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Research Article

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Relationship Between Anthropometric Variables Among Hypertensive and Type 2 Diabetes Patients Attending a Nigerian Tertiary Hospital

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Abstract

Background

A myriad of discrepancies abounds as to which anthropometric measures have the best marker for assessing obesity a major risk factor for hypertension and Type 2 diabetes. This study sought to determine the strength of the relationship between the following obesity risk factors, including, Waist circumference, body mass index, and Waist Hip Ratio. Their predictive ability of obesity in these subjects were also determined.

Methods

A total of two hundred and one (201) male and female hypertensive (n=122) and type 2 diabetes (n=79) subjects participated in this study. Blood pressure, anthropometric measurements, blood glucose were obtained from each subject. Data were analyzed using, descriptive statistics, Spearman's, and Pearson's correlation.

Results

The mean age, weight, and height of the subjects were 53.02±12.02 years, 72.91±15.68kg, and 1.66±0.08m, respectively. In the hypertensive subject Waist Hip Ratio indicated that 71.35% were obese, Waist Circumference indicated 39.3% and Body mass Index indicated 25.4% obesity. For the subject with type 2 diabetes, Waist Hip Ratio indicated 75.9% obesity, Waist Circumference (40.5%), and Body Mass Index (22.8%). A strong positive relationship (r=0.85) was found between Waist Circumference and Body Mass Index in the hypertensive subject and a strong positive relationship (r=0.72) between WHR and BMI in the subjects with type 2 diabetes.

Conclusion

Overall, the study affirms that the Waist Hip Ratio is a better anthropometric measure for assessing obesity and that it predicts obesity in hypertensive and type 2 diabetes subjects better than other measures.

Keywords: Obesity, Waist Hip Ratio, Body Mass Index, Waist Circumference, Hypertension, Type 2 Diabetes.

Introduction

The cardio-metabolic disorder including hypertension and diabetes are among the leading occurring non-communicable diseases and the foremost cause of death in low-income and middle-income countries of which Nigeria falls [1]. There is a global consensus that among three adults, one is likely to be hypertensive, a condition that causes half the rate of mortality that is accrued from heart diseases and stroke, and that one in ten adults has diabetes [2]. Statistics collected from 194 countries revealed that half of the adult populations in some African countries are hypertensive and about ten percent have diabetes [2]. Hypertension as defined by the National Clinical Guideline Centre [3], "is a condition of raised blood pressure of 140/90 mmHg which can be accompanied by a high systemic arterial blood pressure". On the other hand, "a varied group of syndromes categorized by a disorder of protein, fat and carbohydrate metabolism is labeled diabetes" [4].

Varied distinct types of diabetes exist with Type 1 Diabetes Mellitus (T1D) caused by the body's self-destruction of the beta cells, which leads to insulin deficiency, and Type 2 Diabetes (T2D), a disorder associated with an increased level of glucose, resistance to insulin and dysfunction in the secretion of insulin around the body [4, 5]. In the Nigerian adult population, the prevalence of diabetes mellitus is about 3.9% [6]. With T2D accounting for about 90%, and TID and gestational diabetes account for the remaining 10% of diabetes [7]. The foremost risk factors for the development of hypertension and T2D include but are not exclusive to ethnicity, sex, obesity, a lifestyle of inactivity, smoking, and family social history [4].

Available studies conducted overseas have proven that to predict the risk factor for diabetes and hypertension, anthropometric measures like Waist Height Ratio (WHtR), body mass index (BMI), Waist Hip Ratio (WHR), and Waist Circumference (WC), can be employed [4, 8].

In clinical practice, BMI is the most frequently utilized predictor for the status of weight [9] and combined with WC, they can also be utilized to predict cardiometabolic risk factors [10]. However, BMI and WC have some flaws, because as regards the distribution of body fat within an individual, they cannot provide information for ethnicity and cultural variation in height, the shape of the body, and lean body mass [10]. Other measures such as WHR and WHtR have shown greater capacity than the afore-mentioned indicators of obesity in determining these challenges by considering the variation within individuals and the deposit of central fat [11]. However, there still exist a controversy and unclear findings as regards which of this measure is endowed with the best marker for predicting body fat distribution and cardiometabolic risk factor [12, 8].

Available studies carried out in countries overseas (China, Nepal), believe that anthropometric measures have varied abilities to predict hypertension and T2D [13-23]. The predictive ability of anthropometric measures and their appropriate cut-off points in the Sahel region of Nigerian is lacking in the literature. There appears to be a gap of knowledge on the relationship between these obesity indicators and also the degree to which these indicators predict the risk factors of cardiovascular disease and T2D is not very clear. This study was therefore carried out to determine the relationship between various risk factors of obesity such as WC, WHR, and BMI among hypertensive and T2D patients attending UMTH.

Subject, Material, and Methods

Subjects

This cross-sectional survey design study conveniently sampled a total of 201 male and female hypertensive and T2D subjects attending the University of Maiduguri Teaching Hospital (UMTH), who were present and show a willingness to participate. To be recruited, subjects must be adults (male or female) of age 20- 90 years, with a diagnosis of hypertension or T2D, and must be receiving treatment in UMTH. Hypertensive or T2D subjects with other comorbidities, pregnant women, and children were excluded from participating.

Instruments

Information relating to the subject's height, weight, age, and health history were collected using the physical characteristics and socio-demographic form. A height meter made of wood that has a headpiece above and calibrated from 0-90 cm was used to measure the height of each subject to the nearest 0.1cm. The weight of each subject was measured to the nearest 0.1 kilograms with a bathroom weighing scale (Harson, model H89 Black, made in China) with calibrations from 1-160 kilograms. A non-flexible tape measure (butterfly brand made in China, Shanghai) was used to measure hip and waist circumference to the nearest centimeter. The blood pressure of the subjects was manually measured with a stethoscope and sphygmomanometer (Litman and Brkang stethoscope). Paper and pencil were used in the data collection. An eraser/razor blade was used to obliterate or correct any mistake during writing and for sharpening the pencil, respectively.

Procedure

The ethical approval of the Research and Ethical Committee of the UMTH was sought before the commencement of the study. The subjects were contacted and approach during their normal visiting clinic days at the above-named study site and all measurements were carried out at those sites respectively after permission were sort from the consultants and Heads of Departments of various departments for permission to use the above-named subjects. The purpose and benefits of the study were explained to the prospective subjects and all information obtained from the study remained confidential and was treated with honesty. Information on their age, marital status, was communicated. The procedure of the study was explained to the subjects and their consent was obtained before the commencement of the study.

Anthropometric measurements

The height and weight of the subject were measured as detailed elsewhere [24] with the wooden height meter and bathroom weighing scale, respectively. The BMI was calculated from the measurement obtained from the height and the weight by the formulae; BMI = weight/height2 (kg/m^2) Guideline for BMI $\leq 30kg/m^2$ [25]. To measure the WC, subjects were asked to stand and breathe normally, after which two landmarks, the costal margin, and iliac crest were palpated. The WC was then measured at the center of this two-point using the tape measure. This was immediately followed, by measurement of HC to the nearest 0.5 centimeters at the broadest point around the greater trochanter. Measurement was recorded in centimeters using the guideline ≤ 39 inches (100 cm) for both males and females [26]. The values obtained from WC and HC were used to calculated WHR using the formulae; WHR = WC/HC. Putting in consideration the WHO guideline for male and female as ≤ 0.95 and ≤ 0.80 respectively [2].

Blood pressure and blood glucose levels

The blood pressure was measured once with the subjects seated down on a chair and the sphygmomanometer cuff wound around the upper arm on the left side with the lower edge one inches proximal to the elbow. It was attached firmly with the Velcro fastener and folds back the leftover flap. The pressure gauge was attached to the holding strap so that it is easily readable. The valve was close with the set screw and air was inflated to a pressure of about 180 mmHg or to a point where the brachial artery is fully occluded. The stethoscope diaphragm was then positioned on the medial half of the anterior elbow joint over the brachial artery. Gradually, the valve was open slightly to allow for the escape of air. The first Korotkoff sound was recorded as systolic pressure. To take a record of the diastolic pressure the air was continually released, until the sound suddenly disappears. All readings were taken in millimeters of mercury and BP of 140/90 mmHg and above was considered for all subjects as hypertensive. The Blood glucose level of each subject in this study was obtained from examination report tests or past medical history, using procedures described elsewhere [27, 28].

Data analysis

The physical characteristics such as blood sugar, height, weight, BMI, WC, blood pressure, and WHR were analyzed using descriptive statistics of mean and standard deviation. A simple percentage was used to determine which among these selected anthropometric measures has the greatest predisposing risk among the subjects in each group.The relationship between WC, BMI, and WHR were analyzed using Pearson and Spearman's correlation coefficient. The level of significance was set at $p < 0.05$.

Results

Physical Characteristics of the Subjects

A total of 201 male and female hypertensive and T2D subjects participated in this study. 60.7% (n= 122) were hypertensive consisting of 56 males (27.9%) and 66 females (32.8%) while 79 (39.3%) were T2D consisting of 37 males (18.4%) and 42 females (20.9%). The mean age, weight, and height of the subjects were 53.02±12.02 years, 72.91±15.68 kg, and 1.66±0.08 m, respectively. The sex groups categorization of the subjects, followed by their various occupational endeavors with percentages of 26.9% civil servants, 10% retired civil servants, 2.5% househusbands, 37.8% housewives, 0.5% soldier, 15.9% traders, 0.5% driver, 3.4% teachers, 2.9% farmers were presented using simple chars as shown in Figure 1 and Figure 2, respectively.

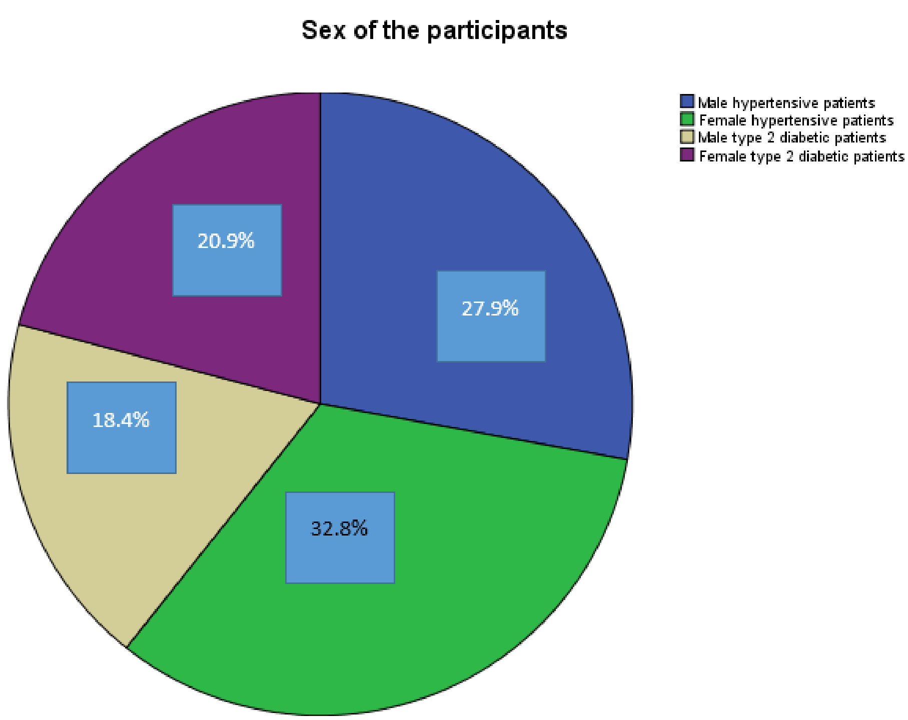

Figure 1: Pie chart showing sex categorization of the subjects in each of the condition

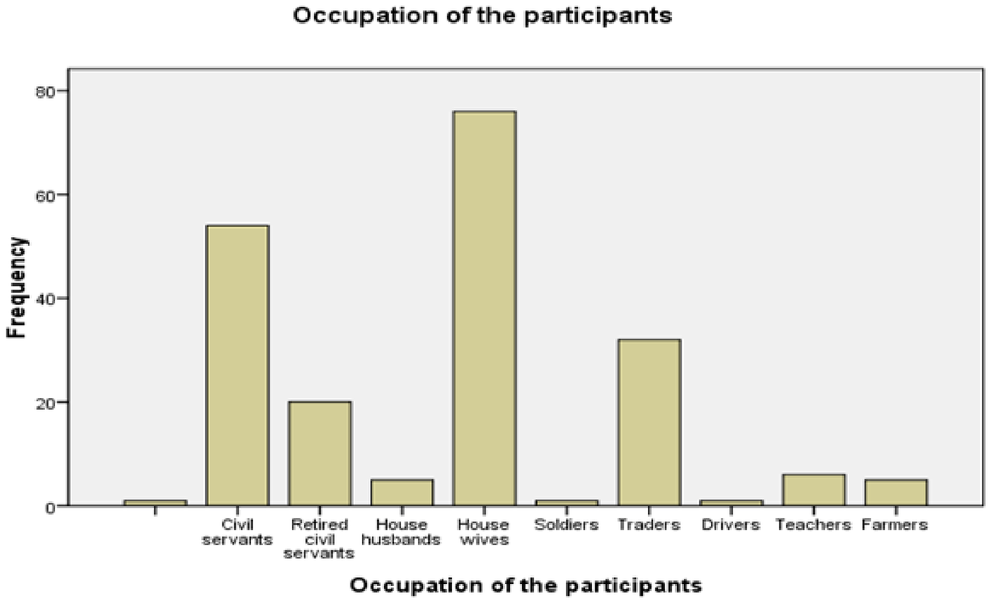

Figure 2: Bar chart showing occupational endeavors of the subjects

The Relationship between anthropometric variables

For the hypertensive subjects, a strong positive significant relationship was found between WC and BMI (r = 0.85; p = 0.01). A weak positive significant relationship was found between WC and WHR (r = 0.33; p = 0.01) while a negative weak non-significant relationship was found between WHR and BMI (r = -0.02; p = 0.86), as shown in table 1.

Table 1: Relationship between WHR, WC and BMI in hypertensive and T2DM Subjects

Subjects	Variables	r – values	p – values
Hypertensive	WC – WHR	0.33	0.01 **
	WC – BMI	0.85	0.01 **
	WHR -BMI	-0.02	0.86^{NS}
Type 2 diabetic	WC – WHR	0.22	0.05^{NS}
	WC – BMI	0.13	0.27^{NS}
	WHR -BMI	0.72	0.01**

WHR -WC = Relationship between Waist-Hip Ratio and Waist Circumference
WHR- BMI = Relationship between Waist-Hip Ratio and Body Mass Index
WC -BMI = Relationship between Waist Circumference and Body Mass Index
^{NS} p>0.05= not significant, ** p<0.01= highly significant

For the T2D Subjects, a strong positive significant relationship was found between WHR and BMI (r = 0.72; p = 0.01), while a weak positive non-significant relationship was found between WC and WHR (r = 0.22; p = 0.05) and between WC and BMI (r = 0.13; p = 0.27), as shown in [table 1].

Table 2: Gender based Physical characteristics of subjects (Vales are mean and SD)

Variables	Hypertensive subjects		T2D subjects	
	M	F	M	F
Height	1.7±0.17	1.6±0.06	1.71±0.07	1.6±0.05
Age	56±11.2	46.6±12.7	56.7±12	51.1±10.5
Weight	72.6±14.7	73.1±19.5	71.2±9.85	74.5±14.8
WC	89.4±12.3	90.5±14.7	89.3±10.7	93±13.8
HC	92±9.43	99.5±0.05	92.5±10.9	101±13.9
WHR	0.97±0.09	0.92±0.1	0.97±0.07	0.92±0.08
BMI	24.8±17.8	28.1±7.16	24.4±2.97	28.7±5.3
SBP	136±17.8	146±25	141±21	140±25.7
DBP	84.7±13	89.9±12.7	85±11.5	86.4±14
FBS			8.88±4.97	9.01±5.18
F= Female, M= Male, HC=Hip Circumference (cm), WC = Waist Circumference (cm), WHR= Waist Hip Ratio, BMI= Body Mass Index (Kgm^2), SBP=Systolic Blood Pressure (mmHg), DBP=Diastolic Blood Pressure (mmHg), FBS= Fasting Blood Sugar (mmol/l), SD= Standard Deviation				

Table 3: Physical Characteristics of the Subjects (values are in mean and SD)

Variables	Mean	SD
Age (years)	53.02	12.02
Weight (kg)	72.91	15.68
Height (m)	1.66	0.08
BMI (kg/m^2)	26.62	5.70
WC (cm)	90.48	13.18
HC (cm)	96.47	14.00
WHR (cm)	0.94	0.09
SBP (mmHg)	141.29	23.33
DBP (mmHg)	86.84	13.04
FBS (mmol/l)	8.95	5.05
BMI = Body mass index; WC = Waist circumference; HC = Hip circumference; WHR = Waist-hip ratio; SBP = Systolic blood pressure; DBP = Diastolic blood pressure; FBS = Fasting blood sugar; SD = Standard deviation		

Anthropometric measures of obesity indicators of the subjects.

Table 4 shows the anthropometric characteristics of the subjects classified as obese or non-obese. For the hypertensive subjects, WHR indicated that 71.3% of the subjects were obese, this was followed by WC with 39.3% and the least been BMI with 25.4%.

For the T2D subjects, WHR indicated that 75.9% of the subject were obese, this was again followed by WC with 40.5% and 22.8% for BMI. These results clearly showed that the best obesity indicator for this cohort of the subject was the WHR.

Table 4: Anthropometric of obesity indicators of the subjects

Variables	Frequency	Percentage	Ranges of values
WHR of hypertensive subjects			
Obese	87	71.3 %	> 0.95 for male, > 0.8 for female
Not obese	35	28.7 %	≤ 0.95 for male, ≤ 0.8 for female
WC of hypertensive subjects			
Obese	48	39.3 %	≥ 102cm for male, ≥ 88cm for female
Not obese	74	60.7 %	< 102cm for male, < 88cm for female
BMI of hypertensive subjects			
Obese	31	25.4 %	≥ 30 kg/m^2
Not obese	91	74.6 %	< 30 kg/m^2
WHR of T2D subjects			
Obese	60	75.9 %	> 0.95 for male, > 0.8 for female
Not obese	90	24.1 %	≤ 0.95 for male, ≤ 0.8 for female
WC of T2D subjects			
Obese	32	40.5 %	≥ 102cm for male, ≥ 88cm for female
Not obese	47	59.5 %	< 102cm for male, < 88cm for female
BMI of T2D subjects			
Obese	18	22.8 %	≥ 30 kg/m^2
Not obese	61	77.2%	< 30 kg/m^2
WHR= Waist Hip Ratio; T2D= type 2 diabetes; WC= Waist Circumference; BMI= Body mass Index			

Discussion

The present study discovered that the WHR has a higher ability to determine the presence of obesity in hypertensive and T2D subjects. This is consistent with the findings of Ta et al., [29] but contradicts with the finding of Khader and Zhang et al., [8, 21] with reports that for an adult population living in Jordan, WHtR predicts the presence of obesity among hypertension and diabetes better than those other measures and finding by Wang et al., [23] with "WC a better predictor". Similar findings by, Ojao and Nyamdorj [19] reported that "WC or WHR discriminate better the cases with diabetes from those without when compared with BMI". This attests to the fact that ethnocultural differences may have an impact on the weight status of subjects with hypertension and T2D.

The hypertensive and T2D subjects reflected similarities in Age and anthropometric variables (heights, weight, WC, HC, WHR, and BMI). Higher mean (SD) age of male (56.7±12 years) T2D subjects compared to their female (51.1±10.5 years) counterparts were inconsistent with the findings by Bahijri et al., [30] with reports of higher mean (SD) age of female (60.4 ±10.1 years) compared to male (56.0 ±11.5 years). A higher percentage of the female gender as compared to male in each of the groups contradicts the findings of Joshi and Shrestha [4] who reported that females were less in the diabetes subjects and more in the non-diabetes subjects. Higher occupations as housewives indicated that more females participated in the study (figure 1 & 2). As regards occupational grouping, in the present study, the civil servants were ranked next to housewives, this is consistent with findings of Le et al., [31]. This can be accredited to long hours of sitting, inactivity, and lack of exercise associated with this occupational group.

The weight, height, and BMI (72.91±15.68kg, 1.66±0.08m, and 26.62±5.7kg/m^2) of the subject in the present study correspond to abnormal value and status of being overweight was consistent with a report by WHO [2]. The BMI of the hypertensive male (24.8±17.8 kg/m^2) was similar to T2D male (24.4±2.97 kg/m^2), likewise, the BMI of the hypertensive female (28.1±7.16 kg/m^2) was also similar to T2D females (28.7±5.3 kg/m^2), this clearly shows that the female subject had a higher BMI range in both groups. This finding contradicts the study of Joshi and Ojao and Nyamdorj [4, 19] where the BMI range was not similar in both groups of subjects.

In the present study, the WC of both hypertensive (M=89.4±12.3 cm, F=90.5±14.7 cm) and T2D (M= 89.3±10.7 cm; F=93±13.8 cm) subjects were similar. Although the WC of female subjects was higher than the male subject in both groups. This finding contradicts the study of Joshi & Shrestha and Shah et al., [4, 32] where the WC of male diabetes subjects was significantly higher than their non-diabetes counterpart. This result showed that the female subject had more risk to come down with hypertension and T2D. However, WC values above 90 cm are a major risk for both sexes to develop obesity.

The previous finding by Patel and Sigh [22] reported that the risk of coming down with T2D and invariably hypertension in males double with WC > 98 cm. In the present study, the WHR of both hypertensive and T2D were similar. This finding again contradicts the findings of Joshi & Shrestha, Shah et al., and Ojao &Nyamdorj [4, 32, 19] where the WHR of the diabetes subject was higher than that of the non-diabetes subject. These findings indicate that both male and female subject stands at similar risk of becoming obese in their current health status. In the present study, the WHR is above normal and studies have concluded that abnormal WHR was associated with hypertension and T2DM [19].

The present study also found a strong positive significant (r =0.85) relationship between WC and BMI in the hypertensive subject and a strong positive significant relationship (r = 0.72) between WHR and BMI in the diabetic subjects, this was consistent with the result found by Bahathiq, Seidell and Klein et al., [17, 18, 14]. This was due to an increase in both central and generalized fat mass of the subjects used in the study. A weak negative (not significant) relationship between WHR& BMI in the hypertensive subject and a weak (not significant) relation between WC & BMI and WC & WHR in the T2D subjects were consistent with the result found by Shah et al., and Feldstein et al., [33, 13]. A weak positive non-significant relationship found between WC/WHR and WC/BMI among T2DM subjects was inconsistent with the finding of Ojao & Nyamdorj [19]. This may be accredited to a difference in fat distribution in different regions of the body among subjects and to the sex of the subjects which attest to fat distribution discrepancy between central and generalized body fat between sex groups.

The cut point for WHR of females was 0.92 and that of the male was 0.97 in the present study. A high ratio as defined by WHO is > 0.90 for males and > 0.8 for females which is a risk for diagnosing cardio-metabolic risk. Abnormal WHR finding in this study is consistent with findings of Joshi & Shrestha [4] with a report of higher WHR above WHO cut-off. The subjects in this study were advised to cut down on their weight by engaging in frequent physical activity and moderation in caloric intake. The strength of this study is that, apart from checking medical records and self-report of hypertension, the researchers also took the blood pressure of each subject to confirm their status. One of the weaknesses of this study was that the subject blood glucose level was obtained from the medical record without checking to confirm. This study is hospital-based, hence caution needs to be taken when using the result of this study in a community-based study.

Conclusion

The present study shows that there was a strong positive relationship between WC and BMI in the hypertensive subject. There was also a strong positive relationship between WHR and BMI in the T2D subjects. A weak positive significant relationship was found between WC and WHR in the hypertensive subjects. The relationship between WC and BMI was strongly positive in the hypertensive subject. On the contrary, it was weakly positive in the T2D subjects. While the relationship between WHR & BMI was strong and positive in the T2D subjects, it was very weak and negative in the hypertensive subjects. Holistically, the WHR is a better indicator of obesity and a predictor of hypertension and T2D when compared to other measures.

Declaration

Ethical Approval

The ethical approval of the Research and Ethical Committee of the UMTH was sought before the commencement of the study.

Authors Contribution

JB conceived the idea. ONS, MO, LIE, IW, PAA and PAE edited the manuscript. All authors contributed in preparing and writing the manuscript. All authors have read and approved the manuscript.

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Conflict of interest

The authors declare has no conflict of interest associated with this paper.

References

1. World Health Organization. NCD mortality and morbidity, Global Health Observatory (GHO) data. Available at: http://www.who.int/gho/ncd/mortality_morbidity/en/2015 [Accessed 1 July, 2019].
2. World Health Organization. New data highlight increases in hypertension, diabetes incidence. World Health Statistics; Available at: http://www.who.int/mediacentre/news/releases/2012/world_health_statistics_20120516/en/2012. Accessed October 4, 2017. [Google Scholar]
3. National Clinical Guideline Centre (UK). Hypertension: The Clinical Management of Primary Hypertension in Adults: Update of Clinical Guidelines 18 and 34 [Internet]. London: Royal College of Physicians (UK); 2011 Aug. (NICE Clinical Guidelines, No. 127.) 14, Reference list. Available from: https://www.ncbi.nlm.nih.gov/books/NBK83285/.
4. Joshi B and Shrestha L (2019). A Comparative Study of Waist Hip Ratio and Body Mass Index (BMI) in Diabetic and Non-Diabetic Individuals of Chitwan, Nepal. J Diabetes Metab 10: 817. DOI: 10.35248/2155-6156.19.10.817
5. Powers AC. Harrison's principles of internal medicine. In: Fauci AS, Braunwald E, Kasper DL, Hauser SL, Longo DL, et al. (16th ed) New York: McGraw Hill, 2008 Companies Inc pp: 2139-2154.
6. International Diabetes Federation. A Prevalence estimate of diabetes mellitus, 2010 by Country Percent of adult population with diabetes, ranked highest to lowest %. Available at http://www.allcountries.org/ranks/diabetes_prevalence_country_ranks.html. Accessed on 16th Aug, 2103.
7. David G., Gardner. Dolores, Shoback. Greenspan's basic & clinical endocrinology (9th Ed.). New York, McGraw-Hill Medical: China pp. Chapter 17; 2011.
8. Khader Anwar Batieha, Hashem Jaddou, Mohammed El-Khateeb and Kamel Ajlouni. The performance of anthropometric

measures to predict diabetes mellitus and hypertension among adults in Jordan: BMC Public Health. 2019; 19:1416. https://doi.org/10.1186/s12889-019-7801-2

9. Isomaa B, Almgren P, Tuomi T, Forsén B and Lahti K, et al. (2011). Cardiovascular morbidity and mortality associated with the metabolic syndrome. Diabetes Care. 24: 683-689.
10. Ashwell M, Gunn P and Gibson S (2012). Waist-to-height ratio is a better screening tool than waist circumference and BMI for adult cardiometabolic risk factors: systematic review and meta-analysis. Obes Rev. 13:275-286.
11. Ashwell M and Gibson S (2016). Waist-to-height ratio as an indicator of 'early health risk': simpler and more predictive than using a 'matrix' based on BMI and waist circumference. BMJ Open. 6: e010159.
12. Gallagher D, Visser M, Sepu'lveda D, Pierson RN and Harris T, et al. (1996). How useful is the body mass index for comparison of body fatness across age, sex, and ethnic groups. American Journal of Epidemiology.143: 228-239.
13. Feldstein CA, Akopian M, Olivieri AO, Kramer AP and Nasi M, et al. (2005). A comparison of body mass index and waist-to-hip ratio as indicators of hypertension risk in an urban Argentine population: a hospital-based study. Nutrition Metabolic Cardiovascular Disorder.15:10-15.
14. Klein S, David B, Allison SB, Heymsfield and David EK, et al. (2007). Waist circumference and cardiometabolic risk: a consensus statement from Shaping America's Health. American Journal of Clinical Nutrition.85:1197-1202.
15. Rachel Huxley, Federica Barzi, Crystal M Y Lee, Scott Lear and Jonathan Shaw, et al. (2007): Waist circumference thresholds provide an accurate and widely applicable method for the discrimination of diabetes. Diabetes Care. 30:3116-3118.
16. Nyamdorj R, Qiao Q, Oderberg S, Pitkäniemi J and Zimmet P, et al. (2008). Comparison of body mass index with waist circumference, waist-to-hip ratio, and waist-to-stature ratio as a predictor of hypertension incidence in Mauritius. J Hypertens. 26: 866-870.
17. Bahathiq AOS (2010). Relationship of Leptin Hormones with Body Mass Index and Waist Circumference in Saudi Female Population of the Makkah Community. The Open Obesity Journal. 2: 95-100.
18. Seidell JC (2010). Waist circumference and waist/hip ratio in relation to all-cause mortality, cancer and sleep apnea. European Journal of Clinical Nutrition. 64: 35-41.
19. Qiao Q and Nyamdorj R (2010). Is the association of type II diabetes with waist circumference or waist-to-hip ratio stronger than that with body mass index? European Journal of Clinical Nutrition. 64: 30-34.
20. Browning LM, Hsieh SD and Ashwell M (2010). A systematic review of waist-to-height ratio as a screening tool for the prediction of cardiovascular disease and diabetes: 0.5 could be a suitable global boundary value. Nutr Res Rev. 23: 247-69.
21. Zhang ZQ, Deng J, He LP, Ling WH and Su YX, et al. (2013). Comparison of various anthropometric and body fat indices in identifying cardiometabolic disturbances in Chinese men and women. PLoS One. 8: e70893.
22. Patel DN and Singh MP (2013). Comparison of anthropometric indicator of General obesity (BMI) to anthropometric Indicators of central obesity (WC, WHR) in Relation to diabetes mellitus in male Population. Natl J Community Med. 4: 377-380.
23. Wang H, Liu A, Zhao T, Gong X and Pang T, et al. (2017). Comparison of anthropometric indices for predicting the risk of metabolic syndrome and its components in Chinese adults: a prospective, longitudinal study. BMJ Open. 7: e016062.
24. Oyeyemi A, Ayi Ewah Patrick and Oyeyemi Adewale (2015). Comparison of recovery responses of young physically active and sedentary Nigerian undergraduates following exercise testing. International Journal of Physical Education, Sports and Health. 2: 60-65.
25. World Health Organization. Global Database on Body Mass Index. Geneva. World health Organization. 2015.
26. Colby SE and Johnson L (2006). Total and Saturated Fat Intake are Associated with Increased Waist Circumference. Journal of American Diet Association. 106: A44.
27. Vijan S (2010). In the clinic. Type 2 diabetes. Annals of internal medicine.152: ITC31–15; quiz ITC316.
28. American Diabetes Association (2010). Diagnosis and classification of diabetes mellitus. Diabetes Care. 1: 10-62.
29. Ta MT, Nguyen KT, Nguyen ND, Campbell LV and Nguyen TV (2010). Identification of undiagnosed type 2 diabetes by systolic blood pressure and waist-to-hip ratio. Diabetologia. 53:2139-2146.
30. Bahijri SM, Ahmed M, Al-Shali K, Bokkhari S and Alhozali A, et al. (2016). The relationship of management modality in Saudi patients with type 2 diabetes to components of metabolic syndrome, Y glutamyl transferase and highly sensitive C-reactive protein. Therapeutic advances in chronic disease. 7: 246-254.
31. Lee IM, Shiroma Eric J, Lobelo, Felipe and Puska, et al. (2012). "Effect of physical inactivity on major non-communicable diseases worldwide: an analysis of burden of disease and life expectancy". The Lancet. 380:219-229.
32. Shah A, Bhandary S, Malik SL, Risal P and Koju R (2009). Waist circumference and waist-hip ratio as predictors of type 2 diabetes mellitus in the Nepalese population of Kavre District. Nepal Med Coll J. 11: 261-267.
33. Scott A Lear, Karin H Humphries, Simi Kohli, Arun Chockalingam and Jiri J Frohlich, et al. (2007). Visceral adipose tissue accumulation differs according to ethnic background: results of the Multicultural Community Health Assessment Trial (MCHAT). Merican Journal of Clinical Nutrition. 86: 353-359.