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Research Article

BLOOD PRESSURE AND OBESITY VARIATION AMONG POPULATION OF AMRITSAR DISTRICT

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ABSTRACT
Blood pressure is a continuously distributed variable in population and is influenced by obesity. Obesity is defined either by increased waist circumference (WC), waist-stature-ratio (WSR), waist-hip ratio (WHR) and/or body mass index (BMI). As individuals from the developing countries consume more quantities of high-energy food and have less physical activity, the number of overweight and obese individuals increase. Obesity has a detrimental effect on blood pressure and increases cardiovascular events. As no well coordinated data is available on variations caused in blood pressure by various risk factors especially obesity, therefore, the present study was conducted to find out association of blood pressure with severity of obesity. A total of 400 adults (200 male and 200 female) agreed to take part in the same. Blood pressure (SBP and DBP) was measured on left arm by auscultatory method using a mercury sphygmomanometer. The anthropometric measurements have been recorded using standard procedures. Females had higher means with respect to the overweight & obesity than male but the prevalence of hypertension was more in male than females. It was observed that BMI had high significant correlation with systolic blood pressure in male and female whereas WHR was significantly correlated with diastolic blood pressure in both male and female.

Key Words: *Obesity, Blood pressure, BMI, WHR*

INTRODUCTION
Blood pressure is a continuously distributed variable in the population and is a dynamic physiological function that varies with each heart beat (James and Baker, 1995).The term blood pressure means the force exerted by the blood against any unit area of the vessel wall (Guyton and Hall, 2006). If this force is very high beyond certain limits, a condition known as hypertension or high blood pressure. High blood pressure usually may have no symptoms. In fact, many people have high blood pressure for years without knowing it. That is why it is called the "Silent killer" (Black, 1998).
Obesity is defined either by increased waist circumference (WC), waist-stature ratio (WSR), waist-hip ratio (WHR) and/or body mass index (BMI). As individuals from the developing countries consume more quantities of high-energy food and have less physical activity, the number of overweight and obese individuals increase. Obesity has a detrimental effect on blood pressure and increases cardiovascular events. As individuals from both developed and developing countries consume more and more quantities of high energy food and have less physical activity, the number of overweight and obese individuals increases to epidemic proportions (WHO, 2002). Obesity has a potential detrimental effect on blood pressure and increases cardiovascular events. Body mass index has been traditionally promulgated by the World Health Organization (WHO) as a useful epidemiological measure of obesity. Numerous studies have now established the relationship between obesity, overweight and underweight (Matusik, Malwcka-Tendera and Klimek, 2007).
A number of cut-off points to differentiate between obese, overweight and underweight individuals have also been proposed. However, WHO goes on to state that BMI is a crude index that does not take into

account the distribution of body fat, resulting invariability among different individuals and populations (WHO, 2002).

Punjab is an economically advanced and physically robust state of the country. Urban upper middle class population of Punjab has achieved a socioeconomic status similar to that of the developed societies, especially with respect to living conditions and nutritional intake. The socioeconomic development has created changes in dietary intake, food consumption patterns and physical activity levels. They all have contributed to the problem of increasing obesity in Punjabi population (WHO, 1998) especially the population of Amritsar. Traditionally as this part of population is very fond of all kind of energy rich foods e.g. junk foods, fried foods, sweets etc, the prevalence of obesity in this holy city is much more compared to rest of the Punjab and even India, which has further been complicated by the associated sedentary life styles.

Blood Pressure and Hypertension

The term 'Blood Pressure' refers to the mean systemic arterial blood pressure in the largest arteries near the heart. The normal blood pressure is defined as <120 mm Hg systolic blood pressure (SBP) and <80 mm Hg diastolic blood pressure (DBP). Hypertension was defined by blood pressure equal or higher than 140/90 mm Hg (Fuchs *et al.,* 2005). An individual is considered to be hypertensive if he/she possesses a SBP of>140 mm Hg and/or DBP of >90 mm Hg (Stranges *et al.,* 2004). Chronic hypertension is a 'silent killer' causing changes in blood vessels and retina, abnormal thickening of heart muscles, kidney failure and brain damage. Hypertension is caused by numerous factors such as genes, age, alcohol intake, excessive intake of salt, overweight, obesity and a sedentary lifestyle. It has been observed that overweight could be a major factor in determining the increasing rates of coronary heart disease by its influence on blood pressure (Reddy *et al.,* 2002).

Relationship between Obesity and Blood Pressure

It has been very recently observed that blood pressure levels and the prevalence of hypertension are related to adiposity, and the main components of adiposity are BMI, waist/hip ratio, waist/stature ratio (WSR) and percent body fat (Kotchen *et al.,* 2008). Another very convenient measure of abdominal adipose tissue is WC (Bouguerra *et al.,* 2007). Studies have shown that WC has a significant role to play in the prevalence of hypertension (da Silva and Rosa, 2006; Sung *et al.,* 2007). Some studies have also focused on sex differences in the prevalence of blood pressure (Turconi *et al.,* 2006). Studies also documented association of hypertension with WSR and considered it as the best indicator of hypertension and estimation body fat (Nagai *et al.,* 2008). One important issue that is currently assuming relevance in studies involving blood pressure and anthropometric parameters is the mean arterial pressure or MAP (Sadhukhan *et al.,* 2007).

Studies Done in Obesity and Blood Pressure in India

It is a well-recognized fact that overweight, obesity and hypertension are some of the major public health concerns in India. Although there have been steady increases in the prevalence of these parameters among the Indian population (Gupta, 2004; Gupta *et al.,* 2008) there exists limited data on such issues among different Indian populations and caste groups (Deshmukh *et al.,* 2006; Gupta *et al.,* 2007). Association of higher socioeconomic status, higher body mass index and central obesity in North Indian adults with higher fat intake, lower physical activity, higher prevalence and level of hypertension indicate that these populations may benefit by decreasing the dietary fat intake and increasing physical activity, with an aim to decrease central obesity for decreasing hypertension in North Indians (Pedro *et al.,* 2006).

Therefore, accurate estimates of prevalence of hypertension and risk factors associated with it are necessary to plan effective control measures but there are no well-coordinated national surveys of prevalence of hypertension available from the Indian subcontinent. Several regional surveys with varying protocols and using casual blood pressure readings have reported prevalence, which varies widely from population to population. So it is important to realize that developing country like India would be adversely affected in the long run and strategies must be developed to control these emerging health problems on an urgent basis. As no well coordinated data is available on variations caused in blood

pressure by various risk factors especially obesity, therefore, the present study was conducted to find out association of blood pressure with severity of obesity. The severity of obesity will be assessed by the estimation of body mass index (BMI), waist hip ratio (WHR).

MATERIALS AND METHODS

This cross sectional study was carried out during the period 2007-2010. House-to-house visits had been utilized for collecting the data for the present study. Male and female individuals belonging to the Amritsar population in age group 30-50 years were identified. Older individuals were not considered as it has been shown that blood pressure increases among the elderly population. For more precision, only those individuals who were not taking medication or were on erratic medication for hypertension have been included in the present study. A total of 500 individuals (250 males and 250 females) were approached for taking part in the study. The objectives of the study and the methods were explained to them and finally 400 individuals (200 males and 200 females) agreed to take part in the same.

Measurement of Blood Pressure

A rough estimation of systolic blood pressure with palpatory method was done before the actual measurement of blood pressure. Blood pressure was measured after a rest of 15 minutes by auscultatory method using mercury sphygmomanometer. Appearance of first Korotkoff sound and disappearance of fifth Korotkoff sound was used to estimate systolic and diastolic blood pressure respectively. Three measurements were recorded by following the recommendations of American Heart Association, (American Heart Association ,1981) the lowest value was included in the study as being the nearest to basal blood pressure level and also because by recording the lowest reading, anxiety induced effect on measurement of blood pressure is reduced (Gravy and Baker, 1979).

Anthropometric Measurements Recorded

Following anthropometric measurements were taken on each subject using standard methodology (Weiner and Lourie, 1981).

1. Height
2. Weight
3. Waist circumference (WC)
4. Hip circumference (HC)

Body weight was recorded to the nearest 0.5kg with the subject standing motionless on a bath room weighing scale. Height was measured to the nearest 0.1 cm with the subject standing in the erect position with the head in the ear-eye plane, with the help of an anthropometer. Waist circumference was measured at the level half way between the iliac crest and the coastal margin in the mid-axillary line after exhaling with the subject in the standing position. Hip circumference was measured at the level of the greater trochanters with the subject in a standing position with two feet together. Two consecutive readings were recorded for WC and HC to the nearest 0.1 cm using a non-stretchable measuring tape without compression of skin. The mean of the two values has been used (WHO, 1998).

Assessment of Body composition

Analysis of body composition by Bioelectrical Impedance method was done using Body Fat Analyzer (Body Stat – 1500, UK made). Percent body fat, total body fat and fat free mass was noted.

Assessment of Obesity

Following parameters were used for assessment of obesity:

Body Mass Index (BMI): BMI was calculated with the following formula.

$$\text{BMI} \quad (\text{in kg/m}^2) = \frac{\text{Weight (kg)}}{\text{Height (m)}^2}$$

Waist circumference (WC): Waist circumference cut-offs were taken as >90 cm for male and > 80 cm for female to define abdominal obesity (www.org/asiapacific, 2008).

Waist-Hip-Ratio (WHR): For the assessment of abdominal obesity WHR was calculated using following formula:

$$WHR = \frac{WC\ (cm)}{HC\ (cm)}$$

The WHR of >0.80 for female and >0.90 for male is taken as obese (Webb,2002).

Waist to Stature ratio (WSR): The WSR was estimated from the following formula:

$$WSR = \frac{WC\ (cm)}{Height\ (cm)}$$

The cut-off for assessment of obesity was 0.5 for both sexes (Hsieh and Muto, 2004).

Percent body fat: Upper limit of percent body fat defining obesity are still debatable. Percent body fat was defined as indicative of obesity if it was >25% in male and >30% in female (Dudeje *et al.*, 2001).

Statistical Analysis

The data was statistically analyzed using SPSS 17.0. Statistical constants have been utilized to document the population characteristics, anthropometric indicators, SBP, DBP. Means were compared between sexes using paired t-test. Correlations were utilized to determine the association between the anthropometric indicators and blood pressure indicators. Step wise regression analysis was used to assess the influence of BMI, WC, WHtR, and WHR on SBP, DBP. The level of significance was taken as $p<0.05$.

RESULTS

The Baseline Characteristics of the Study Population

The present study has included 400 individuals (200 male and 200 female), the nature of which has been discussed in the previous section. The mean age of the male was 42.68$\pm$1.53 years and that of the females were 41.42$\pm$2.54 years. The mean and standard deviations of the anthropometric measurements and blood pressures observed in the present study is shown in Table I. The mean height was 164.52$\pm$8.88 cm and 156.46$\pm$5.31 cm among males and females respectively. The mean weight was 64.85$\pm$6.21 kg and 59.49$\pm$5.14 kg among males and females respectively. Similarly, BMI was higher in females than in males (27.12$\pm$1.85 kg/m2 and 26.72$\pm$1.57kg/m2 respectively). Waist circumference is also higher in males (106.65$\pm$7.40 cm) than in females (89.86$\pm$6.53 cm). Males also have a higher mean WSR (0.55$\pm$0.04) than the females (0.53$\pm$0.03). Waist-hip ratio is seen to be marginally higher in males than in females (0.91 and 0.88 respectively). Males have a higher mean SBP 131.70$\pm$15.70 mm/Hg than their female counterparts (119.05$\pm$8.72 mm/Hg). Similarly, DBP also show a higher mean in case of male individuals (85.20$\pm$9.04mm/Hg) than in female individuals (79.60$\pm$8.12). The mean arterial blood pressure also shows a sex difference, with the males having a higher mean (100.27$\pm$10.98 mm/Hg) than the females 94.08$\pm$9.16).

Assessment of obesity :(Table II,)

In the present study following parameters have been used for the assessment of obesity:

- Body Mass Index (BMI)
- Waist Circumference (WC)
- Waist Hip Ratio (WHR)
- Waist Stature Ratio (WSR)
- Percent Body Fat(PBF)

Body Mass Index (BMI): BMI is the most commonly recommended and widely used for classifying overweight and obese subjects for survey purpose. In the present study 46.20% men and 58.20% women were obese (overweight /obese). Thus in the pooled sample of 400 subjects prevalence of obesity (overweight /obese) was 52.20%.

Table I: Mean and standard deviation (SD) of various Anthropometric and Physiological variables of adult male and Female of Amritsar

Anthropometric & Physiological variables	Male (n=200)	Female (n=200)
Age (years)	42.68±1.53	41.42±2.54
Height (cm)	164.52±8.88	156.46±5.31
Weight (Kg)	64.85±6.21	59.49±5.14
Waist Circumference (cm)	106.65±7.40	89.86±6.53
Hip Circumference (cm)	95.26±6.00	97.94±6.12
Waist Hip Ratio	0.91±0.06	0.88±0.04
Waist Stature Ratio	0.55±0.04	0.53±0.03
Body Mass Index Kg/m^2	26.72±1.57	27.12±1.85
Percent Body Fat (%)	21.22±5.47	34.94±5.34
Total body Fat (Kg)	13.75±3.76	20.81±4.05
Fat free mass (Kg)	51.10±5.87	38.68±4.09
Systolic Blood Pressure (mmHg)	131.70±15.70	119.05±8.72
Diastolic Blood Pressure (mmHg)	85.20±9.04	79.60±8.12
Pulse Pressure (mmHg)	46.00±10.65	39.55±5.41
Mean Arterial Pressure (mmHg)	100.27±10.98	94.08±9.16

Table II: Percentage prevalence of obesity with different anthropometric

Sex	Total no of subjects	WC	WHR	WSR	Percent Body Fat
Male	200	73.00 (146)	73.00 (146)	82.00 (164)	87.50 (175)
Women	200	91.00 (182)	93.50 (187)	84.00 (168)	89.50 (179)
Total	400	82.00(328)	83.25 (333)	83.00 (332)	88.50 (354)

**Figures in parenthesis indicates number of subjects*

Table III: Percentage prevalence of hypertension

Sex	Total number	←----------Percentage----------→ Normal	Prehypertension	Hypertension
Male	200	19.5 (39)	55.0 (110)	25.5 (51)
Female	200	43.0 (86)	47.5 (95)	9.5 (19)
Total	400	31.25 (125)	53.75 (205)	17.5 (70)

**Figures in parenthesis indicates no of subjects*

TABLE IV: Percentage prevalence of hypertension among obese and non-obese male and female according to obesity indicators

Sex	Hypertensive Subjects	Body Mass Index		Waist circumference		Waist hip ratio		Waist Stature ratio		Percent body fat	
		Obese	Non obese	Obese	Non obese	Obese	Non obese	Obese	Non obese	Obese	Non obese
Male	51 (200)	16.00 (32)	9.50 (19)	22.50 (45)	3.00 (6)	23.00 (46)	2.50 (5)	25.50 (51)	0.0 (0)	23.50 (47)	2.00 (4)
Female	19 (200)	6.00 (12)	3.50 (7)	9.50 (19)	0.0 (0)	9.50 (19)	0.0 (0)	9.50 (19)	0.0 (0)	9.0 (18)	0.5 (1)
Total	70 (400)	11.00 (44)	6.50 (26)	16.00 (64)	3.00 (6)	16.25 (65)	1.25 (5)	17.50 (70)	0.0 (0)	16.25 (65)	1.25 (5)

**Figures in parenthesis indicates numbers of subjects*

Table V: Correlation of SBP and DBP with anthropometric parameters in male and female subjects

Obesity variables	Male				Female			
	SBP		DBP		SBP		DBP	
	r	p	r	p	r	p	r	p
Body Mass Index (kgm^2)	0.275	<0.0001	0.216	<0.001	0.207	<0.001	0.129	<0.05
Waist Hip Ratio	0.461	>0.05	0.258	<0.0001	0.363	<0.0001	0.271	<0.0001
Waist Circumference (cm)	0.362	<0.0001	0.319	<0.0001	0.250	<0.0001	0.163	<0.05
Waist Stature Ratio	0.403	>0.05	0.306	<0.0001	0.280	<0.0001	0.191	<0.005
Percent Body Fat (%)	0.404	>0.05	0.266	<0.0001	0.139	<0.05	0.0389	>0.05

Waist circumference (WC): According to WC In the present study 73.0% male and 91.0% female were obese. Thus in a pooled sample prevalence of obesity was 82.0%.
Wais -hip- ratio (WHR): According to WHR in the present study 73.0% male and 93.5% female were obese and the pooled sample prevalence of obesity was 83.25%.
Waist stature ratio (WSR): In the present study 82.0% male and 84.0% female were obese according to WSR and in the pooled sample prevalence of obesity were 83.0%.
Percent body fat (PBF): According to percent body fat 87.50% male and 89.50% female were obese. Thus in a pooled sample prevalence of obesity was 88.50%.
Assessment of Hypertension: (Table III & IV)
In a pooled sample of 200 male (18-50 years of age) 19.5% were normotensive, 55.0% were prehypertensive and 25.5% were hypertensive. On the other hand in a pooled sample of 200 female (18-50 years of age), 9.5% were hypertensive, 47.5% were prehypertensive and 43.0% female were normotensive. Thus in the pooled sample of 400 subjects (18-50 years of age) 31.25 % were normotensive, 53.75%, were prehypertensive and 17.5% were hypertensive
In the present study percentage prevalence of hypertension has also been studied in relation to various obesity parameters. For studying relationship between hypertension and obesity the whole sample has been divided into two groups i.e. Obese & Non-obese under different anthropometric variable of obesity.
Body mass index (BMI): In the present study hypertension was present in 16.0% male and 6.0% female who were obese (BMI>25 kg/m^2). In non-obese men and women the percentage prevalence hypertension was 9.50% and 3.50%, respectively. While among pooled sample prevalence of hypertension was 11.0% in obese and 6.50% in non-obese subjects
Waist circumference (WC): In non-obese men the percentage prevalence hypertension was 3.0%. While among obese male & female the percentage prevalence of hypertension was 22.50% and 9.50% respectively. Thus in the pooled sample prevalence of hypertension was 16.0% in obese and 3.0% in non-obese subjects.
Waist-hip-ratio (WHR): According to WHR in obese male and female percentage prevalence of hypertension was 23.0% and 9.50% respectively. In non-obese men the percentage prevalence hypertension was 2.50%. Thus in the pooled sample prevalence of hypertension was 16.25% in obese and 1.25% in non-obese subjects.
Waist stature ratio (WSR): In the present study hypertension was present in 20.50% male and 9.50% females who were obese. Hypertension was not present in non-obese men and women. Thus in the pooled sample prevalence of hypertension was 17.50% in obese and absent in non obese subjects.
Percent body fat: On the basis of percent body fat 23.50% obese male and 9.0% obese females were hypertensive. On the other hand 2.00% and 0.50% non-obese men & women were hypertensive respectively. Thus in the pooled hypertension was present in 16.25% obese and 1.25% in non-obese subjects.

DISCUSSION

Obesity is essentially a disorder of energy balance characterized by an excess of body fat. It is chronic and often associated with a wide range of metabolic abnormalities and degenerative diseases. This complex condition of multifactorial origin is considered to be the scourge of modern affluent societies both in developed and developing countries. The extent of overweight/obesity reported in Indian studies is not comparable because of variation in the criteria for BMI cut off points used, variation in age, socioeconomic status of the subjects and periodic dissimilarities.

The percentage prevalence of obesity in the studied sample is higher than the various other parts of India. Also the state of Punjab has attained a status akin to the developed nations in matters of nutritional and socioeconomic development. This could be the reason for higher percentage prevalence of overweight & obesity in this region (Sidhu, Kaur and Prabhjot, 2005 ; NFHS-2, 2001).Also 20.4% of the male and 25.0% of female were found overweight in the present sample with an overall prevalence of 22.7 %.

In the present study, some interesting observations for WHR were seen. 93.5% female had abdominal obesity compared to 73.0% of the male. In other words combined prevalence of obesity in male and female was 83.25 % (Table -II).

According to percent body fat; 87.50% of male and 89.50% female of the present sample were classified as obese. This showed that the prevalence of obesity in female was 2% more than the male. It was interesting to note that by all methods less numbers of males in the present sample were abdominally obese than female (Table-II). The present study in this regard has made very interesting observations - abdominal obesity was seen in a high proportion of subjects not only in the obese category, but also in subjects with normal BMI. Indeed, the overall prevalence of abdominal obesity was found to be higher than the overall prevalence of overweight/obesity (BMI>23).These data also suggest that, while abdominal obesity frequently, coexists with general overweight/obesity, it could be present in the absence of general overweight/obesity.

The percentage prevalence of hypertension in the present study was found to be 17.5% (Table III & IV). The prevalence of hypertension in the various studies is not comparable because of variation in the socioeconomic status of the subjects, their life style, genetic makeup, food habits and periodic dissimilarity. It was found to be closer to other studies in Delhi (Reddy, 1993) where overall prevalence of hypertension is 17.4%. It was also evident from the present sample that a very high prevalence of hypertension was noted in obese male and female. It was clear from the Table-V that prevalence of hypertension varied according to the status of BMI. The subjects having BMI more than 23 kg/m^2 (Obese) having high prevalence of hypertension 11.0% than the subjects having BMI less than 23 kg/m^2 (Non-Obese) i.e.6.5%.

In the present study, Table-V showed significant correlation of BMI with SBP in male and female ($r=0.275$, $p <.0001$) and ($r=0.207$, $p<.001$) respectively. High correlations between SBP and BMI have also been reported in other studies (Nagai *et al.,* 2008; Sadhukhan *et al.,* 2007; Gupta, 2004).

In the present study, WHR was significantly correlated with DBP in both male and female with ($r =0.258$, $p < .0001$) and ($r =0.271$, $p < .0001$) respectively. Correlation analysis of WHR with clinical parameters showed that in male there was a positive relationship of WHR with diastolic blood pressure ($r = 0.11$) but not with age and height. In female no significant relationship was seen with these variables (Gupta, 2008).

In male and female SBP was highly significant with WC. In male and female, correlation of SBP with WC was ($r=0.362$, $p<.0001$) and ($r=0.250$, $p<.0001$) respectively. High correlations between SBP and WC have also been reported in other studies (Nagai *et al.,* 2008; Deshmukh *et al.,* 2006).

In the present study, the results of univariate analysis of correlation of BMI, WC, WHR, WSR and PBF were presented in Table-V. The data showed that these obesity variables were significantly correlated with SBP and DBP. SBP was best associated with BMI and WC followed by WSR, PBF and WHR in male, whereas in female it was best associated with WC, WSR and WHR followed by BMI and PBF. DBP was best associated with WC, WHR, WSR, PBF followed by BMI in male, whereas in female it was best associated with WHR followed by WSR, BMI, WC and PBF.

Conclusion

It was concluded that incidence of hypertension increased with age both in male and female. Variation in SBP was significantly correlated with BMI, WC in male while in female it was significantly correlated with BMI, WC, WHR, WSR and PBF. Variation in DBP in both male and female was significantly correlated with BMI, WC, WHR, WSR and PBF. Percentage prevalence of obesity increased with age more in female than in male. Obesity parameters (BMI, WC, WHR, WSR and PBF) showed statistically significant variation with increasing age in male as well as female. Thus from all these results it can be concluded that obesity and prevalence of hypertension were interrelated / associated significantly in both sexes.

REFERENCES

American Heart Association (1981). Report of subcommittee of postgraduate education committee recommendation for human blood pressure determination by sphygmomanometer: *Circulation* **64** 501A-509B.

IOTF (2000). Asia-Pacific perspective-Redefining obesity and its treatment. Available: http://www.iotf.org/asiapacific/ [Accessed 10 April, 2008]

Black HR (1992). New concepts in hypertension. Focus on the elderly. *American Heart Journal* **135** S2-S3.

Bouguerra R, Alberti H, Smida H, Salem LB, Rayana CB, El Atti J, Achour A, Gaigi S, Slama CB, Zouari B and Alberti KG (2007). Waist circumference cut-off points for identification of abdominal obesity among the Tunisian adult population. *Diabetes, Obesity and Metabolism* **9** 859-868.

Da Silva AC and Rosa AA (2006). Blood pressure and obesity of children and adolescents association with body mass index and waist circumference: *Archivos Latinoamericanos de Nutrición* **56** 244-250.

Deshmukh PR, Gupta SS, Dongre AR, Bharambe MS, Maliye C, Kaur S and Garg BS (2006). Relationship of anthropometric indicators with blood pressure levels in rural Wardha. *Indian Journal of Medical Research* **123** 657-664.

Dudeje V, Misra A, Pandey RM, Devina G, Kumar G and Vikram NK (2001). BMI does not accurately predict overweight in Asian Indians in Northern India: *British Journal of Nutrition* **86** 105-112.

Fuchs FD, Gus M, Moreira LB, Moraes RS, Wiehe M, Pereira GM and Fuchs SC (2005). Anthropometric indices and the incidence of hypertension: A comparative analysis. *Obesity Research* **13** 1515-1517.

Gupta R (2004). Trends in hypertension epidemiology in India. *Journal of Human Hypertension* **18** 73-78.

Gupta R, Joshi P, Mohan V, Reddy KS and Yusuf S (2008). Epidemiology and causation of coronary heart disease and stroke in India. *Heart* **94** 16-26.

Gupta R, Rastogi P, Sarna M, Gupta VP, Sharma SK and Kothari K (2007). Body mass index, waist-size, waist hip ratio and cardiovascular risk factors in urban subjects: *Association of Physicians of India* **55** 621-627.

Guyton AC and Hall JE (2006). The Circulation: In: Guyton AC and Hall JE editors. Textbook of Medical Physiology 11th edition Philadelphia, Pennsylvania: *Elsevier* 166-167.

Hsieh SD and Muto T (2004). A simple and practical index for assessing the risk of metabolic syndrome during routine health checkups: *Nippon Rinsho* (62) 1143-1149.

James GD and Baker PT (1995). Human population biology and blood pressure: Evolutionary and ecological considerations and interpretations of population studies. In: Laragh JH and Brenner BM, editors. Hypertension, Pathophysiology, Diagnosis and management *2nd edition New York: Raven press* 115-126.

Kotchen TA, Grim CE, Kotchen JM, Krishnaswami S, Yang H, Hoffmann RG and McGinley EL (2008). Altered relationship of blood pressure to adiposity in hypertension. *American Journal of Hypertension* **21b** 284-289.

Matusik P, Malwcka-Tendera E, Klimek K and Polish Childhood Obesity Study Group (2007). Nutritional state of Polish prepubertal children assessed by population-specific and international standards. *Acta Paediatrica* **96** 276-280.

Mc Gravy ST and Baker PT (1979). The effect of modernization and migration on Samoan blood pressure: *Human Biology* (51) 461-479.

Nagai M, Komiya H, Mori Y and Ohta T (2008). Developments in estimating visceral fat area from medical examination data. *Journal of Atherosclerosis and Thrombosis* **15** 193-198.

NFHS (2001). National Family Health Survey India 1998-99 Punjab. International Institute for population Sciences Mumbai.

Pedro Velasquez-Mieyes, Sylvia Perez and Petricia A Cowon (2006). Identifying Children at Risk for Obesity, Type II Diabetes and Cardiovascular Disease: *Diabetes Specturm* **5**(2) 50-53.

Reddy RS (1993). Cardiovascular diseases in India. World Health Statistics Quarterly **46** 101-107.

Reddy KS, Prabhakaran D, Shah P and Shah B (2002). Differences in body mass index and waist: Hip ratios in North Indian rural and urban populations. *Obesity Reviews* **3** 197-202.

Sadhukhan SK, Bose K, Mukhopadhyay A and Bhadra M (2007). Age variations in overweight men and female in rural areas of Hooghly district, West Bengal. *Indian Journal of Public Healt*h **51** 59-61.

Sidhu S, Kaur A and Prabhjot (2005). Prevalence of overweight and obesity among urban and rural adult females of Punjab. *Anthropologischer Anzeiger* 63.

Stranges S, Wu T, Dorn JM, Freudenheim JL, Muti P, Farinaro E, Russell M, Nochajski TH and Sung RY, Yu CC, Choi KC, McManus A, Li AM, Xu SL, Chan D, Lo AF, Chan JC Fok TF (2007). Waist circumference and body mass index in Chinese children: Cutoff values for predicting cardiovascular risk factors: *International Journal of Obesity* **31** 550-558.

Turconi G, Guarcello M, Maccarini L, Bazzano R, Zaccardo A and Roggi C (2006). BMI values and other anthropometric and functional measurements as predictors of obesity in a selected group of adolescents. *European Journal of Nutrition* **45** 136-143.

Trevisan M (2004). Relationship of alcohol drinking pattern to risk of hypertension: A population-based study. *Hypertension* **44** 813-819.

Webb GP (2002). Nutrition: A health promotion approach. *2nd edition London: Arnold Publishers* 186.

Weiner JS and Lourie JA (1981). Human Biology: A guide to Field Methods. Practical human biology. *New York: Academic Press Incorporation* 34-49.

WHO (1998). Obesity preventing and managing the global epidemic. *Technical Report Series* 894.

World Health Organization (1998). Obesity: Preventing and Managing Global Epidemic. Geneva: WHO.

World Health Organization (2002). Reducing Risks, Promoting Healthy Life-The World Health Report Geneva: WHO.