Original Article

Role of body visceral fat in hypertension and dyslipidemia among the diabetic and nondiabetic ethnic population of Tripura—A comparative study

Bidhan Goswami[1], Taranga Reang[2], Swapan Sarkar[3], Shauli Sengupta[4], Bhaskar Bhattacharjee[5]

Departments of [1]Microbiology, [2]Community Medicine and [3]Medicine, Agartala Government Medical College, [4]Research Scientist - I, Multidisciplinary Research Unit, Agartala Government Medical College, [5]Research Scientist - II, Multidisciplinary Research Unit, Agartala Government Medical College, Agartala, Tripura, India

Abstract

Background: Excess fat in the upper part of human body correlates with increased mortality and risk for diabetes, dyslipidemia, and hypertension. In India, there are very limited data available on the association of excess body visceral fat with hypertension and dyslipidemia independent of obesity and diabetes. **Objective:** The objective of this study is to assess the role of body visceral fat percentage in hypertension and dyslipidemia among diabetic and nondiabetic indigenous ethnic population of Tripura. **Methods:** Random blood sugar test was done for each of the study subjects with the help of a standard and validated glucometer. Then, blood samples were obtained after an 8–12-h overnight fast using vacutainer. Later on, all the blood samples were transported to the MRU laboratory at Agartala Government Medical College maintaining cold chain for following investigations: (1) FBS, PP by GOD-POD method; (2) HbA1c by immunoturbidimetric method; (3) cholesterol estimation by CHOD-PAP method; and (4) triglyceride estimation by glycerol phosphate oxidase method. **Results:** In this study, it has been found that 62.5% diabetic subjects having high body visceral fat are suffering from Dyslipidemia, whereas only 42.9% nondiabetic subjects with high body visceral fat percentage are having dyslipidemia. Fisher's exact test showed association between diabetes status and body visceral fat ($P = 0.048$). It has been also observed that there was significant ($P < 0.05$) association between hypertension and body visceral fat among local indigenous ethnic population of Tripura. **Conclusion:** Body visceral fat percentage is significantly associated with hypertension, dyslipidemia, and type-2 diabetes among indigenous ethnic population of Tripura.

Keywords: Body mass index, body visceral fat, ethnic population, hypertension, lipid profile

Introduction

Adiponectin is an adipokine, which is abundantly produced and secreted by adipose tissues and mainly recognized for its antidiabetic, anti-inflammatory, anti-atherogenic, and cardioprotective effects.[1-3] Adiponectin's function is to regulate body fat. In several human studies, decreased serum adiponectin level has been found to be associated with a number of cancer types, mainly breast cancer and endometrial cancer.[4] Body visceral fat normally inhibits adiponectin. Body visceral fat is generally wrapped around major human organs, such as liver, pancreas, and kidney. It ensures that there is some distance between each organ. Too much visceral fat deposits can lead to inflammation and high blood pressure, which increases the risk of serious health problems. It was found that in nondiabetic men, high body visceral fat, high blood pressure, and insulin resistance can cause interconnected abnormalities.[5] From earlier studies,

Address for correspondence: Dr. Taranga Reang, Department of Community Medicine, Agartala Government Medical College, Agartala - 799 006, Tripura, India.
E-mail: tarangareang@gmail.com

Received: 31-01-2020 **Revised:** 13-03-2020
Accepted: 03-04-2020 **Published:** 30-06-2020

Access this article online

Quick Response Code:

Website: www.jfmpc.com

DOI: 10.4103/jfmpc.jfmpc_187_20

How to cite this article: Goswami B, Reang T, Sarkar S, Sengupta S, Bhattacharjee B. Role of body visceral fat in hypertension and dyslipidemia among the diabetic and nondiabetic ethnic population of Tripura—A comparative study. J Family Med Prim Care 2020;9:2885-90.

it has been observed that, in moderate obesity, regional fat distribution appears to be an important indicator of metabolic and cardiovascular risk. Even studies have also shown that excess fat in the upper body correlates with increased mortality and risk for diabetes, hyperlipidemia, and hypertension. Although the cause–effect relationship has not been yet established, the available evidence indicates that body visceral fat may be a common factor linking the many aspects of the metabolic syndrome like glucose intolerance, hypertension, dyslipidemia, and insulin resistance.[6] A study among the children showed that blood pressure is associated with hyperinsulinemia and body visceral fat excess.[7] In obese hypertensive women, accumulation of fat in the abdominal viscera was associated with higher blood pressure levels and insulin resistance.[8] In India, there are very limited data available on association of excess body visceral fat with hypertension and dyslipidemia independent of obesity and diabetes.

Tripura, third smallest state of the country, lies in a geographically disadvantageous location in India, as only one major highway, the National Highway 8, connects it with the rest of the country. Bengali Hindus form the majority population, while about 30% of the state consists of 19 indigenous communities. The traditional food habits are variable and devoid of fats, oils, and spices amongst different groups of ethnic population. Fermented fish products and locally available forest-grown wild vegetables are common food recipe in the daily diets of almost all the ethnic population groups.[9] So, this observational study was planned to determine the association of visceral fat percentage with hypertension and lipid profile among diabetic and nondiabetic indigenous population. The main objective of this study was to assess the role of body visceral fat percentage in hypertension and dyslipidemia in both diabetic and nondiabetic ethnic population.

Methods

This community-based study was conducted in rural areas of Tripura with effect from February 2018 to March 2019. Two hundred and eight subjects were recruited in this study. Sample size (n) = $[\{Z^2_{1-\alpha/2} \times P(1-P)\}/\ell^2 \times 2)]$ was calculated using proportion considering the prevalence of hypertension among diabetic population as 80%[10] at 95% confidence with 10% relative error and a design effect of 2. Multistage sampling technique was used for selecting rural blocks. Out of 58 blocks of Tripura, 10 blocks having predominantly indigenous ethnic population were selected by simple random sampling. In the next stage, one primary health center (PHC) under each of these 10 block areas was selected by simple random sampling. Overall, 10 health camps were organized at 10 different PHC areas with the help of accredited social health activist (ASHA) workers, Anganwadi workers, and multipurpose health workers. Free health check-up was performed in each of the camps in presence of a physician and prescribed medicines were distributed free of cost.

Exclusion criteria

Subjects with pregnancy, below 18 years, on antipsychotic medication, on anti-TB, anticancer, and steroid medication were excluded from this study. Written informed consent was obtained from these study subjects before participating in this study. The selected subjects were interviewed in presence of an ASHA worker. On average 10 min was spent for interviewing each participant. Data were collected using questionnaire containing sociodemographic information, diet information, record of BP, height, weight, body visceral fat content, and so on, an electronic weighing scale with a precision of 100 g, one stadiometer, one sphygmomanometer, one automated body-fat analyzer, and an auto-analyzer for estimation of FBS, HbA1c, and serum lipid profile. Hypertension (by Auscultatory method) was defined according to the recent American guidelines of hypertension[11] with a systolic blood pressure (SBP) more than 130 mmHg and a diastolic blood pressure (DBP) more than 80 mmHg. Blood pressure was measured three times at 2 min intervals using sphygmomanometer and then these three measurements were averaged.[11] For diabetes, random blood glucose ≥200 mg/dl, fasting glucose ≥126 mg/dl, or HbA1c level ≥6.5% had been considered as per American Diabetes Association 2015 guidelines. WHO guidelines were followed for lipid profile references.

Body composition monitor (OMRON, HBF-701, Japan) was used for collecting all anthropometric measurements like weight, BMI, body fat percentage, and visceral fat percentage of all the study subjects. As per protocol of this equipment, 10% was considered as the cut-off value for body visceral fat percentage. Random blood sugar test was done with the help of a standard and validated glucometer. Blood samples were obtained after 8–12 h of overnight fasting using vacutainer.[12] Samples were transported to the research laboratory maintaining cold chain for following investigations: (1) FBS, PP by GOD-POD method using fully automated analyzer; (2) HbA1c by immunoturbidimetric method; (3) cholesterol estimation by CHOD-PAP method; and (4) triglyceride (TG) estimation by glycerol phosphate oxidase method.

Ethical clearance

Approval was taken from Institutional Ethics Committee (vide No. F.4(6-9)/AGMC/ Academic/IEC Committee/2015, dated, 06.12.2017) before conducting this research study.

Statistical methods

Statistical Package for Social Sciences Software, version 25.0, was used for statistical analysis. P value <0.05 was considered statistically significant. Statistical analysis was verified by an expert biostatistician from Multidisciplinary Research Unit of Agartala Govt. Medical College. Dichotomized data were analyzed by using Chi-square test and continuous data were analyzed by Student's t-test for testing of significance. The correlation of body visceral fat percentage with diabetic status and lipid profile was evaluated by using the Pearson's correlation coefficient. Ethical clearance was obtained from institutional ethics committee of Agartala Govt. Medical College before conducting this study.

Results

Two hundred and eight subjects were included in this study from ethnic communities of Tripura. Among them, 37% were male and 63% were female. The mean age (SD) of female and males were 48.35 (±15.22) and 46.82 (±15.39) years, respectively.

Overall, 29% were diabetic and 71% nondiabetic. It was observed that four diabetic subjects come under Type-I DM, whereas remaining was Type-II DM and 48% were hypertensive.

All study subjects were divided into two groups, persons having higher body visceral fat percentage (>10%) in one group and visceral fat within cut-off value (10%) in another group. The group having higher visceral fat had significantly higher mean values of body fat percentage, BMI, blood pressures, blood sugar levels, and almost all laboratory data than those in the low visceral fat group. The mean values of SBP (SD) and DBP (SD) among the group with high visceral fat percentage were 135.24 (±17) and 83.4 (±9.0), whereas in other group, 127.1 (±21.4) and 80 (±9.7), respectively. Out of all the participants, 171 subjects (82%) have normal range of body visceral fat, that is, below 10% (cut-off value of body visceral fat as per manual of the equipment), whereas 37 subjects (18%) have high body visceral fat percentage. Table 1 summarizes the clinical characteristics of all study subjects based on their body visceral fat percentage.

Among 37 subjects who are having high body visceral fat, 43% are diabetic and 57% are nondiabetic. Fisher's exact test shows positive association between diabetic status and body visceral fat among these indigenous study subjects (*P*-value = 0.048). But out of these 16 diabetic subjects, 50% population were suffering from both hypertension and dyslipidemia, whereas in case of nondiabetic subjects, only 38% were having hypertension and dyslipidemia.

Table 1: Distribution of participants based on body visceral fat percentage

Variables	Total (mean±SD)	V-fat <10%	V-fat ≥10%	*P*
n	208	171	37	-
Sex				**0.002**
M-Male	M-76 (37%)	M-58	M-18	
F-Female	F-132 (63%)	F-113	F-19	
Mean age in years	47.79±15.27	47.15±15.86	50.73±11.9	0.778
SBP (mmHg)	128.55±20.85	127.1±21.4	135.24±17	**0.004**
DBP (mmHg)	80.64±9.68	80±9.7	83.4±9.0	**0.001**
Cholesterol (mg/dl)	169.57±46.73	164.2±43.3	194.16±54.3	**<0.001**
LDL (mg/dl)	92.67±30.60	89.3±27.9	108.2±37.70	**<0.001**
Triglyceride (mg/dl)	167±90	154.65±76.67	224.58±121.20	**<0.001**
VLDL (mg/dl)	33.31±18.54	30.84±16.34	44.72±23.52	**<0.001**
HDL (mg/dl)	53.40±18.73	53.75±18.31	51.75±20.78	0.096
FBS (mg/dl)	111.70±48.28	109.9±48.74	119.97±45.83	0.198
HbA1c (%)	5.67±1.73	5.6±1.7	6.02±1.75	**0.012**

SBP=Systolic blood pressure, DBP=Diastolic blood pressure, V-fat=Visceral fat, LDL=Low density lipoprotein, VLDL=Very low density lipoprotein, HDL=High density lipoprotein, FBS=Fasting blood sugar, HbA1c=Glycated hemoglobin. Data are represented here as mean±SD (standard deviation)

It has been observed that 62.5% diabetic subjects having high body visceral fat were suffering from dyslipidemia, whereas 42.9% nondiabetic subjects with high body visceral fat percentage were having dyslipidemia.

BMI and body fat percentage were associated with body visceral fat percentage among the local indigenous communities. The mean value of BMI (SD) for the subjects having normal body visceral fat was 21.35 (±3.8), whereas the mean value of BMI (SD) for the subjects having high body visceral fat was 28.27 (±2.89) ($P < 0.001$). Similarly, BMI (SD) for the subjects having normal body visceral fat, the average body fat percentage was 25.31 (±7.34), whereas for the subjects having high body visceral fat the average body fat percentage was 32.4 (±6.88) (<0.001) [Table 2]. Significant association was found between hypertension and body visceral fat among indigenous tribal population of Tripura ($P < 0.007$) [Table 3]. Figure 1 (scatter plot diagram) showed a linear relationship between two variables, body visceral fat percentage, and BMI among the study subjects. Figure 2 showed distribution of body fat percentage among hypertensive and normotensive male and female participants.

Discussion

There are many socially deprived communities in India, out of which tribal communities are the most vulnerable ones. India has a number of tribal communities that constitute about 8.6% of the total population.[13] In India, a few studies are available on role of body fat percentage or body visceral fat percentage in noncommunicable diseases (NCDs) but from the state of Tripura, almost no significant study has been reported. A recent study from Tripura done by Shilpi *et al.* in 2019 suggested a clear evidence of ethnic variation in fat patterning where Chakma tribal girls showed a greater subcutaneous adiposity in comparison with Bengali girls.[14]

There are 427 different ethnic communities in India and out of which 127 reside in North East India.[15] A large percentage

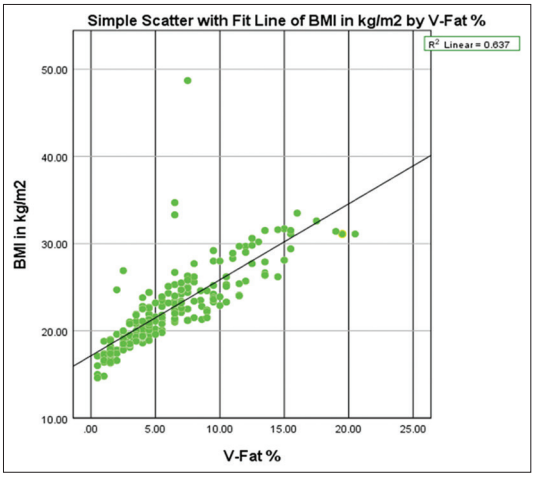

Figure 1: Correlation between body visceral fat with BMI among the participants

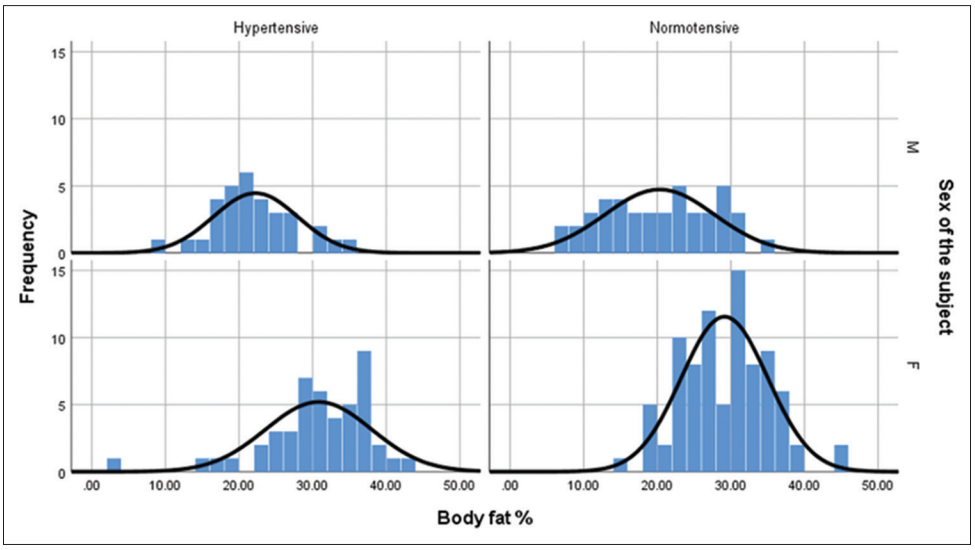

Figure 2: Body fat percentage among hypertensive and normotensive male and female participants

Table 2: Correlation of BMI and body fat percentage with V-fat

Name of the variables	Mean value	Normal body visceral fat percentage	High body visceral fat percentage	Pearson correlation with V-fat percentage (*r*)	*P*
BMI (kg/m²)	22.57±4.51	21.35±3.8	28.27±2.89	0.679	**<0.001**
Body fat (%)	26.57±7.73	25.31±7.34	32.4±6.88	0.297	**<0.001**

BMI=Body mass index, V-fat=Visceral fat

Table 3: Association between hypertension and body visceral fat percentage among participants

Body visceral fat percentage	Hypertensive	Normotensive	Total	χ^2	*P*
<10%	74 (43%)	97 (57%)	171	**7.197**	**0.007**
>10%	25 (68%)	12 (32.4%)	37		(*P*<0.05)
Total	99	109	208		

χ^2 test

of ethnic population of Tripura are also adversely affected by various social, economic, and traditional beliefs and customs that potentially expose them to high rates of malnutrition and other health-related problems.

In this study, the association between body visceral fat percentage and hypertension was observed (*P*-value = 0.007) irrespective of their diabetic status.

It was observed that among the study subjects having higher body visceral fat, around 67.57% were hypertensive and only 32.43% were normotensive, whereas in case of subjects having normal body visceral fat, 43.27% were hypertensive and 56.72% were normotensive. Wang *et al.*[16] reported that excess visceral body fat was strongly associated with higher risk of hypertension ($P < 0.0001$) which supports our present study. Cheah *et al.*[17] in Malaysia showed that there was a significant association ($P < 0.01$) between hypertension and body visceral fat which was also similar to our study. These studies showed that body visceral fat played an important role in the development of hypertension than body weight itself.

In this study, it was observed that SBP and DBP mean levels were higher in case of subjects having high body visceral fat percentage than the subjects with normal body visceral fat. In a recent study, a positive association was observed between reduction in body visceral fat and improvements in both SBP and DBP in males in a 12-week meal replacement intervention.[18] Fox *et al.* also observed that body visceral fat significantly correlated ($P < 0.001$) with SBP and DBP[19] among Americans. Their study also showed that both SAT (subcutaneous abdominal adipose tissue) and VAT (visceral adipose tissue) were positively associated with prevalence of hypertension, but only VAT provides significant information beyond BMI and waist circumference. From earlier studies, it has been observed that among Japanese Americans and whites, only VAT was associated with hypertension, even after adjustment for BMI and waist circumference[20,21] whereas among blacks, both SAT and VAT were associated with hypertension in men and women[22] which indicated the relative importance of visceral fat deposits among different ethnic groups. Similarly, Boyko *et al.*[23] also reported the association between body visceral fat and SBP or DBP which also in concordance with present study (*P*-value for SBP is 0.004 and *P* value for DBP is 0.001).

In present study, HbA1c level was significantly ($P = 0.012$) associated with body visceral fat percentage. It was found that there was association between diabetic status and body visceral fat among the study subjects. Anjana *et al.* found that visceral fat had a strong positive association with type 2 diabetes ($P = 0.005$) in a case-control study among Indians.[24] It was in concordance with present study.

In this study, it was also observed that body visceral fat percentage had significant positive correlation with cholesterol, TG, and LDL ($P < 0.001$). Fox *et al.*[19] reported that body visceral fat had significant positive correlation with the TG ($P < 0.0001$) among 3001 Americans, which was similar to present study. As per the study done by Shweta *et al.*, excessive body visceral fat is positively associated with blood pressure in Indian adolescents.[25] They also concluded that increased level of body visceral fat influences risk for development of cardiovascular diseases.

Katsuki *et al.* also[26] reported that visceral fat percentage was positively correlated with TG levels ($P < 0.01$) in nonobese type 2 diabetes Japanese subjects. As per another study done by Kobayashi *et al.*,[27] among Japanese nonobese men, body visceral fat had a significant positive correlation with TG ($P < 0.01$). The correlation coefficient between body visceral fat and HDL was (−0.277), which was not statistically significant. In this present study, the body fat percentage was positively related to TG and negatively related to HDL and was basically in concordance with these results. So, to the best of knowledge, this may be the first study for the indigenous population from this part of country where such kind of association between body visceral fat percentage and lipid profile has been observed.

Nowadays, noncommunicable diseases (NCDs) are a roaring problem and account for majority of death in the world. So, in future if body visceral fat estimation is incorporated in the facilities of primary health-care centers of underdeveloped states of India, especially north eastern states, it will definitely support the identification of vulnerable groups who are at increased risk for developing chronic diseases like CKD, diabetes, and so on in future. Even it may also provide an insight into health and level of awareness regarding the role of lifestyle in prevention of NCDs among the local population.

Conclusion

In conclusion, present study results confirmed that body visceral fat percentage was significantly associated with hypertension, dyslipidemia, and type 2 diabetes among indigenous ethnic population of Tripura, northeast India. So, body fat percentage analysis should be included in routine screening programs of all the district level or PHC level health centers across the country to avoid any kind of health complications in future.

Limitations

There were many methods for measuring body visceral fat and computed tomography is currently considered as the gold standard. However, the costs and radiation exposure may not justify its use as a screening tool. Being a cross-sectional study, it cannot be concluded any cause and effect relationship either between high body visceral fat percentage and dyslipidemia or between hypertension and high body visceral fat among diabetic and nondiabetic indigenous ethnic population.

Strength of the study

This study was based on ethnic subjects residing in different community level of this state, where simple random sampling technique was used for selecting the sample so that chance of any type of selection bias was avoided.

Acknowledgments

The authors are indebted and thankful to the Department of Health Research (DHR), Ministry of Health and Family Welfare, Govt. of India, New Delhi, for funding and also for all logistic supports through Multidisciplinary Research Unit of AGMC. Authors are also thankful to the two laboratory technicians and one laboratory assistant of multidisciplinary research unit, Agartala Government Medical College for their immense hard work for successful completion of this research work.

Financial support and sponsorship

Department of Health Research (DHR), Ministry of Health and Family Welfare, Govt. of India, New Delhi.

Conflicts of interest

There are no conflicts of interest.

References

1. Kern PA, di Gregorio GB, Lu T, Rassouli N, Ranganathan G. Adiponectin expression from human adipose tissue: Relation to obesity, insulin resistance, and tumor necrosis factor-α expression. Diabetes 2003;52:177985.
2. Lee B, Shao J. Adiponectin and energy homeostasis. Rev Endocr Metab Disord 2014;15:149-56.
3. Ohashi K, Ouchi N, Matsuzawa Y. Anti-inflammatory and anti-atherogenic properties of adiponectin. Biochimie 2012;94:2137-42.
4. Ohbuchi Y, Suzuki Y, Hatakeyama I, Nakao Y, Fujito A, Iwasaka T, *et al.* A lower serum level of middle-molecular-weight adiponectin is a risk factor for endometrial cancer. Int J Clin Oncol 2014;19:667.
5. Sironi MA, Gastaldelli A, Mari A, Ciociaro D, Postano V, Buzzigoli E, *et al.* Visceral Fat in Hypertension-Influence on Insulin Resistance and β-Cell Function. Hypertension 2004;44:127-33.
6. Despres JP. The insulin resistance-dyslipidemic syndrome of visceral obesity: Effect on patients' risk. Obes Res 1998;6:8S-17S.
7. Nishina M, Kikuchi T, Yamazaki H, Kameda K, Hiura M, Uchiyama M. Relationship among systolic blood pressure, serum insulin and leptin, and visceral fat accumulation in obese children. Hypertens Res 2003;26:281-8.
8. Faria AN, Ribeiro Filho FF, Gouveia Ferreira SR, Zanella MT. Impact of visceral fat on blood pressure and insulin sensitivity in hypertensive obese women. Obes Res 2002;10:1203-6.
9. Uchoi D, Roy D, Majumdar RK, Debbarma P. Diversified traditional cured food products of certain indigenous tribes of Tripura, India. Indian J Tradit Knowl 2005;14:440-6.
10. Makuyana D, Gomo Z, Munyombwe T, Matenga JA, Hakim JG. Metabolic syndrome disorders in urban black Zimbabweans

with type 2 Diabetes mellitus. Cent Afr J Med 2004;50:24-9.

11. Whelton PK, Carey RM, Aronow WS, Casey DE Jr, Collins KJ, Dennison Himmelfarb C, *et al.* ACC/AHA/AAPA/ABC/ACPM/AGS/APhA/ASH/ASPC/NMA/PCNA guideline for the prevention, detection, evaluation, and management of high blood pressure in adults: Executive summary: A report of the American College of Cardiology/American Heart Association task force on clinical practice guidelines. J Am Coll Cardiol 2017;71:2199-269.
12. WHO guidelines on drawing blood: Best practices in phlebotomy. ISBN 978 9241599221.
13. Census of India. The Registrar General and Census Commissioner of India, Government of India, India. 2011. Available from: http://www.censusindia.gov.in. [Last accessed on 2018 Aug 29].
14. Saha S, Sil SK. A comparative study on fat pattern between tribal and non-tribal girls of Tripura, North-East India. Indian J Paediatr 2019;86:508-14.
15. Deka S. Health and nutritional status of the Indian tribes of Tripura and effects on education. Inquiries J 2011;3:1-20.
16. Wang Z, Zeng X, Chen Z, Wang X, Zhang L, Zhu M, *et al.* Association of visceral and total body fat with hypertension and pre-hypertension in a middle-aged Chinese population. J Hypertens 2015;33:1555-62.
17. Cheah WL, Majorie Ensayan J, Helmy H, Chang CT. Hypertension and its association with anthropometric indices among students in a public university. Malays Fam Physician 2018;13:2-9.
18. Guo X, Xu Y, He H, Cai H, Zhang J, Li Y, *et al.* Visceral fat reduction is positively associated with blood pressure reduction in overweight or obese males but not females: An observational study. Nutr Metab 2019;16:44.
19. Fox CS, Massaro JM, Hoffman U, Pou KM, Maurovich-Horvat P, Liu CY, *et al.* Abdominal visceral and subcutaneous adipose tissue compartments: Association with metabolic syndrome risk factors in the Framingham heart study. Circulation 2007;116:39-48.
20. Hayashi T, Boyko EJ, Leonetti DL, McNeely MJ, Newell-Morris L, Kahn SE, *et al.* Visceral adiposity is an independent predictor of incident hypertension in Japanese Americans. Ann Intern Med 2004;140:992-1000.
21. Hayashi T, Boyko EJ, Leonetti DL, McNeely MJ, Newell-Morris L, Kahn SE, *et al.* Visceral adiposity and the prevalence of hypertension in Japanese Americans. Circulation 2003;108:1718-23.
22. Ding J, Visser M, Kritchevsky SB, Nevitt M, Newman A, Sutton-Tyrrell K, *et al.* The association of regional fat depots with hypertension in older persons of white and African American ethnicity. Am J Hypertens 2004;17:971-6.
23. Boyko EJ, Fujimoto WY, Leonetti DL, Newell-Morris L. Visceral adiposity and risk of type 2 diabetes: A prospective study among Japanese-Americans. Diabetes Care 2000;23:465-71.
24. Shweta P, Hasmukh S, Singh SK. Relationship between visceral fat and blood pressure in Indian adolescents. Natl J Integr Res Med 2017;8:57-61.
25. Anjana M, Sandeep S, Deepa R, Vimaleswaran KS, Farooq S, Mohan V. Visceral and central abdominal fat and anthropometry in relation to diabetes in Asian Indians. Diabetes Care 2004;27:2948-53.
26. Katsuki A, Sumida Y, Urakawa H, Gabazza EC, Murashima S, Maruyama N, *et al.* Increased visceral fat and serum levels of triglyceride are associated with insulin resistance in Japanese metabolically obese, normal weight subjects with normal glucose tolerance. Diabetes Care 2003;26:2341-4.
27. Kobayashi H, Nakamura T, Miyaoka K, Nishida M, Funahashi T, Yamashita S, *et al.* Visceral fat accumulation contributes to insulin resistance, small-sized low-density lipoprotein, and progression of coronary artery disease in middle aged non-obese Japanese men. Jpn Circ J 2001;65:193-9.