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Original Article

Internal Medicine Section

# Evaluation of Microalbuminuria and Loss of Nocturnal Blood Pressure Dipping in Prediabetic Individuals: A Cross-sectional Study

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## ABSTRACT

**Introduction:** Diabetes can lead to serious problems, such as microvascular and macrovascular disorders. Pre-diabetes is a serious condition in which blood sugar levels are high but not high enough to be called diabetes mellitus a critical period for intervention to prevent disease progression. Timely identification of issues like microalbuminuria and changes in nocturnal blood pressure dipping patterns might yield significant insights into the pathophysiology of pre-diabetes and suggest potential therapeutic approaches.

**Aim:** To determine the prevalence of microalbuminuria and abnormal nocturnal blood pressure dipping patterns among prediabetic individuals and to evaluate their relationship with gender.

**Materials and Methods:** The cross-sectional study was conducted at the Department of General Medicine, SRM Medical College Hospital and Research Centre, Kattankulathur, Tamil Nadu, India encompassing both In-patient (IP) and Outpatient (OP) Departments from March 2024 to June 2024, on 110 prediabetic people, aged 18 years or older. The baseline tests were Fasting Blood Sugar (FBS), Oral Glucose Tolerance Test (OGTT), Glycated Haemoglobin (HbA1c), and lipid profile, which included Total Cholesterol (TC), Low-Density Lipoprotein (LDL), High Density Lipoprotein (HDL), Triglycerides (TG), and Very Low Density Lipoprotein (VLDL). The amounts of microalbumin in the urine and blood pressure were monitored for 24 hours to observe night-time BP dipping pattern. The statistical analysis was performed using SPSS (version 22.0). An Independent t-test and Chi-square test for correlation were employed, with p-value <0.05 being statistically significant.

**Results:** The study comprised 110 prediabetic patients, with a mean age of 46.5±8.2 years; of whom 64 (58.2%) were male and 46 (41.8%) were female. No notable variations (p>0.05) were detected between males and females regarding glycaemic indicators (FBS, OGTT, HbA1c). Males had markedly elevated TG and reduced HDL levels; however, these variations were not statistically significant, and other lipid parameters exhibited similarity among genders. Microalbuminuria had a marginally greater prevalence in males (46.9%) than in females (41.3%); yet, this disparity was not statistically significant (p=0.86). A significant percentage of subjects (n=80; 72%) demonstrated either absent or irregular nocturnal blood pressure dropping patterns. Furthermore, microalbuminuria was more prevalent in those exhibiting irregular dipping patterns, observed in 46.5% of non dippers and 32.4% of inadequate dippers, in contrast to merely 16.7% among normal dippers, indicating a possible link between impaired night-time blood pressure regulation and early renal impairment in prediabetic patients.

**Conclusion:** Regular examination of microalbuminuria and BP dipping in those who are prediabetic this may facilitate the early detection of cardiovascular and renal complications. No significant metabolic differences were observed between men and women, indicating that gender may not play a major role in metabolic risk among individuals with prediabetes.

**Keywords:** Ambulatory, Dyslipidaemia, Early renal involvement, Lipid metabolism, Microvascular risk

## INTRODUCTION

Pre-diabetes is a growing global health concern. The condition occurs when blood sugar levels are high but not high enough to be identified as Type 2 Diabetes Mellitus (T2DM). A large number of people all over the world have this condition. The International Diabetes Federation (IDF) 2021 study indicates that about 541 million persons aged 20 to 79 globally were living with impaired glucose regulation (pre-diabetes), signifying a substantial global risk for the development of diabetes mellitus [1].

By 2045, that number is expected to rise to 730 million. The rise in prevalence is attributed to factors like unhealthy diets, higher rates of obesity and sedentary lifestyles [2]. Countries such as China, India, and the United States have a significant number of prediabetics due to the ageing population [3]. Subsequently, 20-30% of adults in many countries are prediabetic. In this condition, around 5-10% of patients with pre-diabetes progress to type 2 diabetes annually, and up to 70% could acquire diabetes within a period of five years [4].

Microalbuminuria refers to the presence of a moderate level of albumin in the urine, typically between 30 and 300 mg per day, which is not detectable by standard urine dipstick tests. It is an early indicator of kidney damage, particularly in people with diabetes or hypertension. Microalbuminuria levels in prediabetic individual show an early risk of getting chronic kidney disease. Besides renal health, microalbuminuria is classified as an important indicator of cardiovascular risk to predict cardiovascular events among the diabetic and prediabetic populations, which emphasises the significance as an early risk detection [5]. Also, nocturnal or night-time blood pressure dipping trends are the normal drop in blood pressure that happens during sleep in healthy people, usually by 10-20%. This decrease helps to lessen the strain on the heart and blood vessels while you sleep. But for some people, especially those who are prediabetic or diabetic, this night-time drop is lessened

or doesn't happen at all. This is called "non dipping." Clinically, losing the night-time drop in blood pressure is linked to a higher risk of heart disease, including a higher chance of heart attacks, strokes, and other heart-related events [6].

People who are prediabetic are more probable to get atherosclerosis, hypertension, and dyslipidaemia, which can cause heart attacks as well as strokes. Therefore, early identification is crucial to prevent these complications. In addition to this, understanding the other risk factors that contribute to cardiovascular complications in prediabetic individuals is essential. Factors such as a family history of cardiovascular disease or diabetes, high blood pressure, lipid profile and a glycaemic or diabetes diagnostic test play a significant role [7]. Healthcare providers can take steps to lower the risk by recognising these risk factors [8].

Chaamba SG and Khan RMM et al., stated that either microalbuminuria or BP patterns in people with T2DM, but not many have focused at both of these markers at the same time in individuals who are prediabetic, especially in India population [9,10]. Also, differences in lipid profiles and renal markers between male and female who are prediabetic, even though it is known that male and female have different metabolic responses. Therefore, the study assesses the association among microalbuminuria, lipid profiles, and nocturnal blood pressure dipping patterns in prediabetic people. It also examines gender disparities and metabolic factors to facilitate the early identification of renal and cardiovascular concerns.

## MATERIALS AND METHODS

The cross sectional study was conducted at the Department of General Medicine, SRM Medical College Hospital and Research Centre, Kattankulathur, Tamil Nadu, India, encompassing both In-patient (IP) and Outpatient (OP) Departments.

The study adhered to ethical guidelines as outlined by the Institutional review board (SRMIEC-ST0124-1365; Date: 14/02/2024). The written informed consent was acquired from the participants, and confidentiality of data was strictly maintained. The study spanned six months from the date of ethical approval (20/2/2024 – 20/8/2024).

**Sample size and calculation:** The sample size was calculated using the prevalence rate of microalbuminuria in prediabetics, which was 30.3% based on previous literature [10,11]. Using an estimated error margin of 7%, a minimum of 103 participants was required. However, to account for potential dropouts, 110 participants were enrolled. The sample size was calculated by using the formula.

$$n = Z^2 * P * \frac{(1-p)}{d^2} \quad (1)$$

$$Z = 1.96;\ P = 0.08;\ d = 0.05$$

$$N = \frac{0.2826}{0.0025}$$

$$N = 113.04 \approx 110$$

**Inclusion criteria:** Patients aged ≥18 years with pre-diabetes, as defined by the American Diabetes Association (ADA) 2023 criteria, must meet the following conditions: Fasting Plasma Glucose (FPG) ranging from 100 to 125 mg/dL (5.6 to 6.9 mmol/L), or Two-hour plasma glucose levels during the OGTT ranging from 140 to 199 mg/dL (7.8 to 11.0 mmol/L), or HbA1c readings ranging from 5.7% to 6.4% [12].

**Exclusion criteria:** Participants were excluded, if they had a prior diagnosis of type 2 diabetes mellitus, systemic hypertension, urinary tract infections in the past two weeks, chronic kidney disease or hyperlipidemia, recent exercise or weight lifting activities and active menstruation or vaginal discharge during sample collection.

### Study Procedure

- **Fasting lipid profiles:** TC; <200 mg/dL, LDL; <100 mg/dL, HDL; ≥40 mg/dL in men, ≥50 mg/dL in women, TG; <150 mg/dL and VLDL; 2-30 mg/dL [13,14].
- **Glycaemic or diabetes diagnostic test:** Based on the American Diabetes Association's (ADA) diagnostic standards, the pre-diabetes was defined using following criteria such as FBS, OGTT, and HbA1C were applied to determine prediabetic status [15].
- **Ambulatory Blood Pressure Monitoring (ABPM):** It was used to measure nocturnal blood pressure patterns. ABPM was conducted utilising an automated monitor (CONTEC ABPM), with bands correctly sized based on arm circumference to guarantee precision. Patients were directed to continue their regular daily activities and to refrain from too much activity during measurements.

Categories for nocturnal blood pressure were defined as:

a **Normal dipping:** >10% reduction in night-time BP.

b **Inadequate dipping:** 0-10% reduction.

c **No dipping:** No reduction or rise in BP during night-time [16].

**Microalbuminuria** was defined as a urine albumin to creatinine Ratio (ACR) >30 mg/g [17].

## STATISTICAL ANALYSIS

The analysis of data was performed utilising Statistical Package for Social Sciences (SPSS) version 20.0. The Chi-square analysis was employed for categorical data, whereas the Mann-Whitney analysis was utilised for the variables are not normally distributed. Statistical significance was determined at a $p<0.05$.

## RESULTS

The gender distribution in the dataset reveals a higher representation of males compared to females. Of the 110 individuals, 64 (58.18%) were male, while 46 (41.82%) female. This gender distribution is represented in [Table/Fig-1], which highlights a predominance of male participants over the female participants. The analysis of age distribution demonstrated variability in the frequency of participants across different age groups. The highest proportion of individuals was observed in the 51-60 years age group 38 patients (34.5%), followed by the 31-40 years, 34, patients (30.9%) and 41-50 years, 32 patients (29.1%) categories. In contrast, the lowest representation was noted in the 61-70 years, 4 (3.6%) and 71-80 years, 2 (1.8%) age groups [Table/Fig-1].

| Variables | Category | n (%) |
|---|---|---|
| Gender | Male | 64 (58.2%) |
| | Female | 46 (41.8%) |
| Age range (in years) | 20-30 | 6 (5.5%) |
| | 31-40 | 34 (30.9%) |
| | 41-50 | 32 (29.1%) |
| | 51-60 | 38 (34.5%) |
| | 61-70 | 4 (3.6%) |
| | 71-80 | 2 (1.8%) |

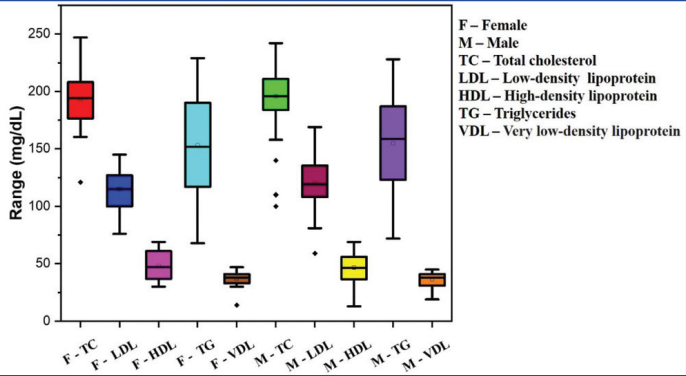
**[Table/Fig-1]:** Age and gender distribution of participants (N=110).

### Fasting Lipid Profile

The male and female populations' lipid profile analysis is illustrated in [Table/Fig-2,3]. The interquartile and median range showed that the female TC levels exceeded that of the males. Likewise, LDL values had a marginally elevated pattern in females compared to males. Conversely, HDL values were reduced in males than in females [Table/Fig-2]. TG levels were higher in males, accompanied by many outliers, signifying inter-individual variation. VLDL levels demonstrated a similar trend in both males and females, with only minor variations in median values. Whereas males and females exhibited minor variations in lipid levels, no significantly different gender-specific variations were detected for TC, LDL, HDL, TG, or VLDL (p-value >0.05 for all).

| Group | Median | IQR | p-value |
|---|---|---|---|
| F - TC | 210 mg/dL | 195-225 mg/dL | 0.37 |
| M - TC | 200 mg/dL | 185-215 mg/dL | |
| F - LDL | 120 mg/dL | 100-140 mg/dL | 0.15 |
| M - LDL | 125 mg/dL | 110-140 mg/dL | |
| F - HDL | 55 mg/dL | 45-65 mg/dL | 0.73 |
| M - HDL | 50 mg/dL | 40-60 mg/dL | |
| F - TG | 155 mg/dL | 120-190 mg/dL | 0.81 |
| M - TG | 170 mg/dL | 140-200 mg/dL | |
| F - VLDL | 35 mg/dL | 30-40 mg/dL | 0.78 |
| M - VLDL | 38 mg/dL | 35-42 mg/dL | |

**[Table/Fig-2]:** Distribution of lipid profile parameters in prediabetic Males (M) and Females (F).




**[Table/Fig-3]:** The box plot showing the way the lipid profile parameters are distributed between prediabetic males and females.

## Assessment of FBS, HbA1c and OGTT

The glycaemic indicators, comprising FBS, OGTT, and HbA1c, were analogous between prediabetic males and females. The Mann-Whitney U test demonstrated no significant gender differences in FBS (p=0.46), OGTT (p=0.23), or HbA1c (p=0.72), suggesting comparable glycaemic control in prediabetic males and females [Table/Fig-4].

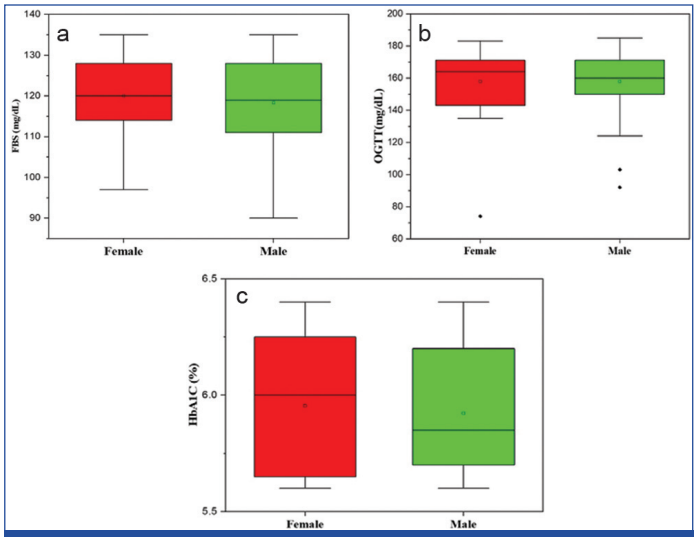
| Parameters | Group | Median | IQR | p-value |
|---|---|---|---|---|
| FBS (mg/dL) | Female | ~122 | 115-130 | 0.46 |
| | Male | ~120 | 112-128 | |
| OGTT (mg/dL) | Female | ~160 | 145-175 | 0.23 |
| | Male | ~155 | 140-170 | |
| HbA1C (%) | Female | ~6.0 | 5.8-6.2 | 0.72 |
| | Male | ~5.9 | 5.7-6.1 | |

**[Table/Fig-4]:** Comparison of FBS, OGTT and HbA1C in prediabetic males and females.

Box plots [Table/Fig-5a-c] depict the distributions of FBS, OGTT, and HbA1c, revealing overlapping interquartile ranges and affirming the lack of notable outliers.

## Prevalence of Microalbuminuria

The analysis of microalbuminuria distribution reveals that out of a total of 110 patients, 49 individuals (44.54%) exhibited microalbuminuria (urine ACR >30). Gender-specific results show that 46.88% of males (30 out of 64) and 41.30% of females (19 out of 46) are affected. While the proportion of microalbuminuria is slightly higher among males, both genders demonstrate a substantial prevalence, highlighting the importance of monitoring kidney health in prediabetic individuals [Table/Fig-6]. These findings emphasise the potential risk of early renal complications irrespective of gender. A Chi-square p-value=0.86 signifies the absence of a statistically significant variation within the studied groups. This indicates that the occurrence of microalbuminuria is comparable between genders, underscoring the need for kidney health monitoring in all individuals with pre-diabetes [Table/Fig-6].




**[Table/Fig-5]:** Box plot showing: (a) FBS; (b) OGTT; and (c) HbA1C in prediabetic males and females.

| Gender | Total patients | n (%) | p-value |
|---|---|---|---|
| Male | 64 | 30 (46.88%) | 0.86 |
| Female | 46 | 19 (41.30%) | |

**[Table/Fig-6]:** Gender-wise distribution of study participants with microalbuminuria.

## Blood Pressure Dipping Pattern

The analysis of the 24-hour blood pressure monitoring report reveals three distinct categories of blood pressure behaviour. The majority of the study population 43 (39 %) showed no dipping, indicating a lack of physiological night-time reduction. Subsequent to this, inadequate dipping 37 (34%) noted in the high number of the population, suggesting only a partial decrease in night-time blood pressure. Lastly, 30 (27%) of participants exhibited a significant dipping of BP during the night, representing the expected physiological pattern [Table/Fig-7]. These results highlight a significant portion of individuals with abnormal nocturnal blood pressure profiles, which indicate the further clinical attention.

| Dipping status | n (%) |
|---|---|
| Dipping | 30 (27%) |
| Inadequate dipping | 37 (34%) |
| No dipping | 43 (39%) |

**[Table/Fig-7]:** Distribution of dipping status within the entire study population (N=110).

## Association between Microalbuminuria and Dipping Pattern

The overall distribution of dipping patterns across the study population; however, descriptive analysis revealed that microalbuminuria was more prevalent among non dippers 20 out of 43 (46.5%) and inadequate dippers 12 out of 37 (32.4%) than among dippers 5 out of 30 (16.7%) are depicted in [Table/Fig-7]. This tendency indicates a potential link between impaired nocturnal blood pressure reduction and early renal changes in prediabetic people, necessitating confirmation in larger populations.

# DISCUSSION

The present study examined the age and gender distribution of prediabetic people and its association with microalbuminuria and nocturnal blood pressure patterns. The majority of participants were between the ages of 31-40 years and 51-60 years, consistent with the study Antonio-Villa NE et al., (2022) who indicated that the highest frequency of pre-diabetes occurs in middle aged adults [18]. Although, Lee S et al., stated that the risk of prediabetes typically

escalates with age, younger persons (30-40 years) are increasingly impacted due to lifestyle modifications [19]. In the present study, 64 (58.18%) were male, while 46 (41.82%) were female. A study conducted by Abufaraj M et al., reported a higher proportion of males than females, indicating a marginally greater prevalence among males, consistent with National Health and Nutrition Examination Survey (NHANES) data [20]. In addition to this Park KS et al., displayed gender disparities in metabolic risk may affect the transition from pre-diabetes to type 2 diabetes; nevertheless [21], previous Asian research indicate comparable or marginally elevated prevalence in females attributed to Body Mass Index (BMI) and metabolic variables [22,23].

The study identified distinct gender-specific variations in lipid metabolism: females exhibited elevated TC and LDL, whereas males demonstrated increased TG and reduced HDL- an atherogenic profile aligned with previous findings of Ji XW et al., [24].

Prediabetic individuals frequently exhibit elevated TG and VLDL levels, which are significantly associated with increased resistance to insulin [25]. Also, Buysschaert M et al., indicate that those with pre-diabetes usually have normal or slightly higher levels of LDL and TC [26]. The current study investigation found that both groups had no significant difference in LDL levels. This supports the premise that HDL and TG abnormalities are better signs of a metabolic issue than LDL alone. The research conducted by Siam NH et al., (2024), Muniyappa R and Narayanappa SBK (2024), Das M et al., (2024) and Deedwania PC and Fonseca VA (2025), revealed that changes in lipid metabolism in prediabetic individuals enhance atherosclerosis and endothelial dysfunction, thus elevating cardiovascular risk prior to the development of overt diabetes [27-30]. The higher TG and lower HDL levels found in males in the current study could be an early marker of metabolic dysfunction. This demonstrates the importance early intervention and lipid monitoring. The current study results show the significance of variation in lipid profile among the genders and the possible impact of metabolic illnesses, such as pre-diabetes.

The study also investigated the levels of FBS, OGTT, and HbA1c in male and female who were prediabetic. The current study data showed that the glycaemic indicators were the same for both genders, which means that both genders had the same metabolic profile in the prediabetic stage.

**Fasting Blood Sugar (FBS):** The study found that both men and women had similar FBS values. This is in line with results from the Diabetes Prevention Program (DPP) experiment, which also showed that there were very few differences in FBS between men and women who were prediabetic [31]. Conversely, earlier research indicates that males typically show marginally higher FBS levels than females, which may be attributed to reduced insulin sensitivity and differences in visceral fat distribution [32].

**Oral Glucose Tolerance Test (OGTT):** The results showed that male had somewhat higher levels of glucose after eating than female, although the difference was not statistically significant (p=0.23).

Previous research shows that male tend to have higher glucose levels after a glucose load. This could be because their liver produces less glucose and their insulin clears it less quickly [33,34]. Buysschaert M et al., in their research exhibited that OGTT outcomes fluctuate according to physical activity, genetic predisposition and body composition [26]. The OGTT data in the current study investigation indicated no significant gender disparities, but males exhibited marginally elevated post-load glucose levels. Variability was noted in both groups, indicating individual metabolic disparities. These changes align with prior research indicating that OGTT responses are affected by factors like hepatic glucose control, insulin sensitivity, physical exercise, and body composition [35].

**Glycated haemoglobin (HbA1c):** The study's results showed that the levels of HbA1c were similar for both genders. Siam NH et al., demonstrate that females may have somewhat higher HbA1c levels because of differences in mechanism of glycation [27]. Although this study provides significant insights, certain considerations must be addressed. The limited sample size may restrict the generalisability of the findings. Moreover, elements such as physical activity, genetic predispositions, and dietary habits- though pertinent- exceeded the parameters of the present research. Future research should include longitudinal designs to enhance comprehension of the transition from pre-diabetes to diabetes in both gender. The present study emphasises that gender-based differences in glycaemic indicators among persons with prediabetes are negligible, endorsing the application of standardised diagnostic and treatment approaches for both genders. The findings underscore the continuing necessity for personalised strategies that take into account individual metabolic responses.

Microalbuminuria was more frequent in males (46.88%) than in females (41.30%). This corresponds with prior research conducted by Genuth SM which revealed the male population with prediabetes or diabetes have a higher possibility for potential kidney injury due to heightened endothelial dysfunction and glomerular pressure [36]. Also, in the present study, considerable 39% of the population displayed no or inadequate dipping, whereas a smaller number of the study population exhibited a normal dipping pattern. The lack of nocturnal BP dropping is a recognised indicator of cardiovascular risk, especially in persons who are prediabetic and hypertensive individuals.

The current study results are in line with earlier research which indicates that persons with the prediabetic condition commonly have autonomic dysfunction, which makes it harder to control blood pressure [37].

Jug J et al., (2023) also found that individuals with pre-diabetes who had non dipping blood pressure changes were associated with stiffness of arteries and a higher risk of cardiovascular disease [38]. Thus, early identification of microalbuminuria and blood pressure dipping tendencies is essential for the implementation of preventive treatments, encompassing changes in lifestyle and pharmaceutical interventions [39]. The current study findings highlight the increasing concern about early and cardiovascular impairment in prediabetic people.

### Limitation(s)

The study results indicated that primarily it is difficult to prove a causal link among the onset of microalbuminuria and non dipping blood pressure patterns due to the cross-sectional design. Second, blood pressure results were taken using 24-hour ambulatory monitoring, which is dependable but subject to patient adherence and activity during the observation period. Third, a single centre was included in the population being studied, which could restrict the implications of the findings to larger populations. Fourth, there was insufficient control over additional confounding variables like medication use, sleep issues, consumption of sodium in the diet, and levels of physical activity. Fifth, the study could not provide a direct cross-tabulation of microalbuminuria across each dipping group due to data limitations. Lastly, evaluation of the long-term renal and cardiovascular consequences linked to non dipping patterns in prediabetic people is not possible due to the lack of longitudinal follow-up.

## CONCLUSION(S)

The present study of prediabetic people revealed that 44.5% displayed microalbuminuria, and the majority demonstrated non dipping or insufficient nocturnal blood pressure trends. Glycaemic indicators (FBS, OGTT, HbA1c) were comparable across males and females however males exhibited elevated TG and VLDL levels. These findings suggest an early risk of renal and cardiovascular complications in prediabetes. Consistent assessment of renal function, blood pressure, and cholesterol levels is advised to facilitate prompt preventive measures.

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