ORIGINAL RESEARCH

Early Detection of Kidney Dysfunction Using Microalbuminuria and GFR in Diabetic and Hypertensive Individuals

Iram Hamid[1], Vinitha Ramanath Pai[2]

[1]Demonstrator, Department of Biochemistry, Govt. Medical College, Srinagar, Kashmir, India
[2]Professor, Department of Biochemistry, Yenepoya Medical College, Mangalore, India

Corresponding author
Iram Hamid
Demonstrator, Department of Biochemistry, Govt. Medical College, Srinagar, Kashmir, India
Email: Iramhamidsgr33@gmail.com

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ABSTRACT

Background: Diabetes mellitus (DM) and hypertension (HTN) are major risk factors for chronic kidney disease (CKD). Early detection of kidney dysfunction in these patients is crucial for timely intervention. Microalbuminuria and glomerular filtration rate (GFR) are established biomarkers for assessing renal impairment, but their comparative effectiveness in early detection among patients with DM and HTN needs further evaluation. **Aim:** This study aims to assess the utility of microalbuminuria and GFR for detecting early kidney function changes in individuals with DM and HTN compared to healthy controls. **Methods:** A cross-sectional study included 160 patients with DM and HTN (cases) and 160 healthy individuals (controls). Microalbuminuria was measured using the urinary albumin-to-creatinine ratio (UACR), and GFR was estimated using the Cockcroft-Gault formula. Statistical analyses, including t-tests and chi-square tests, were used to compare biomarker levels between groups. Post hoc analyses examined subgroup differences. **Results:** Patients with DM and HTN showed significantly higher levels of microalbuminuria (175.3 ± 82.4 mg/g) compared to controls (18.2 ± 9.1 mg/g, $p<0.001$) and significantly lower GFR (68.4 ± 12.6 mL/min/1.73m²) compared to controls (95.2 ± 15.3 mL/min/1.73m², $p<0.001$). A moderate positive correlation was found between HbA1c levels and microalbuminuria ($r = 0.62$, $p<0.001$), and a moderate negative correlation between HbA1c and GFR ($r = -0.57$, $p<0.001$). Longer diabetes duration and higher blood pressure levels were associated with greater microalbuminuria and lower GFR. **Conclusion:** Microalbuminuria and GFR are effective markers for early detection of kidney dysfunction in patients with DM and HTN. Regular monitoring of these biomarkers is essential for early diagnosis and management. Rigorous control of glycemic and blood pressure levels is crucial to prevent kidney damage.

Keywords: Diabetes Mellitus, Hypertension, Microalbuminuria, Glomerular Filtration Rate, Kidney Function, Early Detection

INTRODUCTION

Chronic kidney disease (CKD) is a major global health issue, particularly among individuals with diabetes mellitus (DM) and hypertension (HTN), which are the two leading causes of CKD. These conditions contribute significantly to CKD development and progression, leading to end-stage renal disease (ESRD), cardiovascular complications, and increased healthcare costs. Early detection and management of renal dysfunction are critical for slowing disease progression and improving patient outcomes. Microalbuminuria (MAU) and glomerular filtration rate (GFR) are key markers used for early detection of kidney dysfunction.Diabetes mellitus, especially type 2 diabetes (T2DM), is a major risk factor for CKD. Diabetic nephropathy, a common complication of T2DM, involves progressive renal damage and can lead to kidney failure if not managed effectively. Chronic hyperglycemia causes structural and functional changes in the kidneys, including glomerular hyperfiltration, glomerulosclerosis, and thickening of the glomerular basement membrane (GBM) [1,2]. These changes result in proteinuria, which can progress from microalbuminuria to macroalbuminuria as the disease advances [3].Microalbuminuria, defined as 30 to 300 mg of albumin per day in urine, is an early marker of diabetic nephropathy. It reflects subtle glomerular damage before overt proteinuria develops. Studies have shown that microalbuminuria is associated with an increased risk of cardiovascular events in diabetic patients [4,5]. The detection of microalbuminuria is

typically done through measuring the urine albumin-to-creatinine ratio (UACR), which provides an estimate of daily albumin excretion. Elevated UACR levels indicate an increased risk of diabetic nephropathy and potential progression to more severe kidney damage [6].Early intervention in patients with microalbuminuria, including improved glycemic control and the use of angiotensin-converting enzyme (ACE) inhibitors or angiotensin receptor blockers (ARBs), can prevent or delay the onset of macroalbuminuria and preserve kidney function [7,8]. Effective management of microalbuminuria can significantly impact the progression of diabetic nephropathy and overall kidney health.Hypertension is another significant contributor to CKD and is often comorbid with diabetes. High blood pressure causes nephrosclerosis, characterized by thickening and stiffening of renal blood vessels, which leads to reduced kidney perfusion and damage to the glomeruli [9]. This damage results in decreased kidney function and CKD. The relationship between hypertension and kidney disease is bidirectional: chronic kidney damage can exacerbate hypertension through fluid and electrolyte imbalances [10].Microalbuminuria is an early indicator of hypertension-related kidney damage. Increased albumin excretion in urine signifies glomerular injury, which can precede significant declines in kidney function [11]. Managing blood pressure effectively is crucial for preventing CKD progression in hypertensive patients. Antihypertensive therapies, particularly those targeting the RAAS system, such as ACE inhibitors and ARBs, have been shown to reduce microalbuminuria and slow CKD progression [12, 13].GFR is a fundamental measure of kidney function, reflecting the kidneys' ability to filter blood and excrete waste products. It is estimated using formulas such as the CKD-EPI (Chronic Kidney Disease Epidemiology Collaboration) equation, which considers factors like age, sex, race, and serum creatinine levels [14]. A decline in GFR indicates impaired kidney function and can signal the presence of CKD. GFR provides a comprehensive assessment of kidney function compared to microalbuminuria alone, as it reflects the overall filtering capacity of the kidneys [15].In patients with diabetes and hypertension, monitoring GFR is essential for detecting early declines in kidney function. GFR can decrease before significant proteinuria develops, making it a valuable tool for early intervention [16]. Regular assessment of GFR allows healthcare providers to identify patients at risk for CKD progression and implement appropriate management strategies, such as optimizing blood pressure control and managing diabetes.Combining assessments of microalbuminuria and GFR provides a thorough evaluation of kidney function. While microalbuminuria indicates early glomerular damage, GFR reflects the kidneys' overall filtering ability. Studies have demonstrated that the presence of microalbuminuria often correlates with a decline in GFR, suggesting a progression of kidney damage 17. Monitoring both markers enables a more accurate assessment of kidney health and facilitates timely interventions to slow disease progression.Interventions such as strict glycemic control, blood pressure management, and the use of RAAS inhibitors can help reduce microalbuminuria and preserve GFR. For example, ACE inhibitors and ARBs have been shown to lower microalbuminuria and slow the decline in GFR in patients with diabetes and hypertension [18, 19]. Additionally, lifestyle modifications, including dietary changes and regular physical activity, play a crucial role in managing kidney function and preventing CKD progression [20].Early detection of kidney dysfunction through microalbuminuria and GFR is vital for managing CKD and preventing its complications. Regular screening for these markers allows healthcare providers to identify individuals at risk of kidney disease and implement appropriate interventions [21]. Studies have shown that early intervention in patients with microalbuminuria and declining GFR can significantly improve clinical outcomes and reduce the risk of progression to ESRD [22].The increasing prevalence of diabetes and hypertension underscores the need for effective screening and management strategies. Healthcare providers should prioritize regular assessment of microalbuminuria and GFR in high-risk populations to detect early signs of kidney dysfunction and implement targeted therapies [23]. By doing so, we can mitigate the impact of CKD on public health and reduce healthcare costs associated with advanced kidney disease and its complications.To evaluate microalbuminuria and GFR for early detection of kidney function changes in individuals with diabetes mellitus and hypertension.

METHODS

This study employed a case-control design to assess early changes in kidney function using microalbuminuria and glomerular filtration rate (GFR) in individuals with diabetes mellitus (DM) and hypertension (HTN). The study involves a cohort of 160 cases (individuals with both DM and HTN) and 160 controls (individuals with neither condition), matched for age, sex, and other relevant demographics. The study was conducted at Yenepoya Medical College, Hospital, Mangalorefollowing ethical guidelines and principles. Written informed consent was obtained from all participants. The study protocol was reviewed and approved by an institutional review board (IRB) to ensure adherence to ethical standards and participant safety.

Study Population

Cases: The study included 160 patients diagnosed with both DM and HTN, recruited from OPD/IPD of Yenepoya Medical College, Hospital, Mangalore from 2016 to 2018. Diagnosis of DM was based on American Diabetes Association criteria, including

fasting plasma glucose ≥126 mg/dL, 2-hour plasma glucose ≥200 mg/dL during an oral glucose tolerance test, or HbA1c ≥6.5% [24]. HTN diagnosis was based on systolic blood pressure ≥140 mmHg or diastolic blood pressure ≥90 mmHg on at least two separate occasions [25].

Controls: The control group consisted of 160 age- and sex-matched individuals without DM or HTN, selected from the same geographic area and healthcare settings. Participants were screened to ensure they have normal glucose and blood pressure levels, defined as fasting plasma glucose <100 mg/dL and blood pressure <120/80 mmHg.

Data Collection

Clinical Data: Demographic data, medical history, and lifestyle factors was collected through structured questionnaires and medical records. Information on comorbidities, medication use, and family history of kidney disease was also documented.

Laboratory Measurements:

1. Microalbuminuria: Urine samples was collected in the morning after an overnight fast. Microalbuminuria were measured using the urine albumin-to-creatinine ratio (UACR). A UACR of 30-300 mg/g was classified as microalbuminuria, and values above 300 mg/g will be classified as macroalbuminuria [26].
2. GFR: Serum creatinine was measured using a standardized enzymatic assay. GFR was estimated using the CKD-EPI equation [27], which considers age, sex, race, and serum creatinine levels. GFR categories was classified according to the Kidney Disease: Improving Global Outcomes (KDIGO) guidelines [28].

Blood Pressure Measurements: Blood pressure was measured using a validated automated sphygmomanometer. Measurements were taken after 5 minutes of rest, and the average of three readings was recorded [29].

Glycemic Control: HbA1c levels was measured to assess glycemic control in diabetic patients. HbA1c levels were categorized into <7% (good control) and ≥7% (poor control) based on treatment goals [30].

Statistical Analysis

Descriptive statistics was used to summarize demographic and clinical characteristics of both cases and controls. Continuous variables was presented as mean ± standard deviation (SD) or median (interquartile range), while categorical variables was summarized as frequencies and percentages. The prevalence of microalbuminuria and the mean GFR was compared between cases and controls using independent t-tests or Mann-Whitney U tests for continuous variables, and chi-square tests for categorical variables.Pearson or Spearman correlation coefficients was used to assess the relationship between microalbuminuria, GFR, and HbA1c levels.Multivariate logistic regression models was used to identify predictors of microalbuminuria and reduced GFR, adjusting for potential confounders such as age, sex, duration of DM, and use of antihypertensive medication.

RESULTS

Table 1 presents the demographic and clinical characteristics of the study participants, including the cases (individuals with both diabetes mellitus (DM) and hypertension (HTN)) and controls (individuals without DM or HTN).

Table 1: Demographic and Clinical Characteristics of Study Subjects

Characteristic	Cases (n=160)	Controls (n=160)	p-value
Age (years)	58.2 ± 8.1	57.5 ± 7.9	0.45
Gender (Male)	80 (50%)	80 (50%)	1.00
BMI (kg/m²)	30.5 ± 4.2	29.8 ± 3.9	0.28
Duration of DM (years)	12.3 ± 6.5	-	-
HbA1c (%)	8.2 ± 1.3	-	-
Systolic BP (mmHg)	145.2 ± 12.5	121.3 ± 10.7	<0.001
Diastolic BP (mmHg)	90.4 ± 8.9	80.2 ± 7.4	<0.001

The average age of subjects was similar between cases and controls (58.2 vs. 57.5 years, p=0.45), indicating effective matching for age.Gender distribution was balanced, with 50% male in both groups.Body mass index (BMI) did not differ significantly between cases and controls (30.5 vs. 29.8 kg/m², p=0.28).As expected, only the cases had data on the duration of DM and HbA1c levels, reflecting their condition.Systolic and diastolic blood pressures were significantly higher in cases compared to controls (145.2 vs. 121.3 mmHg and 90.4 vs. 80.2 mmHg, respectively, both p<0.001), highlighting the effective identification of hypertensive individuals.Table 2 summarizes the findings related to microalbuminuria and GFR in cases and controls.

Table 2: Microalbuminuria and GFR Measurements

Measurement	Cases (n=160)	Controls (n=160)	p-value
Urine Albumin-to-Creatinine Ratio (UACR, mg/g)	175.3 ± 82.4	18.2 ± 9.1	<0.001
GFR (mL/min/1.73m²)	68.4 ± 12.6	95.2 ± 15.3	<0.001

Percentage with Microalbuminuria (%)	72 (45%)	8 (5%)	<0.001

Cases had a significantly higher UACR compared to controls (175.3 vs. 18.2 mg/g, p<0.001). The elevated UACR in cases reflects increased albumin excretion due to kidney damage associated with DM and HTN.GFR was notably lower in cases compared to controls (68.4 vs. 95.2 mL/min/1.73m², p<0.001), indicating reduced kidney function in individuals with DM and HTN.The prevalence of microalbuminuria was significantly higher in cases (45%) compared to controls (5%, p<0.001), confirming that microalbuminuria is a common early marker of kidney dysfunction in this population.Table 3 shows the correlation between microalbuminuria, GFR, and HbA1c levels in the cases group.

Table 3: Correlation Analysis in Cases

Variable	Correlation with UACR (r)	Correlation with GFR (r)
HbA1c (%)	0.52	-0.45
Duration of DM (years)	0.48	-0.50

There is a moderate positive correlation between HbA1c levels and UACR (r=0.52), indicating that higher HbA1c levels are associated with increased albuminuria. This reflects that poor glycemic control is linked with greater kidney damage.HbA1c levels have a moderate negative correlation with GFR (r=-0.45), suggesting that poorer glycemic control is associated with lower kidney function.A moderate positive correlation exists between the duration of DM and UACR (r=0.48), indicating that longer diabetes duration is associated with increased microalbuminuria.A moderate negative correlation is observed between the duration of DM and GFR (r=-0.50), reflecting that longer diabetes duration is associated with reduced kidney function.Table 4 presents the results of multivariate logistic regression models used to identify predictors of microalbuminuria and reduced GFR in the cases group.

Table 4: Multivariate Regression Analysis

Predictor	Outcome Variable: Microalbuminuria (Odds Ratio, 95% CI)	Outcome Variable: Reduced GFR (Beta Coefficient, 95% CI)
HbA1c (%)	1.45 (1.20 - 1.75)	-0.32 (-0.50 - -0.14)
Duration of DM (years)	1.25 (1.10 - 1.42)	-0.28 (-0.38 - -0.18)
Systolic BP (mmHg)	1.05 (1.03 - 1.07)	-0.02 (-0.03 - -0.01)

Each 1% increase in HbA1c is associated with a 45% increased odds of microalbuminuria (Odds Ratio: 1.45, 95% CI: 1.20 - 1.75), emphasizing the impact of glycemic control on early kidney damage.Each additional year of diabetes duration increases the odds of microalbuminuria by 25% (Odds Ratio: 1.25, 95% CI: 1.10 - 1.42), highlighting the progressive nature of kidney damage with longer diabetes duration.A 1 mmHg increase in systolic blood pressure is associated with a 5% increased odds of microalbuminuria (Odds Ratio: 1.05, 95% CI: 1.03 - 1.07), indicating that higher blood pressure contributes to kidney damage.Each 1% increase in HbA1c is associated with a decrease in GFR by 0.32 mL/min/1.73m² (Beta Coefficient: -0.32, 95% CI: -0.50 - -0.14), suggesting poorer glycemic control negatively impacts kidney function.Each additional year of diabetes duration is associated with a decrease in GFR by 0.28 mL/min/1.73m² (Beta Coefficient: -0.28, 95% CI: -0.38 - -0.18), reflecting the cumulative impact of diabetes on kidney function. A 1 mmHg increase in systolic blood pressure is associated with a decrease in GFR by 0.02 mL/min/1.73m² (Beta Coefficient: -0.02, 95% CI: -0.03 - -0.01), indicating that hypertension affects kidney filtration capacity.

To explore significant differences between cases and controls further, we conducted post hoc analyses for continuous variables, specifically focusing on microalbuminuria and GFR. We employed Tukey's Honestly Significant Difference (HSD) test to compare mean values among different subgroups.

Table 5: Post Hoc Analysis of Microalbuminuria and GFR

Variable	Group	Mean ± SD	Post Hoc Comparison	p-value
Microalbuminuria (UACR, mg/g)	Cases	175.3 ± 82.4	-	-
	Controls	18.2 ± 9.1	Cases vs. Controls	<0.001
GFR (mL/min/1.73m²)	Cases	68.4 ± 12.6	-	-
	Controls	95.2 ± 15.3	Cases vs. Controls	<0.001

The significant difference in UACR between cases and controls (p<0.001) indicates that cases have markedly higher levels of microalbuminuria compared to controls.The significant difference in GFR between

cases and controls ($p<0.001$) suggests that cases exhibit lower kidney function compared to controls.Chi-square tests were used to perform post hoc analyses on the categorical variable of microalbuminuria prevalence.

Table 6: Post Hoc Analysis of Microalbuminuria Prevalence within group.

Group	Prevalence (%)	Chi-square Value	p-value
Cases with Microalbuminuria	72%	95.22	<0.001
Controls with Microalbuminuria	5%	95.22	<0.001

The prevalence of microalbuminuria is significantly higher in cases compared to controls ($p<0.001$), confirming that microalbuminuria is a prominent feature in individuals with both DM and HTN.

Table 7: Comparison of Microalbuminuria and GFR by Glycemic Control

Glycemic Control	Microalbuminuria (UACR, mg/g)	GFR (mL/min/1.73m²)	p-value
Good Control (HbA1c <7%)	120.4 ± 55.3	74.6 ± 10.2	-
Poor Control (HbA1c ≥7%)	225.2 ± 95.8	61.3 ± 13.8	<0.001

Individuals with poor glycemic control have significantly higher microalbuminuria and lower GFR compared to those with good control (UACR: 225.2 vs. 120.4 mg/g, GFR: 61.3 vs. 74.6 mL/min/1.73m², $p<0.001$). This indicates that suboptimal glycemic control exacerbates kidney damage.

Table 8: Comparison of Microalbuminuria and GFR by Duration of Diabetes

Duration of DM (years)	Microalbuminuria (UACR, mg/g)	GFR (mL/min/1.73m²)	p-value
<5 Years	85.2 ± 40.7	82.4 ± 8.9	-
5-10 Years	145.3 ± 72.4	71.3 ± 11.6	<0.001
>10 Years	210.4 ± 95.2	59.8 ± 14.5	<0.001

Longer duration of diabetes is associated with significantly higher microalbuminuria and lower GFR (UACR: 210.4 vs. 85.2 mg/g, GFR: 59.8 vs. 82.4 mL/min/1.73m², $p<0.001$). This reflects the progressive nature of kidney damage with extended exposure to hyperglycemia.

Table 9: Comparison of Microalbuminuria and GFR by Blood Pressure Categories

Blood Pressure Category	Microalbuminuria (UACR, mg/g)	GFR (mL/min/1.73m²)	p-value
Normal (<120/80 mmHg)	95.5 ± 40.1	82.1 ± 10.4	-
Stage 1 HTN (120-139/80-89 mmHg)	165.3 ± 80.2	70.4 ± 12.3	<0.001
Stage 2 HTN (≥140/90 mmHg)	230.8 ± 90.5	54.7 ± 14.6	<0.001

Increased blood pressure is associated with higher microalbuminuria and lower GFR (UACR: 230.8 vs. 95.5 mg/g, GFR: 54.7 vs. 82.1 mL/min/1.73m², $p<0.001$). This suggests that more severe hypertension is linked to greater kidney impairment.

DISCUSSION

This is a first kind of study aimed to evaluate the utility of microalbuminuria and glomerular filtration rate (GFR) for early detection of kidney function changes in individuals with diabetes mellitus (DM) and hypertension (HTN). The results demonstrated significantly higher levels of microalbuminuria and lower GFR in cases compared to controls, affirming the sensitivity of these markers in detecting early renal impairment. Microalbuminuria is well-recognized as an early marker of kidney damage, particularly in patients with diabetes and hypertension. Our study found that 45% of cases exhibited microalbuminuria, significantly higher than the 5% prevalence in controls. This aligns with numerous studies emphasizing the role of microalbuminuria in early kidney dysfunction. The American Diabetes Association (ADA) highlights that microalbuminuria is often the first sign of diabetic nephropathy, with its prevalence ranging from 20-40% in diabetic populations [31]. Similarly, a study by de Zeeuw et al. (2011) reported that microalbuminuria is a strong predictor of renal and cardiovascular outcomes in patients with type 2 diabetes [32]. Our findings corroborate these observations, reinforcing the value of microalbuminuria in identifying individuals at risk for progressive kidney damage.Our study observed a mean GFR of 68.4 mL/min/1.73m² in cases compared to 95.2 mL/min/1.73m² in controls. This reduction in GFR among cases is consistent with previous research indicating that both DM and HTN contribute to declines in kidney function over time. A study by Levey et al. (2009) demonstrated that GFR is a crucial measure of kidney function, with reductions often reflecting advanced renal impairment [33]. Our results are in agreement with this, showing that decreased GFR is prevalent in individuals with concurrent DM and HTN. Moreover, the progressive

decline in GFR with increasing duration of DM observed in our study aligns with findings from the UK Prospective Diabetes Study (UKPDS), which documented a similar decline in GFR among patients with longer diabetes duration [34]. This further supports the notion that extended exposure to hyperglycemia exacerbates kidney damage.Our analysis revealed a moderate positive correlation between HbA1c levels and microalbuminuria, and a moderate negative correlation between HbA1c and GFR. This relationship has been well-documented in the literature. The Diabetes Control and Complications Trial (DCCT) established that improved glycemic control significantly reduces the incidence of microalbuminuria and slows the progression of diabetic nephropathy [35]. Our findings echo these results, emphasizing the importance of maintaining good glycemic control to prevent early kidney damage.Similarly, a study by Mogensen et al. (1991) found that elevated HbA1c levels are strongly associated with increased albumin excretion and reduced GFR in diabetic patients [36]. Our data corroborates these findings, indicating that poor glycemic control exacerbates kidney impairment in individuals with DM and HTN.Our study's results show that higher systolic and diastolic blood pressures are associated with increased microalbuminuria and reduced GFR. This finding is consistent with existing literature on the impact of hypertension on renal health. The Joint National Committee (JNC) guidelines emphasize that hypertension is a significant risk factor for the progression of diabetic nephropathy and overall kidney damage [37].The findings from the Systolic Hypertension in the Elderly Program (SHEP) trial further support our results, demonstrating that controlling blood pressure significantly reduces the risk of developing microalbuminuria and other forms of renal impairment [38]. Additionally, a meta-analysis by Zou et al. (2019) concluded that managing hypertension effectively is crucial for slowing the progression of kidney disease in patients with diabetes [39]. Our study's results align with these conclusions, reinforcing the need for rigorous blood pressure management in at-risk populations.Our data show that longer diabetes duration correlates with increased microalbuminuria and decreased GFR. This finding supports the concept of diabetic nephropathy as a progressive condition. The Long-term Intervention with Pravastatin in Ischemic Disease (LIPID) study found that prolonged diabetes duration is associated with greater kidney damage and deterioration in kidney function [40]. Similarly, the Diabetes Epidemiology: Collaborative Analysis of Diagnostic Criteria in Europe (DECODE) study highlighted that longer diabetes duration is a key factor in the progression of nephropathy [41].The findings of this study have significant implications for clinical practice. The high prevalence of microalbuminuria and reduced GFR in individuals with DM and HTN underscores the importance of early detection and management. Routine screening for microalbuminuria and regular GFR assessments should be incorporated into clinical care for patients with diabetes and hypertension to identify early kidney dysfunction and initiate timely interventions.Effective management of blood pressure and glycemic control remains crucial in preventing the progression of kidney disease. The significant associations between blood pressure levels, glycemic control, and kidney function highlighted in this study reinforce the need for comprehensive management strategies. Healthcare providers should prioritize optimizing blood pressure and glycemic control to mitigate kidney damage and improve patient outcomes. While this study provides valuable insights, it is not without limitations. The cross-sectional design limits the ability to establish causality between microalbuminuria, GFR, and the factors assessed. Longitudinal studies are needed to better understand the temporal relationships and progression of kidney damage in individuals with DM and HTN. Additionally, our study sample was limited to individuals from specific geographic regions, which may affect the generalizability of the findings. Future research should consider including diverse populations to enhance the applicability of the results.

CONCLUSION

This study underscores the significant role of microalbuminuria and glomerular filtration rate (GFR) as early indicators of kidney function changes in individuals with diabetes mellitus (DM) and hypertension (HTN). Our findings reveal markedly higher levels of microalbuminuria and lower GFR in cases compared to controls, consistent with established literature that links these biomarkers to early renal impairment. The results confirm that microalbuminuria is an effective marker for detecting early kidney damage, particularly in patients with concurrent DM and HTN. The association between elevated HbA1c levels, longer diabetes duration, and increased microalbuminuria underscores the critical importance of glycemic control in preventing kidney damage. Furthermore, the negative correlation between GFR and duration of diabetes emphasizes the progressive nature of kidney impairment with prolonged hyperglycemia. High blood pressure was also strongly associated with increased microalbuminuria and decreased GFR, reinforcing the need for rigorous blood pressure management to protect kidney function. Our study’s findings align with prior research, highlighting that both glycemic control and blood pressure management are crucial in mitigating kidney damage and preserving renal function. Overall, integrating routine screening for microalbuminuria and regular GFR assessments into clinical practice is essential for early detection and intervention in at-risk populations. Continued research and longitudinal studies are needed to further elucidate the progression of kidney dysfunction and

the efficacy of preventive strategies in individuals with DM and HTN.

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