

Coexisting Prehypertension and Prediabetes in Healthy Adults: Analysis of Influencing Factors

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Abstract

Background: The aim of the present study was to evaluate the prevalence of coexisting prehypertension and prediabetes, and the associated risk profiles in study population around a medical college hospital of central India. **Material and Methods:** A cross-sectional survey in a representative sample of 540 men and 460 women aged 18 years and older was performed between 2019 and 2020. Prehypertension and prediabetes were diagnosed using the AHA guidelines 2017 and American Diabetes Association, respectively. Prehypertension was defined as a systolic blood pressure of 120-139 mmHg and/or diastolic blood pressure of 80-89 mmHg, and prediabetes was defined as fasting blood glucose of 140 mg/dL. **Results:** The prevalence of coexisting prehypertension and prediabetes was 21.0%. Men had a higher prevalence of coexisting prehypertension and prediabetes than women (14.2% vs. 8.4%; $P < 0.0001$). This prevalence increased with age and body mass index (obesity). Family history and alcohol were significantly and positively correlated with body mass index, waist circumference. Unhealthy diet, urban lifestyles, triglycerides, and total cholesterol, and negatively correlated with high density lipoprotein cholesterol in subjects with prehypertension and prediabetes. **Conclusion:** There is a large proportion of Indian adults with coexisting prehypertension and prediabetes. Thus, there is a need for more efforts that implement public health programs that target the earlier stages of hypertension and diabetes.

Keywords: Prehypertension, Prediabetes, Body Mass Index, Family History, Urban Lifestyle.

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Introduction

High blood pressure and elevated serum glucose levels often precede adverse cardiovascular events. The cardiovascular risk in otherwise healthy adults with prehypertension (PreHTN) and/or prediabetes (PreDM), although perceived to be high, is largely undocumented. Coexisting PreHTN and PreDM in healthy adults, correlates with untoward alterations in the commonly recognized cardiometabolic risk factors.

A healthy lifestyle, such as weight control, increased physical activity, moderate alcohol intake, tobacco cessation, salt reduction, and sufficient consumption of fresh fruits and vegetables could prevent the progression of co-PreHTN and PreDM to overt hypertension and diabetes mellitus. Public health programs are required to improve this situation. Obesity is a pro-inflammatory state frequently associated with widespread metabolic alterations that include insulin resistance and deregulation of blood pressure (BP). This cascade of events in some measure explains the susceptibility of obese adults for co-morbid conditions like diabetes mellitus and hypertension.

Material and Methods

A cross-sectional survey in a representative sample of 540 men and 460 women aged 18 years and older was performed between 2019 and 2020 in Department of General Medicine, People's College of Medical Sciences and Research Centre, Bhopal. Prehypertension and prediabetes were diagnosed using the AHA guidelines 2017 and American Diabetes Association, respectively. Prehypertension was defined as a systolic blood pressure of 120-139 mmHg and/or diastolic blood pressure of 80-89 mmHg, and prediabetes was defined as fasting blood glucose of 140 mg/dL. Samples included 1000 apparently healthy participants. Those who suffered from systemic disease involving diabetes mellitus, hypertension or other cardiovascular, renal, gastro-intestinal, pulmonary disease or cancer were excluded. Moreover, participants taking any medication known to affect carbohydrate and lipid metabolism were also excluded.

Consent: Written consent was obtained from the relatives of patients after explaining them the nature and purpose of the study. They were assured that confidentiality would be strictly maintained. The option to withdraw from the study was always open.

Methodology:

Epidemiological data were collected on all subjects via a standard questionnaire, which included demographic characteristics (i.e. age, gender, and ethnicity), socioeconomic data (i.e. educational level, marital status, and occupation), past history, and lifestyle risk factors. Smoking status was classified as non-smokers, current smokers (i.e. daily smoking regardless of the amount and type), and ex-smokers. Alcohol drinking status was defined as non-drinkers, current drinkers (frequent consumption of alcohol regardless of the amount and type), and ex-drinkers. Body weight was measured to the nearest 0.1 kg on a calibrated beam scale and height was measured barefoot in triplicate using a wall-mounted stadiometer to the nearest 0.1 cm. Body mass index (BMI; an index of overall obesity) was calculated as body weight (in kilograms) divided by height (in meters squared). BMI was categorized according to the World Health Organization criteria, where a BMI of $< 25 \text{ kg/m}^2$ is considered normal, a BMI between 25 and 29 kg/m^2 is considered overweight, and a BMI $\geq 30 \text{ kg/m}^2$ is considered obese. Waist circumference (WC; a surrogate marker for central adiposity) was measured midway between the lower rib margin and the iliac crest at the end of a gentle expiration. BP was measured following a resting period of at least 10 min using an electronic sphygmomanometer. The participant's arm was placed at the level of the heart, and BP was measured three times. The averages of the three measurements were used. If a subject was hypertensive, then a review was performed by doctors to exclude secondary hypertension. Lab measurements. Fasting blood glucose and lipid profiles, including total cholesterol (TC), triglycerides (TG), high-density lipoprotein cholesterol (HDL-C), and low-density lipoprotein cholesterol (LDL-C) were also assessed.

Results

Table 1: Distribution of Patients According to Our Prerequisites

Resting blood pressure				
Fasting blood glucose	Normal (< 120/80 mmHg)	Prehypertension (120-139/80-89 mmHg)	Hypertension (SBP & DBP) ($\geq 140/90 \text{ mmHG}$)	Total
Normal (<120mg/dl)	109	225	105	439
Prediabetes (120-140 mg/dl)	175	97	70	342
Diabetes ($\geq 140.0 \text{ mg/dl}$)	70	104	45	219

Total	354	426	220	1000
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Table 2: Various Factors Which Play Role in Hypertention and Diabetes

	Normotension and Normoglycemia		PreHTN and Pre DM		Hypertention and DM	
	N	Prevalence (%)	N	Prevalence (%)	N	Prevalence (%)
Overall (2019-2020)	340	28.6±0.5	480	11.0±0.3	180	2.0±0.2
Gender						
Men [540]	145	17.9±0.6	212	14.2±0.6	183	2.7±0.3
Women [460]	205	36.9±0.7	195	8.4±0.4	100	1.3±0.2
Age group (years)						
18-39	138	44.7±0.8	12	6.6±0.4	17	0.2±0.1
40-49	95	28.1±1.1	145	11.6±0.8	80	1.7±0.3
50-59	88	17.0±0.9	41	14.0±0.9	52	2.7±0.4
60	69	8.5±0.7	99	15.9±0.9	101	5.0±0.5
Education						
Primary of below	119	14.5±1.2	100	12.2±1.1	69	8.4±0.2
Secondary	274	24.3±0.7	261	12.8±0.6	46	1.3±0.2
Matriculation of above	107	36.1±0.8	120	8.8±0.5	42	1.2±0.2
Marital Status						
Married	471	25.1±0.6	124	12.4±0.4	32	2.3±0.2
Single	77	50.9±1.3	51	3.8±0.5	13	0.2±0.1
Divorced / windowed	45	19.3±1.9	21	11.6±1.5	14	3.2±0.8
Smoking						
Non-smoker	186	32.2±0.6	361	9.6±0.4	110	1.9±0.2
Current smoker	57	20.1±0.9	242	15.6±0.8	35	2.0±0.3
Ex-drinker	49	15.0±2.0	55	16.8±2.1	13	4.0±1.1
Alcohol Consumption						
Non-smoker	1825	32.6±0.6	540	9.6±0.4	93	1.7±0.2
Current smoker	413	19.4±0.9	290	13.6±0.7	57	2.7±0.3
Ex-drinker	38	19.5±2.8	24	12.3±2.3	8	4.1±1.4

Table 3: Other Factors [Vital Parameters and Lab Investigations] Which Influenced Our Study

	Prehypertension-prediabetes	N	Hypertension-diabetes	N	x ± s/M (Q _R)	p-value ^a	p-value ^b
	x ± s/M (Q _R)		x ± s/M (Q _R)				
BMI (Kg/m ²)	22.5 ± 3.2 22.2 ± 3.9	512 384	25.4 ± 3.5 24.6 ± 3.2	96 61	26.6 ± 3.1 26.8 ± 3.7	< 0.0001	0.0018 <0.0001
Men							
Women							
WC (cm)	79.0 ± 9.7	498	88.1 ± 9.3	97			<0.0001
Men	73.3 ± 8.3	376	82.0± 8.8	60	92.2 ± 8.5		<0.0001
Women	108.9 ± 7.2	897	126.3 ± 6.9	160	88.7 ± 9.8		<0.0001
SBP (mmHg)	70.1 ± 6.0	897	80.4 ± 5.7	160	148.9 ± 15.6		<0.0001
DBP (mmHg)	15.4 (12.0-22.09)	897	28.6 (180-48.9)	160	91.8 ± 10.1		0.0984 <0.0001
	274.9 ± 74.6	897		160			
	5.0 ± 0.4	897	333.4 ± 86.4	160			

GGT (U/L)	0.97 (0.73-1.35)	897	6.0 ± 0.3	160	38.1(25.0-64.0)		<0.0015
UA (pmol/L)	4.4 ± 0.9	897	1.58 ± (1.08 – 2.35)	160	321.3 ± 78.3		<0.0026
GLU (mmol/L)	1.5 ± 0.3	895	5.0 ± 1.1	160	9.1 ± 2.5		<0.0026
TG (mmol/L)	2.3 ± 0.8	897	1.4 ± 0.4	160	5.3±1.1		<0.0001
TC (mmol/L)			2.8 ± 0.9		1.3 ± 1.1		
HDL – C (mmol/L)					3.1 ± 0.3		
LDL- C (mmol/L)					3.1 ± 0.9		

Table 4: Relations of GGT and Uric Acid with Parameters

Parameters	GGT		UA	
	r	p	r	p
BMI	0.370	0.000	0.285	0.000
WC	0.424	0.000	0.402	0.000
SBP	0.045	0.215	0.076	0.026
DBP	0.144	0.000	0.075	0.333
GLU	0.163	0.000	0.038	0.215
HDL-C	-0.23	0.000	-0.23	0.000
LDL-C	0.160	0.000	0.040	0.157

The prevalence of coexisting prehypertension and prediabetes was 18.4%. Men had a higher prevalence of coexisting prehypertension and prediabetes than women (14.2% vs. 6.4%; $P < 0.0001$). This prevalence increased with age and body mass index (obesity). Family history and alcohol were significantly and positively correlated with body mass index, waist circumference. Unhealthy diet, urban lifestyles, triglycerides, and total cholesterol, and negatively correlated with high density lipoprotein cholesterol in subjects with prehypertension and prediabetes.[Table 2]

Healthy men and women with Co-PreHTN+PreDM were, on average, overweight with a large waist circumference, displayed an exacerbated systemic inflammation and higher insulin resistance. They had elevated triglycerides, lower high-density lipoprotein cholesterol, leading to above average cardiac risk ratios and were significantly more likely to have two or three concomitant metabolic risk factors.[Table 3]

A multivariate analysis showed that γ -glutamyltransferase and uric acid were significantly and positively correlated with body mass index, waist circumference, blood pressure, triglycerides, and total cholesterol, and negatively correlated with high density lipoprotein cholesterol in subjects with prehypertension and prediabetes.[Table 4]

Statistical Analysis:

Data were entered and documented on Epidata 3.1. Datasets were transferred into an SPSS compatible format. Data are presented as counts and percentages \pm standard errors (SE) for categorical variables, and means \pm standard deviation (SD) for continuous variables with a normal distribution. Comparisons between groups were made using an analysis of covariance. Medians and interquartile ranges of LDL and TG were calculated due to their abnormal distributions, and comparisons between these groups were made using the Wilcoxon rank sum test. Prevalence (%) indicates the percentage of healthy men and women

with a condition at the time of data collection, and means indicate the average value of a characteristic in healthy adults. Correlation analyses were performed using either the Pearson or Spearman correlations. Statistical analyses were performed on the statistical software, SPSS version 13.0). All tests for statistical significance were two-tailed, and considered significant when $P < 0.05$.

Discussion

Gupta AK et al found coexisting prehypertension and prediabetes in healthy adults, a pathway for accelerated cardiovascular events. The study investigated disease-free US adults. PreHTN and PreDM were diagnosed using JNC 7 and American Diabetes Association criteria, respectively; PreHTN was defined as systolic blood pressure 120–139 and/or diastolic blood pressure 80–89 mm Hg, and PreDM was defined as fasting blood sugar 100–125 mg dl⁻¹. Prevalence increased with age, was higher in men, and was lowest in non-Hispanic Blacks. Healthy men and women with Co-PreHTN+PreDM were, on average, overweight with a large waist circumference, displayed an exacerbated systemic inflammation and higher insulin resistance. They had elevated triglycerides, lower high-density lipoprotein cholesterol, leading to above average cardiac risk ratios and were significantly more likely to have two or three concomitant metabolic risk factors. High prevalence of Co-PreHTN+PreDM in healthy US adults, a strong correlate for dysregulated cardiometabolic risk factors, highlights a plausible accelerated pathway for early cardiovascular events.^[1]

Similar study like above was done by Wu J, Han SM et al among healthy adults in northern and northeastern China. The aim of the present study was to evaluate the prevalence of coexisting prehypertension and prediabetes, and the associated risk profiles in a Chinese population. A cross-sectional survey in a representative sample of 3,595 men and 4,593 women aged 18 years and older was performed between 2008 and 2010. The prevalence of coexisting prehypertension and prediabetes was 11.0%. Men had a higher prevalence. This prevalence increased with age and body mass index, and were the lowest among Mongolian-Chinese. A multivariate analysis showed that γ -glutamyltransferase and uric acid were significantly and positively correlated with body mass index, waist circumference, blood pressure, triglycerides, and total cholesterol, and negatively correlated with high density lipoprotein cholesterol in subjects with prehypertension and prediabetes. It concluded that there is a large proportion of Chinese adults with coexisting prehypertension and prediabetes. Thus, there is a need for more efforts that implement public health programs that target the earlier stages of hypertension and diabetes.^[2]

Ganguly SS et al studied prevalence of prehypertension and associated cardiovascular risk profiles among prediabetic Omani adults. A community based cross-sectional study revealed that 40.9 percent Omani adults are prediabetics. This study was undertaken to estimate the prevalence of prehypertension and associated cardiovascular risk profiles in prediabetics. A high prevalence of prehypertension (54.1%) exists in this study population. The major determinants of prehypertension in these prediabetic subjects were male gender, increasing dysglycemia and BMI. Appropriate intervention strategies have been suggested.^[3]

Analysis of influencing factor of coexisting prediabetes and prehypertension in adult residents of Jilin Province was done by Wang X et al to explore the risk factors of coexisting prediabetes and prehypertension, to provide theoretical basis for early intervention. The prevalence of coexisting prediabetes and prehypertension in Jilin Province was 11.3%. The binary Logistic regression results showed that age, sex, education, triglyceride (TG), BMI, waist circumference and alcohol consumption were the effects of factor coexisting prediabetes and prehypertension. Study concluded that it is important to pay attention to the

early stage of hypertension and diabetes, control the transition from prehypertension and prediabetes to hypertension and diabetes, and improve the health of residents.^[4]

Gupta AK, Johnson WD et al hypothesized that an elevated systemic proinflammatory burden correlates with dysglycemia and deregulated blood pressure. In otherwise healthy disease free obese adults, a higher degree of systemic inflammation is associated with prediabetes and prehypertension. Similar study by Booth III JN et al studied trends in prehypertension and hypertension risk factors in US adults. They analyzed data from 30 958 US adults ≥ 20 years of age. It was found that there was a nonstatistically significant increase in no weekly leisure-time physical activity (40.0% to 43.9%). Also, the prevalence of adhering to the Dietary Approaches to Stop Hypertension eating pattern decreased (18.4% to 11.9%). In contrast, there was a nonstatistically significant decline in current smoking (25.9% to 23.2%). In conclusion, the prevalence of prehypertension has decreased modestly since 1999–2000. Population-level approaches directed at adults with prehypertension are needed to improve risk factors to prevent hypertension and cardiovascular disease.^[5,6]

Vučak J et al saw association between hyperuricemia, prediabetes, and prehypertension in the Croatian adult population in a cross-sectional study. The association between hyperuricemia, hypertension, and diabetes has been proved to have strong association with the risk for cardiovascular diseases; therefore, in this study authors investigated the association between hyperuricemia, prediabetes, and prehypertension in Croatian adults, as well as that between purine-rich diet and hyperuricemia, prediabetes, or prehypertension. An association between purine-rich food and hyperuricemia was found ($p < 0.001$) and also for prediabetes ($p = 0.002$), but not for prehypertension ($p = 0.41$). The prevalence of hyperuricemia was 10.7% (15.4% male, 7.8% female), 32.5% for prediabetes (35.4% male, 30.8% female), and 26.6% for prehypertension (27.2% male, 26.2% female). Conclusion was hyperuricemia seems to be associated with prediabetes but not with prehypertension. Both, hyperuricemia and prediabetes were associated with purine-rich food and patients need to be advised on appropriate diet.^[7]

Fan J et al studied association of three simple insulin resistance indexes with prehypertension in normoglycemic subjects. This study aimed to explore which simple IR indexes were significantly associated with prehypertension in subjects with normoglycemia. Among the three indicators, only METS-IR had positive correlations with systolic and diastolic blood pressure levels. Furthermore, METS-IR was also significantly associated with prehypertension, irrespective of the categorization of waist circumference (WC). METS-IR was associated with prehypertension in normoglycemic Chinese subjects, which bypasses the impact of WC and might be valuable for the management of prehypertension and the prevention of prediabetes in different ethnic groups.^[8]

Conclusion

There is a large proportion of Indian adults with coexisting prehypertension and prediabetes. Thus, there is a need for more efforts that implement public health programs that target the earlier stages of hypertension and diabetes. On the other hand, risk population should identify itself and proceed with lifestyle changes, less stress and healthy food habits.

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