ORIGINAL ARTICLE

Prevalence and Risk Factors of Pre-hypertension in Diabetes Mellitus Cases of North Indian Population

Ajay Kumar[1], Puja Kumari Jha[2], Rajesh Ranjan[3], Vinay Kumar Rastogi[3]

ABSTRACT

Background: Many studies have reported high frequency of pre-hypertension as well as hypertension in the patients of diabetes mellitus (DM). The important risk factors are duration of diabetes, glycaemic control, dyslipidaemia, obesity, age, microalbuminuria, and some lifestyle related factors. **Objectives:** This study was designed to find the prevalence of pre-hypertension in North Indian urban DM cases and correlation with dietary habits, demographic profile, HbA1c, obesity, lipid profile, urinary albumin level, tobacco smoking, alcoholism, and physical inactivity. **Materils and Methods:** DM patients (N=100, ≥18 years), diagnosed as per the criteria of ADA, were recruited. JNC-7 criteria were applied for hypertension. The demographic profile, dietary habits and lifestyle related factors were obtained through questionnaire. Physical examination and laboratory investigation for biochemical parameters were performed and compared with appropriate statistical tool. **Results:** Prevalence of the Pre-HTN in DM patients was 42% and more in the males. DM with Pre-hypertension had reported significantly higher intake of salt and junk food with increased waist circumference. The urinary albumin level was significantly higher in DM with pre-hypertension. There was significant positive association of tobacco smoking and alcohol intake in development of pre-hypertension. Increased duration of DM, low physical activity and increased BMI were significantly contributing to Pre-hypertension. Dyslipidaemia, especially high Triglycerides(r=0.867) had significantly strong correlation with pre- hypertension in DM patients. **Conclusion:** Screening strategies for pre-hypertension should be initiated at an early age in the diabetic community. The importance of lifestyle modifications with respect to dietary habits, physical activity, and relaxation techniques needs to be implemented.

KEY WORDS: Pre-hypertension, Diabetes Mellitus, Prevalence, Dyslipidaemia, Microalbuminuria, Lifestyle.

Introduction

Pre-hypertension (Pre-HTN), also known as high normal blood pressure (BP), is defined as "Systolic blood pressure (SBP) ranging between 120-139 mmHg and/or diastolic blood pressure (DBP) ranging between 80-89 mmHg.[1]It has been reported that pre-HTN could significantly increase the risk of hypertension, target organ damage, cardiovascular events, and mortality.[2] Many physicians worldwide have observed a high frequency of pre-HTN as well as hypertension in the patients of diabetes mellitus. The studies have reported that the prevalence of hypertension had increased as much as six-fold among diabetic compared with nondiabetic patients.[3] Therefore, HbA1c, the indicator of glycaemic control, may be correlated with the hypertension stage in diabetic patients.[4]

Microalbuminuria, defined as persistent elevation of albumin in the urine in the range of 30-300 mg/day (20-200 μg/min), is associated with the susceptibility of an individual to cardiovascular (CV) disease in pre-diabetes and pre-hypertension.[5] It is therefore an ideal target for early primary prevention using CV

Access this article online

Quick Response Code:

Website: www.jmsh.ac.in

Doi: 10.46347/jmsh.v10.i2.24.125

[1]Department of Family Medicine, Jaipur Golden Hospital, Delhi, 110085, India, [2]Department of Biochemistry, University College of Medical Sciences and GTB Hospital (University of Delhi), Dilshad Garden, Delhi, 110095, India, [3]Department of Internal Medicine, Jaipur Golden Hospital, Delhi, 110085, India

Address for correspondence:
Puja Kumari Jha, Department of Biochemistry, University College of Medical Sciences and GTB Hospital (University of Delhi), Dilshad Garden, Delhi, 110095, India. E-mails: pujajha26@gmail.com, pkjha@ucms.ac.in

protective therapy regimens and can be used as biomarker.[6]

The changes in the lifestyle and eating habits, which has occurred more in the urban population as compared to rural population, are added risk factors. The urban population can be defined as people living in urban areas as defined by national statistical offices. The urban population has greater population density and overall, more compact than rural population[7]. Urban people have adopted a sedentary lifestyle, unhealthy food habits and addictions like tobacco smoking, alcoholism which increases the risk for many lifestyles related diseases like Diabetes mellitus, Hypertension etc. Diabetes mellitus (DM) is a condition where blood sugar (glucose) level is are higher than normal due to body's inefficiency in utilization of blood glucose or storing of blood glucose for energy[8]. Therefore, apart from traditional risk factors like duration of diabetes, glycaemic control (HbA1c), microalbuminuria, dyslipidaemia, obesity (BMI, Waist circumference), age there are some non-traditional risk factors that include food habits, tobacco smoking, alcoholism and physical inactivity in a particular patient and have to be studied in detail so that an insight into the prevention and proper treatment planning can be made.

Recently both pre-HTN and pre-diabetes have caught the attention of clinicians as well as epidemiologists due to their high prevalence rate as compared to hypertension and DM and affecting the prime productive years of life. Further, targeted intervention at this stage will prevent or postpone progress to overt disease and will reduce the cardiovascular risk.

Though several studies have reported the prevalence of Pre-HTN among DM in the Indian population, the reports are conflicting. Furthermore, there is a paucity of data on the correlation of pre-HTN with dietary habits, demographic profile, HbA1c, waist circumference, lipid profile and urinary albumin level. This study tried to evaluate the prevalence of Pre-HTN in DM and other correlations in the North Indian population so that early identification of the risk factors will help in proper treatment strategy that will reduce the complications of hypertension in the long run and will also improve the quality of life of the patients.

Material and Methods

This comparative, cross-sectional and observational study was conducted in the Department of General Medicine at Jaipur Golden Hospital, Delhi, India from November 2020 to December 2021. Ethical clearance was obtained from the Institutional Ethical Committee for Human Research (IEC-HR) prior to execution of the study. The present study was according to declaration of Helsinki. Prior written informed consent was obtained from the participants.

Selection of Cases

The DM patients of 18 years and older were recruited from the cases visiting to outpatient department (OPD) of Internal Medicine at Jaipur Golden Hospital based on the criteria of American diabetic association[9]. The study participants were selected by purposive sampling technique as per their characteristics. Duration of diabetes mellitus was calculated from the onset of diabetes either self-reported or diagnosed by blood investigation up to the date of censoring. JNC-7 criteria were used to divide the diabetic population in normotensive and pre-hypertensive. Considering reported value of a previous study, the required samples size was 100 at 5% level of significance with 93 % power of the study. Pre-Diabetics, patients with Gestational diabetes, Pregnancy induced hypertension and established Hypertension were excluded from the study.

Clinical history, physical examination, and laboratory investigations

Detailed clinical history was taken as per case record proforma; followed by clinical examination and laboratory investigations. Body Mass Index (BMI) were calculated by using the standard formula (Quetlet's index). All the screening investigation were a part of routine care and special investigation was done as required for the study. Blood samples were collected after 12 hours of overnight fasting in EDTA and Plain vial for analysis of Complete Blood Count (CBC), glycated haemoglobin (HbA1c), Fasting Blood Sugar (FBS), Postprandial Blood Sugar (PPBS), Lipid profile parameter and Renal profile parameter. Urinary albumin level was also analysed. Biochemical investigations were performed using Roche Cobas C 311 fully automated biochemistry analyser, Roche, Germany.

Lifestyle related parameters like dietary habits (salt intake, junk food consumption), addictions (tobacco smoking, alcohol consumption) and physical activity

High salt intake: As Indian studies have reported that routine salt consumption is much higher in India than the WHO recommendation and is around 11 g/day.[10] Therefore, high salt intake in this study was defined as salt intake of more than 11 g/day, which is approximately 2 teaspoons as one teaspoon salt is equivalent to 5.75 g of salt. Total amount of salt consumed in 24 hours in terms of teaspoon was analysed by a self-administered questionnaire which includes approximate quantity used in cooking in entire day, type of salt, additional salt intake during meal and number of individuals in the house. Questionnaire also included intake of sauce, packaged salty snacks, canned salty food, pickles, marinades, packed cheese, other salty meat and chicken products, salty fish in a week.

Junk foods are defined as foods that are readily available, low-nutritional value with more calories, more salt, high content of saturated fat and low levels of iron, calcium, and dietary fibre.[11] Consumption of junk food $\geq$3 times a week of any item is concluded to be harmful.[12] Common junk food items were included in the list namely instant noodles, biscuits, cookies, chips, bread pakora, samosa, chowmein, momos, soft drinks, burgers, pizza, canned food, fried potatoes, meat products, etc. for clarity to the participants.

Irrespective of categories of tobacco smoking any participant who had been smoking for more than a year were considered as smokers. Similarly, participants were categorized as alcoholic or non-alcoholic based on whether they had used alcohol or not for more than one year. As there is no safe level of tobacco smoking and alcohol intake.[13,14] Even WHO had published advisory from time to time that there is no safe level of alcohol intake.

Metabolic equivalent of task (MET) is used to categorize the intensity of physical activity and participants were divided into light, moderate, and sedentary activity as there were no participants involved in vigorous activity.

Statistical Analysis

Descriptive statistics was analyzed with SPSS version 20 software. Continuous variables are presented as mean $\pm$ SD. Categorical variables are expressed as frequencies and percentages. The chi-square test was used to compare between two groups. Other tests which were used are independent t-test and Pearson's correlation analysis. $p<0.05$ was considered statistically significant.

Results

The prevalence of Pre-HTN in DM patients was calculated. The participants were then categorized in two groups. Group I comprises DM cases with Pre-HTN and Group II comprises normotensive DM cases. Group I and Group II was compared with respect to age, gender, duration of DM, dietary habits, tobacco smoking, alcoholism, obesity (BMI, Waist circumference) HbA1c, lipid profile parameters, urinary albumin level and physical activity. The correlation between lipid profile parameters and systolic and diastolic blood pressure was also evaluated. Prevalence of the Pre-HTN in DM patients was 42% and significantly more in the males (56.14%) as compared to females (23.25%) (Table 1). Group I had higher mean age of presentation (47.52 years vs 39.37years). Group I had also reported significantly higher intake of salt and junk food with increased waist circumference (Table 2). In our study, the percentage of people with high salt (>11 grams) intake was higher in the pre-hypertensive group (23.72%) as compared to the normotensive group (20.09%). Similarly, the percentage of people with increased frequency of junk food intake per week was lower in the normotensive group (19.82%) as compared to 26.36% in the pre-hypertensive group. The mean waist circumference was smaller (73.64cm) in Group II than Group I (87.05 cm) Glycaemic control was poor though non-significant in Group I as compared to Group II (Table 2). There was significant positive association of tobacco smoking and alcohol intake in development of pre-HTN as evident from Table 3. The present study reported that 44 participants had the habit of cigarette smoking, out of whom 25 were found to be pre-hypertensive. Among 42 participants who reported that they had a habit of drinking alcohol, 29 had pre-HTN (Table 3). Increased duration of DM, low physical activity and increased BMI were significantly contributing to pre-HTN development in diabetic patients (Table 3). In this study, 28 out of 42 DM patients with pre-HTN had high weight (7 were overweight, 5 were class I obese, 10 had class II obesity, and 6 were class III obese) (Table 3). A higher BMI shows a greater prevalence($p<0.05$) of pre-HTN. Lipid profile parameters were significantly deranged in Group I with high triglycerides, high

total cholesterol, high low-density lipoprotein (LDL-c) and decreased high density lipoprotein (HDL-c) (Table 4). The mean urinary albumin level was also in the range of microalbuminuria in significantly higher percentage in Group I (29.35%) as compared to Group II (8.96%). Dyslipidaemia, especially high Triglycerides (r=0.867) had significantly strong correlation with Pre-HTN in DM patients (Table 5).

Table 1: Prevalence of pre-HTN in DM patients and Gender preponderance

	DM with Pre-HTN (n=42)		Normotensive DM (n=58)	
Total (n=100)	42%		58%	
Gender Preponderance	Male	Female	Male	Female
	32 (56.14%)	10 (23.25%)	33 (76.67%)	25 (43.85%)
p-value	0.001		0.001	

[1]Chi-square test was used to compare gender preponderance, p value(<0.05) considered significant.

Table 2: Comparison of mean age, salt intake, junk food intake, waist circumference and HbA1c among Group I (DM with Pre-HTN) and Group II (Normotensive DM)

Parameters	GROUP I (DM with Pre-HTN)	GROUP II (Normotensive DM)	p-value
	Mean± SD		
Age (years)	47.52±15.72	39.37±12.09	0.004
High Salt intake (%)	23.72±2.63	20.09±1.41	0.000
Junk food intake (%)	26.36±2.51	19.82±1.56	0.000
Waist circumference (cm)	87.05±8.20	73.64±5.05	0.000
HbA1c (%)	13.01±1.89	12.87±1.17	0.665

Data is represented as Mean± SD. Independent t test was usedto compare mean values. p value(<0.05) considered significant.

Discussion

This study attempted to find the current prevalence of Pre-HTN among DM in the North Indian urban population and association of pre-HTN with lifestyle related parameters (dietary habits, tobacco smoking, alcohol consumption, physical activity, Obesity (waist circumference, BMI), HbA1c, lipid profile parameters and urinary albumin level.

Table 3: Comparison of tobacco smoking, alcohol drinking, BMI, and physical activity in Group I (DM with Pre-HTN) and Group II (Normotensive DM)

Parameters		GROUP I (DM with Pre-HTN)	GROUP II (Normotensive DM)	p-value
Tobacco smoking	Yes	25	19	0.008
	No	17	39	
Alcohol	Yes	29	13	0.000
	No	13	45	
BMI	Underweight	9	15	0.000
	Normal	5	22	
	Overweight	7	20	
	Obese class I	5	1	
	Obese class II	10	0	
	Obese class III	6	0	
Physical activity	Sedentary	23	14	0.008
	Light	14	22	
	Moderate	5	20	
Duration of DM	<5 YRS	26	58	<0.0001
	6-10 YRS	15	0	
	11-15 YRS	1	0	

Chi-square test was used for comparison. P value <0.05 consider significant.

Table 4: Comparison of Lipid profile & Urinary albumin in Group I (DM with Pre-HTN) and Group II (Normotensive DM)

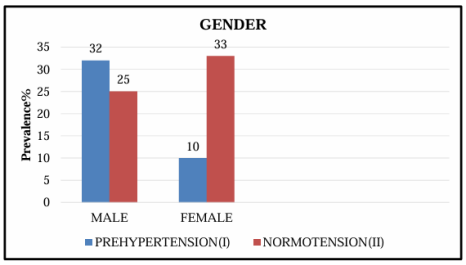
Lipid profile parameters	GROUP I (DM with Pre-HTN)	GROUP II (Normotensive DM)	p-value
Total cholesterol (mg/dl)	199.88±7.58	139.72±10.32	0.000
LDL (mg/dl)	119.02±7.07	94.24±4.86	0.000
VLDL (mg/dl)	35.52±4.76	29.91±3.82	0.000
HDL (mg/dl)	37.57±5.23	50.08±2.47	0.000
Triglycerides (mg/dl)	181.73±9.41	137.87±5.39	0.000
Urine Albumin(percentage)	29.35±6.82	8.96±2.74	0.000

Data is represented as Mean± SD. Independent t test was used. p value < 0.05 consider significant.

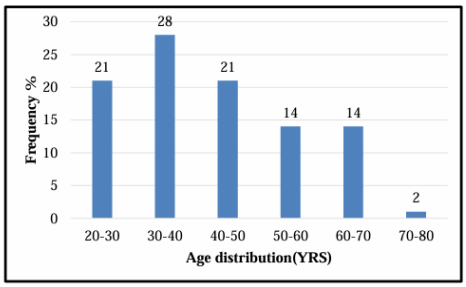
Table 5: Correlation of Lipid profile parameters with Blood pressure in DM with Pre-HTN

Parameters	Total cholesterol	LDL-C	VLDL-C	Triglyceride	HDL-C
DM with Pre-HTN					
Systolic blood pressure (SBP)	r = 0.671*	r = 0.391*	r = 0.399*	r = 0.867*	r = -0.541*
Diastolic blood pressure (DBP)	r = 0.678*	r = 0.588*	r = 0.347*	r = 0.554*	r = -0.594*
Normotensive DM					
Systolic blood pressure (SBP)	r = 0.209	r = -0.114	r = 0.058	r = -0.078	r = -0.039
Diastolic blood pressure (DBP)	r = 0.134	r = -0.123	r = 0.128	r = -0.126	r = 0.035

Pearson's correlation test was used. The magnitude of correlation is denoted by "r". P value <0.05 consider significant.



Graph 1: Prevalence of pre-HTN in DM patients on the basis of gender (N=100)



Graph 2: Frequency distribution of age in DM patients (N=100)

As per the finding of this cross-sectional study, reported prevalence of the Pre-HTN in DM patients was 42% and more preponderant in the males (56.14%) as compared to females (23.25%) (Table 1). Similar study by Metri et al., had reported even a higher prevalence of pre-HTN in DM (59.7%) and prediabetes (57.3%) cases. Increasing age and male sex were significantly associated with both pre-HTN and hypertension.[15] DM is an important risk factor for hypertension. The pathogenesis of both DM and hypertension indicates towards common mechanism namely increased inflammation, altered autonomic function and disturbed renin angiotensin aldosterone system.[16]

Our study suggests that people belonging to the pre-hypertensive group had higher salt and junk food intake as compared to the normotensive group (Table 2). Consumption of salty foods and the addition of extra salt in meals was significantly associated with pre-HTN. It has been reported that consuming salty foods on a regular basis was significantly associated with an increased risk of pre-HTN.[17] There are findings from different studies suggesting that decreased frequency of junk food intake leads to favourable lipid profile and lower BMI and reported a significant association of junk food consumption with elevated blood pressure.[18] Waist circumference in DM with pre-HTN was significantly higher and there is study reporting that waist circumference had a positive odd with Pre-HTN.[19] There was no significant difference in HbA1C level in two groups suggesting that degree of hypertension was not associated with diabetic control. Contrary to our findings, there are reports concluding that HbA1c was significantly associated with blood pressure.[20,21]

Our study reported that the occurrence of pre-HTN was more in DM cases with tobacco smoking alcohol intake, high BMI and reduced physical activity (Table 3). Parthaje et al. had reported similarly that individuals with tobacco and alcohol use, obesity, and low physical activity had significantly higher levels of prehypertension and hypertension.[22] In a meta-analysis by Whelton et al., it had been reported that increment in total daily physical activity reduces the hazard ratios of hypertension. Apart from exercising >3 times/week, intermittent small episodes of 10 min walk, collectively 30 min walk reduces systolic blood pressure in pre-HTN. Studies had concluded in their finding that the odds of being hypertensive and pre-hypertensive is more

among tobacco smokers and alcohol consumer.[13,23] Though the exact mechanism of hypertension in alcoholics is not clear but imbalance of CNS, impaired baroreceptors, stimulated renin angiotensin system, high sympathetic activity and increased vasoconstriction with loss of relaxation are proposed mechanisms[24]. In this study out of 42 patients having pre-HTN, 7 were overweight, 5 patients were class I obese, 10 had class II obesity and 6 were class III obese (Table 3) and Group I had significantly higher waist circumference (Table 2). Overweight, obesity, and abdominal obesity were significantly associated with pre-HTN and hypertension[25]. Obesity leads to onset of hypertension through interaction of environmental, genetic, lifestyle and dietary factors and leads directly to renal, cardiac, and vascular dysfunction through impaired inflammatory and immunological response.[26]

Lipid profile parameters were significantly deranged in DM with pre-HTN as compared to normotensive DM cases (Table 4). A significant positive correlation was found between SBP and DBP with dyslipidaemia ($p < 0.05$) (Table 5) in pre hypertensive DM patients only. It has been reported earlier that youths with altered serum levels of TC, HDL-C, or non-HDL-C had either high or borderline BP.[27] Therefore, Dyslipidaemia is an independent risk factor for prehypertension and hypertension development especially high triglyceride level had a very strong positive correlation ($r=0.867$). Total cholesterol ($r=0.67$) also had strong positive, and HDL-c had a moderate negative($r=0.54$) correlation with development of pre-HTN. A study reported by Chen S et al. suggests that the risk of hypertension increases by 0.2% for every 1 mg/dl rise in Total cholesterol, LDL-c, and non-HDL-c.[28] Both triglyceride and HDL-c are inflammatory and metabolic predictor.

The mean urinary albumin excretion was also in the range of microalbuminuria in significantly higher percentage in DM with pre-HTN (29.35%) as compared to normotensive (Table 4). A study reported earlier that microalbuminuria was seen 22.2% of isolated prediabetics, 25% of isolated prehypertensives and 58% of subjects with both pre-HTN and prediabetes with significant association of microalbuminuria with cardiac changes. A study reported by Anjaneyaprasad et al. on 500 prediabetic patients, had concluded that Prediabetes patients with higher microalbuminuria and CRP levels had significantly elevated lipid levels.[28]

Effective management of risk factors is central to the effective prevention and management of NCDs, and for limiting the substantial socioeconomic burden imposed by these conditions.[29] This requires the cooperation of scientists, the medical community, and policymakers to facilitate the development and implementation of prevention and control strategies for hypertension in patients with type II diabetes mellitus. We strongly recommend periodic screening of both BP and blood glucose to allow both hypertension and diabetes to be detected, and to facilitate early intervention with the goal of preventing complications. In addition, education and supervised implementation of a healthy lifestyle including physical activity, a healthy diet, and stress management should be implemented in patients with type II diabetes and hypertension. Complementary therapies such as yoga have also been shown to make a contribution to the prevention and management of type II diabetes and hypertension.[30]

Conflict of Interest:

Authors declare that there is no Conflict of Interest.

References

1. E R Miller I, Jehn ML. New high blood pressure guidelines create new at-risk classification: changes in blood pressure classification by JNC 7. The Journal of Cardiovascular Nursing. 2004;19(6):367–371. Available from: https://journals.lww.com/jcnjournal/abstract/2004/11000/new_high_blood_pressure_guidelines_create_new.6.aspx.
2. Niiranen TJ, Larson MG, Mccabe EL, Xanthakis V, Vasan RS, Cheng S. Prognosis of Prehypertension Without Progression to Hypertension. Circulation. 2017;136(13):1262–1264. Available from: https://doi.org/10.1161/CIRCULATIONAHA.117.029317.
3. Petrie JR, Guzik TJ, Touyz RM. Diabetes, Hypertension, and Cardiovascular Disease: Clinical Insights and Vascular Mechanisms. Canadian Journal of Cardiology. 2018;34(5):575–584. Available from: https://doi.org/10.1016/j.cjca.2017.12.005.
4. Bower JK, Appel LJ, Matsushita K, Young JH, Alonso A, Brancati FL, et al. Glycated hemoglobin and risk of hypertension in the atherosclerosis risk in communities study. Diabetes Care. 2012;35(5):1031–1037. Available from: https://doi.org/10.2337/dc11-2248.
5. Prasad VA, Murthy VK, Babu KP. Microalbuminuria in prediabetes group in rural general hospital. International Journal of Medical & Pharmaceutical Sciences. 2013;3(9):1–7. Available from: https://www.ijmps.org/abstract.php?article_id=13.
6. Pang W, Sun Z, Zheng L, Li J, Zhang X, Liu S, et al. Body mass index and the prevalence of prehypertension and hypertension in a Chinese rural population. Internal

Medicine. 2008;47(10):893–897. Available from: https://doi.org/10.2169/internalmedicine.47.0528.
7. Country Profiles. . Available from: http://esa.un.org/unpd/wup/Country-Profiles.
8. National Institute of Diabetes and Digestive and Kidney Diseases (NIDDK). 2014. Available from: https://www.niddk.nih.gov/.
9. Association AD. Classification and Diagnosis of Diabetes: Standards of Medical Care in Diabetes—2020. Diabetes Care. 2020;43(Supplement_1):S14–S31. Available from: https://doi.org/10.2337/dc20-S002.
10. Johnson C, Santos JA, Sparks E, Raj TS, Mohan S, Garg V, et al. Sources of Dietary Salt in North and South India Estimated from 24 Hour Dietary Recall. Nutrients. 2019;11(2):1–9. Available from: https://doi.org/10.3390/nu11020318.
11. Wang X, Wang M, Shao S, Zhang Y, Liu S, Shen Y, et al. Analysis of influencing factor of coexisting prediabetes and prehypertension in adult residents of Jilin Province. BMC Endocrine Disorders . 2018;18:1–8. Available from: https://doi.org/10.1186/s12902-018-0316-5.
12. Huang YQ, Liu L, Huang JY, Lo K, Chen CL, Yu YL, et al. Prehypertension and risk for all-cause and cardiovascular mortality by diabetes status: results from the national health and nutrition examination surveys. Annals of Translational Medicine. 2020;8(6):1–10. Available from: https://doi.org/10.21037/atm.2020.02.144.
13. Owiredu EW, Dontoh E, Essuman S, Bazanfara BB. Demographic and lifestyle predictors of prehypertension: A cross-sectional study among apparently healthy adults in Kumasi. BioMed Research International. 2019;2019(1):1–10. Available from: https://doi.org/10.1155/2019/1764079.
14. Kar SS, Selvaraj K, Ramaswamy G, Premarajan KC, Saya GK, Kalidoss V. High Prevalence of Prehypertension and its Association with Modifiable Risk Factors: Findings of Household STEPS Survey from Urban Puducherry, South India. International Journal of Preventive Medicine. 2020;11(1):1–9. Available from: https://doi.org/10.4103/ijpvm.ijpvm_6_19.
15. Metri KG, Raghuram N, Ram CVS, Singh A, Patil SS, Mohanty S, et al. The Deadly Duo of Hypertension and Diabetes in India: Further Affirmation from a New Epidemiological Study. Journal of the Association of Physicians of India. 2022;70(7):11–12. Available from: https://doi.org/10.5005/japi-11001-0048.
16. Lastra G, Syed S, Kurukulasuriya LR, Manrique C, Sowers JR. Type 2 diabetes mellitus and hypertension: an update. Endocrinology and Metabolism Clinics of North America. 2014;43(1):103–122. Available from: https://doi.org/10.1016/j.ecl.2013.09.005.
17. Kini S, Kamath VG, Kulkarni MM, Kamath A, Shivalli S. Pre-Hypertension among Young Adults (20-30 Years) in Coastal Villages of Udupi District in Southern India: An Alarming Scenario. PLoS ONE. 2016;11(4):1–12. Available from: https://doi.org/10.1371/journal.pone.0154538.
18. Alsabieh M, Alqahtani M, Altamimi A, Albasha A, Alsulaiman A, Alkhamshi A, et al. Fast food consumption and its associations with heart rate, blood pressure, cognitive function and quality of life. Pilot study. Heliyon. 2019;5(5):1–6. Available from: https://doi.org/10.1016/j.heliyon.2019.e01566.
19. Sun JY, Hua Y, Zou HYY, Qu Q, Yuan Y, Sun GZ, et al. Association Between Waist Circumference and the Prevalence of (Pre) Hypertension Among 27,894 US Adults. Frontiers in Cardiovascular Medicine. 2021;8:1–11. Available from: https://doi.org/10.3389/fcvm.2021.717257.
20. Liu L, Zhen D, Fu S, Sun W, Li H, Zhao N, et al. Associations of the baseline level and change in glycosylated hemoglobin A1c with incident hypertension in non-diabetic individuals: a 3-year cohort study. Diabetology & Metabolic Syndrome . 2022;14(1):1–10. Available from: https://doi.org/10.1186/s13098-022-00827-8.
21. Parthaje PM, Unnikrishnan B, Thankappan KR, Thapar R, Fatt QK, Oldenburg B. Prevalence and Correlates of Prehypertension Among Adults in Urban South India. Asia Pacific Journal of Public Health. 2015;28(1 suppl):93S–101S. Available from: https://doi.org/10.1177/1010539515616453.
22. Whelton SP, Chin A, Xin X, He J. Effect of aerobic exercise on blood pressure: a meta-analysis of randomized, controlled trials. Annals of Internal Medicine. 2002;136(7):493–503. Available from: https://doi.org/10.7326/0003-4819-136-7-200204020-00006.
23. Udayar SE, Thatuku ST, Jevergiyal DP, Meundi AM. Prevalence and predictors of prehypertension and hypertension in adult population of rural Southern India—An epidemiological study. Journal of Family Medicine and Primary Care. 2021;10(7):2558–2565. Available from: https://dx.doi.org/10.4103/jfmpc.jfmpc_2415_20.
24. Husain K, Ansari RA, Ferder L. Alcohol-induced hypertension: Mechanism and prevention. World Journal of Cardiology. 2014;6(5):245–252. Available from: https://dx.doi.org/10.4330/wjc.v6.i5.245.
25. Dulskiene V, Kuciene R, Medzioniene J, Benetis R. Association between obesity and high blood pressure among Lithuanian adolescents: a cross-sectional study. Italian Journal of Pediatrics. 2014;40(1):1–10. Available from: https://dx.doi.org/10.1186/s13052-014-0102-6.
26. Chen S, Cheng W. Relationship Between Lipid Profiles and Hypertension: A Cross-Sectional Study of 62,957 Chinese Adult Males. Frontiers in Public Health. 2022;10:1–11. Available from: https://dx.doi.org/10.3389/fpubh.2022.895499.
27. Kit BK, Kuklina E, Carroll MD, Ostchega Y, Freedman DS, Ogden CL. Prevalence of and Trends in Dyslipidemia and Blood Pressure Among US Children and Adolescents, 1999-2012. JAMA Pediatrics. 2015;169(3):272–279. Available from: https://dx.doi.

org/10.1001/jamapediatrics.2014.3216.
28. Markus MRP, Ittermann T, Baumeister SE, Huth C, Thorand B, Herder C, et al. Prediabetes is associated with microalbuminuria, reduced kidney function and chronic kidney disease in the general population. Nutrition, Metabolism and Cardiovascular Diseases. 2018;28(3):234–242. Available from: https://dx.doi.org/10.1016/j.numecd.2017.12.005.
29. Gupta R, Ram CVS. Hypertension epidemiology in India: emerging aspects. Current Opinion in Cardiology. 2019;34(4):331–341. Available from: https://doi.org/10.1097/HCO.0000000000000632.
30. Raghuram N, Ram V, Majumdar V, Rajesh SK, Singh A, Patil S, et al. Effectiveness of a Yoga-Based Lifestyle Protocol (YLP) in Preventing Diabetes in a High-Risk Indian Cohort: A Multicenter Cluster-Randomized Controlled Trial (NMB-Trial). Frontiers in Endocrinology. 2021;12:1–11. Available from: https://dx.doi.org/10.3389/fendo.2021.664657.

How to cite this article: Kumar A, Kumari Jha P, Ranjan R, Rastogi VK. Prevalence and Risk Factors of Pre-hypertension in Diabetes Mellitus Cases of North Indian Population. J Med Sci Health 2024; 10(2):190-197

Date of submission: 16.04.2024
Date of review: 04.05.2024
Date of acceptance: 11.07.2024
Date of publication: 29.07.2024