Original Research Article

DOI: http://dx.doi.org/10.18203/2394-6040.ijcmph20184015

A study on associations and influence of health determinants on systolic and diastolic blood pressure

Sreenivasa V. Yalamanchili*

Balagangadhara Varma Nursing Home and Research Centre, Chennai, Tamil Nadu, India

Received: 12 August 2018 Accepted: 12 September 2018

*Correspondence:

Dr. Sreenivasa V. Yalamanchili, E-mail: drysvarma@gmail.com

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ABSTRACT

Background: The aim of the study was to assess the prevalence of hypertension among Indian urban educated population and evaluate the association of various modifiable and non-modifiable risk factors on the development of systolic blood pressure (SBP) and diastolic blood pressure (DBP).

Methods: The retrospective study comprised of medical data obtained from 175 individuals who had undergone routine annual medical check-up during the period 2016 -2017. The data was analysed and interpreted using summary statistics, correlations and linear regression analysis. Most of the variables were measured values.

Results: Out of 175 reports analysed, 40 (22.9%) individuals comprising of 29 males and 11 females were found to be hypertensives. Isolated systolic hypertension was present in 4 (2.3%) individuals, isolated diastolic hypertension in 26 (14.9%) individuals and in 10 (5.7%) individuals both systolic and diastolic blood pressure was raised. Significant correlations were observed. Multiple linear regression showed significant positive influence of DBP, age and BMI on SBP whereas serum vitamin D level and left ventricular cardiac ejection fraction was negatively influencing SBP (R²=0.638, p=0.000). furthermore, multiple regression analysis with DBP as the dependent variable showed SBP, and serum vitamin D level to be the significant influencing determinants (R²=0.602, p=0.000).

Conclusions: The present study on the Influence of modifiable and non-modifiable risk factors on development of SBP and DBP improves knowledge for better preventive strategies.

Keywords: Hypertension, Systolic blood pressure, Diastolic blood pressure, Health determinants

INTRODUCTION

Hypertension or blood pressure is usually reported on the basis of both systolic blood pressure (SBP) and diastolic blood pressure (DBP). The impact of SBP and DBP on staging of hypertension or the resultant community burden varies with populations, age groups or gender. Hypertension is a very common condition in clinical practice, and it rarely causes symptoms in the early stages and many people go undiagnosed until developing cardiovascular complications, stroke, kidney failure and premature mortality or disability. As per the WHO report on non-communicable diseases (NCD's) in India, the 2008 estimated prevalence of raised blood pressure was 33.2% males and 31.7% in females. High prevalence of

hypertension is despite the fact that it can be easily measured and is a well-known modifiable risk factor. Pre hypertension has a high likelihood of converting to hypertension if left untreated. Hypertension is a leading risk factor for cardiovascular diseases. The most striking fact emerging from the rapidly changing global health environment in the past few decades is the shift of disease burden from communicable to non-communicable diseases. Globalisation, demographic changes, rapid urbanisation, unhealthy lifestyles are the common causes of global disease burden. India is dealing with a dual disease burden. The disease burden in India, measured in DALYs (Disability-Adjusted Life Years) shows communicable diseases have decreased from 295 million (in 1996) to 153 million (in 2016) whereas non

communicable diseases increased from 184 million (in 1996) to 259 million (in 2016). In 2016, cardiovascular disease contributed to 14.1% of the total disease burden in India. Lack of physical activity, stress, high fat and increased salt intake are some of the causes of hypertension. The adverse health consequences of hypertension are compounded because of associated risk factors such as obesity, high cholesterol and diabetes mellitus. Hypertension can be prevented and controlled with lifestyle modifications. This study analyses the associations and influences of health correlates on SBP and DBP in a group of educated and middle class employees and their spouses in Chennai, India.

METHODS

This was a retrospective cohort study using data obtained from reports of annual health check-up undertaken by educated, middle class employees of a national research organisation and their spouses in Chennai, India were collected for study data. The annual medical check-up was done during the period 2016 to 2017. Data was quantitative and empirical in nature. All participants gave their informed consent. Out of total 227 reports collected, incomplete data was excluded. The data of 175 individuals were found to be complete in all respects and considered in the study for further analysis and interpretation. All anthropometric measurements (Height in cm and Weight in Kg), Blood pressure readings, haematology (Blood Haemoglobin), biochemical values (serum lipid profile, serum thyroid stimulating hormone, serum vitamin D, serum vitamin B12, serum calcium), Cardiac ejection fraction percentage and ultrasonogr staging of fatty liver status was studied. Hypertension was defined as systolic blood pressure of ≥140 mmHg and diastolic blood pressure of ≥90 mmHg as per seventh report of Joint National Committee (JNC-7) on the prevention, detection, evaluation and treatment of high blood pressure. Body mass index (BMI) was calculated from height and weight measurements.

Statistical analysis was conducted using Statistical Package for Social Sciences version 16.0 (SPSS Inc., USA). Categorical variables (gender, fatty liver status staging) are reported as frequencies. Continuous variables are reported as descriptive statistics. Correlations analysis was conducted to analyse the associations between variables and linear regression analysis was conducted to analyse the influencing determinants on SBP and DBP independently. P<0.05 were considered significant.

RESULTS

General profile of the sample data

The total sample of 175 individuals comprised of 108 (61.7%) males and 67 (38.3%) females.

All the individuals were educated, belong to middle income group and reside in urban locality. The age of

male individuals ranged from 36 years to 60 years with mean and standard deviation (SD) of 44.1±5.6 years. The age of female individuals ranged from 35 years to 64 vears with mean and standard deviation of 42.8±5.4 years. The mean BMI of males was 25.44±3.71 (SD) and of females 27.56±4.17 (SD). 56.7% females had <12.5 gm/dL haemoglobin (Hb) level while only 2.8% males had less than <13.0 gm/dL (Normal haemoglobin reference value used in females 12.5-14.5 gm/dL and males 13.0-17.0 gm/dL). 80.6% females showed deficient serum vitamin D levels (<20 ng/ml), 14.9% insufficient serum vitamin level (<30 ng/ml). Likewise 68.5% males had <20 ng/ml and 25% <30 ng/ml serum vitamin D levels. 31.5% males and 19.4% females were found to have low serum vitamin B12 level (<180 pg/ml). 16.7% males and 32.8% females were found to have low serum calcium level (<8.6 mg/ml). 15.7% males and 13.4% females had serum Thyroid stimulating hormone (TSH) >5.33 µIU/ml (Normal TSH reference value 0.38-5.33µIU/ml). Majority of females (74.6%) had high Serum Triglycerides (TGL), 46.3% had high total cholesterol level, 23.9% had low high density lipoprotein cholesterol (HDL-C) and 49.3% high low density lipoprotein cholesterol (LDL-C). In males, 35.2% had high TGL, 57.4% high total cholesterol, 37% low HDL-C and 58.3% high LDL-C. Serum total cholesterol <170 mg/dL, serum TGL <150 mg/dL, serum LDL-C <100 mg/dL and Serum HDL-C >40 mg/dL were taken as reference values for data analysis. Ultrasonogram study of staging of fatty liver disease showed 74.1% males and 77.6% females had no fatty liver changes, 16.7% males and 16.4% females had grade I fatty liver changes and 9.3% males and 6% females showed grade II fatty liver changes. There was no appreciable difference in the range and mean values of the cardiac left ventricular ejection fraction (males- 68.5% ±5.2 (SD) and females 69.7% ±5.4 (SD)).

Hypertension prevalence and analysis

Out of 175 sample population, 40 (22.9%) individuals comprising of 29 males and 11 females were found to be hypertensives. Among the 40 hypertensives, isolated systolic hypertension was present in 4 (2.3%) individuals, isolated diastolic hypertension in 26 (14.9%) individuals and in 10 (5.7%) individuals both systolic and diastolic blood pressure was raised. Overall there is an increase in percentage of hypertensive individuals with increasing age as shown in Figure 1. In the present study, the prevalence of hypertension in the age group 35 to 44 years is 15.6% as compared to 31% in the age group 45 to 54 years and 62.5% in the age group 55 to 64 years. The prevalence of isolated SBP was 0%, 5.2% and 12.5% in the age groups 35 to 44 years, 45 to 54 years and 55 to 64 years respectively. The prevalence of isolated DBP was 11.9%, 19% and 25% in the age groups 35 to 44 years, 45 to 54 years and 55 to 64 years respectively. The prevalence of SBP and DBP was found among 3.7%, 6.9% and 25% of the individuals in the age groups 35 to 44 years, 45 to 54 years and 55 to 64 years respectively.

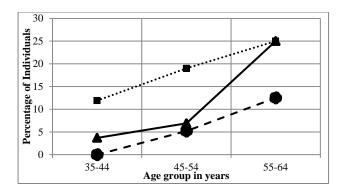


Figure 1: Age distribution prevalence of hypertensive individuals.

Legend:

--•-- Percentage of individuals with isolated SBP.

Percentage of individuals with isolated DBP.
--▲-- Percentage of individuals with SBP and DBP.

The correlation between SBP and DBP in the study population was highly positive and significant (r=0.744,

p < 0.001).

SBP is significantly and positively correlated with Age, Weight, BMI and serum TGL; while DBP is significantly

and positively correlated with Age, Weight, BMI, Serum TGL, Height and Haemoglobin level (Table 1).

Comparison between individuals with DBP <90mmHg with individuals with DBP ≥90 mmHg, shows that there is a significant increase in age, BMI, SBP (p<0.001), Haemoglobin level (p=0.015), serum vitamin D level, and serum calcium level in the group with DBP ≥90 mmHg. The comparison of lipid profile shows increase in serum total cholesterol (p=0.029), serum TGL, and serum LDL-C and a decrease in HDL-C level in the group whose DBP ≥90 mmHg. Serum TSH, serum vitamin B12 levels and the left ventricular Ejection fraction decreases in individuals with DBP ≥90 mmHG group. Similarly, comparing the mean change in study parameters between individuals with SBP <140 mmHg with individuals with SBP ≥140 mmHg, it is found that there is an increase in age (p=0.013), BMI (p=0.019), DBP (p=0.001), haemoglobin level, serum calcium level (p=0.003) and an decrease in serum vitamin D level, serum TSH, serum vitamin B12 levels and left ventricular Ejection fraction in the group with BP ≥140 mmHg. All the Lipid profile parameters TGL (p=0.081) and serum total cholesterol (p=0.074)) studied show an increase in the group whose SBP \geq 140 mmHg (Table 2).

Table 1: Significant correlations of SBP with other study parameters.

Parameter	"r"	"p"	Interpretation				
Correlations of SBP with study parameters [Pearson correlation sig 2 tailed]							
DBP	0.744	0.000	Highly Significant high positive correlation				
Age	0.300	0.000	Highly Significant mild positive correlation				
Weight	0.281	0.000	Highly Significant weak positive correlation				
BMI	0.254	0.001	Significant weak positive correlation				
Serum TGL	0.204	0.007	Significant weak positive correlation				
Correlations of DBP w	Correlations of DBP with study parameters [Pearson correlation sig 2 tailed]						
Weight	0.341	0.000	Highly Significant mild positive correlation				
Haemoglobin level	0.245	0.001	Significant weak positive correlation				
Height	0.211	0.005	Significant weak positive correlation				
Serum TGL	0.197	0.009	Significant weak positive correlation				
BMI	0.191	0.011	Significant weak positive correlation				
Age	0.175	0.020	Significant weak positive correlation				

Table 2: Comparison of study parameters among different groups.

Study parameters	DBP <90 mmHg		DBP ≥90 mmHg		SBP <140 mmHg		SBP ≥140 mmHg	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Age in years	43.24	5.18	45.03	6.67	43.15	5.13	48.86	7.40
Height in cm	163.17	9.44	164.74	8.34	163.38	9.17	164.82	10.15
Weight in kg	69.33	10.37	74.02	13.11	69.75	10.84	76.52	12.66
BMI kg/m ²	26.01	3.91	27.21	4.31	26.10	4.08	28.06	2.60
Systolic BP mmHg	116.01	9.93	133.61	8.33	117.48	9.72	144.29	6.46
Diastolic BP mmHg	75.18	6.44	91.67	5.07	77.52	8.08	90.71	11.41
Haemoglobin/dL	13.58	1.79	14.43	1.81	13.72	1.78	14.17	2.28
Total cholesterol mg/dL	171.72	33.09	180.81	47.45	173.16	33.43	178.52	63.87
Serum TGL mg/dL	128.48	68.36	145.42	71.57	128.44	66.70	172.50	85.76
Serum HDL mg/dL	44.07	9.76	43.56	7.55	43.77	8.47	46.21	16.63
Serum LDL mg/dL	101.96	28.83	110.81	30.82	103.71	27.74	104.64	45.62

Continued.

Study parameters	DBP <90 mmHg		DBP ≥90 mmHg		SBP <140 mmHg		SBP ≥140 mmHg	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Serum TSH μIU/ml	3.70	3.53	3.43	2.30	3.68	3.40	3.21	2.05
Serum vitamin D ng/ml	14.82	8.14	16.16	8.77	15.10	8.31	15.04	8.05
S Vitamin B12 pg/ml	289.20	222.83	253.88	116.10	282.29	211.88	277.79	116.39
Serum calcium mg/dL	8.74	0.32	8.80	0.32	8.74	0.33	8.92	0.18
Cardiac LV EF%	68.96	5.27	68.89	5.30	68.97	5.35	68.64	4.27
Gender male%	58.99		72.22		60.25		78.57	
Gender female%	41.01		27.78		39.75		21.43	
Fatty liver grade 0%	78		67		78		50	
Fatty liver grade I%	15		22		14		43	
Fatty liver grade II%	7		11		8		7	
Number of cases	139		36		161		14	

Table 3: Multivariate analysis – linear regression (n=175) –dependent variable – systolic blood pressure.

Independent variables	Unstandardized coefficients		Standardized coefficients		Cia
independent variables	В	Std. Error	Beta	L Comment	Sig.
(Constant)	21.066	18.049		1.167	0.245
Age	0.386	0.107	0.179	3.597	0.000
Gender (female-0, male-1)	0.255	1.762	0.010	0.145	0.885
BMI	0.435	0.158	0.146	2.752	0.007
DBP	0.892	0.069	0.678	12.841	0.000
Haemoglobin	-0.311	0.481	-0.047	-0.645	0.520
Total cholesterol	0.017	0.019	0.048	0.866	0.388
Triglycerides	0.006	0.010	0.034	0.610	0.543
TSH	-0.125	0.182	-0.035	-0.690	0.491
Vitamin D	-0.160	0.073	-0.111	-2.202	0.029
Vitamin B12	-0.004	0.003	-0.075	-1.531	0.128
Calcium	3.058	1.995	0.082	1.533	0.127
Fatty liver staging (normal -0, Grade I - 1, Grade II- 2)	0.068	0.967	0.003	0.070	0.944
Left Ventricular EF	-0.320	0.112	-0.141	-2.848	0.005

 R^2 =0.638, F = 21.871, Sig. 0.000 [p< 0.050 is significant].

Table 4: Multivariate analysis – linear regression (n=175) dependent variable – diastolic blood pressure.

Independent variables	Unstandardized coefficients		Standardized coefficients	4	Cia
	В	Std. Error	Beta	l	Sig.
(Constant)	4.069	14.452		0.282	0.779
Age	-0.121	0.088	-0.074	-1.367	0.174
Gender (female -0,male-1)	0.656	1.405	0.035	0.467	0.641
BMI	0.050	0.129	0.022	0.385	0.701
Haemoglobin	0.594	0.382	0.119	1.556	0.122
Total cholesterol	0.007	0.016	0.026	0.452	0.652
Triglycerides	0.002	0.008	0.012	0.195	0.846
TSH	0.105	0.145	0.038	0.724	0.470
Vitamin D	0.136	0.058	0.124	2.348	0.020
Vitamin B12	0.001	0.002	0.025	0.479	0.632
Calcium	-1.326	1.599	-0.047	-0.829	0.408
Fatty liver staging (normal -0, Grade I - 1, Grade II - 2)	0.371	0.770	0.025	0.481	0.631
Left ventricular EF	0.136	0.091	0.078	1.487	0.139
SBP P ² -0.602 E-18.742 Sig. 0.000 In c	0.567	0.044	0.746	12.841	0.000

 R^2 =0.602, F= $\overline{18.742}$, Sig. 0.000 [p<0.050 is significant].

A multivariate linear regression model was proposed in which SBP was proposed to be a dependent variable on independent variables-age, gender, BMI, DBP, blood haemoglobin level, serum total cholesterol, serum triglycerides, serum TSH, serum vitamin D, serum vitamin B12, serum calcium, fatty liver staging and left ventricular ejection fraction respectively. The model showed a significant positive influence of DBP, age and BMI on SBP, whereas a significant negative influence of serum vitamin D and left ventricular ejection fraction was observed on SBP. Of the significantly influencing independent variables, DBP has the highest magnitude of influence followed by age, left ventricular ejection fraction, BMI and vitamin D in the order. The model had a reasonable explanatory power (r²=0.638), thus inferring that variations in independent variables correlated with variations in dependent variables to an estimated precision of 63.8% (Table 3).

DBP was proposed to be a dependent variable on independent variables—age, gender, BMI, SBP, blood haemoglobin level, serum total cholesterol, serum triglycerides, serum TSH, serum vitamin D, serum vitamin B12, serum calcium, fatty liver staging and left ventricular ejection fraction respectively and a multivariate regression analysis was done. The model showed a significant positive influence of SBP and serum vitamin D level on DBP. Of which, SBP was found to be the most important independent variable influencing DBP. The model has a reasonable explanatory power (r²=0.602), thus inferring that variations in independent variables correlated with variations in dependent variables to an estimated precision of 60.2% (Table 4).

DISCUSSION

Hypertension is a common health issue especially in emerging economies like India, china and African nations owing to changing lifestyle factors such as physical inactivity, increased salt intake, highly processed food, fatty food consumption, stress, rapid urbanisation and increased longevity.³ Geldsezter et al in their study carried out between 2012 to 2014 with sample size of 1.3 million adults in India, reported high prevalence of diabetes and hypertension in India among middle and old age and across all geographical and socio demographic distribution.⁴ The also reported that hypertension prevalence among young adults is higher than previously thought.

Here, in the present study, we attempted to study the prevalence of hypertension among the sample group and identify the associations and influences of the factors that lead to hypertension. We found that the 22.9% prevalence of hypertension among the study group was consistent to that reported from similar studies.⁵⁻⁷ The prevalence of hypertension was found to increase with increasing age and significant positive correlations between age with SBP and age with DBP were noted. Similar associations between age and hypertension were reported from earlier

studies.⁸⁻¹¹ Multivariate logistic regression analysis in the present study shows that both SBP and DBP was significantly associated with age and this agrees with that reported by Rani et al and Mungreiphy et al. 11,12 The prevalence of hypertension was more in male when compared to females in the present study similar to that reported by earlier researchers. 10,13 Prevalence of overweight and abdominal obesity is higher in women than men. Even then they had a lower prevalence of hypertension due to using of lower cut-off point for abdominal obesity among women or due to biological protection of women against the effect of excess adiposity. 14 Progressive physical inactivity and stress are known determinants for developing hypertension as age increases. Significant positive correlations between BMI and hypertension were noted in the study. We observed for SBP the correlation coefficient was 0.254 with BMI and for DBP it was 0.191 with BMI, similar to that reported by Deshmukh et al and multivariate analysis showed BMI to be a significant risk factor for SBP wear as the influence of BMI on DBP was found to be insignificant.¹⁵ Hypertension study group reported higher BMI to be associated with increased odds of being hypertensive. ¹⁶ Most of the other studies, reported a significant association of escalating hypertension with obesity and truncal obesity in both sexes. 13,17 They observed that increasing hypertension in India correlated with increasing adiposity levels. Our study shows that though the correlation of haemoglobin with SBP and DBP were significant, multiple regression analysis did not consider haemoglobin level as a significant risk factor influencing SBP or DBP. This could be due to the presence of cofounders in the regression analysis.

In our study we noted significant positive correlation of haemoglobin level with DBP (correlation coefficient 0.245). However no significant correlation was noted between Haemoglobin and SBP. Atsma et al in their study reported that haemoglobin level is positively associated with both SBP and DBP in healthy individuals and their observations showed consistent effects both between persons and also within persons. The mechanisms that might lead to an elevated blood pressure in individuals with an increased Haemoglobin level are not entirely known. Increased blood viscosity due to increase in haematocrit and haemoglobin levels coupled with arterial stiffness has a role in the development of hypertension.

In the present study, of the lipid parameters, Serum TGL was significantly correlated with both SBP and DBP. In individuals with DBP $\geq\!\!90$ mmHg, there was an increase in mean Serum Total Cholesterol, Serum TGL and Serum LDL values and decrease in mean HDL levels when compared to the group of individuals with DBP $<\!\!90$ mmHg. In individuals with raised SBP $\geq\!\!140$ mmHg all the lipid profile parameters were increased. This can be attributed to the fact that increase in Serum total cholesterol, serum LDL and serum TGL and low serum HDL indicate dyslipidaemia, a known risk factor in the

development of hypertension. Dyslipidaemia with physical inactivity causes increased adiposity, overweight, obesity and leads to hypertension. 13,17,19

The mean TSH levels were lower in individuals with SBP \geq 140 mmHg and DBP \geq 90 mmHg when compared to normotensive individuals. The correlations of TSH with SBP and DBP were insignificant and also multiple regression analysis did not establish TSH as a significant risk factor. Dhanju et al observed a positive linear correlation between TSH levels and SBP. ²⁰ Liu et al reported the prevalence of hypertension in subclinical hypothyroidism group significantly higher than in euthyroid group in females and also the change of TSH in normal range did not affect blood pressure. ²¹

There are many studies with opposing views on the role of Vitamin D on development of hypertension; it appears that Vitamin D levels in the body modulate the blood pressure indirectly.²² Studies that support the role of vitamin D on development of hypertension have mostly reported that SBP and DBP had increased among individuals experiencing inadequacy of vitamin D which is associated with renin-angiotensin-aldosterone system regulation. Our study confirms with these findings. Multiple regression analysis in our study shows that Vitamin D has significant influence on SBP and DBP. Also in our study, serum calcium was not found to be influencing SBP or DBP. Few studies have reported that vitamin D or calcium supplementation had no influence on SBP or DBP of and individual.

The present study did not observe any difference among the hypertensive and non-hypertensive groups with regards to fatty liver grading of the individuals. We observed a significant correlation between left ventricular ejection fraction of the heart and SBP while an insignificant correlation existed between left ventricular ejection fraction of the heart and DBP. It is well known that strain on the cardiac muscle due to increased SBP leads to decrease in left ventricular ejection fraction of the heart and ultimately cardiac failure. Left ventricular hypertrophy, ischaemic changes on ECG, cardiomegaly on chest x-ray and hypertensive retinopathy changes were significantly higher in hypertensive group as compared to normal individuals.¹⁹

CONCLUSION

The prevalence of hypertension among the urban, educated group in Chennai confirms the rising trend of hypertension in India. Multiple linear regression analysis in the present study infers that DBP, age, BMI and serum vitamin D level of the individuals were found to explain 63.8% of the variation in SBP altogether. SBP and Serum vitamin D levels of the individual explains 60.2% variation altogether in DBP. These findings help create awareness on the various risk factors in the development of SBP and DBP. This helps build preventive strategies for control and management of hypertension.

Funding: No funding sources Conflict of interest: None declared Ethical approval: Not required

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Cite this article as: Yalamanchili SV. A study on associations and influence of health determinants on systolic and diastolic blood pressure. Int J Community Med Public Health 2018;5:4590-6.