMCID: PMC4705447.

3.Humalda JK, Navis G. Dietary sodium restriction: a neglected therapeutic opportunity in chronic kidney disease. Curr Opin Nephrol Hypertens. 2014 Nov;23(6):533-40. doi: 10.1097/MNH.0000000000000073. PMID: 25222815; PMCID: PMC4189688.

4.McMahon EJ, Bauer JD, Hawley CM, Isbel NM, Stowasser M, Johnson DW, Campbell KL. A randomized trial of dietary sodium restriction in CKD. J Am Soc Nephrol. 2013 Dec;24(12):2096-103. doi: 10.1681/ASN.2013030285. Epub 2013 Nov 7. PMID: 24204003; PMCID: PMC3839553.

5.Rysz J, Franczyk B, Ciałkowska-Rysz A, Gluba-Brzózka A. The Effect of Diet on the Survival of Patients with Chronic Kidney Disease. Nutrients. 2017 May 13;9(5):495. doi: 10.3390/nu9050495. PMID: 28505087; PMCID: PMC5452225.

6.Wright JA, Cavanaugh KL. Dietary sodium in chronic kidney disease: a comprehensive approach. Semin Dial. 2010 Jul-Aug;23(4):415-21. doi: 10.1111/j.1525-139X.2010.00752.x. Epub 2010 Jun 14. PMID: 20557489; PMCID: PMC2921029.

7.Kang SC, Kang M, Ryu H, Kim S, Kim JH, Kang E, Jeong Y, Kim J, Kim YS, Kim SW, Kim YH, Oh KH. Measured sodium excretion is associated with cardiovascular outcomes in non-dialysis CKD patients: results from the KNOW-CKD study. Front Nephrol. 2023 Aug 25;3:1236177. doi: 10.3389/fneph.2023.1236177. PMID: 37675361; PMCID: PMC10479682.

8.Garofalo C, Borrelli S, Provenzano M, De Stefano T, Vita C, Chiodini P, Minutolo R, De Nicola L, Conte G. Dietary Salt Restriction in Chronic Kidney Disease: A

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Meta-Analysis of Randomized Clinical Trials. Nutrients. 2018 Jun 6;10(6):732. doi: 10.3390/nu10060732. PMID: 29882800; PMCID: PMC6024651.

9.Doukky R, Avery E, Mangla A, Collado FM, Ibrahim Z, Poulin MF, Richardson D, Powell LH. Impact of Dietary Sodium Restriction on Heart Failure Outcomes. JACC Heart Fail. 2016 Jan;4(1):24-35. doi: 10.1016/j.jchf.2015.08.007. PMID: 26738949; PMCID: PMC4705447.

10.Shi H, Su X, Li C, Guo W, Wang L. Effect of a low-salt diet on chronic kidney disease outcomes: a systematic review and meta-analysis. BMJ Open. 2022 Jan 11;12(1):e050843. doi: 10.1136/bmjopen-2021-050843. PMID: 35017237; PMCID: PMC8753423.

11.Borrelli S, Provenzano M, Gagliardi I, Michael A, Liberti ME, De Nicola L, Conte G, Garofalo C, Andreucci M. Sodium Intake and Chronic Kidney Disease. Int J Mol Sci. 2020 Jul 3;21(13):4744. doi: 10.3390/ijms21134744. PMID: 32635265; PMCID: PMC7369961.

12.Saran R, Padilla RL, Gillespie BW, Heung M, Hummel SL, Derebail VK, Pitt B, Levin NW, Zhu F, Abbas SR, Liu L, Kotanko P, Klemmer P. A Randomized Crossover Trial of Dietary Sodium Restriction in Stage 3-4 CKD. Clin J Am Soc Nephrol. 2017 Mar 7;12(3):399-407. doi: 10.2215/CJN.01120216. Epub 2017 Feb 16. PMID: 28209636; PMCID: PMC5338699.

13.McMahon EJ, Campbell KL, Bauer JD, Mudge DW, Kelly JT. Altered dietary salt intake for people with chronic kidney disease. Cochrane Database Syst Rev. 2021 Jun 24;6(6):CD010070. doi: 10.1002/14651858.CD010070.pub3. PMID: 34164803; PMCID: PMC8222708.

14.Jaques DA, Wuerzner G, Ponte B. Sodium Intake as a Cardiovascular Risk Factor: A Narrative Review. Nutrients. 2021 Sep 12;13(9):3177. doi: 10.3390/nu13093177. PMID: 34579054; PMCID: PMC8470268.

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Table No:1.Blood Pressure Control Data:

Parameter	Sodium-Restricted Group	Standard Diet Group	p-value
Systolic BP Decrease (mmHg)	12	4	< 0.001
Diastolic BP Decrease (mmHg)	8	2	< 0.01
Pulse Pressure Decrease (mmHg)	4	0	< 0.01

Table No:2 Left Ventricular Hypertrophy (LVH) and Left Ventricular Mass Index (LVMI) Data:

Parameter	Sodium-Restricted Group	Standard Diet Group	p-value
Prevalence of LVH Regression (%)	20	8	0.02
LVMI Reduction (g/m^2)	10	3	0.04

Table No:3 Heart Failure Hospitalization Data:

Parameter	Sodium-Restricted Group	Standard Diet Group	p-value
Hospitalization Rate (%)	6.7	20	0.004

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Average Length of Stay (days)	4	7	0.03

Table No:4 Kidney Function Data:

Parameter	Sodium-Restricted Group	Standard Diet Group	p-value
eGFR Decline (mL/min/1.73 m^2)	4.5	6.8	0.03

Table No:5.Electrolyte Levels Data:

Parameter	Sodium-Restricted Group	Standard Diet Group	p-value
Serum Sodium (mEq/L)	138	139	0.08
Potassium Levels (mEq/L)	4.3	4.4	0.11

Table No:6.Quality of Life Data:

Parameter	Sodium-Restricted Group	Standard Diet Group	p-value
Quality of Life Improvement (%)	15	8	< 0.01

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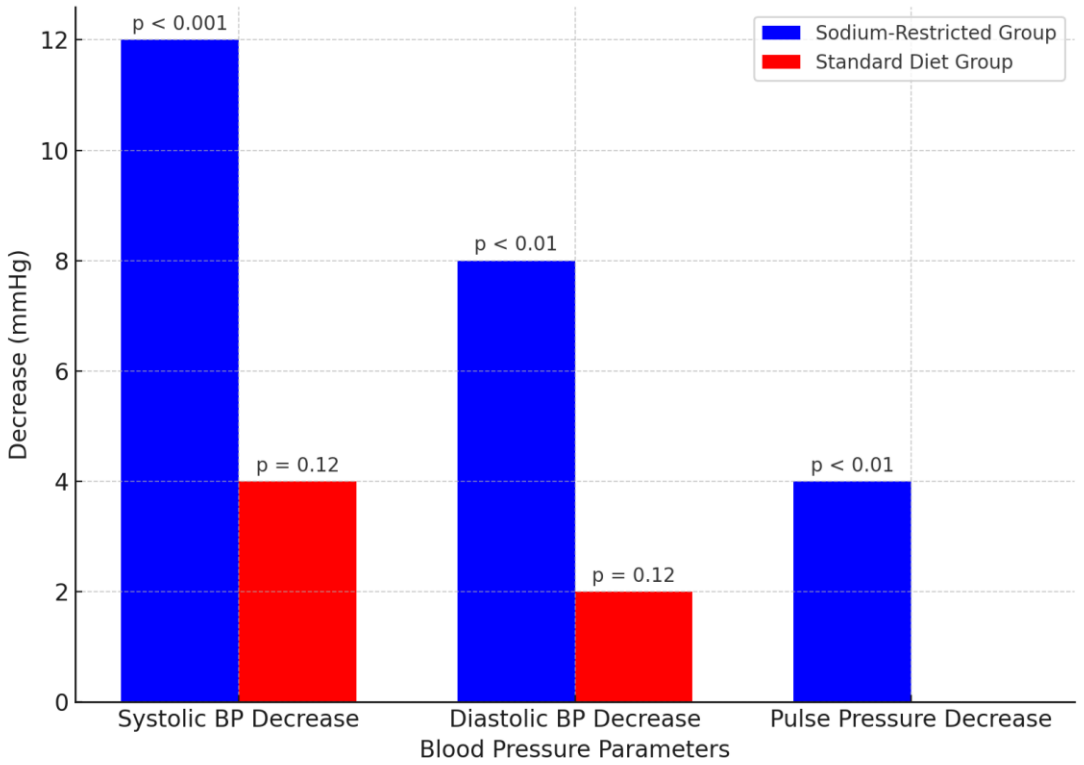

Figure No:1.Blood Pressure Control: Sodium -Restricted vs Standard Diet

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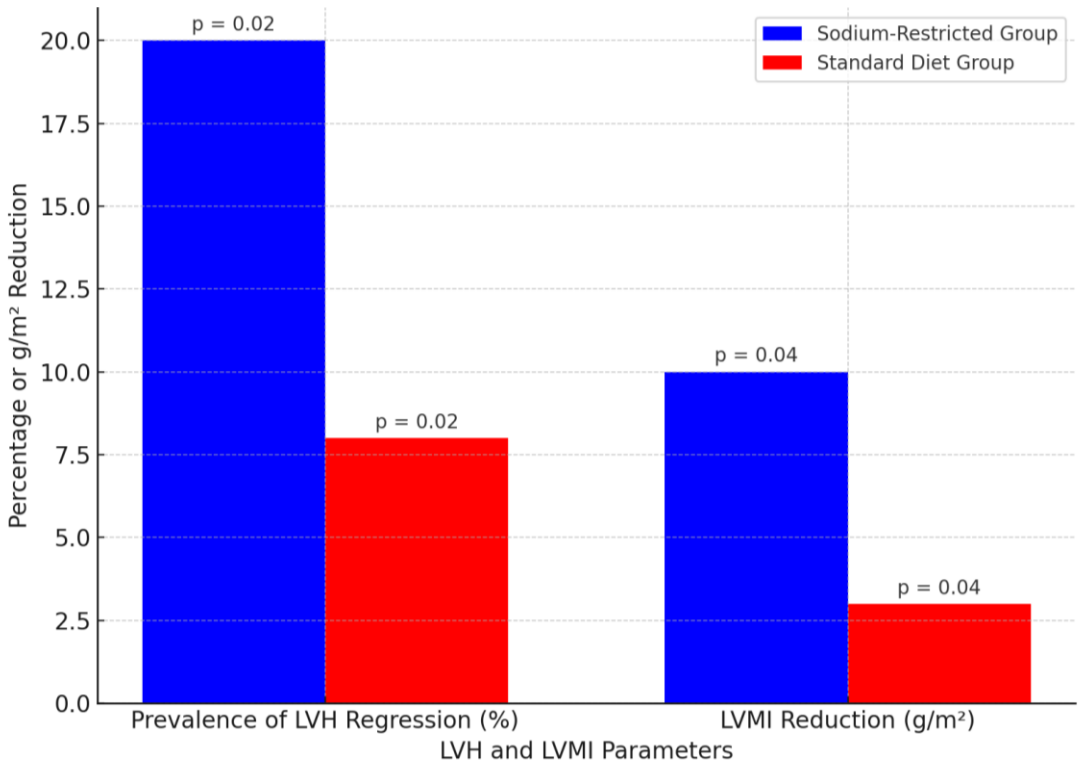

Figure No:2 LVH Regression and LVMI Reduction:Sodium-Restricted vs. Standard Diet

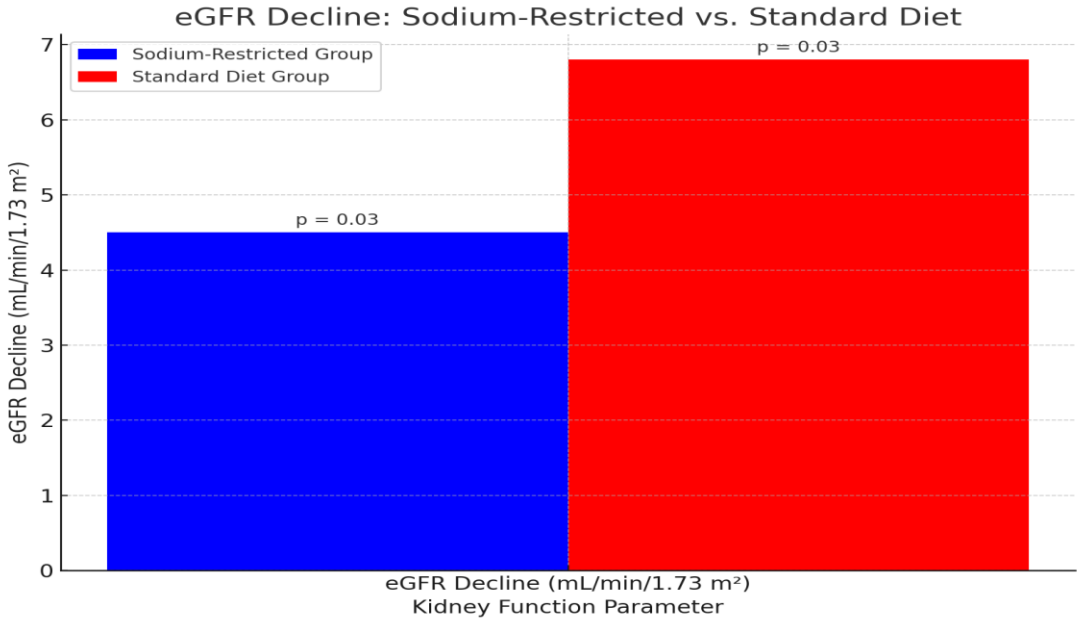

Figure No:3. eGFR Decline: Sodium-Restricted vs.Standard Diet

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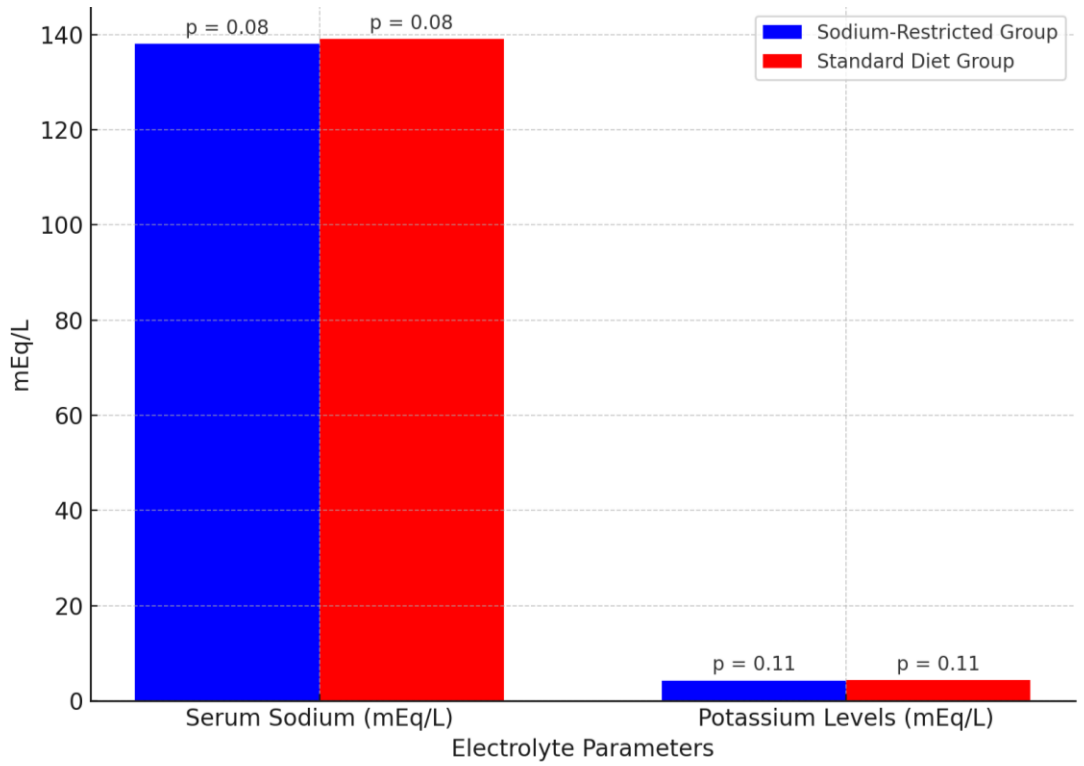

Figure No:4. Electrolyte Levels: Sodium-Restricted vs. Standard Diet