ajfand SCHOLARLY, PEER REVIEWED
AFRICAN JOURNAL OF FOOD, AGRICULTURE, NUTRITION AND DEVELOPMENT
Volume 21 No. 1
January 2021
PUBLISHED BY AFRICAN SCHOLARLY SCIENCE COMMUNICATIONS TRUST
ISSN 1684 5374

Afr. J. Food Agric. Nutr. Dev. 2021; 21(1): 17365-17378 https://doi.org/10.18697/ajfand.96.19915

ASSOCIATIONS OF BLOOD GLUCOSE LEVELS WITH SOME DIABETES RISK FACTORS (BODY MASS INDEX, BLOOD PRESSURE AND TOTAL BODY FAT) IN INHABITANTS OF HO MUNICIPALITY, GHANA: A CROSS-SECTIONAL SURVEY

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ABSTRACT

One complex metabolic disorder that can unenviably affect the normal human physiology is diabetes mellitus (DM). It is indeed one of the commonest non-communicable diseases that has heightened to an epidemic level worldwide. For diseases like DM, hypertension, cardiovascular disease, type II DM, and other chronic diseases, body mass index (BMI) is identified as a positive and independent risk factor associated with morbidity and mortality. The objective of the study was to determine the relationships between BMI, blood pressure, and total body fat among inhabitants of peri-urban Ho, Ghana. A cross-sectional survey was carried out between May and June, 2018, among 132 inhabitants of Ho to determine the prevalence and associations among DM risk factors. The participants were selected by systematic random sampling. Standardized international protocols were used to measure BMI, blood pressure, blood glucose, and total body fat. Out of 132 respondents, majority 96 (72.7%) were female and the most common age group was 54-60 (31.1%). From the BMI classifications, 65 (49.2%) people were of normal weight while 6 (4.5%) were underweight. Total body fat (%) and blood pressure, likewise total body fat and BMI recorded significant associations of values (0.299, $p<0.001$-systolic; 0.298, $p=0.001$-diastolic), and 0.585 ($p<0.001$), respectively. On the contrary, there were insignificant associations found between blood glucose and diastolic blood pressure and also blood glucose and systolic blood pressure (0.100, $p=0.253$) and (0.057. $p=0.514$), respectively using the Spearman's correlation analysis. Lastly, the test of association of socio-demographics and anthropometrics revealed there was a significant ($p<0.001$) correlation between total body fat and BMI using Pearson's correlation analysis. BMI is closely related to total body fat and blood pressure; hence, education on lifestyle modification needs to be intensified to create awareness among the inhabitants of Ho municipality of Ghana. It is imperative to educate Ghanaians and beyond about the risk factor associations that predispose an individual to DM.

Key words: Diabetes mellitus, risk factors, associations, BMI, blood glucose, blood pressure

https://doi.org/10.18697/ajfand.96.19915

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INTRODUCTION

An unparalleled increase in non-communicable diseases (NCDs) is experienced worldwide as this is driven by urbanization, the globalization of markets, and increasing longevity. The World Health Organization (WHO) [1] indicated that four diseases, diabetes mellitus (DM), cardiovascular disease, cancer, and chronic respiratory disease are responsible for over 80% of NCD deaths of which more than 40% occur in people under 70 years of age. Diabetes Mellitus (DM), a leading NCD in Africa, contributes to the increasing disease burden among adults. Data available from WHO [2] revealed that as of the year 2019, approximately 463 million people had DM. This figure has been projected to escalate to 851,000 people by the year 2030. In sub-Saharan Africa, 21.5 million people live with diabetes, leading to approximately half a million diabetes-related deaths in 2013 [3].

Various researchers across the globe have identified several risk factors for DM. These risk factors fall under the four broad groups of risk factors for NCDs. A good number of these risk factors border on lifestyle and dietary patterns [4-6]. Another way of considering DM risk is from a preventive, treatment, or interventional point of view, which looks at the various risk factors as modifiable or non-modifiable [7]. Modifiable risk factors such as obesity, excessive use of alcohol, physical inactivity, and dietary factors can be altered in the prevention of the disease. Non-modifiable risk factors like age, ethnicity, and family history may serve to alert an individual of his or her baseline risk of contracting the disease. The risk of an individual developing DM is dependent on the total presence and combination of exposure to both modifiable and non-modifiable risk factors [7].

Cross-country studies have revealed differences in social and behavioral factors of subjective wellbeing and disability among diabetic patients, as well as in the role gender plays in the wellbeing of these patients [8, 9]. In this regard, country-specific studies have found an association between DM and socio-economic factors such as education, employment status, wealth, and social class [10-12]. Diabetes Mellitus (DM) has also been associated with individual behavioral characteristics such as physical inactivity, poor dietary intake, inadequate intake of fruits and vegetables, tobacco use, and alcohol consumption [13].

The International Diabetes Federation (IDF) stimulates global public health interest by publishing best estimates of the total numbers of people in the world, who are either undiagnosed (example pre-diabetic) or diagnosed with DM. The American Diabetes Association (ADA) and the IDF both advocate self-management to be a core component of diabetes care [14]. Also, adequate knowledge of diabetes is a key component of diabetic care.

Many studies have shown that increasing patient knowledge regarding a disease and its complications has significant benefits on patient compliance to treatment and decreasing complications associated with the disease [15]. Although some researchers [16-18] have reported findings of the knowledge and management of DM, its prevalence keeps rising in Ghana [19, 20]. This study aimed to determine the distribution and correlations of

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blood glucose levels with some risk factors of DM among the inhabitants of Ho municipality, Ghana.

MATERIALS AND METHODS

Sample Size Determination

For three months of data collection, the total expected study population was 240. A minimum acceptable sample size of 130 at 95% confidence level, 5% allowable error, and a response distribution of 50% were calculated. The Raosoft *online* sample size calculator was employed.

Anthropometric measurements

The weights of subjects were taken in minimum clothing with the Body Composition Monitor and Scale (HBF-516 IL, USA). The same instrument was used in estimating visceral fat. Standard protocols were followed in taking their heights to the nearest 0.1 cm using the Seca Stadiometer (Hamburg, Germany). Height and weight measurements were used in computing the Body Mass Index (BMI) of the participants. The following categorization was used in classifying them: underweight (<18.5 kg/m^2), normal (18.5–24.9 kg/m^2), overweight (25.0–29.9 kg/m^2), and obese (≥30.0 kg/m^2) [21].

Blood Pressure (BP)

Subjects were made to sit in a relaxed and comfortable position before taking blood pressure measurements. The measurements were taken using a digital BP machine (OMRON CEO 197, Kyoto, Japan.). All measurements were taken on the right arm. Blood pressure levels (in mmHg) were categorized as prescribed by Bimenya *et al*. [22] as follows: *systolic* (≤120, acceptable; >120, unacceptable) and *diastolic* (≤80, acceptable; >80, unacceptable).

Total body fat

The lipid profile was assessed by drawing 3 mL of venipuncture blood from subjects into gel separator tubes. Blood samples were centrifuged at 3,000 rpm for 10 minutes and serum samples used for the analysis.

Blood Glucose

126 mg/dL of blood was taken from participants. This was done by measurements using a glucometer (Omron, US). Categorizations into diabetics and intermediate hyperglycemic were made according to WHO [22].

Inclusion criteria

All persons with normal blood glucose levels: 14-17 g/dL for men and 12.3-15 g/dL for women.

Ethical Clearance

Approval was obtained from the Research and Ethics Committee of the University of Health and Allied Sciences, Ho, Ghana. Informed consent of the participants in the study was obtained and respondents were assured of the confidentiality of the information supplied. Participants' pain during blood withdrawal was managed by engaging an

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experienced phlebotomist who identified the vein before jabbing and also by priming them to be enduring before vein jabbing. Participants were not compensated.

Statistical Analysis
Data obtained were analyzed using International Business Machines Statistical Package for the Social Scientist (IBM SPSS Inc., USA) version 23. Data were summarized using descriptive statistics (frequencies and percentages). Also, inferential statistics were conducted to explore relationships between variables. A statistical test with *p-value* ≤ *0.05* was considered significant. Before conducting inferential statistics, the dataset was assessed for normality subjectively using histograms and stem and leaf, and objectively using the Kolmogorov-Smirnov tests. The results of normality testing indicated that the data were not normally distributed, while Kolmogorov-Smirnov tests indicated statistically significant p values ($p \leq 0.05$). Hence, the non-parametric Spearman's Rank Order Correlation (rho) was conducted to explore relationships between the anthropometric indices.

RESULTS AND DISCUSSION

Demographics
The socio-demographic results of the survey conducted are presented below (Table 1). Out of a total of 132 participants, the majority 96 (72.7%) were female. The age group of 54-60 years with 41 (31.1%) constituted most of the participants. Most participants were married 54(41.2%) while only 1 (8%) person cohabited with the partner. Monogamy was dominant 117 (89.3%) and the family size in the range of 4-7 (55%) constituted the majority. The level of education for most of the participants was Junior High School (JHS) and Senior High School (SHS) levels with 49 (37.1%) and 50 (37.9%), respectively.

Body Mass Index values of the respondents were ranked according to the WHO. Majority 65 (49.2%) of the respondents had normal weight, while 6 (4.5%) of the respondents were underweight. However, overweight and obese respondents were also common with recorded values of 28 (21.2%) and 32 (24.2%), respectively.

Blood pressure of the majority of the respondents was acceptable (diastolic- 96 (72.7%); systolic 84 (63.6%). Only a few of them had unacceptable (diastolic-36 (27.3%); systolic-48 (36.4%) blood pressure readings.

Blood glucose levels were categorized into: not normal, normal, and diabetic. A greater proportion (47%) of the respondents had their blood glucose levels in the normal range, while less than 10% were within the diabetic category. The prevalence of diabetes in the study population was 12%. A significant ($p<0.05$) majority (49.2%) of the respondents had their total body fat (%) being >36%, while the rest were equitably distributed (Table 2).

Associations of some anthropometric indices of respondents
Table 3 shows results obtained from the different associations of some anthropometric indices of respondents. There was a significant association between the BMI and the

https://doi.org/10.18697/ajfand.96.19915

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diastolic BP of the respondents (0.353, p<0.001). There was also a significant association between total body fat and the diastolic BP of the respondents (0.298, p=0.001). Similarly, respondents, BMI was strongly associated with their systolic BP (0.398, p<0.001). Also, a strong relationship was established between total body fat and systolic BP (0.299, p<0.001). Lastly, a significant (p<0.001) association (0.746) between systolic BP and diastolic BP was observed.

Contrary to these observations, there was neither an association between the blood glucose and the diastolic BP nor systolic BP of the respondents with values of 0.100 (p=0.253) and 0.057 (p=0.514), respectively. Results of association between blood glucose and BMI were not significant (p=0.954, -0.005). Lastly, there was no significant association between total body fat and blood glucose (0.130, p=0.137).

Results obtained from the tests of relationships between socio-demographics and the anthropometrics of the respondents can be found in Table 4. Out of the many parameters tested with the Pearson's correlation test, only total body fat (%) and BMI (kg/m^2) had a significant (0.585, p<0.001) association. There were no statistically significant (p>0.05) associations found among the anthropometric indices and demographic indicators.

The results of this survey showed good associations between total body fat and systolic BP, which corroborates results reported by several researchers [23-25]. Body Mass Index (BMI) was also found to be a major contributor to high blood pressure in our study. Generally, overweight and obese young adults (adolescents) have more body fat and higher BP than adults with normal weight [26]. Flynn and Faulkner [27], showed a strong relationship between BMI and BP, which is well established for both systolic and diastolic BP. This relationship was also observed in our population, with a stronger effect of BMI on systolic BP.

The high and ever-increasing prevalence of overweight, as well as obesity and hypertension, is a huge health challenge. The adverse consequences of these abnormalities can potentially affect public health and can be considered as risk factors for systemic disorders. Obesity is a major cause of metabolic syndrome, which leads to the development of hypertension and diabetes. Hypertension tends to develop more often in patients with diabetes [28-31] and can lead to severe complications including diabetic retinopathy, cardiovascular disorders, and kidney disease [29, 32]. Tesfaye *et al.* [33] suggested that generally, associations between BMI and risk of hypertension seem to hold in multiethnic populations, although the extent may vary.

Results from the current study showed a strong association of total body fat and BP. This agreed with the previous finding by Wang *et al.* [34], who also found strong associations of total body fat and blood pressure in middle-aged Chinese populations. Recently, Chen *et al.* [35] and Chandra *et al.* [36] reported increasing evidence that visceral adiposity is a pathological depot that accumulates when subcutaneous depots are overwhelmed or unavailable for storage. Visceral fat is characterized by being more sensitive to lipolysis and by its ability to secrete higher amounts of inflammatory cytokines [37]. Although these are unwanted and likely contributory effects, the exact mechanism underlying the association of visceral fat and hypertension remains unknown. Increased adipose tissue may release a variety of adipokines that are related to a decrease in the production and use of nitric oxide, which has important functions in the control of vascular tone and suppression of vascular smooth muscle cell proliferation. A decrease in the effect of nitric oxide has been associated with endothelial dysfunction and arterial hypertension [38]. The BMI, which reflects body fat mass was shown to be an independent risk factor for hypertension, an observation that is consistent with previous studies [39, 40]. Keaney *et al.* [41] and Narayan *et al.* [42] stressed that the chronic nature and long-term economic burden make diabetes and hypertension archetypal public health problems. The results obtained in this work support evidence from other studies [43, 44] that lifestyle factors including physical activity in particular probably play a large part by affecting BP and also body composition. Vasodilation is achieved by regular exercise, which increases and preserves muscle mass, and also lowers blood pressure through a number mechanisms including activation of the β-adrenergic system. Ghanaians must be educated to exercise regularly to minimize the risk of contracting type 2 diabetes [45].

CONCLUSION

These results showed significant associations between BMI and BP (diastolic and systolic) and then total body fat and BP (especially systolic). The risk of hypertension is higher among population groups with overweight and obesity.

Knowledge of the interactions of these indices is imperative since education can have a significant impact on an individual's life by becoming well informed to undertake regular exercises, good nutrition, not engaging in too many stressful activities and several others. Studies have shown that individuals, especially adolescents, who develop hypertension may be considered high-risk for concurrent target hypertensive organ damage and future cardiovascular diseases risk based on several factors, including major indices such as BP and BMI magnitudes as well as the minor indices such as age, family history, and ethnicity. Lifestyle modification and pharmacotherapies have been demonstrated to be successful in preventing hypertension and reducing already elevated BP in humans if well informed on these risk factors.

Competing Interests

Authors declare no competing interests

Authors' Contributions

NKK, PTA, EKE, SKA, and PTA performed the experiments and wrote the manuscript. NKK, DA, SKA, and CY were responsible for data collection and analysis. PTA, NKK, EKO, AK-D, and CT helped conceive the experiments and prepared the manuscript. NKK, HWA, EKE, and PTA conceived the original study. CY, AK-D, PTA, and NKK led the sampling and study in Ghana. All authors read and approved the final manuscript.

ACKNOWLEDGEMENTS

Authors are grateful to the Nutrition and Dietetics Department, University of Health and Allied Sciences, Ho-Ghana for providing the equipment used in this experiment and also to all respondents who participated in the study. Our heartfelt thanks go to the families of the researchers for their undying support.

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Table 1: Socio-demographic data of the respondents

Characteristics		Frequency	Percent (%)
Gender	Male	36	27.3
	Female	96	72.7
Age	<18	1	8.0
	19-25	11	8.3
	26-32	8	6.1
	33-39	18	13.6
	40-46	29	22.0
	47-53	24	18.2
	54-60	41	31.1
Marital Status	Married	54	41.2
	Single	48	36.6
	Cohabitation	1	8.0
	Separated	17	13.0
	Widowed	11	8.4
Family Setting	Polygamy	13	9.9
	Monogamy	117	89.3
	Others	1	8.0
Household Size	2-3	36	27.3
	4-7	55	41.7
	8-10	20	15.2
	>10	21	15.9
Educational level	No Formal Education	12	9.1
	JHS	49	37.1
	SHS	50	37.9
	Tertiary	21	23.2

https://doi.org/10.18697/ajfand.96.19915

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Table 2: Anthropometric data of the respondents

Characteristics		Frequency	Percent (%)	P-value
BMI (Kg/m^2)	n=131			
Underweight	<18.5	6	4.6	<0.001
Normal	18.5-24.9	65	49.6	
Overweight	25-29.9	28	21.4	
Obese	>30	32	24.4	
Systolic blood pressure (BP)				
Acceptable	<120	84	63.6	<0.001
Unacceptable	>120	48	36.4	
Diastolic BP				
Acceptable	<80	96	72.7	<0.001
Unacceptable	>80	36	27.3	
Blood Glucose				
Not normal	<3	29	22.0	0.004
(IGT)	4-6	30	22.7	
Normal	7-9	37	28.0	
Diabetic	10-12	26	19.7	
	>12	10	7.6	
Total Body Fat (%)	<10	9	6.8	
	11-15	14	10.6	<0.001
	16-20	7	5.3	
	21-25	11	8.3	
	26-30	7	5.3	
	31-35	19	14.4	
	>36	65	49.2	

The proportion of participants with underweight, normal weight, overweight and obese were significantly different (p<0.001). The participants with unacceptable blood pressure were significantly lower than those with acceptable levels for both diastolic and systolic blood pressures (p<0.001). Also, the proportions of participants for the various levels of blood glucose and total body fat (%) were significantly different (p<0.01). BMI = Body mass index

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Table 3: Associations of anthropometric measurements using the Spearman's rho correlation analysis

	Body Mass Index (BMI)	Systolic Blood Pressure	Diastolic Blood Pressure	Total Body Fat(%)	Blood Glucose
1. BMI	1.00				
2. Systolic Blood Pressure	0.398**	1.00			
3. Diastolic Blood Pressure	0.353**	0.746**	1.00		
4. Total Body Fat (%)	0.585**	0.299**	0.298*	1.00	
5. Blood Glucose	-0.005	0.057	0.100	0.130	1.00

** Correlation is significant at the 0.01 level (2-tailed)

*Correlation is significant at the 0.05 level (2-tailed)

Table 4: Relationships of some socio-demographic and anthropometric indices using Bivariate Spearman's rho correlation analysis

	Body mass index (BMI)	Educational level	Total body Fat (%)	Blood Glucose	Age
BMI	1				
Educational level	0.040	1			
Total body fat (%)	0.585**	-0.018	1		
Blood Glucose	-0.005	-0.141	0.130	1	
Age	0. 019	-0.026	-0.072	0.009	1

** Correlation is significant at the 0.01 level (2- tailed)

REFERENCES

1. **World Health Organization**. *Global status report on non-communicable diseases*. Geneva: World Health Organization, 2014.

2. **Gatimu SM, Benson Milimo W and SM Sebastian** Prevalence and determinants of diabetes among older adults in Ghana. *BMC Public Health* 2016; **16**:1174, 1-12. https://doi.org/10.1186/s12889-016-3845-8

3. **IDF: IDF Diabetes Atlas**. 6 ed. Brussels, Belgium: International Diabetes Federation; International Diabetes Federation. Global guidelines for type 2 diabetes. Diabetes Research and Clinical Practice. 2013. https://www.idf.org/our-activities/advocacy-awareness/resources-and-tools/79:global-guideline-for-type-2-diabetes.html *Accessed 24 January 2019*.

4. **OnKin JB, Longo-Mbenza B, Okwe N, Kabangu NK and SD Mpandamadi** Prevalence and risk factors of diabetes mellitus in Kinshasa Hinterland. *Int J Diabetes Metab*. 2008; **16**:97–106.

5. **Danquah I, Bedu-Addo G, Terpe K-J, Micah F, Amoako YA, Awuku YA, Dietz E, van der Giet M, Spranger J and FP Mockenhaupt** Diabetes mellitus type 2 in urban Ghana: characteristics and associated factors. *BMC Public Health*, 2012; **12(1)**:210.

6. **Murray AE, McMorrow AM, O'Connor E, Kiely C, Ananey OM and D O'Shea** Dietary quality in a sample of adults with type 2 diabetes mellitus in Ireland; a cross-sectional case control study. *Nutr J.* 2013;**12(1)**:110.

7. **Paulweber B, Valensi P, Lindström J, Lalic N, Greaves C and M McKee** European evidence-based guideline for the prevention of type 2 diabetes. *Horm Metab Res*. 2010;**42(S 01):** S3–36.

8. **Assari S** Cross-country variation in additive effects of socio-economics, health behaviors, and comorbidities on subjective health of patients with diabetes. *J Diabetes Metab Disord*. 2014; **13**:36.

9. **Assari S, Lankarani RM and MM Lankarani** Cross-country differences in the association between diabetes and disability. *J Diabetes Metab Disord*. 2014; **13**:3.

10. **Abubakari AR and RS Bhopal** Systematic review on the prevalence of diabetes, overweight/obesity and physical inactivity in Ghanaians and Nigerians. *Public Health*. 2008; **122(2)**:173–82.

11. **Mensah GA** Descriptive epidemiology of cardiovascular risk factors and diabetes in sub-Saharan Africa. *Prog Cardiovasc Dis*. 2013;**56(3)**:240–50.

12. **Werfalli M, Engel ME, Musekiwa A, Kengne AP and NS Levitt** The prevalence of type 2 diabetes among older people in Africa: a systematic review. *Lancet Diabetes Endocrinol.* 2016;**4(1)**:72–84.

13. **Motala AA, Esterhuizen T, Gouws E, Pirie FJ and MA Omar** Diabetes and other disorders of glycemia in a rural South African community: prevalence and associated risk factors. *Diabetes Care*. 2008;**31(9)**:1783–1788.

14. **International Diabetes Federation (IDF).** Global Guidelines Development. Global guideline for type 2 diabetes. *Diabetes research and clinical practice*. 2014; **104(1)**:1.

15. **Murugesan N, Snehalatha C, Shobhana R, Roglic G and A Ramachandran** Awareness about diabetes and its complications in the general and diabetic population in a city in southern India. *Diabetes Res Clin Pract.* 2007;**77(3)**: 433–37.

16. **Aikins A-G** Healer shopping in Africa: new evidence from rural-urban qualitative study of Ghanaian diabetes experiences. *BMJ.* 2005; **331(7519)**: 737.

17. **Hall V, Thomsen RW, Henriksen O and N Lohse** Diabetes in Sub Saharan Africa 1999–2011: epidemiology and public health implications. A systematic review. *BMC Public Health.* 2011; 11**scddfddd**: 564.

18. **Desalu O, Salawu F, Jimoh A, Adekoya A, Busari O and A Olokoba** Diabetic foot care: self-reported knowledge and practice among patients attending three tertiary hospital in Nigeria. *Ghana Med J.* 2011; **45(2)**:60–5.

19. **Doherty ML, Owusu-Dabo E, Kantanka OS, Brawer RO and JD Plumb** Type 2 diabetes in a rapidly urbanizing region of Ghana, West Africa: a qualitative study of dietary preferences, knowledge and practices. *BMC Public Health*. 2014; **14(1)**:1.

20. **Obirikorang Y, Obirikorang C, Anto EO, Acheampong E, Batu EN, Agyemang Duah S, Omerige C and PK Brenya** Knowledge of complications of diabetes mellitus among patients visiting the diabetes clinic at Sampa Government Hospital, Ghana: a descriptive study. *BMC Public Health* 2016; **16**:637, 1-8. https://doi.org/10.1186/s12889-016-3311-7

21. **WHO**. Physical Status; The use and interpretation of anthropometry http://whqlibdoc.who.int/trs/WHO_TRS_854.pdf. 1995 *Accessed on 20/6/19*.

22. **Bimenya GS, Byarugaba W, Kalungi S, Mayito J, Mugabe K, Makabayi R and M Muhame** Blood pressure profiles among Makerere University undergraduate students. *African Health Sciences*, 2005; **5(2)**: 99–106.

23. **World Health Organization**. Mortality country fact sheet 2006. Available from: http://www.who.int/whosis/mort/profiles/mort_searo_tha_thailand.pdf *Accessed July 22, 2009*.

24. **Wang, Z, Zeng X, Chen, Z, Wang, X, Zhang, L, Zhu M and D Yi** Association of visceral and total body fat with hypertension and prehypertension in a middle-aged Chinese population. *J. Hypertens*. 2015; **33(8)**:1555-1562. https://doi.org/10.1097/HJH.0000000000000602

25. **SunyueY, Zhu C, Wei C, Yang M, Zheng W, Gan D and S Zhu** Associations of body composition with blood pressure and hypertension. *Obesity* 2018; **26**: 1644-1650. https://doi.org/10.1002/oby.22291

26. **Han, TS, Al-Gindan YY, Govan L, Hankey CR and MEJ Lean** Associations of body fat and skeletal muscle with hypertension. *J. Clinical Hypertension* 2019; **21**: 230-238.

27. **Kelly RK, Magnussen CG, Sabin MA, Cheung M and M Juonala** Development of hypertension in overweight adolescents: a review. *Adolescent Health, Medicine and Therapeutics* 2015; **6**: 171–187. https://doi.org/10.2147/AHMT.S55837

28. **Flynn JT and BE Falkner** Obesity hypertension in adolescents: epidemiology, evaluation, and management. *J Clin Hypertens* (Greenwich). 2011; **13(5)**:323–331.

29. **American Diabetes Association**. Treatment of hypertension in adults with diabetes. *Diabetes Care* 2002; **25**:571–573.

30. **Lago RM, Singh PP and RW Nesto** Diabetes and hypertension. *Nat Clin Pract Endocrinol Metab* 2007; **3**: 667–667.

31. **Channanath AM, Farran B and K Behbehani** State of diabetes, hypertension, and comorbidity in Kuwait. *Diabetes Care* 2013; **36**:75.

32. **Adler AI, Stratton IM, Neil HA, Yudkin JS, Mathews DR, Cull CA, Wright AD, Turner RC and RR Holman** Association of systolic blood pressure with macrovascular and microvascular complications of type 2 diabetes (UKPDS 36): prospective observational study. *BMJ* 2000; **321**: 412–19.

33. **Tesfaye F, Nawi NG, Van Minh H, Bypass P, Berhane Y, Bonita R and S Wall** Association between body mass index and blood pressure across three countries in Africa and Asia. *J Human Hypertens* 2007; **21**:28–37.

34. **Wang, Z, Zeng X, Chen, Z, Wang, X, Zhang, L, Zhu M and D Yi** Association of visceral and total body fat with hypertension and prehypertension in a middle-aged Chinese population. *J. Hypertens*. 2015; **33(8)**:1555-62. https://doi.org/10.1097/HJH.0000000000000602

35. **Chen Y, Liang X, Zheng S, Wang Y and W Lu** Association of Body Fat Mass and Fat Distribution With the Incidence of Hypertension in a Population- Based Chinese Cohort: A 22- Year Follow- Up. *Journal of the American Heart Association* 2018; **7(6)**: 1-9. https://doi.org/10.1161/JAHA.117.007153

36. **Chandra A, Neeland IJ, Berry JD, Ayers CR, Rohatgi A, Das SR, Khera A, McGuire DK, de Lemos JA and AT Turer** The relationship of body mass and fat distribution with incident hypertension: observations from the Dallas Heart Study. *J Am Coll Cardiol*. 2014; **64**:997–1002.

37. **Fain JN, Madan AK, Hiler ML, Cheema P and SW Bahouth** Comparison of the release of adipokines by adipose tissue, adipose tissue matrix, and adipocytes from visceral and subcutaneous abdominal adipose tissues of obese humans. *Endocrinology*. 2004; **145**:2273–2282.

38. **Kotsis V, Stabouli S, Papakatsika S, Rizos Z and G Parati** Mechanisms of obesity-induced hypertension. *Hypertens Res*. 2010; **33**:386–393.

39. **Gus M, Fuchs SC, Moreira LB, Moraes RS, Wiehe M, Silva AF, Albers F and FD Fuchs** Association between different measurements of obesity and the incidence of hypertension. *Am J Hypertens*. 2004; **17**:50–53.38.

40. **Grosso M** Association between anthropometric markers of body adiposity and hypertension in an adult population of Cuiaba. *Rev Bras Epidemiol*.2009; **12**:237–247.

41. **Kearney PM, Whelton M and K Reynolds** Global burden of hypertension: analysis of worldwide data. *Lancet* 2005; **365**:217–23.

42. **Narayan KMV, Williams D, Gregg EW and CC Cowie** Diabetes public health. From data to policy. USA: Oxford University Press, 2010.

43. **Han TS, Bijnen FC, Lean ME and SC Seidell** Separate associations of waist and hip circumference with lifestyle factors. *Int J Epidemiol*. 1998; **27**:422-430.

44. **Newby PK, Muller D, Hallfrisch J, Qiao N, Andres R and KL Tucker** Dietary patterns and changes in body mass index and waist circumference in adults. *Am J Clin Nutr*. 2003; **77**:1417- 1425.

45. **Dankwa S** Prevalence of diabetes mellitus and resources available for its management in the Cape Coast metropolis. *ISABB Journal of Health and Environmental Sciences* 2011; **1(1)**: 1-7.