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OBESITY, AGE AND SEX AS RISK FACTORS OF HYPERTENSION IN SIKKIM, NORTHEAST INDIA

ABSTRACT: It has been observed that hypertension is multi-factorial, where some risk factors are modifiable and some are non-modifiable. The present study examines obesity, sex and age as risk factors of hypertension among the adult urban population of Gangtok, the capital of Sikkim, Northeast India. The data was collected from 343 men and 657 women aged between 20–60 years from three communities namely, Lepcha, Bhutia and Nepali. Anthropometric data and blood pressure was collected from the study population. One way ANOVA, t-test and chi-square was calculated to test the significance. Stepwise linear regression was used to determine the risk factors of systolic and diastolic pressure. Binomial logistic regression was used to predict the adjusted odd ratio for risk of hypertension. The prevalence of hypertension in men and women was 30.32 percent and 19.63 percent respectively. The prevalence of hypertension was significantly higher in obese men (general obese = 50.35%, increased waist circumference = 57.14%, substantially increased waist hip ratio = 42.54%) and women (general obese = 28.66%, increased waist circumference = 27.63%, substantially increased waist hip ratio = 27.37%). 50 percent of the older adults were hypertensive. The mean systolic blood pressure and diastolic pressure were significantly higher among obese groups. Adults with increasing obesity, advancing age and men are at greater risks of hypertension. Behavioural factor like alcohol consumption also possesses a risk for elevated pressure in the present study. Awareness, conscientious lifestyle modification and inclusive urbanization are necessary to reduce the burden of obesity and hypertension.

KEY WORDS: Obesity – Hypertension – Sikkim – Urbanisation

INTRODUCTION

Obesity as a risk factor of hypertension has been established by several studies (Hall *et al.* 2000, 2002, Jiang *et al.* 2016). Several co-morbidities like hypertension (HT), diabetes mellitus (DM) and cardiovascular risk are associated with obesity. It is estimated that when the Body Mass Index (BMI) of a person falls in the range of 25.0 kg/m^2–29.9 kg/m^2, the risk of co-morbidities increases and further escalates to moderate

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or severe when BMI exceeds 30.0 kg/m^2 (WHO 1998). In addition to obesity, multiple other factors influence raised blood pressure such as unhealthy diet, physical inactivity, alcohol and tobacco use etc.; these risk factors are modifiable. The non-modifiable risk factors include genetics, family history, age, sex and ethnicity (CDC 2020). Furthermore, hypertension is a risk factor for coronary heart disease, stroke, atherosclerosis, ischaemic stroke and ischaemic heart disease (WHO 2011). It also accounts for an estimated 182 million disability adjusted life years and 10.4 million deaths annually (IHME 2018).

Obesity is a manifestation of complex interaction of environment, lifestyle and genetics. Population risk studies estimate that at least two-thirds of the prevalence of hypertension is induced by obesity (Krause *et al.* 1998). Excess accumulation of visceral fat is linked to rise in insulin resistance, atherosclerosis and hypertension (Ostchega 2012). The common profile of obese hypertensive patients usually includes insulin resistance, unfavorable plasma cholesterol profile and hyperuricemia (Diaz 2002). The present study takes into account the effect of age and sex as risk factors in prevalence of hypertension. Aging induces arterial changes characterized by narrowing of vessel lumen, decreased elasticity of connective tissue and stiffening of the vessel wall (Folkow 1993, Singh *et al.* 2021). Aging increases the opportunity for environmental and lifestyle stressors to take effect on blood pressure (Stott, Bowman 2000). Moreover, as one aged, they are more prone to increase in weight gain, decreased physical activity and sedentary life. Study by Naqvis *et al.* (2019) shows sexual dimorphism in age related blood pressure, which has been attributed to hormonal and chromosomal factors. Hormonal changes occurring at the time of menarche, pregnancy and menopause contribute largely in the biological sex difference of blood pressure (Arnold *et al.* 2017). A study by Ji *et al.* (2020) showed that women compared to men exhibited a steeper increase in blood pressure that began as early as third decade and continued throughout their life course. Nevertheless, sex differences in blood pressure are also arises due to the complex socio-cultural matrix and lifestyle defined for men and women (Heise *et al.* 2019).

Recent survey by National Family Health Survey (NFHS)-5 (IIPS 2019-20) in India has reported that around quarter of the men and women are burdened with elevated blood pressure. Urban population shows higher prevalence of hypertension compared to rural areas (Kancharla 2020). Sikkim has an overall higher proportion of hypertension in contrast to its population compared to other states (Kancharla 2020). 59.7 percent of women and 74.2 percent of men living in urban areas of Sikkim are hypertensive according to NFHS-5 (IIPS 2019-20). The same survey across 2005-2020of NFHS 3, 4 and 5 (IIPS 2005-06, IIPS 2015-16, IIPS 2019-20) also shows considerable rise in the prevalence of overweight and obesity over the years. The latest report by NFHS-5 (IIPS 2019-20) in Sikkim shows the prevalence of overweight and obesity among adult men and women in urban areas as 40.1 percent and 41.0 percent respectively. 71.9 percent of women and 36.6 percent of men show increased WHR. Such pervasiveness of obesity and hypertension is of large concern to the public health of the people. In addition to the deteriorating health, the economic cost is high as well as quality of life is affected. Epidemiological studies show that health transition is observed with the process of urbanisation and globalisation shifting the burden from infectious disease to non-communicable diseases (Bhagyalaxmi *et al.* 2013). When traditional societies undergo rapid unplanned urbanisation lifestyle changes occur (Allender *et al.* 2010) which include unhealthy diet, sedentary form of work and leisure, consumption of tobacco and alcohol. These are behavioural risk factors for non-communicable diseases like obesity, hypertension, diabetes mellitus and dyslipidaemia (WHO 2021).

Therefore, against this backdrop, the present study aims to examine obesity, age and sex as risk factors of hypertension among the adult population of urban Gangtok, Sikkim, Northeast India.

MATERIALS AND METHODS

The present study was conducted in the urban areas of Gangtok, the capital of Sikkim (*Figure 1 - right view*). The Gangtok town is situated atop the ridge of the Lesser Himalayas (Negi 1998). Sikkim is the 22nd State of the Indian Union. It is located in the northeastern part of India bordered by three international boundaries with China to the North-East, Bhutan to South-East and Nepal in the West. Earlier, it was divided into four districts viz. East, West, North and South. However, with the Reorganisation of Districts Act 2021, which came into force on 21st December 2021, two new districts have been added viz. Soreng and Pakyong, and the earlier districts have been renamed. The East district has been renamed as Gangtok, West as Gyalshing, North as Mangan and South as Namchi.

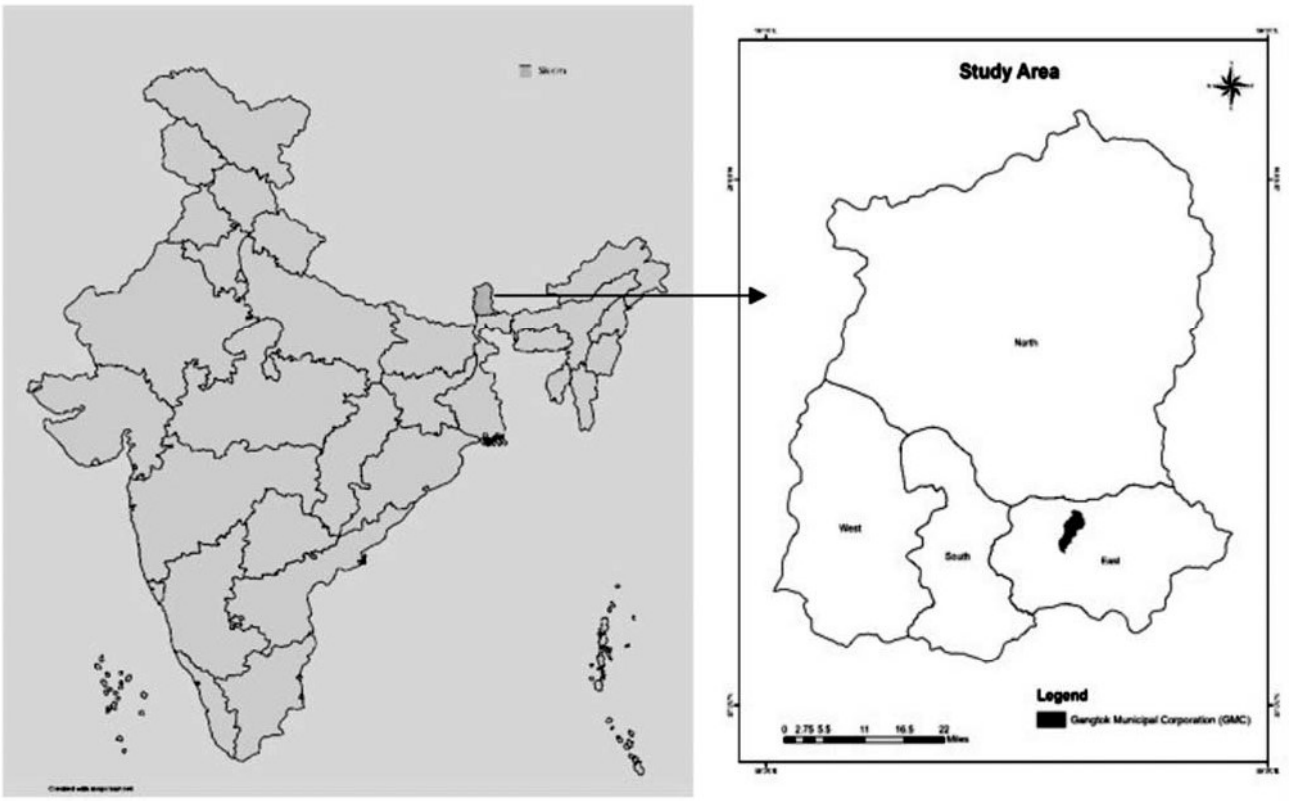

FIGURE 1: Map of India (left picture). Source: https: //www:mapchart.net/india.html. Gangtok Municipal Corporation (Study area) in the map Sikkim (right picture). Source: Map of Sikkim (GIS data map was created using Arc GIS 10.8 software) State Disaster Management Authority, Government of Sikkim, 2023.

Gangtok is the most populated urban area with 1,00286 populations (Census of India 2011). Post-merger, rapid unplanned urbanization increased. The proportion of urban population increased from 2 percent in 1951 to 24 percent in 2011. The highest proportion of urban population increase is shown by the East district from 64 percent in 2001 to 80 percent in 2011 (Paul, Sharma 2016). The rise in the literacy rate has also influenced in ushering economic transition among the people. Large number of populations has transitioned from traditional hunting gathering, pastoralists and agricultural society to take up modern forms of economic activities. Unplanned construction of residential and commercial buildings in high density to accommodate the growing population needs had led to few opportunities for the inclusion of parks, playgrounds and recreational spaces in urban areas of Gangtok. Urban marts, restaurants and food delivery services have been mushrooming at an increasing speed. Overwhelming choices of processed food has substituted the traditional diet. Sedentary forms of leisure and work now encompasses the daily life of greater proportion of the urban population. In an urban setting, population growth, infrastructure, transport facilities, large supermarkets, availability of unhealthy food and mass marketing have led to health challenges along with environmental challenges.

Data was collected from the three ethnic groups, namely, Lepcha, Bhutia and Nepali. Lepchas, also known as "*Rong-Kup*", endonym derived from the Lepcha language (Fonning 1987). They are one of the oldest inhabitants of Sikkim. The Bhutias, also known as "*Denzongpas*" are ethnic group with Tibetan ancestry. The several subgroups under Bhutia are Drukpa, Chumbipa, Dothapa, Tromopa, Lanchenpa and Lachungpa. The Constitution (Sikkim) Schedule Tribe Order, 1978 also includes Sherpa, Kagatey, Yolmo and Tibetans under Bhutia group besides the other subgroups mentioned above (Rai 2013). Nepali is a generic term for diverse ethnic groups, which include

Limboo, Khambu-Rai, Yakha, Sunuwars, Mangar, Gurung, Tamang, Bhujel, Thami, Bahun, Chettri, Kami, Damai, Sarki, Thakuri, Jogi, Sanyasi, Majhi and Newar. Limboos and Tamangs were included in the union list of Scheduled Tribe under the Scheduled Castes and Scheduled Tribes order (Amendment) Act, 2002. The language spoken by Lepcha and Bhutia belong to the Tibeto-Burman family while the Nepali heterogeneous ethnic groups comprise languages of both Indo-Aryan (e.g., Nepali) and Tibeto-Burman family (e.g., Rai and Limboo). Nepali language is the lingua franca of the State. The occupation of these ethnic groups was primarily hunting, gathering, pastoralists and agricultural societies, but especially in urban areas, they have shifted to modern forms of economic activities such as business, administration, trade etc. These communities are distinct from one another and have their own cultural norms, values and belief system. They have been living in close proximity to one another sharing similar social and physical environment, especially in urban areas.

Prior to data collection, purpose and nature of the research was explained to each participant and their consent was taken. The data was collected from 343 men and 657 women aged between 20–60 years through random sampling method following house to house visit. The participant's age was categorised into young adults (20–35 years), middle adults (36–55 years) and older adults (above 55 years).

An anthropometric rod and weighing scale to the nearest of 0.1 cm and 0.5 kg was used to measure the height and weight of the subjects wearing light clothes following the standard technique of Lohman *et al.* (1998). BMI is the most common measure to assess overweight and obesity. According to WHO (1998), BMI $\leq$18.5 kg/m^2 is considered underweight, BMI between 18.5–24.9 kg/m^2 is considered normal, BMI between 25.0–29.9 kg/m^2 is overweight and BMI$\geq$30.0 kg/m^2 is considered obese.

Waist circumference (WC) and hip circumference (HC) was measured following the standard technique recommended by WHO STEPwise approach to surveillance (WHO 2008).Waist circumference was measured to the nearest 0.1 cm horizontally at the midpoint between lower margin of the last palpable rib and top of the iliac crest using a non-stretchable measuring tape at the end of normal expiration. Hip circumference was measured to the nearest 0.1 cm at the greatest horizontal circumference around the widest portion of the buttock. Each measurement was repeated twice and average was calculated. The cut-off point followed by the present research for waist circumference and waist hip ratio (WHR) is in accordance with the WHO Expert Consultation Obesity (2000) where, abdominal obesity is defined as waist hip ratio $\geq$0.90 for men and $\geq$0.85 for women, and waist circumference >94cm for men and >80 cm for women.

Blood pressure was measured using a mercury sphygmomanometer and stethoscope. The participants were requested to be seated and relax. Two readings were taken with a five minutes interval in between and the average of both the readings was taken as the final blood pressure reading. For the classification of blood pressure, Seventh Report of the Joint National Committee on Prevention, Detection, Evaluation and Treatment of High Blood Pressure was used (JNC-7 2003). According to this, normal BP is 120/80 mmHg, pre-hypertension stage is between 120–139/80–89 mmHg, hypertension stage I is between 140–159/90–99 mmHg and hypertension stage II is $\geq$160/$\geq$100 mmHg. For the present study, normal BP range is categorised as normotensive and pre-hypertension stage, hypertension stage I and hypertension stage II are pooled under hypertensive. Data on alcohol consumption and smoking was also recorded as they are modifiable behavioural factors closely related with hypertension.

The data was analysed using SPSS software 20 version. The parameters taken were analysed to find the frequency, mean and standard deviation of the anthropometric measurements. T-test and one way ANOVA was used to test the significance of mean systolic and diastolic pressure in relation to anthropometric parameters. T-test was used to compare the mean between two groups, whereas ANOVA was used to compare the means for more than two groups. Chi square test was also used to test the association between the categorical variables. Stepwise linear regression was used on the associated covariates to determine the independent factors that influence systolic blood pressure (SBP) and diastolic blood pressure (DBP). Binomial logistic regression was used to predict the adjusted odd ratio (OR) for risk of hypertension after adjusting for other correlated variables.

RESULTS

Result shows chi-square analysis and t-test of the association between the anthropometric parameters and behavioural factors with blood pressure (*Table 1*). The association of BMI, WC and WHR were significant

(p<0.001) between the normotensive and hypertensive groups in both the sexes. Alcohol consumption was also found significant in both men (p<0.05) and women (p<0.01), but not smoking. The overall prevalence of hypertension was significantly higher among men and women who are obese (M=50.35%, F=28.66%), increased/substantially increased WC (M=57.14%, F=27.63%), substantially increased WHR (M=42.54%, F=27.37%) and consumed alcohol (M=36.91%, F=27.45%). Significant (p<0.001) differences were also noted in mean BMI, WC and WHR between the normotensive and hypertensive group in both the sexes. The mean BMI, WC and WHR were considerably higher in the hypertensive group compared to the normotensive group.

Significant (p<0.001) differences in mean systolic blood pressure (SBP) and diastolic blood pressure (DBP) were observed between obese and non-obese groups in both the sexes (*Table 2*). The mean SBP and DBP was higher among men who are general obese (SBP=131.38 mmHg, DBP=91.97 mmHg), increased/ substantially increased WC (SBP=133.98 mmHg, DBP=93.74 mmHg) and substantially increased WHR (SBP=128.44 mmHg, DBP=89.69 mmHg). Significant (p<0.05) differences were found in the mean SBP and DBP among men who consumed alcohol (SBP=125.49 mmHg, DBP=86.87 mmHg) compared to those who did not consume alcohol. Smoking showed no significant differences in both the sexes.

Similarly, in women, mean SBP and DBP was significantly (p<0.001) higher among general obese (SBP=122.29 mmHg, DBP=84.67 mmHg), increased/ substantially increased WC (SBP=122.00 mmHg, DBP=84.15 mmHg) and substantially WHR (SBP=121.26 mmHg, DBP=83.51 mmHg). Significant differences were also observed in mean SBP (p<0.01) and DBP (p<0.05) in alcohol consumption. Higher value was recorded among women who consumed alcohol (SBP=120.59 mmHg, DBP=82.44 mmHg).

Present study showed significant association of WC and hypertension (HT) with sex (p<0.001) (*Table 3*). Mean WHR, SBP and DBP showed significant (p<0.001) association with sex. The association of mean BMI and WC with sex were significant at p<0.01 and p<0.05 respectively. The prevalence of general obesity (GO) (45.66%) and central obesity (CO)(WC=57.83%,

TABLE 1: Association of obesity, consumption of alcohol and smoking with normotensive and hypertensive group. Significance level: p<0.001***, p<0.01**, p<0.05*; BMI = Body Mass Index; WC = Waist circumference; WHR = Waist Hip Ratio.

Variable	Normotensive	Hypertensive	p value	Normotensive	Hypertensive	p value
	Male			*Female*		
BMI						
Normal	169 (83.66)	33 (16.33)	45.483***	314 (87.95)	43 (12.04)	28.542***
Overweight/Obese	70 (49.64)	71 (50.35)		214 (71.33)	86 (28.66)	
WC						
Normal	202 (78.29)	56 (21.70)	37.604***	253 (91.33)	24 (08.66)	36.527***
Inc/Subs inc.	36 (42.85)	48 (57.14)		275 (72.36)	105 (27.63)	
WHR						
Normal	135 (83.33)	27 (16.66)	27.090***	260 (90.27)	28 (09.72)	31. 930***
Inc/Subs inc.	104 (57.45)	77 (42.54)		268 (72.62)	101 (27.37)	
Alcohol consumption						
Yes	94 (63.08)	55 (36.91)	5. 418*	111 (72.07)	42 (27.45)	7.772**
No	145 (74.74)	49 (25.25)		417 (82.73)	87 (17.26)	
Smoking						
Yes	78 (70.90)	32 (29.09)	.116	40 (74.07)	14 (25.92)	1.476
No	161 (69.09)	72 (30.90)		488 (80.92)	115 (19.07)	
Mean BMI	23.14±3.15	26.51±5.43	7.196***	24.52±4.47	27.35±5.17	5.698***
Mean WC	83.80±10.01	92.45±10.73	7.187***	82.53±13.07	92.70±14.64	7.732***
Mean WHR	.88±.07	.94±.07	6.036***	.85±.07	.90±.08	7.085***

TABLE 2: Mean SBP and DBP in relation to obesity, consumption of alcohol and smoking. Significance level: p<0.001***, p<0.01**, p<0.05*; SD = Standard deviation; BMI = Body Mass Index; WC = Waist circumference; WHR = Waist Hip Ratio.

Variable	Mean SBP±SD	t value	Mean DBP±SD	t value	Mean SBP±SD	t value	Mean DBP±SD	t value
	Male				**Female**			
BMI								
Normal	116.60±16.34	7.384***	79.01±16.06	7.450***	112.44±17.93	6.740***	75.02±15.82	7.733***
Overweight/Obese	131.38±19.44		91.97±15.55		122.29±19.46		84.67±16.01	
WC								
Normal	119.01±17.85	6.609***	81.29±16.55	6.094***	109.99±16.71	8.482***	72.95±14.98	9.154***
Inc/subs inc.	133.98±18.56		93.74±15.28		122.00±19.45		84.15±16.16	
WHR								
Normal	116.23±16.22	6.295***	78.36±16.23	6.497***	111.40±17.16	6.836***	74.19±19.01	7.495***
Inc/Subs inc.	128.44±19.66		89.69±16.03		121.26±19.73		83.51±16.53	
Alcohol consumption								
Yes	125.49±18.08	2. 408*	86.87±17.52	2. 427*	120.59±21.30	2. 688**	82.44±17.94	2. 431*
No	120.52±19.61		82.39±16.50		115.83±18.48		78.51±16.09	
Smoking								
Yes	121.71 17.00	1. 297	82.60±17.89	.683	120.85±20.81	1.560	80.15±16.71	.333
No	123.13±20.02		85.16±16.64		116.59±19.10		79.36±16.61	

WHR=56.16%) was higher in women, while HT was higher in men (30.32%). Mean WC, WHR, SBP and DBP were significantly higher in male compared to their female counterparts except for mean BMI.

In men, the prevalence of GO, CO and HT showed significant (p<0.001) differences across age groups (*Table 4*). The prevalence of GO, CO and HT was higher among older adults (GO=70.83%, CO: WC=54.16%, WHR=91.66%, HT=50.00%), followed by middle adults (GO=56.43%, CO: WC=43.56%, WHR=83.16%, HT=41.58%) and young adults (GO=30.73%, CO: WC=12.38%, WHR=34.40%, HT=22.93%). Mean BMI, WC, WHR, SBP and DBP also followed similar pattern (p<0.001), where it increased across age groups from younger to older adults.

In women, the prevalence of CO and HT showed significant (p<0.001) rise across the age groups from

TABLE 3: Summarizes the association of sex with general obesity, central obesity, hypertension and mean anthropometric data. Significance level: p<0.001***, p<0.01**, p<0.05* ; BMI = Body Mass Index; WC = Waist circumference; WHR = Waist Hip Ratio.

Variable	Male 343(%)	Female 657(%)	p value
General obesity	141 (41.10)	300 (45.66)	1.896
Central obesity			
WC	84 (24.48)	380 (57.83)	100.134***
WHR	181 (52.76)	369 (56.16)	1.049
Hypertension	104 (30.32)	129 (19.63)	14.399***
Mean BMI	24.16±4.27	25.08± .08	-3.106**
Mean WC	86.42±10.97	84.53±13.98	2.356*
Mean WHR	.90± .07	.86± .08	8.004***
Mean SBP	122.68±19.09	116.94±19.26	4.485***
Mean DBP	84.34±17.07	79.43±16.61	4.396***

TABLE 4: Prevalence of general obesity, central obesity, hypertension and mean anthropometric data across age groups. Significance level: p<0.001***, p<0.01**, p<0.05*; BMI = Body Mass Index; WC = Waist circumference; WHR = Waist Hip Ratio.

Variable	Young adult	Middle adult	Older adult	p value
Male				
General obesity	67 (30.73)	57 (56.43)	17 (70.83)	28. 252***
Central obesity				
WC	27 (12.38)	44 (43.56)	13 (54.16)	49.189***
WHR	75 (34.40)	84 (83.16)	22 (91.66)	81.521***
Hypertension	50 (22.93)	42 (41.58)	12 (50.00)	16.092***
Mean BMI	23.44±4.54	25.21±3.25	26.25±3.97	9.409***
Mean WC	82.38±9.66	92.63±9.08	97.04±10.38	55.694***
Mean WHR	.86± .06	.95± .05	.99± .06	99.882***
Mean SBP	119.62±17.35	127.23±19.85	131.25±24.71	8.424***
Mean DBP	81.38±16.59	88.91±16.87	92.00±16.21	9.801***
Female				
General obesity	126 (31.50)	146 (69.52)	28 (59.57)	84.191****
Central obesity				
WC	154(38.50)	183 (87.14)	43 (91.48)	157.121***
WHR	153 (38.25)	174 (82.85)	42 (89.36)	133.953***
Hypertension	41 (10.25)	68 (32.38)	20 (42.55)	59.593***
Mean BMI	23.61±4.23	27.59±4.70	26.32±4.14	58.823***
Mean WC	79.01±11.88	93.00±12.81	93.59±11.81	104.779***
Mean WHR	.83± .07	.90± .06	.93± .06	93.118***
Mean SBP	111.62±16.19	124.33±20.83	129.19±19.97	45.716***
Mean DBP	74.99±15.21	85.93±16.29	88.15±16.74	41.411***

young (CO: WC=38.50%, WHR=38.25%, HT=10.25%) to middle (CO: WC=87.14%, WHR=82.85%, HT=32.38%) to older adults (CO: WC=91.48% WHR=89.36%, HT=42.55%). However, the prevalence of GO was significantly (p<0.001) higher among middle adults (69.52%), followed by older adults (59.57%) and young adults (31.50%). The mean BMI, WC, WHR, SBP and DBP showed significant (p<0.001) differences across the age groups, which increased from younger to older except for BMI.

The results of stepwise linear regression model examined the independent predictors of SBP and DBP which were statistically significant (*Table 5*). In men, BMI, WHR and alcohol consumption were the independent predictors associated with SBP (F=30.076, df=3, p<0.001). 21 percent of the variance in SBP was accounted for by the aforementioned predictors. WC, BMI and alcohol consumption were also independent predictors for DBP (F=29.685, df=3, p<0.001) and accounted for 20.8 percent of the variance in DBP.

In women, age was significant independent predictor associated with both SBP and DBP. Age and BMI were independent predictors of SBP (F=69.729, df=2, p<0.001) and accounted for 17.6 percent of the variance. Table further showed that age and WC were independent predictors associated with DBP and accounted for 19.1 of the variances in DBP (F=77.132, df=2, p<0.001).

Sex is a significant predictor of hypertension after adjusting for age and alcohol consumption (*Table 6*). Model 2 showed the adjusted odd ratio (OR), where

TABLE 5: Stepwise linear regression for systolic and diastolic blood pressure in both sexes. Significance level: p<0.001***, p<0.01**, p<0.05*; B = Unstandardized coefficient; SE = Standard Error; β = Standardised coefficient.

Male					
SBP (F= 30.076***)	**B**	**SE**	**β**	**t**	**R^2**
BMI	1.38	.26	.301	5.221***	.210
WHR	48.71	14.42	.195	3. 378***	
Alcohol	4.77	1.85	. 124	2.573**	
DBP (F= 29.685***)					
WC	.38	.11	.250	3.423***	.208
BMI	.86	.29	.217	2. 981**	
Alcohol	4.26	1.66	.124	2. 561**	
Female					
SBP (F= 69.729***)	**B**	**SE**	**β**	**t**	**R^2**
Age	.53	.06	.323	8.355***	.176
BMI	.68	.15	.169	4.376***	
DBP (F= 77.132***)					
Age	.40	.05	.283	6.799***	.191
WC	.25	.04	.215	5.163***	

men were at 1.73 higher odds (C.I=1.25–2.39, p<0.001) of being hypertensive compared to women. Age and alcohol consumption were adjusted for BMI, WC and WHR. Overweight/obese men were at4.60 higher odds (C.I=2.74–7.75), increased/substantially increased WC were at 4.11 higher odds (C.I=2.33–7.27) and substantially increased WHR were at 2.95 higher odds (C.I=1.67–5.22) of being hypertensive compared to their non-obese counterparts at p<0.001 significant level. In model 2, after adjusting for alcohol consumption, older men were at 3.49 (C.I=0.62–4.43, p<0.01) higher odds and middle age men were at 2.45 (C.I=0.80–2.70, p<0.001) higher odds of being hypertensive compared to young adults. Men who consumed alcohol were at 1.81 higher odds (C.I=1.12–2.92, p<0.05) of being hypertensive compared to those who did not consume alcohol after adjusting for age.

Overweight/obese women were at 1.94 higher odds (C.I=1.25–3.01, p<0.01), increased/ substantially increased WC were at 2.17 higher odds (C.I=1.27–3.71, p<0.01) and substantially increased WHR were at 1.93 higher odds (C.I=1.16–3.20, p<0.05) of being hypertensive compared to their non-obese counterparts after adjusting for age and alcohol consumption. Across the age groups, older women were at 6.45 higher odds (C.I=3.31–12.56, p<0.001) and middle age women were at 4.11 higher odds (C.I=2.66–6.36, p<0.001) of being hypertensive compared to young women after adjusting for alcohol consumption. Women who consumed alcohol were at 1.72 higher odds (C.I=1.10–2.69, p<0.05) of being hypertensive compared to those who did not consume alcohol after adjusting for age.

DISCUSSION

The present study has elucidated the relationship of hypertension with obesity, age and sex. The relationship between obesity and hypertension differs according to age, sex, geographical area, race and also the criteria used for cutoff of anthropometric indices (OdaKawa 2008, Wakabayashi 2012, Wang *et al.* 2014). The present study has used the standard classification given by World Health Organization for BMI, WC and WHR. There are significant differences in the prevalence of hypertension between the obese and the non-obese groups in both the sexes with the prevalence being higher among obese groups. The mean SBP and DBP are significantly higher among the obese groups in both the sexes. The mean BMI, WC and WHR are also significantly higher in hypertensive group compared to normotensive group. The simultaneous rise of obesity and hypertension in Sikkim is undoubtedly a large concern to the public health of the people as the

TABLE 6: Logistic regression used to determine risk factors of hypertension. Adjusted for confounders = age and alcohol[1], alcohol[2], age[3]. Significance level: p<0.001***, p<0.01**, p<0.05*; O.R = Odds ratio; C.I = Confidence Interval; BMI = Body Mass Index; WC = Waist circumference; WHR = Waist Hip Ratio.

Variables	Model 1 Unadjusted O.R	95% C. I	Model 2 Adjusted O.R	95% C. I
Sex[1]				
Female	1		1	
Male	1.78***	1.31– 2.40	1.73***	1.25– 2.39
Male				
BMI category[1]				
Normal	1		1	
Overweight/Obese	5.19***	3.15– 8.54	4.60***	2.74– 7.75
WC category[1]				
Normal	1		1	
Inc/subs inc.	4. 81***	2. 84– 8.12	4.11***	2.33–7.27
WHR category[1]				
Normal	1		1	
Inc/Subs inc.	3. 70***	2.22– 6.14	2.95***	1.67– 5.22
Agegroup[2]				
Young adults	1		1	
Middle adults	2. 39***	1.44– 3.96	2.45***	.80– 2.70
Older adults	3.36**	1.42– 7.94	3.49**	.62– 4.43
Alcohol consumption[3]				
No	1		1	
Yes	1.906*	1.14– 3.18	1.81*	1.12– 2.92
Female				
BMI category[1]				
Normal	1		1	
Overweight/Obese	2. 93***	1.95– 4.40	1.94**	1.25– 3.02
WC category[1]				
Normal	1		1	1
Inc/subs inc.	4.02***	2.50– 6. 47	2.17**	1.27– 3.71
WHR category[1]				
Normal	1		1	
Subs inc.	3.49***	2.22– 5. 49	1.93*	1.16– 3.20
Age group[2]				
Young adults	1			
Middle adults	4. 19***	2.71– 6. 46	4.11***	2.66– 6.36
Older adults	6.48***	3.34– 12.57	6.45***	3.31–12.56
Alcohol consumption[3]				
No	1		1	
Yes	1.81**	1.18– 2.77	1.72*	1.10– 2.69

association of obesity and hypertension has been established by many studies (Mertens, Gaal 2000, Mungreiphy *et al*. 2011, Dua *et al.* 2014). Positive correlation exits between BMI with SBP and DBP (Droyvold *et al.* 2005). Increased WC acts toward a greater likelihood of developing hypertension (Kanai *et al.* 1990, Guangnano 2001). It is also a better indicator for health risk such as cardiovascular diseases and other metabolic syndromes (Han *et al.*1995, 1997). Clinical studies have shown that reduction in weight helps in

reducing and managing blood pressure and overall risk (Neter *et al.* 2003, Harsha, Bray 2008).

Sex differences are observed in the prevalence of hypertension and obesity in the present study. Although, women have recorded higher prevalence of both general and central obesity compared to men, the prevalence of hypertension is significantly higher among men. Sex is an independent risk factor for hypertension. The present study has shown that men are 1.73 higher odds of being hypertensive compared to women independent of other confounders. Such disparities in the prevalence of hypertension are also indicated by earlier studies in Indian population (Ghosh *et al.* 2016, Kumar, Mishra 2021). The prevalence of hypertension is higher in men than age matched pre-menopausal woman (Taylor, Sullivan 2016) but the risk reverses in post-menopausal ages (Faulkner, Chantemele 2018, Sylvester, Brooks 2019). However, findings of the present study are in contrast to these findings as the mean SBP and DBP are in general higher in men and also across all age groups compared to women similar to the findings of Lalnuneng (2021). According to Dubey *et al.* (2002), sex hormones are the largest contributor of sex differences in hypertension prevalence between men and women. Biological, lifestyle differences and behavioral factors, and the complex interaction of these elements in the socio-cultural fabric that exists attribute to the sex differences in prevalence of hypertension (Sandberg, Ji 2012, Colafella, Denton 2018, Sabbatini, Kararigas 2020).

In present study, it is observed that older adults have the highest prevalence of obesity, followed by middle adults and young adults. The prevalence as well as the mean SBP and DBP increases as one move across to higher age groups in both the sexes. A study shows the association of age and hypertension in both the sexes (Gardner, Poehlman 1995). The structural changes in heart with age lead to arterial and arteriolar stiffness (Pinto 2007). With advancing age, blood vessels lose their elasticity and in women especially, after menopause, the increase in blood pressure considerably rises (Sun 2014). The present study shows that in women, age is a strong predictor for both SBP and DBP, followed by BMI in SBP and WC in DBP. Moreover, age and alcohol consumption are important risk factors associated with hypertension. Older adults are at the higher risk to become hypertensive compared to younger adults in both the sexes. Similar to the present study, advancing age was more strongly associated with women than men in Punjabi community (Dua *et al.* 2014). In addition to the natural process of aging and the physiological changes that accompany it, ovarian hormone to an extent contributes toward lower blood pressure in pre-menopausal women and higher value in post-menopausal women (Dubey *et al.* 2002). Staessen *et al.* (1989) has reported a four-fold increase in the incidence of hypertension in post-menopausal women.

In men, BMI is the strongest predictor of SBP followed by WHR and alcohol consumption, while in case of DBP, WC is the strongest predictor followed by BMI and alcohol consumption. BMI is a common predictor associated to SBP and WC to DBP in both the sexes. Furthermore, general obesity, central obesity, age and alcohol consumption are strong predictors for hypertension. The present study has found a stronger association between general obesity and hypertension in men similar to a study by Wang *et al.* (2014), where it was reflected in both sexes in Chinese population. The association of BMI and blood pressure varies by age, sex and ethnicity, but undoubtedly, BMI has a positive correlation with blood pressure (Brown *et al.* 2000). WC is also a strong risk factor of hypertension compared to WHR in the present study. Mishra *et al.*(2009) study on Rai and Bhutia population in the rural areas of Sikkim shows that WC had better predictability to assess the risk of hypertension.

Alcohol consumption is a strong risk factor of hypertension in both the sexes irrespective of age similar to the finding of Mishra *et al.* (2009) in Sikkim. The prevalence of hypertension as well as the mean SBP and DBP is higher among those who consumed alcohol. According to NFHS-5, Sikkim is one of the leading states in consumption of alcohol among women and second highest in men (Bapat *et al.* 2020). Several studies have shown the association of chronic alcohol consumption with increased blood pressure and cardiovascular risk (Klatsky 2004, Berlin, Puddey 2006, Sesso *et al.* 2008). Higher alcohol consumption is related to rise in SBP compared to DBP (Husain *et al.* 2014).

In conclusion, there is a high prevalence of obesity and hypertension in the study population. Obesity and alcohol consumption management is necessary to reduce the risk of hypertension as well as other associated NCD'S in the urban areas. Although, age may be a non-modifiable risk factor of hypertension, lifestyle changes could potentially delay the onset of hypertension. At the policy maker's level, planned urbanization is necessary with inclusion of parks, playgrounds and recreational spaces targeting all age groups. The population at large needs public awareness, self-awareness and conscious incorporation of healthy dietary habits, lifestyle and physical activity to reduce and manage health risk

associated with obesity and hypertension. The present study highlights that even in the hilly terrains of Sikkim, the populations are experiencing high prevalence of lifestyle associated diseases like obesity and hypertension which requires attention.

LIMITATION

The present study has not taken into account the dietary patterns and physical activity of the studied population which are some of the limitations of the study.

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