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**Correlation between hypertension and hyperglycemia among young adults in India**

Midha T *et al.* Correlation between hypertension and hyperglycemia

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**Abstract**

**AIM:** To assess the correlation between blood pressure levels and fasting plasma glucose levels among young adults attending Chatrapati Shahuji Maharaj University, Kanpur, India.

**METHODS:** The present study was cross-sectional in nature, conducted among students in the Institute of Paramedical Sciences, Chatrapati Shahuji Maharaj University, Kanpur. Study subjects included 185 young adults. Among them, 94 were males and 91 were females, in the age group 17 to 19 years.

**RESULTS:** Mean age among males was 18.5 ± 1.5 years and among females was 17.9 ± 1.8 years. Of the total 185 study subjects, 61 (32.9%) were classified as pre-diabetic and 20 (10.8%) as pre-hypertensive. Mean waist circumference, systolic blood pressure and serum HDL did not vary significantly between normoglycemic and pre-diabetic subjects. However, the mean diastolic blood pressure of pre-diabetics (82 ± 5 mmHg) was significantly higher than normoglycemics (79 ± 6 mmHg). Mean serum cholesterol, serum triglycerides, serum LDL and serum VLDL was also higher among pre-diabetic subjects in comparison to normoglycemic subjects and the difference was statistically significant. Upon multiple linear regression analysis, it was observed that body mass index (BMI) (β = 0.149), diastolic blood pressure (β = 0.375) and serum LDL (β = 0.483) were significantly associated with fasting plasma glucose. Multiple linear regression with diastolic blood pressure as the outcome variable showed that BMI (β = 0.219), fasting blood glucose (β = 0.247) and systolic blood pressure (β = 0.510) were significantly associated.

**CONCLUSION:** A significant prevalence of pre-diabetes and pre-hypertension in young adults is a matter of concern therefore all young adults need to be targeted for screening of diabetes and hypertension and lifestyle modification.

**Key words:** Adolescent; Hypertension; Diabetes; Co-prevalence; India

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**Core tip:** In the present study, 32.9% young adults were pre-diabetic whereas 10.8% were pre-hypertensive. Around 2.7% young adults had both pre-diabetes and pre-hypertension. Among the pre-hypertensives, 25% also had pre-diabetes. However among the pre-diabetics, 8.2% had pre-hypertension. The correlation between systolic blood pressure and fasting plasma glucose was not statistically significant. However, the correlation between diastolic blood pressure and fasting plasma glucose was significant. The mean diastolic blood pressure of pre-diabetics (82 ± 5 mmHg) was significantly higher than normoglycemics (79 ± 6 mmHg).Upon multiple linear regression analysis, it was observed that body mass index (β = 0.149), diastolic blood pressure (β = 0.375) and serum LDL (β = 0.483) were significantly associated with fasting plasma glucose.

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**INTRODUCTION**

Diabetes and hypertension is the twin epidemic, rapidly on the rise in the developing countries[1].Diabetes mellitus or chronic hyperglycemia is a metabolic disorder which results from defects in carbohydrate, fat and protein metabolism that occur as a consequence of deranged insulin secretion or action. Long term hyperglycemia is associated with the development of cardiovascular disease, renal disease, neuropathy, retinopathy, peripheral vasculopathy, and stroke[2].WHO has estimated that globally the number of adults with diabetes will increase from 171 million in 2000 to 366 million in the year 2030[3]. In 2004, worldwide, around 3.4 million people died as a result of hyperglycemia[4].Of the total deaths among diabetics, around 80% occur in developing countries[5] According to World Health Organization (WHO), diabetes will be the 7th leading cause of global mortality in 2030[6]. India has been declared as the capital of diabetes because approximately 41 million Indians have diabetes to date and every fifth diabetic in the world is an Indian[7].

Worldwide, hypertension or high blood pressure has caused around 7.5 million deaths, which accounts for 12.8% of the global mortality. Around 57 million disability adjusted life years (DALYS) or 3.7% of total DALYS have been attributed to hypertension[8]. The global prevalence of hypertension in adults more than 25 years of age, averaged around 40% in 2008[8]. The WHO has estimated that hypertension is directly responsible for about 62% of stroke and 49% of coronary artery disease, worldwide[9]. In a meta-analysis of prevalence studies on hypertension in India, from January 2000 to June 2012, it was observed that the prevalence of hypertension in the urban population was 40.8%whereas that in the rural population was17.9%[10]. Hypertension leads to cardiovascular disease, peripheral vasculopathy, cerebrovascular disease, and nephropathy[11].

It has been observed that diabetes and hypertension often exist together in the population. The risk of developing hypertension is 1.5-2.0 times higher in diabetics as compared to non-diabetics, whereas around one-third of the hypertensives develop diabetes[12].These co-morbidities hasten the progress of vascular complications[13-15].

Diabetes and hypertension both can be prevented and managed by lifestyle modification and medical intervention. Moreover, screening and early management of diabetes and hypertension, through periodic surveillance, will slow down the progress of the disease and prevent complications[16]. American Diabetic Association has described a new entity of impaired glucose metabolism as prediabetes in which two categories are included - Impaired Fasting Glucose, when fasting plasma glucose is between 100 and 125 mg/dL and Impaired Glucose Tolerance, when 2-h result following oral glucose tolerance test is between 140 and 199 mg/dL[17].Persons with prediabetes, are at greater risk for the future development of diabetes as well as cardiovascular disease[18]. According to JNC-7, systolic blood pressure 120-139 mmHg and/or diastolic blood pressure 80-89 mmHg was classified as pre-hypertension[19].Similarly, individuals with pre-hypertension are pre-disposed to developing hypertension in the later years of life.

Though the manifestation of cardiovascular disease occurs in middle age and later, it has now been proved that the initiation of cardiovascular disease occurs in childhood and adolescence[20]. The known risk factors of cardiovascular disease such as hypertension, raised blood glucose, raised serum cholesterol, tobacco consumption, high fat diet and obesity start early in childhood and adolescence and then continue into adulthood[20]. Screening and early identification of these risk factors and their progenitors like pre-diabetes and pre-hypertension may go a long way to prevent cardiovascular morbidity and mortality in adults.

The overall prevalence of glucose intolerance among adolescents in South India was reported to be 3.7%[21]. Prevalence of hypertension among children and adolescents in north India was observed to be 9.4%[22].

The rising prevalence of diabetes and hypertension in India, their beginning in the adolescent age group, and the co-occurrence of the two disease entities, is a cause of concern, therefore this study was planned to study the association between hypertension and hyperglycemia in Indian young adults.

**MATERIAL AND METHODS**

***Stuyd design and sample size***

It was a cross-sectional study. The minimum sample size required (*n* = 89) was calculated taking a prevalence of glucose intolerance of 3.7%, as reported in the ORANGE-2 study, with a precision of 4% and a confidence level of 95%[21]. The formula used was, *n =* Z(1-α/2 )2pq/d2 (where Z(1-α/2) was taken at 95% confidence; *P* = prevalence of obesity, q = 100-p; d = absolute precision). For this study, *P* = 3.7%; q = 96.3%; d = 4%. Adding a 10% for incomplete answers, the total number came out to be 98. A design effect of 2 was included to minimize any error due to inherent variation in the population. The calculated sample size was multiplied by 2 to obtain the sample size of 196.

***Sampling***

The study was conducted among students in the Institute of Paramedical Sciences, affiliated to Chatrapati Shahuji Maharaj University, Kanpur. The Institute of Paramedical Sciences provides a course of 4 years in Paramedical Sciences and enrols around 100 students annually. A list of all the students enrolled in the Institute in the first, second and third year was obtained. Systematic random sampling technique was applied to identify the required number of study subjects. Written informed consent was taken from the students and their parents/guardians. In case a student refused to participate in the study, the next consecutive student was included. The data was analyzed for 185 subjects only whose laboratory test results were available. Among the study subjects thus selected, 94 were males and 91 were females, in the age group 17 to 19 years.

***Methodology***

A standard mercury sphygmomanometer, Diamond Co., Industrial electronics and Allied Products, Pune, Maharashtra, India, was used for recording blood pressure. Blood pressure (BP) was measured on the left arm, in the sitting position, using appropriate size cuffs. Before the measurement was taken, the subject was seated for at least 5 min. Care was taken that the arm muscles were relaxed and the arm was placed at heart level. The cuff was applied to the left upper arm and was inflated until the manometer reading was 30 mmHg above the level at which the radial pulse disappeared, and thereafter the cuff was slowly deflated. The Korotkoff sounds were monitored using a stethoscope applied over the brachial artery. The first (appearance) and the fifth (disappearance) Korotkoff sounds were noted as the systolic and diastolic blood pressure, respectively. Blood pressures were measured twice and their mean was recorded. Subjects were categorized into normotensive, pre-hypertensive and Stage I and Stage II hypertensive based on the blood pressure classification for adolescents for subjects of age 17 years and according to
JNC-7 for subjects ≥ 18 years[19,23]. JNC-7 has classified systolic blood pressure (SBP) < 120 mmHg and a diastolic blood pressure (DBP) < 80 mmHg as normal blood pressure; SBP 120-139 mmHg and/or DBP 80-89 mmHg as pre-hypertension; SBP 140-159 mmHg and/or DBP 90-99 mmHg as Stage I hypertension and SBP≥ 160 mmHg and/or DBP ≥ 100 mmHg as stage Ⅱ hypertension[19]. For adolescents upto 17 years of age, normal BP was defined as systolic and diastolic blood pressure < 90th percentile, Prehypertension as systolic or diastolic blood pressure 90th percentile to < 95th percentile or blood pressure > 120/80 mmHg to < 95th percentile, Stage 1 Hypertension (HTN) as systolic and/or diastolic blood pressure 95th percentile to 99th percentile plus 5 mmHg and Stage 2 HTN as systolic and/or diastolic blood pressure > 99th percentile plus 5 mmHg[23].

According to American Diabetic Asoociation, subjects were classified as normoglycemic when fasting plasma glucose was less than 100 mg/dL after 8 h fasting, prediabetic when fasting plasma glucose was between 100 and 125 mg/dL and diabetic when fasting plasma glucose was more than 126 mg/dL[17].

Body weight was estimated, using Krup’s weighing machine, with a least count of 0.5 kg. The subject was made to stand on the weighing scale, feet around 15 cm apart, and weight distributed on both the legs. Zero setting was done before each measurement. Height was estimated, with the subject standing upright against the wall such that the roof of the external auditory meatus was in line with the lower margin of the orbit. A hard board was placed on the wall, just over the head and height was marked on the wall and measured with a measuring tape with a least count of 0.5 cm.Waist circumference was measured, at the level of the umbilicus, with the subject in the erect position, breathing silently.

Fasting blood samples were drawn on the day subsequent to the interview. A total of 10 mL blood was collected from each subject: 4 mL in EDTA tube and 6 mL in plain tube. The samples were immediately sent to the laboratory in the Department of Biochemistry, Chatrapati Shahuji Maharaj University, Kanpur. The samples were centrifuged without any delay. The samples were analyzed for glucose on the same day. Remaining plasma and serum was aliquoted and stored at -70 deg C. Lipid estimations were done in batches in serum samples. Standard internal quality control procedures for laboratory were followed. Fasting plasma glucose was estimated using the Enzymatic colorimetric GOD – PAP method, Serum Cholesterol using Enzymatic Colorimetric High Performance CHOD – PAP method, Serum HDL using Enzymatic Colorimetric High Performance CHOD – PAP method, and Serum triglycerides using colorimetric method[24].

Data was compiled using Microsoft Excel and analysed using SPSS 17.0.Pearson’s Chi square test was applied to study the difference between categorical variables. Student’s *t*-test was used to analyse the difference between continuous variables. Two-tailed p-value less than 0.05 was considered significant. Pearson’s correlation coefficient was applied to determine the association between fasting plasma glucose and systolic and diastolic blood pressure. Multiple linear regression analysis was done to analyse the association of various determinants with fasting plasma glucose.

***Statistical analysis***

The statistical methods are adequately and appropriately applied to the best of the authors’ knowledge.

**RESULTS**

Data was analyzed for 185 subjects, 94 males and 91 females. Mean age among males was 18.5 ± 1.5 years and among females was 17.9 ± 1.8 years. Among the subjects living in urban area, 47.1% were males whereas among those living in rural areas 57.6% were males (Table 1). Subjects predominantly belonged to Hindu religion. Among those who were sedentary, 40.6% were males, whereas among heavy workers, 66.7% were males. However, there was no statistically significant association between physical activity and gender. Of all the study subjects, 12 (6.4%) were smokers and all were male (100%).The association between smoking and gender was statistically significant.

Among the total study subjects, 61 (32.9%) were pre-diabetic whereas 20 (10.8%) were pre-hypertensive. Five (2.7%) subjects had both pre-diabetes and pre-hypertension. Among the pre-hypertensives, 25% also had pre-diabetes (Table 2). However among the pre-diabetics, 8.2% had pre-hypertension.

The correlation of systolic blood pressure with fasting plasma glucose was not found to be statistically significant. However, the correlation of diastolic blood pressure with fasting plasma glucose was significant (*P* < 0.001) (Table 3).

Among the normoglycemic subjects, mean BMI was 20.6 ± 42. kg/m2 whereas among the pre-diabetic subjects the BMI was 21.8 ± 3.0 kg/m2 and the association was found to be significant.\ (Table 4). There was no significant association between the waist circumference, systolic blood pressure and serum HDL of normoglycemic and pre-diabetic subjects. However, the mean diastolic blood pressure of pre-diabetics (82 ± 5 mmHg) was significantly higher than normoglycemics (79 ± 6 mmHg). Mean serum cholesterol, serum triglycerides, and serum VLDL was also higher among pre-diabetic subjects as compared to normoglycemic subjects and the association was found to be significant.Mean serum LDL was also significantly higher in prediabetics (104.1 ± 22.7 mg/dL) than in normoglycemics (92.7 ± 23.6 mg/dL).

Multiple linear regression analysis for the determinants of fasting plasma glucose was done and the adjusted *R*2 was 23.5% (Table 5). Waist circumference, systolic blood pressure, serum cholesterol, serum triglycerides, serum HDL, serum VLDL were not significantly associated with fasting plasma glucose. For every 1 mmHg increase in diastolic blood pressure, the fasting plasma glucose was expected to rise by 0.375 mg/dL (β = 0.375) and this association was found to be significant (*P* < 0.05). Similarly, BMI (β = 0.149), and serum LDL (β = 0.483) were also significantly associated with fasting plasma glucose.

Multiple linear regression analysis was done for systolic blood pressure as the outcomevariable and the adjusted R2 was 43.7% (Table 6). Diastolic blood pressure and serum LDL were observed to be significantly associated. Multiple linear regression analysis for diastolic blood pressure as the outcome variable showed an adjusted R2 of 49.6% (Table 7). BMI (β = 0.219), fasting plasma glucose (β = 0.247) and systolic blood pressure (β = 0.510) were found to be significantly associated.

**DISCUSSION**

In this study, the overall prevalence of pre-diabetes was 32.9%. In another study from Dhaka, Bangladesh, around 20% subjects aged 11-18 years, with BMI ≥ 95th percentile for age and sex using CDC growth chart, were reported to have impaired glucose tolerance as detected after two hours oral glucose tolerance test[25]. A study from United States revealed that 21 percent of obese adolescents between 11 and 18 years had impaired glucose tolerance following two hours oral glucose tolerance test[26]. The difference from our study may be due to the criteria used for impaired glucose tolerance as we have considered fasting plasma glucose, whereas the other studies have considered the plasma glucose after a two hours oral glucose tolerance test which may have greater specificity in labelling impaired glucose tolerance. In a study from South India, the prevalence of impaired glucose tolerance was 3.7% in children and adolescents 6-19 years following oral glucose tolerance test[21].The low prevalence as compared to our study may be due to the large age range of study subjects and the criteria used for impaired glucose tolerance.

In our study, the prevalence of pre-hypertension was 10.8%. The prevalence of pre-hypertension among adolescents from Wardha, in central India, was reported as 10.6%, which was very similar to our results[27].This was also in concordance with the results of another study from Shimla, in north India wherein the prevalence of prehypertension was found to be 12.3%[28].

The present study revealed that 5 (2.7%) subjects had both pre-diabetes and pre-hypertension.However, the mutli-centre Screening India’s Twin Epidemic (SITE) survey revealed that 20.6% of the study subjects had co-existent diabetes and hypertension[16]. In our study, among the pre-hypertensives, 25% also had pre-diabetes whereas in the SITE study, among 7212 hypertensives, 3227 (44.7%) had diabetes. The present study showed that among the pre-diabetics, 8.2% had pre-hypertension whereas in the SITE study, among 5427 diabetics, 59.5%were hypertensive.These differences may be because only adult subjects more than 18 years were studied in the SITE survey whereas our study included subjects in the 17 to 19 years age group.

Hypertension is responsible for acceleration of the vascular complications of diabetes, including coronary artery disease, renal disease, and retinopathy[29]. The pathophysiology of hypertension occurs at the cellular level in the intima of the arteries, which involves the function of the endothelial cells. Hypertension and diabetes both alter the endothelial cell structure and function. In large and medium size vessels and in the kidney, endothelial dysfunction causes proliferation of vascular smooth muscle cells and vasoconstriction of mesangial cells[29]. These alterations in the smooth muscle cells lead to atherosclerosis and glomerulosclerosis. Similarly, proliferation of retinal capillary endothelial cells causes retinopathy. Therefore, endothelial cell damage is responsible for the complications of diabetes and this damage is accelerated by co-existing hypertension[29].

Co-occurrence of hypertension in diabetics increases the risk of development of macrovascular and microvascular complications[30,31].Diabetic individuals with coexisting hypertension have a much higher occurrence of cerebrovascular accidents as compared to diabetics with normal blood pressure[30,32,33]. The risk of peripheral vasculopathy also increases in case of co-existence of hypertension in diabetics[33]. Both hypertension and diabetes lead to coronary artery disease[34]. It has been observed that in hypertensive diabetics, the risk of death due to cardiovascular disease is almost doubled[34]. Hypertension accelerates the progress of diabetic retinopathy and nephropathy[35,36]. Hypertension in diabetics hastens the occurrence of microalbuminuria and the progress of nephropathy after the development of proteinuria[36].

In our study, mean waist circumference, systolic blood pressure and serum HDL did not vary significantly between normoglycemic and pre-diabetic subjects. However, the mean diastolic blood pressure of pre-diabetics (82 ± 5 mmHg) was significantly higher than normoglycemics (79 ± 6 mmHg). Correlation between systolic blood pressure and fasting plasma glucose was not statistically significant. However, the correlation of diastolic blood pressure with fasting plasma glucose was significant (*P* < 0.001).

In the present study, upon multiple linear regression analysis for fasting plasma glucose, BMI (β = 0.149) diastolic blood pressure (β = 0.375) and serum LDL (β = 0.483) were found to be significantly associated. However, in the study from South India, on multiple regression analysis, only family history of diabetes (OR 4.11) and HOMA-IR (insulin resistance assessed by homeostasis model assessment) (OR 11.22) were found to be significant in girls and only HOMA-IR (OR 5.19) was associated with glucose intolerance in boys[21]. Due to financial constraints, HOMA-IR assessment was not included in our study. Upon multiple linear regression for diastolic blood pressure, it was observed that BMI (β = 0.219), fasting plasma glucose (β = 0.247) and systolic blood pressure (β = 0.510) were significantly associated.

The present study reveals that prediabetes and pre-hypertension begin to occur in young adults. It is well known that the prevalence of cardiovascular disease is increasing among Indians, occurring especially at a younger age[12].Therefore it is imperative that policies and programs be developed for identifying and successfully managing hypertension and diabetes at an early age.

Given the risk associated with co-prevalence of diabetes and hypertension, it is important to identify young adults with pre-diabetes and pre-hypertension who are prone to develop full blown disease as adults, and it is the need of the hour that guidelines be formulated under the National Program for Prevention and Control of Cancer, Diabetes, CVD and Stroke (NPCDCS) for primordial and primary prevention efforts through evidence-based screening and health education initiatives. Health education programs among young adults regarding lifestyle modification to curb diabetes and hypertension in their incipient stage may be considered as a cost-effective public health approach in dealing with the morbidity attributed to consequent cardiovascular diseases.

**COMMENTS**

***Background***

As per WHO estimates, globally the number of adults with diabetes will rise from 171 million in 2000 to 366 million in the year 2030. India has been declared as the capital of diabetes because approximately 41 million Indians have diabetes till date and every fifth diabetic in world is an Indian.The global prevalence of raised blood pressure or hypertension in adults aged 25 and over was around 40% in 2008. A meta-analysis of prevalence studies on hypertension in India, from January 2000 to June 2012, revealed a high prevalence of hypertension in the urban (40.8%) as well as rural population (17.9%). The co-prevalence of diabetes and hypertension is strongly associated with cardiovascular disease. Prevalence of cardiovascular disease is on the rise among Indians, especially at a younger age, therefore early detection and management of hypertension and diabetes may hold the key to reducing cardiovascular mortality in India. Prevalence of glucose intolerance among adolescents in South India was reported to be 3.7%.Prevalence of hypertension among children and adolescents in north India was observed to be 9.4%.The high prevalence of diabetes and hypertension in India with their beginning in the adolescent age group, and the co-occurrence of the two disease entities leading to cardiovascular diseases, is an area of concern. Screening and health education programs regarding lifestyle modification may be considered as a cost-effective public health approach in dealing with the morbidity attributed to cardiovascular diseases. Therefore, a precise estimate of the prevalence of diabetes and hypertension among Indian young adults is required to assess the magnitude of the problem that has to be addressed and to design programs and policies for prevention and control.

***Research frontiers***

Pre-diabetes and pre-hypertension have a high degree of co-prevalence among Indian young adults and this knowledge will help in shaping primordial and primary level preventive programs for our country.

***Innovations and breakthroughs***

In India, very few studies are available on the prevalence of diabetes and hypertension among young adults and none have analysed the association between the two co-morbidities. Given the risk associated with co-prevalence of diabetes and hypertension, it is important to estimate their prevalence among Indian young adults to provide evidence-based guidelines for preventive efforts through screening and health education initiatives.

***Applications***

Very few studies on the prevalence of diabetes and hypertension among young adults are available in India; and this study reveals their co-prevalence in our indigenous population and emphasizes the need to develop a strategy for prevention of these co-morbidities to bring down the consequent cardiovascular morbidity and mortality in our country.

***Terminology***

Regression analysis is a statistical process for estimating the relationships among variables. It includes many techniques for modeling and analyzing several variables, when the focus is on the relationship between a [dependent variable](http://en.wikipedia.org/wiki/Dependent_variable) and one or more [independent variables](http://en.wikipedia.org/wiki/Independent_variable). More specifically, regression analysis helps one understand how the typical value of the dependent variable changes when any one of the independent variables is varied, while the other independent variables are held fixed. In [statistics](http://en.wikipedia.org/wiki/Statistics), linear regression is an approach for modeling the relationship between a scalar [dependent variable](http://en.wikipedia.org/wiki/Dependent_variable) y and one or more [explanatory or independent variables](http://en.wikipedia.org/wiki/Explanatory_variable) denoted X. The case of one explanatory variable is called [simple linear regression](http://en.wikipedia.org/wiki/Simple_linear_regression). For more than one explanatory variable, the process is called multiple linear regression. The beta (β) regression coefficient is computed to assess the strength of the relationship between each predictor variable and the dependent variable.

***Peer review***

This a well written report from a useful study.

**REFERENCES**

1 **World Health Organization**. Global Health Risks: Mortality and Burden of Disease Attributable to Selected Major Risks. December 2010. [Accessed June 18, 2011] Available from: URL: www.who.int/healthinfo/global\_burden\_ disease/GlobalHealthRisks\_report\_full.pdf

2 [**American Diabetes Association**](http://www.ncbi.nlm.nih.gov/pubmed?term=American%20Diabetes%20Association%5BCorporate%20Author%5D)**.** Diagnosis and classification of diabetes mellitus. *Diabetes Care* 2004; **27** Suppl 1: S5-S10 [PMID: 14693921]

3 **Wild S**, Roglic G, Green A, Sicree R, King H. Global prevalence of diabetes: estimates for the year 2000 and projections for 2030. *Diabetes Care* 2004; **27**: 1047-1053 [PMID: 15111519]

4 **Danaei G**, Finucane MM, Lu Y, Singh GM, Cowan MJ, Paciorek CJ, Lin JK, Farzadfar F, Khang YH, Stevens GA, Rao M, Ali MK, Riley LM, Robinson CA, Ezzati M. National, regional, and global trends in fasting plasma glucose and diabetes prevalence since 1980: systematic analysis of health examination surveys and epidemiological studies with 370 country-years and 2·7 million participants. *Lancet* 2011; **378**: 31-40 [PMID: 21705069]

5 Global health risks. Mortality and burden of disease attributable to selected major risks. Geneva, World Health Organization, 2009. Available from: URL: http: //www.who.int/healthinfo/global\_burden\_disease/GlobalHealthRisks\_report\_full.pdf

6 **Mathers CD**, Loncar D. Projections of global mortality and burden of disease from 2002 to 2030. *PLoS Med* 2006; **3**: e442 [PMID: 17132052]

7 **Joshi SR**, Parikh RM. India--diabetes capital of the world: now heading towards hypertension. *J Assoc Physicians India* 2007; **55**: 323-324 [PMID: 17844690]

8 **World Health Organization.** Global Health Repository. Available from: URL: http: //www.who.int/gho/ncd/risk\_factors/blood\_pressure\_prevalence\_text/en/index.html

9 **World Health Report**. Reducing Risks, Promoting HealthyLife. 2002; **4:** 12. Available from: URL: http: //www.who.int/whr/2002/en/whr02\_ch4.pdf

10 **Midha T,** Nath B, Kumari R, Rao YK, Pandey U. Prevalence of hypertension in India: A meta-analysis. *World J Meta-Anal* 2013; **1**: 83-89 [DOI: 10.13105/wjma.v1.i2.83]

11 **Whitworth JA**. 2003 World Health Organization (WHO)/International Society of Hypertension (ISH) statement on management of hypertension. *J Hypertens* 2003; **21**: 1983-1992 [PMID: 14597836]

12 **Sahay BK**: API-ICP guidelines on diabetes 2007. *J Assoc Physicians India* 2007; **55:** 1–50

13 **Mohan V**, Deepa R, Rani SS, Premalatha G. Prevalence of coronary artery disease and its relationship to lipids in a selected population in South India: The Chennai Urban Population Study (CUPS No. 5). *J Am Coll Cardiol* 2001; **38**: 682-687 [PMID: 11527617]

14 **Williams G**. Hypertension in diabetes. In: Pickup J, Williams G, eds. Textbook of Diabetes. London: Blackwell Scientific Publications, 1991: 719–732

15 **Parving HH**, Andersen AR, Smidt UM, Oxenbøll B, Edsberg B, Christiansen JS. Diabetic nephropathy and arterial hypertension. *Diabetologia* 1983; **24**: 10-12 [PMID: 6825976]

16 **Joshi SR**, Saboo B, Vadivale M, Dani SI, Mithal A, Kaul U, Badgandi M, Iyengar SS, Viswanathan V, Sivakadaksham N, Chattopadhyaya PS, Biswas AD, Jindal S, Khan IA, Sethi BK, Rao VD, Dalal JJ. Prevalence of diagnosed and undiagnosed diabetes and hypertension in India--results from the Screening India's Twin Epidemic (SITE) study. *Diabetes Technol Ther* 2012; **14**: 8-15 [PMID: 22050271 DOI: 10.1089/dia.2011.0243]

17 Expert Committee on the Diagnosis and Classification of Diabetes Mellitus of the American Diabetes Association. *Diabetes Care* 2005; **28**: S4-S36 [DOI: 10.2337/diacare.25.2007.S5]

18 Standards of Medical Care in Diabetes—2013. *Diabetes Care* 2013; 36 Supplement 1: S11-S66 Available from: URL: http: //care.diabetesjournals.org/content/36/Supplement\_1/S11/T3.expansion.html

19 **Chobanian AV**, Bakris GL, Black HR, Cushman WC, Green LA, Izzo JL, Jones DW, Materson BJ, Oparil S, Wright JT, Roccella EJ. The Seventh Report of the Joint National Committee on Prevention, Detection, Evaluation, and Treatment of High Blood Pressure: the JNC 7 report. *JAMA* 2003; **289**: 2560-2572 [PMID: 12748199 DOI: 10.1001/jama.289.19.2560]

20 **Praveen PA**, Roy A, Prabhakaran D. Cardiovascular disease risk factors: a childhood perspective. *Indian J Pediatr* 2013; **80** Suppl 1: S3-12 [PMID: 22638996 DOI: 10.1007/s12098-012-0767-z]

21 **Ranjani H**, Sonya J, Anjana RM, Mohan V. Prevalence of glucose intolerance among children and adolescents in urban South India (ORANGE-2). *Diabetes Technol Ther* 2013; **15**: 13-19 [PMID: 23151017 DOI: 10.1089/dia.2012.0236]

22 **Durrani AM**, Waseem F. Blood pressure distribution and its relation to anthropometric measurements among school children in Aligarh. *Indian J Public Health* 2011; **55**: 121-124 [PMID: 21941047 DOI: 10.4103/0019-557X.85246]

23 The fourth report on the diagnosis, evaluation, and treatment of high blood pressure in children and adolescents. *Pediatrics* 2004; **114**: 555-576 [PMID: 15286277]

24 **Tietz NW**. Clinical Guide to Laboratory Tests, 2nd Edition, Saunders WB, Philadelphia, PA, 1990

25 **Mohsin F**, Mahbuba S, Begum T, Azad K, Nahar N. Prevalence of impaired glucose tolerance among children and adolescents with obesity. *Mymensingh Med J* 2012; **21**: 684-690 [PMID: 23134918]

26 **Sinha R**, Fisch G, Teague B, Tamborlane WV, Banyas B, Allen K, Savoye M, Rieger V, Taksali S, Barbetta G, Sherwin RS, Caprio S. Prevalence of impaired glucose tolerance among children and adolescents with marked obesity. *N Engl J Med* 2002; **346**: 802-810 [PMID: 11893791]

27 **Kumar J**, Deshmukh PR, Garg BS. Prevalence and correlates of sustained hypertension in adolescents of rural Wardha, central India. *Indian J Pediatr* 2012; **79**: 1206-1212 [PMID: 22203427 DOI: 10.1007/s12098-011-0663-y]

28 **Sharma A**, Grover N, Kaushik S, Bhardwaj R, Sankhyan N. Prevalence of hypertension among schoolchildren in Shimla. *Indian Pediatr* 2010; **47**: 873-876 [PMID: 20308762]

29 **Hsueh WA**, Anderson PW. Hypertension, the endothelial cell, and the vascular complications of diabetes mellitus. *Hypertension* 1992; **20**: 253-263 [PMID: 1639468]

30 **Epstein M**, Sowers JR. Diabetes mellitus and hypertension. *Hypertension* 1992; **19**: 403-418 [PMID: 1568757]

31 **Cruickshanks KJ**, Orchard TJ, Becker DJ. The cardiovascular risk profile of adolescents with insulin-dependent diabetes mellitus. *Diabetes Care* 1985; **8**: 118-124 [PMID: 3996168]

32 **Sowers JR**, Levy J, Zemel MB. Hypertension and diabetes. *Med Clin North Am* 1988; **72**: 1399-1414 [PMID: 3054360]

33 **Janka HU**, Standl E, Mehnert H. Peripheral vascular disease in diabetes mellitus and its relation to cardiovascular risk factors: screening with the doppler ultrasonic technique. *Diabetes Care* 1980; **3**: 207-213 [PMID: 7389542]

34 **Kannel WB**. Diabetes and cardiovascular disease. The Framingham Study: 18-year follow-up. *Cardiol Dig* 1976: 11-15

35 **Chahal P**, Inglesby DV, Sleightholm M, Kohner EM. Blood pressure and the progression of mild background diabetic retinopathy. *Hypertension* 1985; **7**: II79-II83 [PMID: 4077241]

36 **Hasslacher C**, Stech W, Wahl P, Ritz E. Blood pressure and metabolic control as risk factors for nephropathy in type 1 (insulin-dependent) diabetes. *Diabetologia* 1985; **28**: 6-11 [PMID: 3979689]

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**Table 1 Bio-social characteristics of study subjects**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Determinant | Total | Male (*n* = 94) | Female (*n* = 91) | *P* value1 |
| *n* | % | *n* | % |
| Place of residence |
| Urban | 119 | 56 | 47.1 | 63 | 53.9 | 0.17 |
| Rural | 66 | 38 | 57.6 | 28 | 42.4 |
| Religion |
| Hindu | 164 | 84 | 51.2 | 80 | 48.8 | 0.084 |
| Muslim | 15 | 6 | 40 | 9 | 60 |
| Sikh | 4 | 4 | 100 | 0 | 0 |
| Christian | 2 | 0 | 0 | 2 | 100 |
| Type of family |
| Nuclear | 100 | 36 | 36 | 64 | 64 | < 0.0012 |
| Joint | 85 | 58 | 68.2 | 27 | 31.8 |
| Physical activity |
| Sedentary | 69 | 28 | 40.6 | 41 | 59.4 | 0.056 |
| Moderate | 92 | 50 | 54.3 | 42 | 45.7 |
| Heavy | 24 | 16 | 66.7 | 8 | 33.3 |
| Smoking habit |
| Non-smoker | 173 | 82 | 47.3 | 91 | 52.7 | 0.0012 |
| Smoker | 12 | 12 | 100 | 0 | 0 |
| Alcohol intake |
| Non-alcoholic | 183 | 92 | 50.3 | 91 | 49.7 | 0.162 |
| Alcoholic | 2 | 2 | 100 | 0 | 0 |
| Eating habit |
| Vegetarian | 110 | 52 | 47.3 | 58 | 52.7 | 0.0132 |
| Mixed | 75 | 42 | 56 | 33 | 44 |
| Diabetic status |
| Normoglycemic | 124 | 60 | 48.4 | 64 | 51.6 | 0.347 |
| Pre-diabetic | 61 | 34 | 55.7 | 27 | 44.3 |
| Hypertensive status |
| Normotensive | 165 | 86 | 52.1 | 79 | 47.9 | 0.306 |
| Pre-hypertensive | 20 | 8 | 40 | 12 | 60 |

1Pearson’s χ2 test; 2*P* value < 0.05 is significant.

**Table 2 Co-prevalence of diabetes and hypertension**

|  |  |  |  |
| --- | --- | --- | --- |
|  | Prediabetes | Normoglycemia | Total |
| *n* | % | *n* | % |
| Pre-hypertension | 5 | 25.0 | 15 | 75.0 | 20 |
| Normotension | 56 | 33.9 | 109 | 66.1 | 165 |

**Table 3 Correlation between fasting plasma glucose and systolic and diastolic blood pressure among study subjects**

|  |  |  |
| --- | --- | --- |
| Fasting plasma glucose | Pearson’s correlation coefficient | *P* value1 |
| Systolic blood pressure | 0.045 | 0.546 |
| Diastolic blood pressure | 0.301 | < 0.0012 |

1Pearson’s Correlation coefficient; 2*P* value < 0.05 is significant.

**Table 4 Determinants of impaired fasting plasma glucose**

|  |  |  |  |
| --- | --- | --- | --- |
| Determinant | Normoglycemic (*n* = 124) | Impaired fasting glucose (*n* = 61) | *P* value1 |
| Mean | SD | Mean | SD |
| BMI | 20.6 | 4.2 | 21.8 | 3.0 | 0.0262 |
| Waist circumference | 76.0 | 9.3 | 76.7 | 20.1 | 0.794 |
| SBP | 121 | 12 | 122 | 8 | 0.238 |
| DBP | 79 | 6 | 82 | 5 | 0.0032 |
| S.Cholesterol | 155.9 | 31.6 | 174.2 | 34.5 | 0.0012 |
| S.Triglycerides | 128.1 | 55.9 | 154.7 | 55.6 | 0.0022 |
| S.HDL | 39.3 | 8.6 | 41.4 | 7.3 | 0.095 |
| S.LDL | 92.7 | 23.6 | 104.1 | 22.7 | 0.0022 |
| S.VLDL | 25.6 | 11.2 | 32.8 | 12.3 | < 0.0012 |

1Student’s *t*-test; 2*P* value < 0.05 is significant. BMI: Body mass index; SBP: Systolic blood pressure; DBP: Diastolic blood pressure; HDL: High density lipoprotein; LDL: Low density lipoprotein; VLDL: Very low density lipoprotein.

**Table 5 Multiple Linear regression analysis of determinants of fasting plasma glucose**

|  |  |  |  |
| --- | --- | --- | --- |
| Determinant | Unstandardized coefficients | Standardized β | *P* value1 |
| β | SE |
| (Constant) | 24.067 | 17.964 |   | 0.182 |
| Smoking | 3.075 | 8.899 | 0.023 | 0.730 |
| BMI | 0.53 | 0.263 | 0.149 | 0.0462 |
| Waist Circumference | 0.049 | 0.07 | 0.05 | 0.483 |
| SBP | 0.121 | 0.113 | 0.094 | 0.285 |
| DBP | 0.844 | 0.2 | 0.375 | < 0.0012 |
| Cholesterol | 0.092 | 0.126 | 0.224 | 0.467 |
| Triglycerides | 0.008 | 0.038 | 0.033 | 0.830 |
| HDL | 0.06 | 0.154 | 0.036 | 0.696 |
| LDL | 0.279 | 0.141 | 0.483 | 0.0402 |
| VLDL | 0.151 | 0.146 | 0.132 | 0.301 |

1Multiple linear regression analysis. R2 = 48.5%, adjusted R2 = 23.5%; 2*P* value < 0.05 is significant. BMI: Body mass index; SBP: Systolic blood pressure; DBP: Diastolic blood pressure; HDL: High density lipoprotein; LDL: Low density lipoprotein; VLDL: Very low density lipoprotein.

**Table 6 Multiple Linear regression analysis of determinants of systolic blood pressure**

|  |  |  |  |
| --- | --- | --- | --- |
| Determinant | Unstandardized coefficients | Standardized β | *P* value |
| β | SE |
| (Constant) | 65.983 | 10.961 |   | < 0.001 |
| Smoking | 1.276 | 5.939 | 0.012 | 0.830 |
| BMI | 0.241 | 0.177 | 0.087 | 0.174 |
| Waist circumference | 0.057 | 0.047 | 0.074 | 0.225 |
| DBP | 0.997 | 0.118 | 0.571 | < 0.0012 |
| Cholesterol | 0.018 | 0.084 | 0.056 | 0.831 |
| Triglycerides | 0.009 | 0.025 | 0.048 | 0.715 |
| HDL | -0.135 | 0.103 | -0.104 | 0.188 |
| LDL | 0.085 | 0.095 | 0.189 | 0.0252 |
| VLDL | 0.218 | 0.096 | 0.245 | 0.053 |
| FPG | 0.054 | 0.05 | 0.069 | 0.285 |

1Multiple linear regression analysis. R2 = 66.1%, adjusted R2 = 47.3%; 2*P* value < 0.05 is significant. BMI: Body mass index; SBP: Systolic blood pressure; DBP: Diastolic blood pressure; HDL: High density lipoprotein; LDL: Low density lipoprotein; VLDL: Very low density lipoprotein; FPG: Fasting plasma glucose.

**Table 7 Multiple Linear regression analysis of determinants of diastolic blood pressure**

|  |  |  |  |
| --- | --- | --- | --- |
| Determinant | Unstandardized coefficients | Standardized β | *P* value |
| β | SE |
| (Constant) | 21.387 | 6.314 |   | 0.001 |
| Smoking | 0.682 | 3.214 | 0.012 | 0.832 |
| BMI | 0.347 | 0.093 | 0.219 | < 0.0012 |
| Waist circumference | 0.013 | 0.025 | 0.03 | 0.602 |
| Cholesterol | 0.053 | 0.045 | 0.288 | 0.249 |
| Triglycerides | 0.014 | 0.014 | 0.125 | 0.311 |
| HDL | -0.09 | 0.055 | -0.121 | 0.105 |
| LDL | 0.064 | 0.051 | 0.25 | 0.212 |
| VLDL | 0.062 | 0.053 | 0.121 | 0.242 |
| FPG | 0.11 | 0.026 | 0.247 | < 0.0012 |
| SBP | 0.292 | 0.035 | 0.51 | < 0.0012 |

1Multiple linear regression analysis. R2 = 70.4%, adjusted R2 = 49.6%; 2*P* value < 0.05 is significant. BMI: Body mass index; SBP: Systolic blood pressure; DBP: Diastolic blood pressure; HDL: High density lipoprotein; LDL: Low density lipoprotein; VLDL: Very low density lipoprotein; FPG: Fasting plasma glucose.