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Research Article

Sarcopenia as a Predictor of Diabetic Nephropathy: Evidence from a Cross-Sectional Study in Northeast India

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ABSTRACT

Background: Type 2 diabetes mellitus (T2DM) is a growing health challenge in South Asia, with diabetic nephropathy and sarcopenia emerging as critical comorbidities. Recent evidence suggests a bidirectional relationship between muscle loss and renal decline, but region-specific data remain limited.

Objective: To estimate and compare the prevalence of diabetic nephropathy among sarcopenic and non-sarcopenic patients with T2DM.

Methods: A cross-sectional study was conducted at Agartala Government Medical College and Govinda Ballabh Pant Hospital, Tripura, India, between January 2023 and December 2024. A total of 270 patients with T2DM were enrolled. Sarcopenia was diagnosed using CT-based skeletal muscle index (SMI) and functional measures, while diabetic nephropathy was assessed via eGFR and clinical criteria. Statistical analyses included chi-square tests, t-tests, and logistic regression, with $p < 0.05$ considered significant.

Results: Of 270 participants, 72 (26.7%) had sarcopenia, and 61 (22.6%) had diabetic nephropathy. Among patients with diabetic nephropathy, 55.7% were sarcopenic compared to 18.2% without diabetic nephropathy ($p < 0.001$). Significant differences were observed in muscle mass ($p = 0.003$), grip strength ($p = 0.006$), walking endurance ($p = 0.001$), mid-upper arm circumference ($p = 0.001$), and SMI ($p = 0.002$). Patients with diabetic nephropathy had markedly reduced eGFR (42.1 vs 97.2 mL/min/1.73 m², $p < 0.001$).

Conclusion: Sarcopenia and diabetic nephropathy are strongly interlinked in T2DM patients, forming a vicious cycle of muscle loss and renal decline. Routine assessment of muscle health may improve early risk stratification and guide preventive interventions, particularly in high-risk Northeastern populations.

Keywords: Type 2 Diabetes Mellitus, Sarcopenia, Diabetic Nephropathy, Prevalence, Comparison, Northeast India

INTRODUCTION

Type 2 diabetes mellitus (T2DM) is a major global health concern, with prevalence rising sharply in South Asia. Among its microvascular complications, diabetic nephropathy is particularly significant, leading to progressive renal impairment, albuminuria, and eventual end-stage renal disease (ESRD). Diabetic nephropathy

accounts for nearly one-third of ESRD cases worldwide, making it a leading cause of dialysis and transplantation.[1,2] Despite advances in glycemic management and renoprotective therapies that have significantly improved outcomes for diabetes-related complications such as cardiovascular disease, similar progress has not been achieved for Diabetic nephropathy or ESRD. This finding highlights the urgent need for better risk stratification and earlier detection strategies.[3]

Sarcopenia in Diabetes

Sarcopenia is characterised by the progressive loss of skeletal muscle mass, strength, and function, and was traditionally considered a geriatric syndrome. However, recent evidence shows that sarcopenia is highly prevalent among patients with T2DM, with estimates ranging from 7% to 31% depending on diagnostic criteria and population studied.[4] Persistent hyperglycemia in uncontrolled T2DM leads to microvascular injury within intraneural capillaries, impairing nerve perfusion. The consequent sensory loss, neuropathic pain, and muscle weakness contribute to rapid muscle wasting, with diabetic neuropathy emerging as a key determinant of sarcopenia onset and progression.[5]

Interplay Between Sarcopenia and Diabetic Nephropathy

Emerging studies highlight a bidirectional relationship between sarcopenia and diabetic nephropathy. A large hospital-based cohort in China demonstrated that baseline sarcopenia significantly increased the risk of incident diabetic nephropathy, while baseline diabetic nephropathy predicted subsequent sarcopenia, with hazard ratios exceeding 1.5 in both directions.[6] Similarly, a Mendelian randomisation study confirmed that genetically determined low appendicular lean mass predisposes to diabetic nephropathy, whereas diabetic nephropathy progression was associated with reduced grip strength, reinforcing the causal interplay between these conditions.[7]

Clinical observations further support this link. Osaka and Fukui (2023) found that diabetic patients with sarcopenia had much higher rates of nephropathy progression than those without muscle loss.[8] In the same way, Huang et al. showed that sarcopenia raises the risk of diabetic nephropathy progression, which shows its importance as a prognostic factor.[9]

Regional Relevance

South Asian populations, especially in Northeast India, have higher rates of metabolic syndrome, insulin resistance, and hyperuricemia than Western groups.[10] These factors increase the risk of both sarcopenia and diabetic nephropathy. However, there is little region-specific data, particularly from Northeast India, where diet, genetics, and other health conditions may affect the prevalence and severity of these problems. Filling this gap is important for creating better interventions and improving health outcomes for people at high risk.

Rationale for the Present Study

While many investigations have examined sarcopenia as a predictor of diabetic outcomes, few have systematically quantified the proportion of diabetic nephropathy among sarcopenic versus non-sarcopenic patients.[11] Understanding this prevalence is essential for clarifying sarcopenia's role as a biomarker and for guiding clinical decision-making.

Study Objective

The primary objective of this study was to estimate and compare the prevalence of Diabetic Nephropathy among Sarcopenic and non-Sarcopenic study populations, thereby contributing evidence to support the integration of muscle health assessment into routine diabetic care.

MATERIALS AND METHODS

Study Design and Setting:

The investigation adopted a cross-sectional, descriptive approach and was conducted in the Department of Medicine at Agartala Government Medical College and Govinda Ballabh Pant Hospital (AGMC and GBPH), located in Agartala, Tripura, India.

Study Duration:

The study spanned two years, from January 2023 through December 2024.

Study Population:

Participants included patients with T2DM who were admitted to the Medicine Department at AGMC during the study tenure.

Inclusion Criteria

1. Patients with a confirmed diagnosis of T2DM.
2. Patients admitted to the Department of Medicine at AGMC.
3. Patients who agreed to provide written informed consent to participate in the study.

Exclusion Criteria

1. Pregnant or breastfeeding women.
2. Patients with end-stage chronic kidney disease (CKD-ESRD) undergoing hemodialysis.
3. Critically ill individuals requiring life support.
4. Patients with chronic obstructive pulmonary disease (COPD).
5. Patients diagnosed with liver cirrhosis, malignancy, or HIV infection.
6. Patients with other medical conditions known to predispose to sarcopenia.
7. Patients who declined to provide consent for participation.

Sample size: A total of 270 participants were included in this study.

Study Tool:

A structured case record form, which had been pretested for reliability, was utilised to capture the socio-demographic details, clinical profiles, and laboratory findings of all study participants.

Method of Data Collection:

Data were collected systematically to ensure validity and reliability. Patients with type 2 diabetes mellitus admitted to the Department of Medicine at AGMC were screened according to predefined inclusion and exclusion criteria. Eligible individuals were informed about the study objectives, procedures, and potential risks, and written consent was obtained prior to enrolment.

Once enrolled, participants completed a multi-stage evaluation. Sociodemographic data, medical history, diabetes duration, treatment practices, and comorbidities were recorded using a pretested, structured case record form. Clinical examinations evaluated general and systemic health, with emphasis on sarcopenia-related parameters. The Body Mass Index (BMI) was calculated from anthropometric measurements, including height and weight.

Radiological assessment of muscle mass was performed using non-contrast CT imaging (Siemens 128-slice scanner). Axial sections at the L3–L4 vertebral level were analysed to quantify skeletal muscle area (SMA) and skeletal muscle index (SMI), applying established density thresholds and sex-specific cutoffs for sarcopenia diagnosis.

All patient informations (history, clinical findings, imaging results, and laboratory data) was consistently documented in the case record pro forma, ensuring accuracy, confidentiality, and adherence to ethical standards.

Data Management:

Case record proformas were compiled into a spreadsheet to generate a master chart for analysis. Statistical evaluation was performed using SPSS (version 25.0). Categorical variables were expressed as percentages, while continuous variables were summarised as means with standard deviations. Group comparisons were performed using the chi-square test for proportions and the Student's t-test for means. Conditional logistic regression was applied to identify predictors of key outcomes, incorporating variables significant in univariate analysis. A p-value of <0.05 was considered statistically significant.

Ethical Considerations:

Written informed consent was obtained from all participants, and confidentiality was strictly maintained. Approval for the study protocol was granted by the Ethics Committee of AGMC. Permission was also secured from the Medical Superintendent to provide free CT scans for patients not covered under ABPMJAY. All patients received appropriate medical care irrespective of study participation.

RESULTS

The study included 270 participants, of whom 72 (26.7%) were identified as having sarcopenia, while the remaining 198 (73.3%) did not exhibit the condition. Gender-specific analysis showed that among the 131 women, sarcopenia was present in 38 (52.8%), while 93 (47%) were unaffected.

Figure 1 shows the distribution of study participants based on whether they had diabetic nephropathy. Of the total sample of 270 individuals, 61 (22.6%) had diabetic nephropathy, while the remaining 209 (77.4%) did not show evidence of the condition.

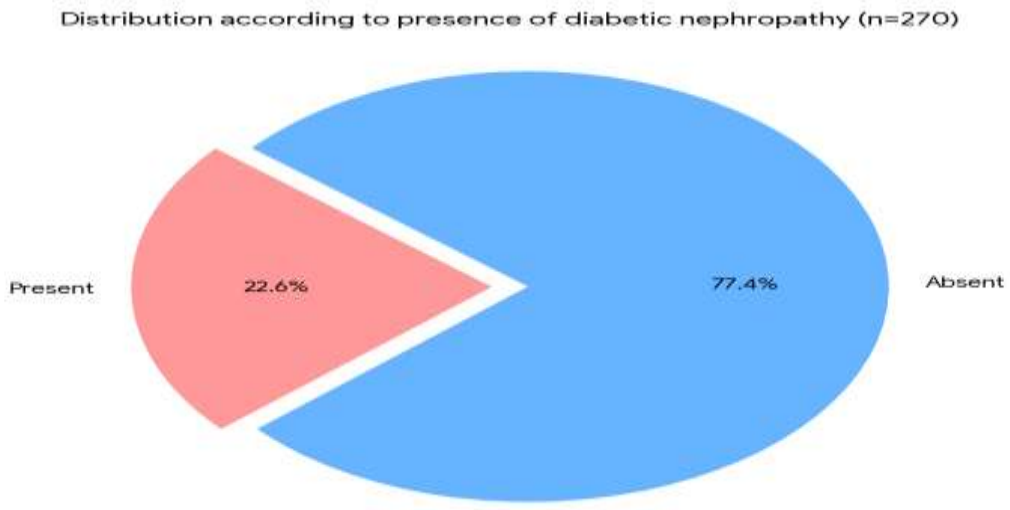
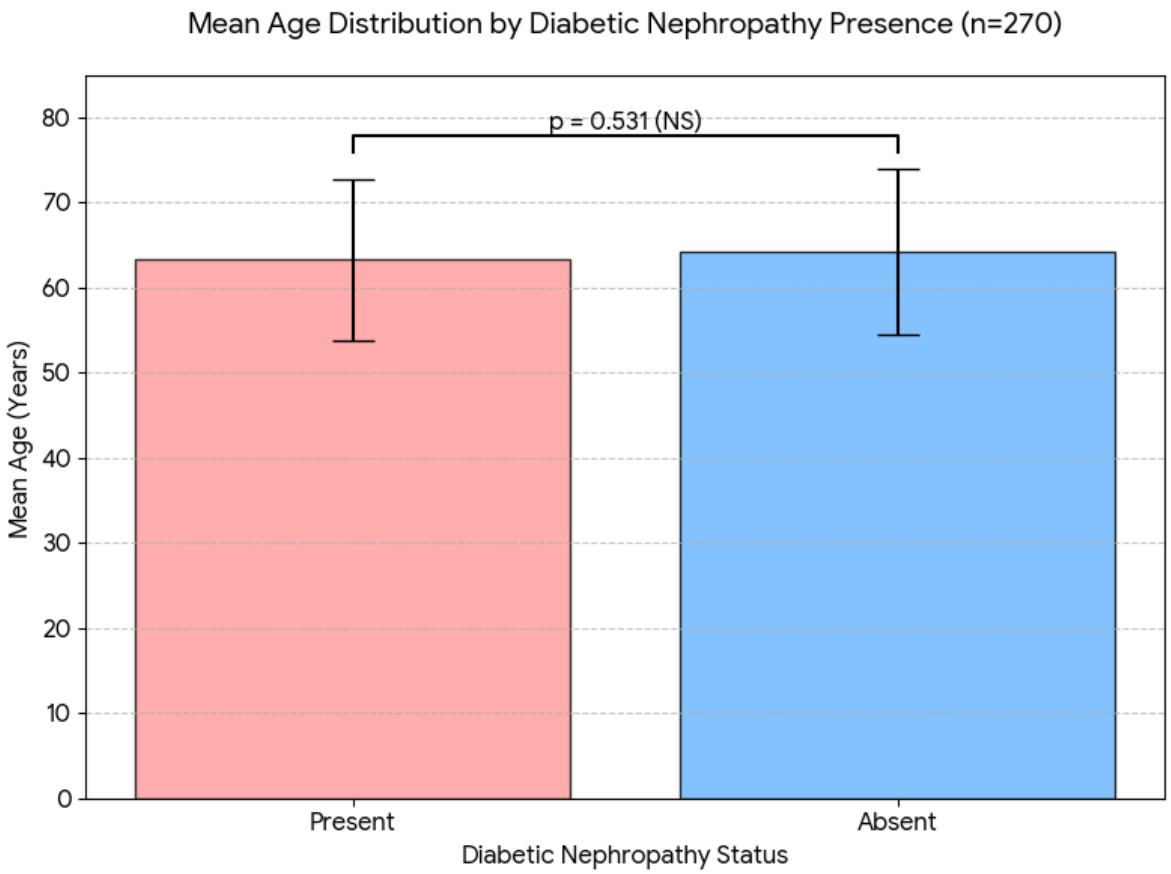


Figure 1: Distribution of Study Participants According to the Presence of Diabetic Nephropathy

Figure 2 demonstrates the relationship between age and the presence of diabetic nephropathy among the study participants. The mean age with diabetic nephropathy was 63.3 years (SD = 9.5), whereas those without nephropathy had a slightly higher mean age of 64.2 years (SD = 9.7). When considering the entire study population, the average age was 64.1 years (SD = 9.6). The statistical comparison between the two groups yielded a p-value of 0.531.



*NS=Not significant

Figure 2: Age distribution of the study participants based on the presence of diabetic nephropathy

Figure 3 illustrates the distribution of diabetic nephropathy among male and female participants. Out of the 131 women in the study, 33 (54.1%) were diagnosed with diabetic nephropathy, while 98 (46.9%) did not have the condition. Among the 139 men, 28 (45.9%) had nephropathy, whereas 111 (53.1%) were free from it. Overall, 61 participants (22.6%) presented with diabetic nephropathy, and 209 (77.4%) did not, for a total sample of 270 individuals. The statistical comparison between sexes yielded a p-value of 0.322.

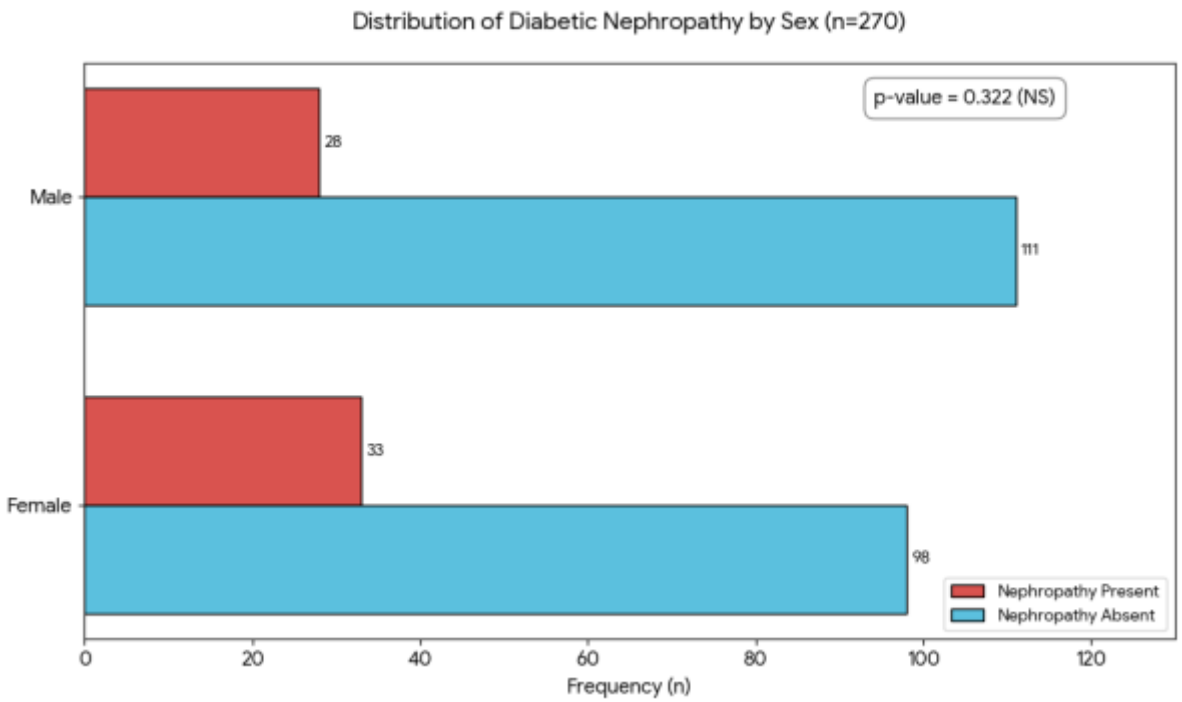


Figure 3: Horizontal Distribution of Diabetic Nephropathy by Sex

Figure 4 demonstrates the distribution of diabetic nephropathy across different socioeconomic status (SES) categories. Among the participants, 19 individuals (31.1%) from Class I were diagnosed with nephropathy, while 59 (28.2%) did not have the condition, making a total of 78 participants in this category. In Class II, 10 participants (16.4%) had nephropathy, compared with 57 (27.3%) without, for a total of 67 individuals. In Class III, 17 participants (27.9%) were affected, while 53 (25.4%) were unaffected, for a total of 70. In Class IV, 15 participants (24.6%) had nephropathy, whereas 40 (19.1%) did not, for a total of 55 individuals. No participants were recorded in Class V. In total, 61 participants (22.6%) had diabetic nephropathy, while 209 (77.4%) did not, across the total sample of 270 individuals. The statistical comparison yielded a p-value of 0.363.

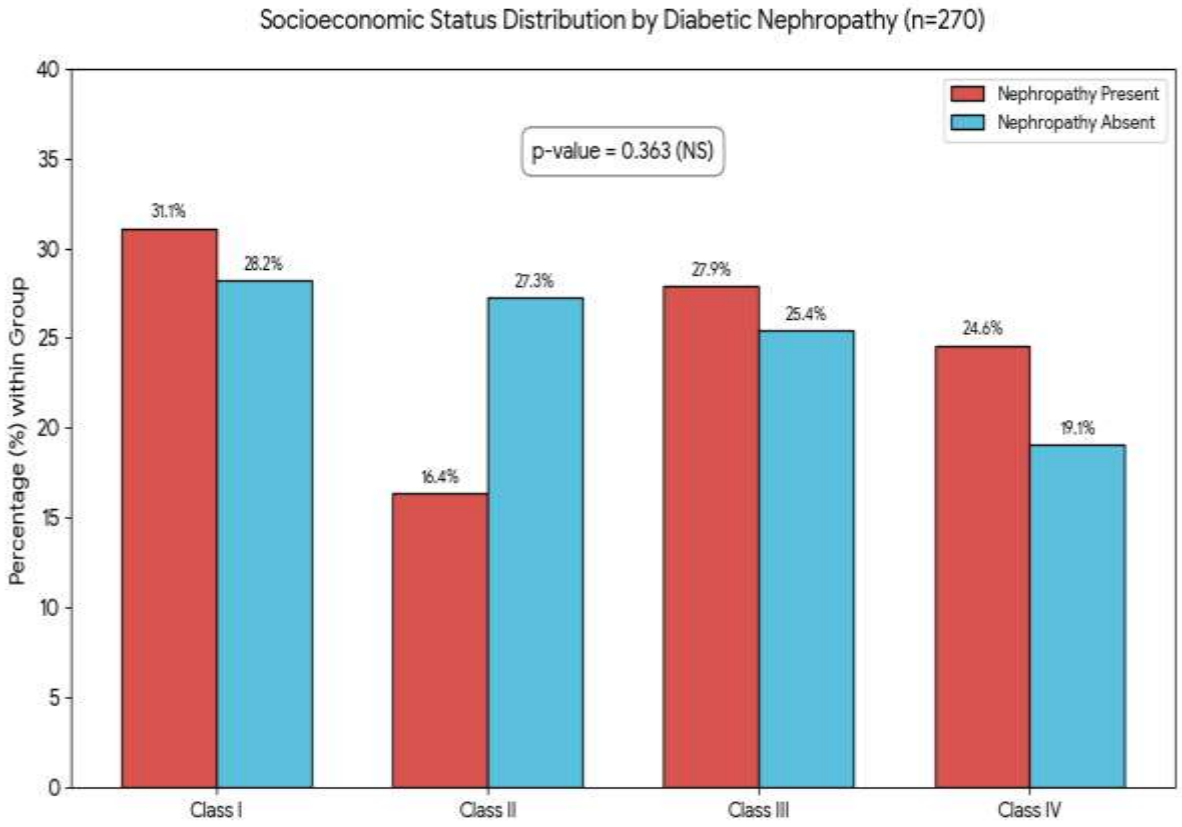


Figure 4: Percentage Distribution of Diabetic Nephropathy Status According to Socioeconomic Status

Figure 5 shows how diabetic nephropathy was distributed among participants by aDSCI (adjusted Diabetes Severity and Complications Index) score. Among those with nephropathy, the largest proportion was observed in individuals with a score of 2 (32.8%), followed by those with a score of 1 (29.5%). Smaller proportions were noted in participants with scores of 0 (21.3%), 3 (11.5%), and 4 (4.9%).

In comparison, among participants without nephropathy, the highest frequency was found in those with a score of 1 (41.1%), followed by scores of 0 (23.9%) and 2 (23.9%). Only 7.7% had a score of 3, and 3.3% had a score of 4.

Overall, across the total study population of 270 individuals, 104 participants (38.5%) had a score of 1, 70 (25.9%) had a score of 2, 63 (23.3%) had a score of 0, 23 (8.5%) had a score of 3, and 10 (3.7%) had a score of 4. The statistical comparison between groups yielded a p-value of 0.360.

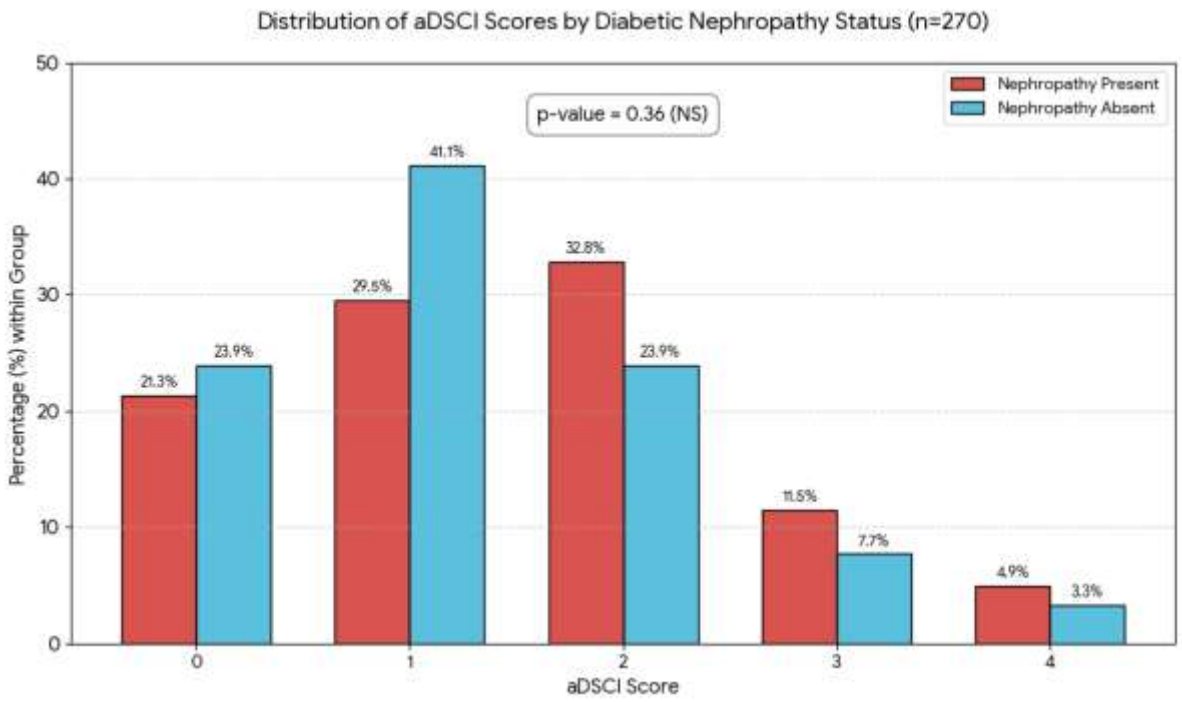
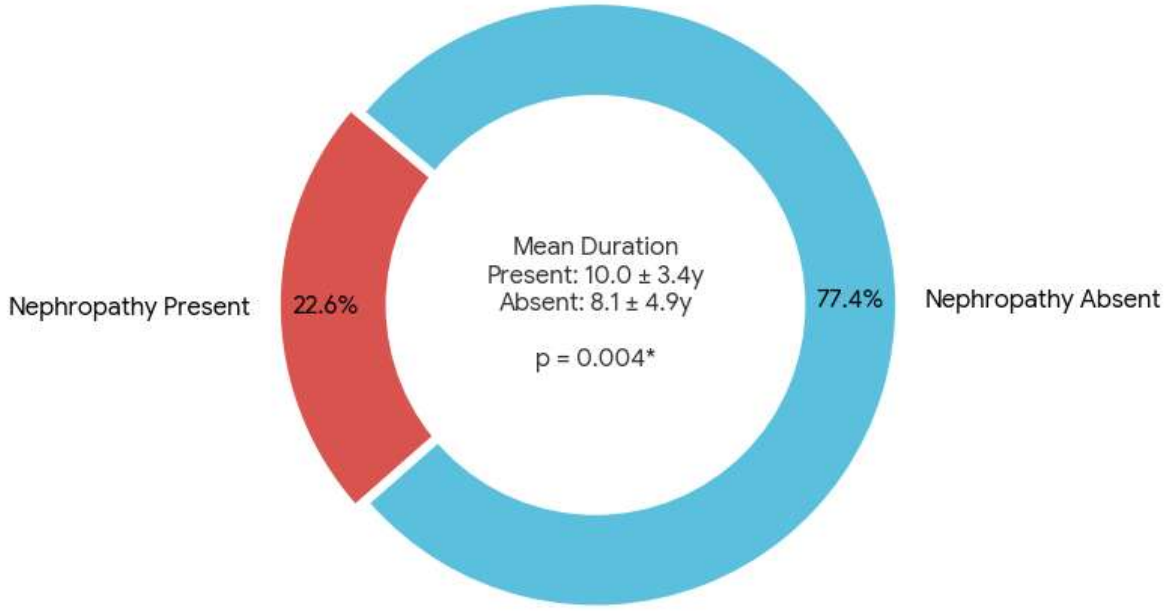


Figure 5: Percentage Distribution of aDSCI Scores According to Diabetic Nephropathy Status

Figure 6 shows the correlation between diabetes duration and the presence of diabetic nephropathy among study participants. The mean duration of diabetes with nephropathy was 10 years (SD = 3.4), notably longer than the mean duration of 8.1 years (SD = 4.9) observed in those without nephropathy. When considering the entire study population, the average duration of diabetes was 8.5 years (SD = 4.7). The statistical analysis produced a p-value of 0.004.



*y=years

Figure 6: Distribution of Diabetes Duration by Nephropathy Status

Figure 7 presents the comparison of various anthropometric parameters between participants with and without diabetic nephropathy. The mean BMI was almost identical across groups,

with 31.9 kg/m² (SD = 5.9) in those with nephropathy and 31.7 kg/m² (SD = 5.5) in those without, showing no significant difference (p = 0.737).

For thigh circumference, individuals with nephropathy had a slightly higher mean (38.6 cm, SD = 6.4) than those without (37.2 cm, SD = 4.9), but this difference was not statistically significant (p = 0.086). Similarly, waist circumference was marginally greater in the nephropathy group (107.6 cm, SD = 11.4) compared to the non-nephropathy group (105.4 cm, SD = 10.3), but the difference was not statistically significant (p = 0.159). Hip circumference values were almost similar between groups (106.7 cm vs. 106.8 cm), with no meaningful difference (p = 0.953).

A notable finding was observed in mid-upper arm circumference (MUAC), with participants with nephropathy having a lower mean (31.3 cm, SD = 4.9) than those without (34.1 cm, SD = 5.8). This difference was statistically significant (p = 0.001). Finally, skin thickness was identical across both groups (27.4 mm) with no significant variation (p = 0.987).

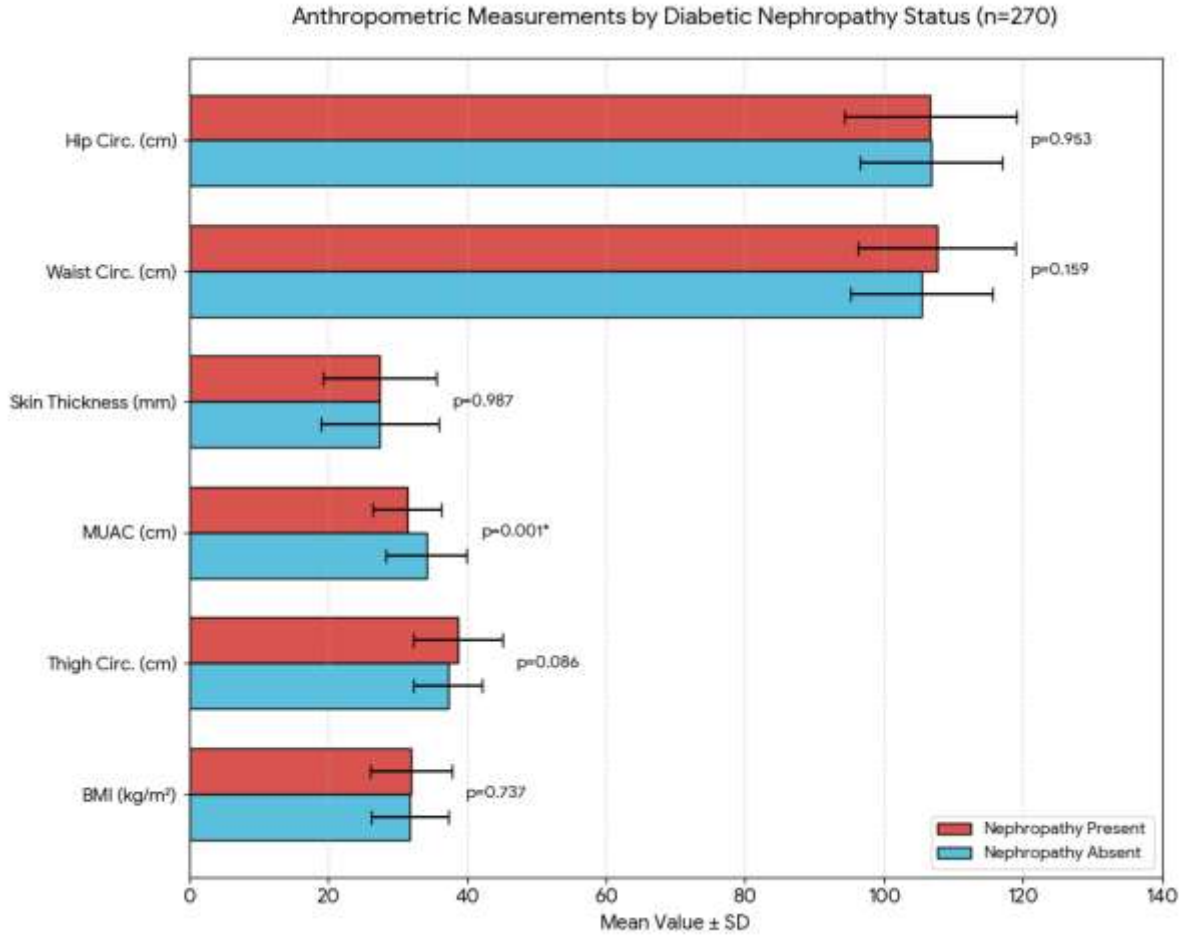


Figure 7: Comparison of Anthropometric Measurements by Diabetic Nephropathy Status

Figure 8 compares sarcopenia-related parameters between participants with and without diabetic nephropathy. The overall fat percentage was similar in both groups, with means of 37.2% (SD = 10.8) in those with nephropathy and 37.6% (SD = 10.2) in those without, showing no significant difference (p = 0.840).

In contrast, visceral fat percentage was significantly lower among participants with nephropathy (11.2%, SD = 2.4) than among those without (12.8%, SD = 3.4), with a p-value of 0.001, indicating a meaningful difference.

For muscle mass percentage, values were nearly identical (27.8%, SD = 5.2 vs 28.2%, SD = 4.7); the difference was not statistically significant (p = 0.600). However, when considering total muscle mass (kg), individuals with nephropathy had a lower mean (8.4 kg, SD = 1.7) compared to those without (9.1 kg, SD = 1.4), and this difference was statistically significant (p = 0.003).

Functional measures also showed notable differences. Hand grip strength was reduced in the nephropathy group (19.2 kg, SD = 8.4) compared to the non-nephropathy group (23.2 kg, SD = 10.4), with a significant p-value of 0.006. Similarly, the walking period was shorter among those with nephropathy (7.5 minutes, SD = 2.8) compared to those without (11.6 minutes, SD = 3.8), and this difference was highly significant (p = 0.001).

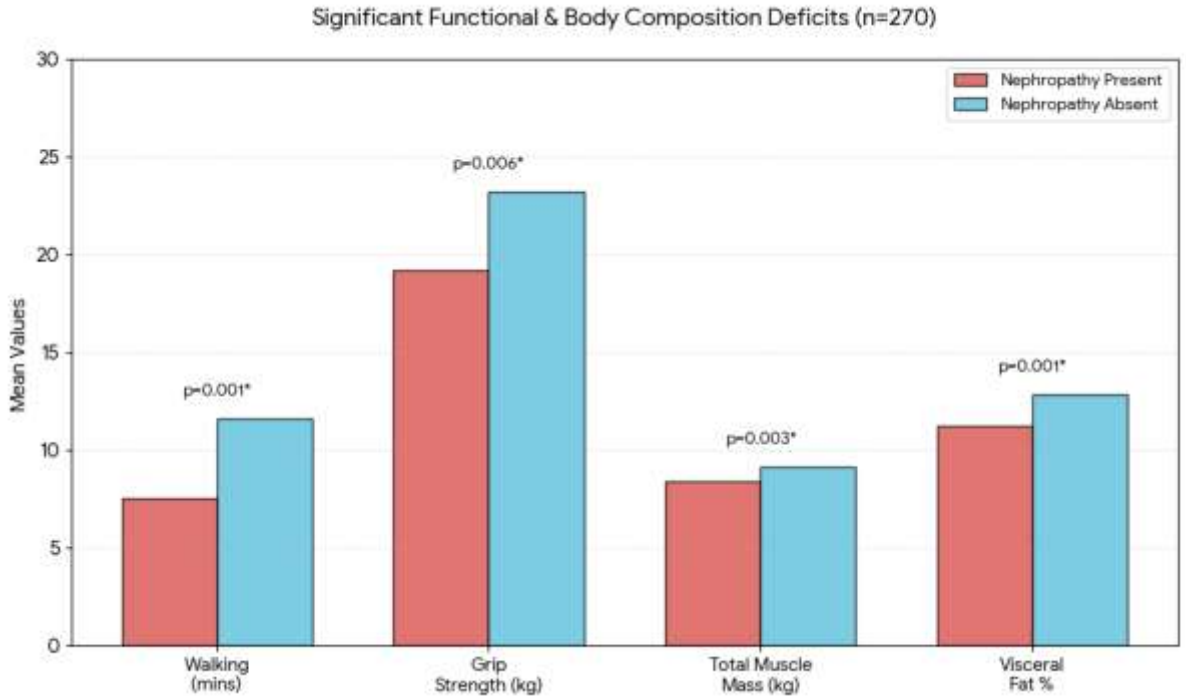


Figure 8: Comparison of Significant Functional and Body Composition Deficits

Figure 9 compares the estimated glomerular filtration rate (eGFR) between participants with and without diabetic nephropathy. The mean eGFR among patients with nephropathy was 42.1 mL/min/1.73 m² (SD = 14.1), which was substantially lower than the mean eGFR of 97.2 mL/min/1.73 m² (SD = 5.4) observed in those without nephropathy. For the overall study population, the average eGFR was 84.8 mL/min/1.73 m² (SD = 24.5). The statistical analysis showed a p-value of <0.001.

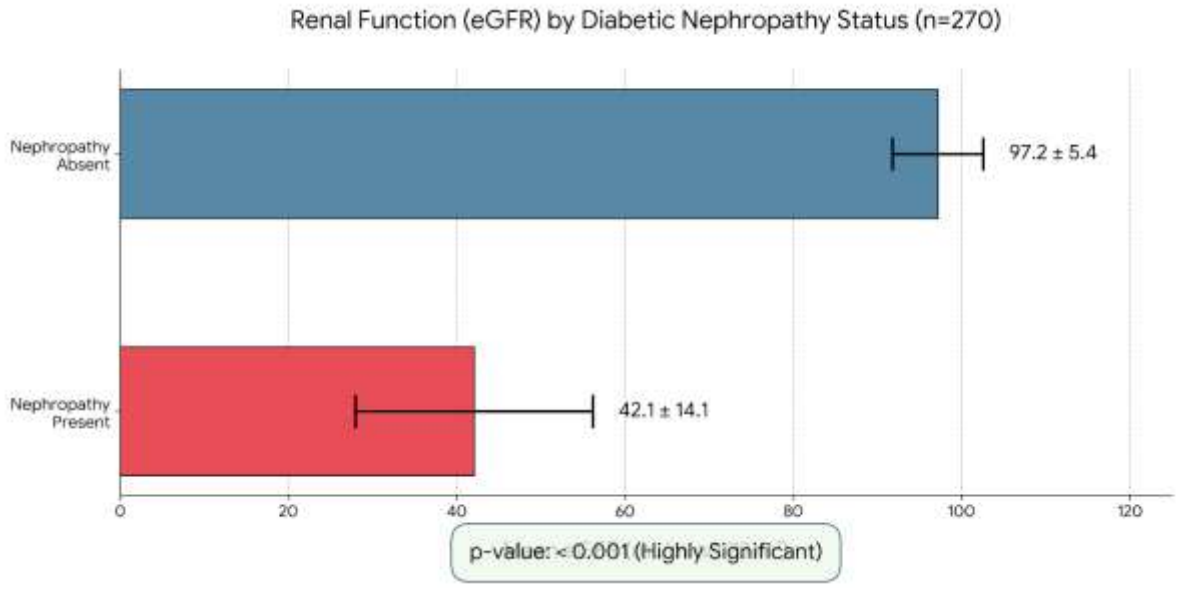


Figure 9: Comparison of Renal Function (eGFR) by Diabetic Nephropathy Status

Figure 10 compares skeletal muscle measurements between participants with and without diabetic nephropathy. The mean SMA was very similar across groups, with 119.4 cm² (SD = 25.4) in individuals with nephropathy and 120.2 cm² (SD = 26.1) in those without. For the overall study population, the average SMA was 120.1 cm² (SD = 25.8). The difference was not statistically significant (p = 0.835).

In contrast, the SMI showed a notable difference. Participants with nephropathy had a lower mean SMI of 38.6 (SD = 5.7) compared to 41.2 (SD = 6.1) in those without nephropathy. The overall mean SMI for the study population was 40.6 (SD = 6.1). This difference was statistically significant (p = 0.002).

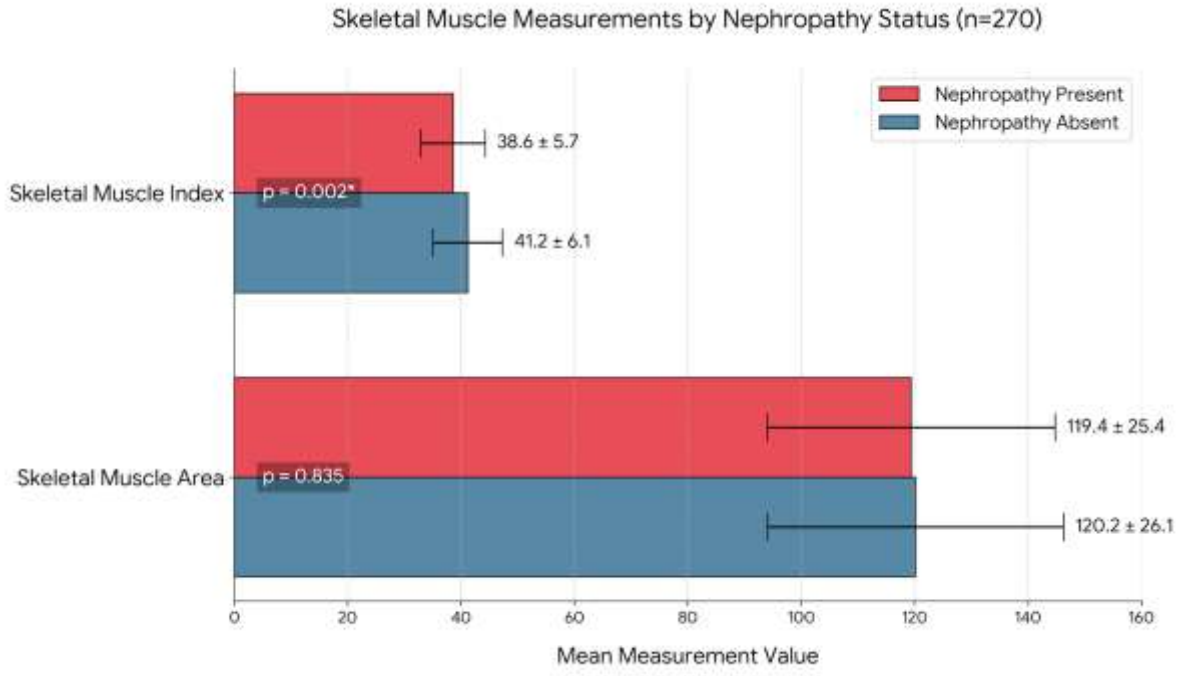


Figure 10: Comparison of Skeletal Muscle Area and Index by Diabetic Nephropathy Status

Figure 11 outlines the relationship between sarcopenia and diabetic nephropathy in the study population. Among the 61 participants with nephropathy, 34 individuals (55.7%) also had sarcopenia, while 27 (44.3%) did not. In contrast, among the 209 participants without nephropathy, only 38 (18.2%) were sarcopenic, whereas the majority, 171 (81.8%), were free of sarcopenia.

Overall, across the total sample of 270 participants, 72 individuals (26.7%) were diagnosed with sarcopenia, while 198 (73.3%) did not have the condition. The statistical analysis produced a p-value of <0.001.

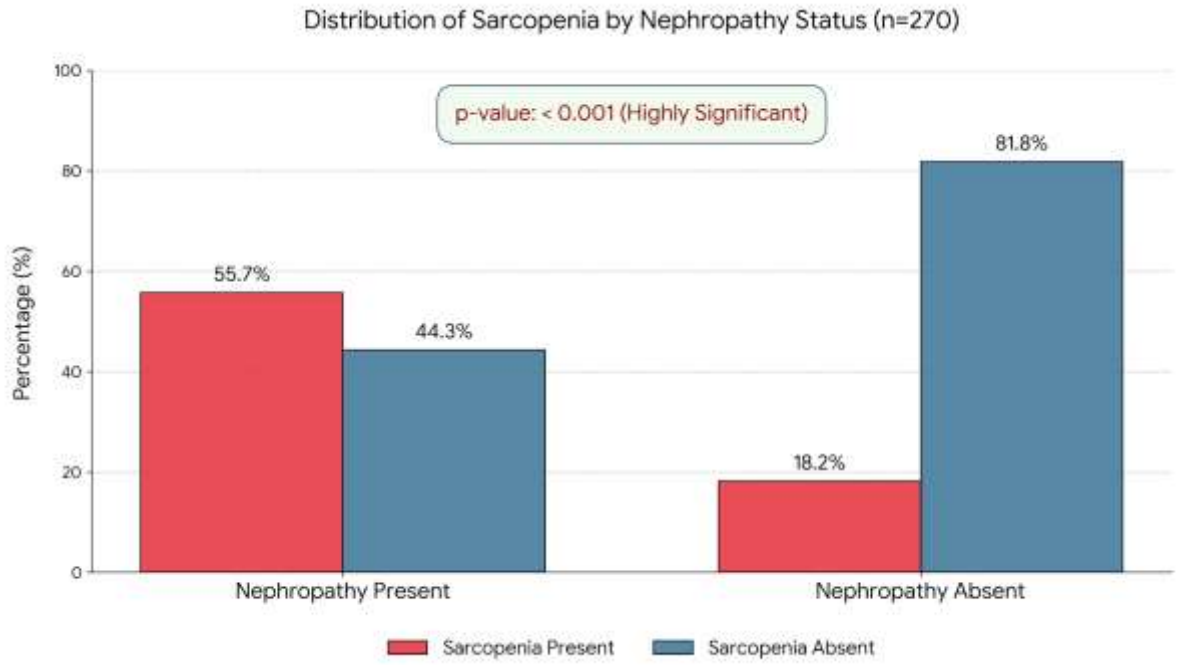


Figure 11: Distribution of Sarcopenia by Diabetic Nephropathy Status

DISCUSSION

Sarcopenia and Diabetic Nephropathy: Bidirectional Risk

The present study demonstrated that 55.7% of patients with diabetic nephropathy also had sarcopenia, compared to only 18.2% among those without nephropathy, a highly significant association ($p < 0.001$). This finding aligns with recent evidence that sarcopenia is not merely a geriatric condition but a critical comorbidity in T2DM. Huang et al. reported that sarcopenia independently predicts severe diabetic nephropathy, even after adjusting for confounders such as age, sex, and glycemic control.[9] Similarly, Wu et al. confirmed a bidirectional association, showing that nephropathy progression reduces muscle strength while sarcopenia predisposes to renal decline.[6]

Functional and Anthropometric Deficits

Our results revealed significant reductions in grip strength ($p = 0.006$), walking endurance ($p = 0.001$), and total muscle mass ($p = 0.003$) among patients with nephropathy. These findings are consistent with Bai et al., who observed that sarcopenia in T2DM patients correlates with vascular and renal complications, suggesting that muscle weakness may serve as an early biomarker of systemic microvascular damage.[12] The reduced mid-upper arm circumference ($p = 0.001$)

further supports the notion that anthropometric deficits can serve as simple, cost-effective screening tools in resource-limited settings.

Renal Function and Muscle Health

Renal function assessment revealed a substantial reduction in eGFR among patients with nephropathy (42.1 mL/min/1.73 m²) compared with those without nephropathy (97.2 mL/min/1.73 m²; $p < 0.001$), accompanied by a significantly lower SMI ($p = 0.002$). This reinforces the hypothesis that renal dysfunction accelerates muscle wasting through metabolic acidosis, inflammation, and reduced protein synthesis. Recent mechanistic studies by Chen et al. suggest that mitochondrial dysfunction in nephropathy diminishes energy production, thereby triggering sarcopenia.[13] Thus, renal impairment and muscle loss appear to form a vicious cycle that worsens patient outcomes.

Regional Relevance

People in South Asia, which includes Northeast India, are more likely to develop early-onset diabetes and metabolic problems even at lower body mass index levels than people in Western countries.[14] In Tripura, 26.7% of diabetic patients have sarcopenia, which matches other regional findings showing higher risks of insulin resistance and kidney issues. These findings suggest that screening protocols in this region should include assessment for muscle health as part of diabetes care.

Clinical and Public Health Implications

Recent research shows that sarcopenia might help predict diabetic nephropathy. Adding muscle-strength and mass checks to regular diabetes care could help identify high-risk patients sooner. Exercise, better nutrition, and good blood sugar control may slow both conditions. Because of differences in socioeconomic status among patients, public health programs should focus on helping those most at risk.

Limitations

- **Cross-sectional setting:** Given its cross-sectional methodology, the study cannot establish causality between sarcopenia and diabetic nephropathy.
- **Single-centre setting:** Conducted at one tertiary hospital in Tripura, limiting generalizability to broader Northeastern populations.
- **Diagnostic criteria:** Sarcopenia was assessed using CT imaging and functional measures, which may not fully capture dynamic changes in muscle health.
- **Exclusion criteria:** Patients with comorbidities such as COPD, cirrhosis, or malignancy were excluded, potentially underestimating sarcopenia prevalence in real-world diabetic populations.
- **Socioeconomic and lifestyle factors:** Dietary habits, physical activity, and genetic predispositions were not comprehensively analysed, though they may influence both sarcopenia and nephropathy risk.
- **Smaller sample size:** While adequate for statistical analysis, larger multicentric studies are needed to validate findings across diverse populations.

CONCLUSION

This study provides robust evidence that sarcopenia and diabetic nephropathy are mutually reinforcing conditions in T2DM patients. The findings emphasise the importance of muscle health assessment as a routine component of diabetic care, particularly in Northeastern populations where metabolic risks are disproportionately high. Future longitudinal research should explore whether early interventions targeting sarcopenia can delay or prevent nephropathy progression, thereby reducing the burden of ESRD in the region.

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