J Surg Med. 2018;2(3):218-222.
DOI: 10.28982/josam.417473

Research article
Araştırma makalesi

Journal of Surgery and Medicine
e-ISSN: 2602-2079

Positive association of neck circumference and cardiometabolic risk factors in Ekiti, Nigeria

Nijerya'da Ekiti'de boyun çevresi ve kardiyometabolik risk faktörlerinin pozitif ilişkisi

Taiwo Hussean Raimi [1], Samuel Ayokunle Dada [1], Abimbola Solanke [2]

[1] Department of Medicine, Ekiti State University /Ekiti State University Teaching Hospital, Ado-Ekiti, Nigeria
[2] Department of Radiology, Ekiti State University Teaching Hospital, Ado-Ekiti, Nigeria

ORCID ID of the authors
THR: 0000-0002-0092-5324
SAD: 0000-0003-4235-2250
AS: 0000-0003-1122-0546

Corresponding author / Sorumlu yazar:
Taiwo Hussean Raimi
Address / Adres: Department of Medicine, Ekiti State University, P.M.B. 5355, Ado-Ekiti, Ekiti State, Nigeria
E-mail: taiwo.raimi@eksu.edu.ng

Ethics Committee Approval: The ethic and research committee of EKSUTH approved the study (EKSUTH/A67/2018/001).
Etik Kurul Onayı: EKSUTH'ın etik ve araştırma komitesi çalışmayı onayladı (EKSUTH / A67 / 2018/001).

Conflict of Interest: No conflict of interest was declared by the authors.
Çıkar Çatışması: Yazarlar çıkar çatışması bildirmemişlerdir.

Financial Disclosure: The authors declared that this study has received no financial support.
Finansal Destek: Yazarlar bu çalışma için finansal destek almadıklarını beyan etmişlerdir.

Received / Geliş Tarihi: 20.04.2018
Accepted / Kabul Tarihi: 11.05.2018
Published / Yayın Tarihi: 11.05.2018

Abstract

Aim: The association between neck circumference (NC) and cardiometabolic risk factors in Southwest Nigeria is unknown. The study aimed at determining the relationship between NC and cardiometabolic risk factors.

Methods: Result of a cross-sectional health survey involving residents of Ado-Ekiti/Ika community in Ekiti State was analyzed. Clinical measurements of body mass index (BMI), waist circumference (WC), waist-to-height ratio (WHtR), neck circumference, systolic/diastolic blood pressures (SBP & DBP) were taken, and random blood glucose (RBG) determined. Bivariate correlations and linear regression models were computed for each sex.

Results: There were 211 participants out of which 78 (37.0%) were men. Among men, NC was significantly correlated with weight (r=0.412, p<0.001) and BMI (r=0.362, p<0.01). Among women, NC correlated with weight (r=0.319, p<0.001), BMI (r=0.228, p<0.01), WC (r=0.238, p<0.01), SBP (r=0.444, p<0.001), DBP (r=0.423, p<0.05), and RBG (r=0.203, p<0.05). NC independently predicted SBP, ORs (95%CI), 2.707 (1.468-3.946) and DBP, ORs (95%CI), 1.780 (0.950-2.611) in women, but not in men. While only the NC of men with general obesity was greater than those who do not have, 39.27(5.68)cm vs 36.96(3.46)cm, p=0.04, the NC of women who were obese or had hypertension were significantly greater than those who were not: general obesity, 33.17(2.58)cm vs 31.57(3.08cm), p=0.002; central obesity, 32.88(2.99)cm vs 31.09(2.62)cm, p<0.001; hypertension, 34.39(2.77)cm vs 31.88(2.88)cm, p=0.001). Compared with those in the upper tertile, men with NC in the middle tertile had lower mean weight [60.82 (8.67) kg vs 68.90 (10.08) kg, p=0.005], BMI [21.31 (2.54) kgm2 vs 23.72 (3.77) kgm2, p=0.022], WC [78.32 (5.57) cm vs 85.14 (8.72), p=0.003], and WHtR [0.464 (0.06) vs 0.50 (0.06), p=0.004].Compared with those in the upper tertile, women with NC in the lower tertile had lower mean weight [56.81(9.80) kg vs 66.08(13.50)kg, p=0.031], SBP [107.53 (15.59) mmHg vs 132.38 (15.85) mmHg, p<0.001], and DBP [69.27 (10.91) mmHg vs 84.69 (10.52) mmHg, p<0.001].

Conclusions: Neck circumference has positive association with, and predicts cardiometabolic risk factors, and may serve as an index of obesity in Ekiti, Nigeria.

Keywords: Cardiometabolic risk factors, Correlations, Neck circumference, Obesity, Hypertension

Öz

Amaç: Güneybatı Nijerya'da boyun çevresi (NC) ve kardiyometabolik risk faktörleri arasındaki ilişki bilinmemektedir. Çalışma, NC ve kardiyometabolik risk faktörleri arasındaki ilişkiyi belirlemeyi amaçlamıştır.

Yöntemler: Ekiti Devletinde Ado-Ekiti / Ika topluluğu sakinlerini içeren kesitsel bir sağlık araştırması sonuçları analiz edildi. Vücut kitle indeksi (BMI), bel çevresi (WC), bel-boy oranı (WHtR), boyun çevresi, sistolik / diyastolik kan basınçları (SBP ve DBP) klinik ölçümleri alındı ve rastgele kan şekeri (RBG) belirlendi. Her cinsiyet için iki değişkenli korelasyonlar ve doğrusal regresyon modelleri hesaplandı.

Bulgular: 78'i (%37,0) erkek olan 211 katılımcı vardı. Erkekler arasında NC, ağırlıkla (r=0,412, p<0,001) ve BMI (r=0.362, p<0,01) ile anlamlı olarak koreleydi. Erkeklerde olmamakla birlikte kadınlar arasında NC (r=0,319, p<0,001), BMI (r=0,228, p<0,01), WC (r=0,238, p<0,01), SBP (r=0,444, p<0,001) ile korele bulundu. DBP (r=0,423, p<0,05) ve RBG (r=0,203, p<0,05). NC bağımsız olarak, kadınlarda SBP, OR (%95 CI), 2,707 (1,468-3,946) ve DBP, OR (%95 CI), 1,780 (0,950-2,611). Genel obezitesi olan erkeklerin sadece NC'si olmayanlardan 39,27 (5,68) cm'ye karşılık 36,96 (3,46) cm, p=0.04 iken, obez olan veya hipertansiyonu olan kadınların NC'si, değil: genel obezite, 33,17 (2,58) cm vs 31,57 (3,08 cm), p=0.002; santral obezite, 32,88 (2,99) cm'ye karşı 31,09 (2,62) cm, p<0.001; hipertansiyon, 34,39 (2,77) cm'ye karşı 31,88 (2,88) cm, p = 0.001) idi. Üst tersiyer ile karşılaştırıldığında, orta hüviyette NC olan erkeklerin oranı daha düşüktü [60,82 (8,67) kg / 68,90 (10,08) kg, p=0,005], BMI [21,31 (2,54) kg/m2 ve 23,72 (3,77) kg/m2 idi. , p=0,022], WC [78,32 (5,57) cm'ye karşı 85,14 (8,72), p=0,003] ve WHtR [0,464 (0,06) / 0,50 (0,06), p=0,004]. Üst tersiyerde bulunanlarla karşılaştırıldı, alt kadranda KKY'li kadınlar daha düşük ortalama ağırlığa sahipti [56,81 (9,80) kg / 66,08 (13,50) kg, p=0,031], SBP [107,53 (15,59) mmHg ve 132,38 (15,85) mmHg, p=0,000] ve DBP [69,27 (10,91) mmHg, 84,69 (10,52) mmHg, p=0,000].

Sonuçlar: Boyun çevresi kardiyometabolik risk faktörleri ile pozitif ilişkilidir ve tahmin eder ve Nijerya'daki Ekiti'de bir obezite endeksi olarak hizmet edebilir.

Anahtar kelimeler: Kardiyometabolik risk faktörleri, Korelasyonlar, Boyun çevresi, Obezite, Hipertansiyon

How to cite / Atıf için: Raimi TH, Dada SA, Solanke A. Positive association of neck circumference and cardiometabolic risk factors in Ekiti, Nigeria. J Surg Med. 2018;2(3):218-222.

Introduction

Worldwide, obesity is a major cause of morbidity and mortality [1]. It is associated with diseases such as diabetes, hypertension, ischemic heart disease, stroke, sleep apnea, osteoarthritis, gall bladder stones, and cancers [2]. The World Health Organization (WHO) estimated the global prevalence of obesity in adults to be 36% in 2016 [2]. A study involving 5,392 participants in five geopolitical zones in Nigeria found the prevalence of obesity to be 17.2% [3]. This is expected to rise due to adoption of western lifestyle amongst other reasons.

A number of anthropometric indices such as body mass index (BMI), waist circumference (WC), waist to hip ratio (WHpR), and waist to height ratio (WHtR) are in use as surrogates of excess body fat, which is what obesity actually connotes [2-4]. These obesity indices correlate with both total and regional body fat [5]. However, some of these indices have their drawbacks. For example, body mass index may over-estimate or under-estimate body fat depending on the build of individual or certain races [6,7]. Additionally, measurement of WC and hip circumference (HC) may be greeted with reservations in certain cultures, especially among females, who may feel awkward when such body parts are being examined [8]. Use of different landmarks while measuring WC is another potential drawback [9]. In addition to these indices, imaging techniques such as ultrasonography, computed tomography, magnetic resonance imaging, and dual energy x-ray absorptiometry (dexa scan) are used to diagnose obesity. These give better assessment of body fat than anthropometric indices, but due to cost, non-availability, and the required technicalities, they are mostly employed in research settings.

Recently, there is a growing interest in the utility of neck circumference (NC) in identifying people with obesity. This new index of upper body adiposity is easy to determine, does not require much body exposure, and was found to correlate with other obesity indices and body fat [10-14]. In the Framingham Heart Study, NC was found to be positively associated with BMI, visceral adipose tissue (VAT) and other cardiovascular disease risk factors [10]. A study conducted among the Turks [11,13] and Saudi Arabs [14] revealed that NC had positive correlation with indices of general and central obesity. Similar studies among the Chinese [15-17], Indians [18,19], Indonesians [20], and other Asian populations [21], also confirmed the positive association between NC with established anthropometric indices and cardiovascular risk factors. Specifically, Fan et al., [22] examined the relationship between NC and arterial hypertension, and found that NC predicted blood pressure, independent of other anthropometric indices.

There are scanty reports on the relationship between NC and established obesity indices and cardiovascular (CVD) risk factors in Nigeria. Specifically, no report(s) has emanated from southwest Nigeria. The aim of this study is to determine the association between NC and the established obesity indices, as well as CVD risk factors in Ekiti State, Nigeria. We hypothesize that NC will correlate with obesity indices and CVD risk factors.

Materials and methods

A health survey with cross-sectional design was conducted among some residents of Ado-Ekiti and Ika community between August and October 2017. With the aid of a questionnaire, relevant demographic and medical history was obtained from the participants. This included age, gender, previous diagnosis of hypertension and diabetes, smoking, and use of alcohol. Clinical measurements of height, weight, waist circumference, neck circumference and blood pressure were taken. Random plasma glucose (RBG) was also taken. Written informed consent was obtained from the participants. The ethic and research committee of EKSUTH approved the study (EKSUTH/A67/2018/001).

Anthropometric and Clinical measurements

Weight was measured with a bathroom weighing scale to the nearest 0.1kg, while the participant wore light clothing. Height was determined with a stadiometer to the nearest 0.1m while standing without shoes, head gear or cap. Body mass index was taken as weight (kg)/height^2 (m). General obesity was defined according to the WHO classification: <18.5 kg/m^2, underweight; 18.5 to 24.9 kg/m^2, normal; 25.0 to 29.9 kg/m^2, overweight; ≥30kg/m^2, obese [2]. Waist circumference was measured after expiration to the nearest 0.5cm, with a non-stretchable tape rule along the umbilicus while standing. Waist to height ratio was taken as waist circumference (cm)/height (cm). Central obesity was defined as follows: (1) WC ≥94cm in men and WC ≥80cm in women [3]; (2) WHtR >0.50 in both men and women [4]. Neck circumference was measured in centimeters below the laryngeal prominence and perpendicular to the long axis of the neck. While taking this reading, the participant was asked to look straight ahead, with shoulders down, but not hunched.

The blood pressure was measured from the left upper arm with the participants in sitting position. Accussons' mercury sphygmomanometer attached to appropriate cuff sizes was used. The first and fifth Koroktoff sounds were taken as the systolic and diastolic blood pressures respectively. Hypertension was defined as blood pressure ≥140/90mmHg [23]. RBG was determined with a glucometer (Accucheck, Roche diagnostics). Those with goiter, pregnant women and nursing mothers were excluded.

Statistical Analysis

Categorical variables were expressed as percentages and compared with Chi-Square, while continuous variables were expressed as mean (standard deviation) and compared with Student's t-test. Pearson's correlation was used to determine the relationship between NC and the traditional obesity indices and blood pressure. Multiple linear regression analysis was used to determine the predictive ability of NC for the cardiometabolic factors. The NC was further categorized, and analysis of variance (ANOVA) was employed to compare the means of the blood pressure and obesity indices in different tertiles of NC. Statistical analyses were done with SPSS (IBM SPSS) version 20.0 (Chicago, Illinois, USA). Statistical significance was taken as $p<0.05$.

Results

There were 211 participants out of which 78 (37.0%) were men. The mean BMI and WHtR were greater in women:

Men vs Women [BMI, 22.92(3.63) kg/m^2 vs 24.12(4.94) kg/m^2, p=0.045; WHtR, 0.49(0.06) vs 0.52(0.08), p=0.006]. Compared to women, the mean neck circumference was greater in men [37.47(4.12) cm vs 32.22(2.98) cm, p<0.001]. The mean SBP and DBP were higher in men: Men vs Women [SBP, 124.55(14.17) mmHg vs 117.32 (14.17) mmHg, p=0.006]; [DBP, 79.61(9.89) mmHg vs 74.98(14.91) mmHg, p=0.008] (Table 1). The result shows that among men, NC positively correlated with weight (r=0.412, p<0.001) and BMI (r=0.362, p<0.01). Similarly among women, NC revealed a positive correlation with weight (r=0.319, p<0.001), BMI (r=0.228, p<0.01), WC (r=0.238, p<0.01), SBP (r=0.444, p<0.001), DBP (r=0.423, p<0.05), and RBG (r=0.203, p<0.05) (Table 2).

Table 1: Clinical characteristics of the participants according to gender

Characteristics	Male n=78 Mean(sd)	Female n=133 Mean(sd)	p
Age	37.93(14.61)	38.21(11.69)	0.883
Weight	66.19(10.48)	62.16(12.91)	0.020
Height	1.70(0.11)	1.61(0.08)	<0.001
BMI	22.92 (3.63)	24.12(4.94)	0.045
WC	83.98(9.21)	83.52(11.61)	0.751
WHtR	0.49 (0.06)	0.52(0.08)	0.006
NC	37.47(4.12)	32.22(2.98)	<0.001
SBP(mmHg)	124.55(14.17)	117.32(14.17)	0.006
DBP(mmHg)	79.61(9.89)	74.98(14.91)	0.008
RBG	5.47(1.04)	5.17(1.11)	0.059

BMI: body mass index, WC: waist circumference, WHtR: waist to height ratio, DBP: diastolic blood pressure, SBP: systolic blood pressure, RBG: random blood glucose

Table 2: Correlation between neck circumference and cardiovascular risk factors by gender

Variables	Men R	p	Women R	p
Age	-0.457	<0.001	0.255	0.004
Weight	0.412	<0.001	0.319	<0.001
BMI	0.362	0.001	0.228	0.008
WC	0.004	0.971	0.238	0.006
WHtR	-0.034	0.766	0.163	0.061
SBP	0.162	0.158	0.444	<0.001
DBP	0.072	0.533	0.423	0.020
RBG	-0.204	0.077	0.203	0.020

BMI: body mass index, HC: hip circumference, WC: waist circumference, WHtR: waist to height ratio, DBP: diastolic blood pressure, SBP: systolic blood pressure, RBG: random blood glucose

In a model that included age, BMI and WC, NC independently predicted systolic and diastolic blood pressures in women, but not in men. The ORs (95%CI) for NC in women for SBP and DBP were 2.707 (1.468-3.946) and 1.780 (0.950-2.611) respectively. The R^2 for the model is 0.288 (28.8%) for SBP and 0.241 (24.1%) for DBP. WHtR was not included in the regression due to collinearity with BMI (Table 3).

The NC of the participants who were overweight or obese was significantly greater than those who had normal BMI (men, 39.27(5.68) cm vs 36.96(3.46) cm, p=0.04; women, 33.17(2.58) cm vs 31.57(3.08) cm, p=0.002).

Additionally, the NC of women who had central obesity and hypertension was greater than those without these CVD risk factors [central obesity, 32.88(2.99) cm vs 31.09(2.62) cm, p<0.001; hypertension, 34.39(2.77) cm vs 31.88(2.88) cm, p=0.001] (Table 4).

Table 4: Mean neck circumference of those with or without cardiovascular risk factors

CVD risk_factors		n	Men NC Means(sd)	P	N	Women NC Means (sd)	p
BMI	Normal	61	36.96(3.46)	0.040	79	31.57(3.08)	0.002
	Overweight / obese	17	39.27(5.68)		54	33.17(2.58)	
WHtR	Normal	49	37.29(2.64)	0.685	53	31.69(2.99)	0.096
	Obese	29	37.77(5.88)		80	32.57(2.94)	
WC	Normal	68	37.74(3.06)	0.449	49	31.09(2.62)	<0.001
	Obese	10	35.61(8.44)		84	32.88(2.99)	
BP	Normal	68	37.34(3.87)	0.553	115	31.88(2.88)	0.001
	Raised	9	38.61(6.01)		18	34.39(2.77)	

CVD: cardiovascular disease, NC: neck circumference, BMI: body mass index, WHtR: waist to height ratio, WC: waist circumference, BP: blood pressure

Compared to those with NC is in the lower tertile, women with NC in the middle and/or upper tertiles had greater mean weight, BMI, WC, WHtR, SBP, and DBP. For lower vs upper tertile: Weight [56.81(9.80) kg vs 66.08(13.50) kg, p=0.031]; SBP [107.53(15.59) mmHg vs 132.38(15.85) mmHg, p<0.001; DBP [69.27(10.91) mmHg vs 84.69(10.52) mmHg, p<0.001]. For lower vs middle tertile: Weight [56.81(9.80) kg vs 67.36(13.64) kg, p<0.001]; BMI [22.46(3.99)kgm2 vs 25.92(5.44) kgm2, p<0.001]; WC [79.69(9.42)cm vs 87.18(12.91), p=0.001]; WHtR [0.50(0.06) vs 0.54(0.09), p=0.012]; SBP [107.53(15.59) mmHg vs 125.0(27.55) mmHg, p<0.001; DBP [69.27(10.91) mmHg vs 79.27(17.14) mmHg, p=0.001] (Table 5).

Table 5: Mean of anthropometric and clinical characteristics of in women according to neck circumference tertiles

Characteristics	NC mean (sd) Lower tertile N=64	Upper tertile N=13	P	Lower tertile N=64	Middle tertile N=56	p
Weight(kg)	56.81(9.80)	66.08(13.50)	0.031	56.81(9.80)	67.36(13.64)	<0.001
BMI(kgm^2)	22.46(3.99)	24.53(4.37)	0.321	22.46(3.99)	25.92(5.44)	<0.001
WC (cm)	79.69(9.42)	86.65(10.04)	0.101	79.69(9.42)	87.18(12.91)	0.001
WHtR	0.50(0.06)	0.53(0.06)	0.347	0.50(0.06)	0.54(0.09)	0.012
SBP(mmHg)	107.53(15.59)	132.38(15.85)	<0.001	107.53(15.59)	125.0(27.55)	<0.001
DBP(mmHg)	69.27(10.91)	84.69(10.52)	<0.001	69.27(10.91)	79.27(17.14)	0.001
RBG(mmol/L)	5.02(0.65)	5.89(0.50)	0.296	5.02(0.65)	5.19(1.28)	0.778

CVD: cardiovascular disease, NC: neck circumference, BMI: body mass index, WHtR: waist to height ratio, WC: waist circumference, SBP: systolic blood pressure, DBP: diastolic blood pressure, SD: standard deviation

Men with NC in the upper tertile had greater mean weight, BMI, WC, and WHtR compared with those in the middle tertile. For middle vs upper tertile: Weight [60.82(8.67) kg vs 68.90(10.08) kg, p=0.005]; BMI [21.31(2.54) kgm^2 vs 23.72(3.77) kgm^2, p=0.022]; WC [78.32(5.57) cm vs 85.14(8.72) cm, p=0.003]; WHtR [0.464(0.06) vs 0.50(0.06), p=0.004].

Table 3: Predictors of systolic and diastolic blood pressures according to gender

	Predictor Variable	Women B	95%CI	p	Model R^2	Men B	95%CI	p	Model R^2
SBP									
Model 1	NC	3.491	2.274-4.707	<0.001	19.7%	0.555	-0.221-1.332	0.158	2.6%
Model 2	NC	2.707	1.468-3.946	<0.001	28.8%	0.130	-0.814-1.075	0.784	10.0%
	BMI	0.663	-0.533-1.1859	0.275		0.254	-0.899-1.407	0.662	
	WC	-0.131	-0.697-0.435	0.648		0.363	-0.061-0.787	0.092	
	Age	0.588	0.222-0.954	0.002		0.130	-0.440-1.077	0.166	
DBP									
Model 1	NC	2.115	1.332-2.898	<0.001	17.9%	0.172	-.376-.720	0.533	0.5%
Model 2	NC	1.780	0.950-2.611	<0.001	24.1%	0.093	-0.737-0.551	0.774	12.1%
	BMI	0.231	-0.571-1.032	0.570		-0.034	-0.820-0.752	0.931	
	WC	-0.113	-0.493-0.266	0.555		0.364	0.075-0.6532	0.014	
	Age	0.359	0.114-0.604	0.004		-0.149	-0.325-0.028	0.097	

BMI: body mass index, NC: neck circumference, WC: waist circumference, DBP: diastolic blood pressure, SBP: systolic blood pressure

No statistically significant difference was observed in the SBP, DBP and RBG of the two groups. Only 4 men had NC in the lower tertile. Therefore, no comparison was made (Table 6).

Table 6: Mean of anthropometric and clinical characteristics of men according to neck circumference tertiles

Characteristics	Middle tertile n=22	Upper tertile n=52	p
Weight(kg)	60.82(8.67)	68.90(10.08)	0.005
BMI(kgm^2)	21.31(2.54)	23.72(3.77)	0.022
WC (cm)	78.32(5.57)	85.14(8.72)	0.003
WHtR	0.464(0.06)	0.50(0.06)	0.004
SBP(mmHg)	118.76(11.18)	126.52(14.87)	0.085
DBP(mmHg)	75.67(1.26)	80.88(9.13)	0.101
RBG(mmol/L)	5.53(0.86)	5.33(1.05)	0.728

CVD: cardiovascular disease, NC: neck circumference, BMI: body mass index, WHtR: waist to height ratio, WC: waist circumference, SBP: systolic blood pressure, DBP: diastolic blood pressure, RBG: random blood glucose

Discussion

NC is an upcoming upper body obesity index. Its determination is easy, not influenced by meal, footwear or clothing, is inexpensive and requires minimal or insignificant body exposure. This study examined the correlation between NC and other obesity indices. The correlation with blood pressure and random blood glucose were also determined. Additionally, the predictive ability of NC for blood pressure was determined. Furthermore, we compared the NC of those who had obesity and hypertension versus those who did not, as well as the mean of CVD risk factors at different tertiles of NC.

The mean NC in men and women who participated in this study was 37.47(4.12) cm and 32.22(2.98) cm, respectively. The values are similar to what Zhou et al., [15], found but lower than the findings of Alfadhi et al [14], and Lindarto et al., [20]. It was however higher than what Adamu et al., [24] found. Compared with our participants, those of Alfadhi et al [14], and Lindarto et al., [20] had higher mean BMI and WC. The participants in the study by Lindarto et al., [20] were also older than ours. Contrariwise, those who took part in the study by Adamu et al., [24] were younger, and had a lower mean BMI and WC. The differences are not unexpected given the relationship between NC with age, BMI and WC. Consistent with previous studies men had a higher mean NC [14,18,21].

We found a significant correlation between neck circumference with weight, and BMI in both men and women. Additionally, NC significantly correlated with WC, SBP, DBP and RBG in women but not in men. The association was however weak to modest. We found no correlation between NC and WHtR in this study. Other workers also found significant correlation between NC and indices of general and central obesity, blood pressure and blood glucose [11,17,21,25,26]. Additionally, some workers also found correlation between NC and other metabolic parameters such as serum total cholesterol, high density lipoprotein (HDL-C), triglycerides, C-reactive protein and insulin resistance [26]. NC is a surrogate for upper body subcutaneous adipose tissue and has been found to correlate with VAT [10,16]. Since BMI and WC correlates with VAT, it is unexpected that NC also correlated with these obesity indices.

The correlation between NC and blood pressure may be related to the hemodynamic changes that accompany neck fat deposition. Ectopic fat in the neck is associated with obstructive sleep apnea (OSA), which in turn may lead to increased sympathetic tone and endothelial dysfunction [27]. These will eventually lead to increased peripheral resistance and hypertension. This fat depot may also cause insulin resistance, which is associated with activation of sympathoadrenal axis, poor renal sodium handling, increased vascular resistance and stimulation of renin-angiotensin-aldosterone system, resulting in raised blood pressure [28]. Further, ectopic fat secrets adipocytokines, which are implicated in insulin resistance, and vascular inflammation [27]. These metabolic changes may result in dysglycaemia, and may explain the correlation between NC and RBG in this study. Other workers also reported positive correlation between NC and plasma glucose [14,17].

In this study, linear regression analysis demonstrated that NC predicted SBP and DBP, even after controlling for factors such as age, BMI and WC. However, gender-specific analysis revealed that NC predicted blood pressure only in women. In the Framingham Heart study, Preis et al. [10] found that NC was positively associated with SBP and DBP only in men, after adjustment for visceral adipose tissue (VAT) and BMI. Some workers also found varied relationship between NC and cardiometabolic risk factors in the men and women [18]. However, Zhou et al. [15] and Fan et al. [22] found that NC predicted hypertension in both men and women. The effect remained after adjustment for BMI, WC, WHpR and age. Using receiver operating characteristics (ROC) curve analysis, some workers also found that NC predicted arterial blood pressure with a large area under curve [29]. In addition to the relationship between NC and hypertension mentioned above, subcutaneous adipose tissue in the neck contributes to efflux of free fatty acids (FFA) which promotes insulin resistance. Some of the gender differences observed in the relationship between NC and BP may be due to varied metabolism of fatty acids in men and women [10]. Taken together, these findings suggest that NC is related to hypertension independent of other obesity indices.

In this study, the NC of men and women who were overweight or had general obesity were higher than those who were not. Among women, but not in men, the NC of those who had central obesity and hypertension were greater than those who were not. Some workers evaluated the predictive ability of NC for obesity and insulin resistance, and found that the mean NC of participants with overweight/general obesity was higher than those with normal weight [17]. Kumar et al. [18] examined the relationship between NC and metabolic syndrome among Indians, and found that compared with those without the syndrome, more people with metabolic syndrome had abnormal NC. Other workers also reported a higher mean NC in people with metabolic syndrome [25].

The current study further revealed that compared with those in the lower tertile, the mean of CVD risk factors were higher in those with NC in the middle/upper tertiles. In men no difference was found in the mean blood pressure and random blood glucose, while in women no difference was found in the mean random blood glucose. Saka et al. [11] and Selvan et al. [25] reported that participants with high NC were more likely to have cardiometabolic syndrome. Additionally, Selvan et al. [25] showed that more people in the higher tertile of NC had obesity

(general and central) and dyslipidemia, but not hypertension or diabetes mellitus. In a study, Joshipura and associates [26] divided the participants into two groups (normal or high) based on NC, and compared the mean of the CVD risk factors or percentages (for categorical variables) of those with abnormal CVD risk factors. These risk factors include blood pressure, plasma glucose, BMI, WC, HOMA-IR, body fat percentage, and lipids. They found the CVD risk factors to be more prevalent in those with high NC. Additionally the mean of CVD factors were higher in that group.

Summarily this study established a positive association between NC and CVD risk factors. Determination of NC can be used to identify people with adverse cardiometabolic profile, especially among women. As mentioned earlier, some of the gender differences observed in the relationship between NC and CVD risk factors may be due to varied metabolism of fatty acids in men and women [10].

This study is limited by cross-sectional design and small sample size. The findings may therefore not be generalized until a large scale study is conducted. Further, relationship between neck circumference and cardiometabolic risk factors such as triglycerides, total, low-density and high density cholesterol were not explored.

In conclusion, neck circumference has positive association with, and predicts cardiometabolic risk factors in Ekiti, Nigeria. It may serve as an index of obesity in the population studied.

References

1. World Health Organization, http://www.who.int/mediacentre/factsheets/fs311/en/
2. World Health Organization. Obesity: preventing and managing the global epidemic. Report of a WHO consultation. WHO Technical Report Series 894. Geneva: World Health Organization, 2000.
3. Okafor C, Gezawa I, Sabir A, Raimi T, Enang O. Obesity, overweight, and underweight among urban Nigerians. Nig J Clin Pract. 2014;17(6):743-9. doi:10.4103/1119-3077.144389
4. Alberti KG, Zimmet P, Shaw J. The metabolic syndrome-a new worldwide definition. Lancet. 2005;366(9491):1059-62.
5. Ashwell M, Gibson S. 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. 2016 Mar 14;6(3):e010159. doi:10.1136/bmjopen-2015-010159
6. Kim MK, Han K, Kwon HS, Song KH, Yim HW, Lee WC, et al. Normal weight obesity in Korean adults. Clin Endocrinol (Oxf). 2014;80(2):214-20. doi:10.1186/2052-9538-1-9
7. Pasco JA. Body mass index and measures of body fat for defining obesity and underweight: a cross-sectional, population-based study. BMC Obes. 2014 Jun 23;1:9. doi: 10.1186/2052-9538-1-9.
8. Dunkley AJ, Stone MA, Patel N, Davies MJ, Khunti K. Waist circumference measurement: knowledge, attitudes and barriers in patients and practitioners in a multi-ethnic population. Family Practice. 2009;26(5):365-71.
9. Brown RE, Randhawa AK, Canning KL, Fung M, Jiandani D, Wharton S, et al. Waist circumference at five common measurement sites in normal weight and overweight adults: which site is most optimal? Clin Obes. 2018;8(1):21-9. doi:10.1111/cob.12231
10. Preis SR, Massaro JM, Hoffmann U, D'Agostino RB Sr, Levy D, Robins SJ, et al. Neck circumference as a novel measure of cardiometabolic risk: the Framingham Heart study. J Clin Endocrinol Metab. 2010;95(8):3701-10. doi:10.1210/jc.2009-1779
11. Saka M, Türker P, Ercan A, Kızıltan G, Baş M. Is neck circumference measurement an indicator for abdominal obesity? A pilot study on Turkish Adults. Afr Health Sci. 2014;14(3):570-5. doi 10.4314/ahs.v14i3.11
12. Volaco A, Martins CM, Soares JQ, Cavalcanti AM, Moyses ST, Filho RP, et al. Neck Circumference and its Correlation to Other Anthropometric Parameters and Finnish Diabetes Risk Score (FINDRISC). Curr Diabetes Rev. 2017 Oct 2. pii: CDR-EPUB-86087 doi: 10.2174/1573399813666171002113442
13. Ozkaya I, Tunckale A. Neck Circumference Positively Related with Central Obesity and Overweight in Turkish University Students: A Preliminary Study. Cent Eur J Public Health. 2016;24(2):91-4. doi:10.21101/cejph.a4555
14. Alfadhli EM, Sandokji AA, Zahid BN, Makkawi MA, Alshenaifi RF, Thani TS, et al. Neck circumference as a marker of obesity and a predictor of cardiometabolic risk among Saudi subjects. Saudi Med J. 2017;38(12):1219-23. doi: 10.15537/smj.2017.12.20926
15. Zhou JY, Ge H, Zhu MF, Wang LJ, Chen L, Tan YZ, et al. Neck circumference as an independent predictive contributor to cardio-metabolic syndrome. Cardiovasc Diabetol. 2013;12:76. doi:10.1186/1475-2840-12-76
16. Li HX, Zhang F, Zhao D, Xin Z, Guo SQ, Wang SM, et al. Neck circumference as a measure of neck fat and abdominal visceral fat in Chinese adults. BMC Public Health. 2014;14:311. doi: 10.1186/1471-2458-14-311
17. Wang X, Zhang N, Yu C, Ji Z. Evaluation of neck circumference as a predictor of central obesity and insulin resistance in Chinese adults. Int J Clin Exp Med. 2015 Oct 15;8(10):19107-13. eCollection 2015.
18. Kumar NV, Ismail MH, Mahesha P, Girish M, Tripathy M. Neck circumference and cardio- metabolic syndrome. J Clin Diagn Res. 2014;8(7):23-5. doi: 10.7860/jcdr/2014/8455.4641
19. Verma M, Rajput M, Sahoo SS, Kaur N. Neck Circumference: Independent Predictor for Overweight and Obesity in Adult Population. Indian J Community Med. 2017;42(4):209-13. doi: 10.4103/ijcm.IJCM_196_16
20. Lindarto D, Shierly, Syafril S. Neck Circumference in Overweight/Obese Subjects who Visited the Binjai Supermall in Indonesia. Open Access Maced J Med Sci. 2016;4(3):319-23. doi:10.3889/oamjms.2016.072
21. Qureshi NK, Hossain T, Hassan MI, Akter N, Rahman MM, Sultana MM, et al. Neck Circumference as a Marker of Overweight and Obesity and Cut-off Values for Bangladeshi Adults. Indian J Endocrinol Metab. 2017;21(6):803-8. doi: 10.4103/ijem.IJEM_196_17
22. Fan S, Yang B, Zhi X, He J, Ma P, Yu L, et al. Neck circumference associated with arterial blood pressures and hypertension: A cross-sectional community-based study in northern Han Chinese. Sci Rep. 2017;7(1):2620. doi:10.1038/s41598-017-02879-7
23. Chobanian AV, Bakris GL, Black HR, Cushman WC, Green LA, Izzo JL, et al. Seventh report of the Joint National Committee on Prevention, Detection, Evaluation, and Treatment of High Blood Pressure. Hypertension. 2003;42:1206–52.
24. Adamu L, Asuku A, Taura M, Tela I, Datti SS, Imam A. Neck circumference: An upcoming tool of adiposity indices. Niger J Basic Clin Sci. 2013;10(2):82-5. doi:10.4103/0331-8540.122766
25. Selvan C, Dutta D, Thukral A, Nargis T, Kumar M, Mukhopadhyay S, et al. Neck height ratio is an important predictor of metabolic syndrome among Asian Indians. Indian J Endocrinol Metab. 2016;20(6):831-7. doi:10.4103/2230-8210.192927
26. Joshipura K, Munoz-Torres F, Vergara J, Palacios C, Perez CM. Neck Circumference May Be a Better Alternative to Standard Anthropometric Measures. J Diabetes Res. 2016;2016:6058916. doi:10.1155/2016/6058916
27. Ceccato F, Bernkopf E, Scaroni C. Sleep apnea syndrome in endocrine clinics. J Endocrinol Invest. 2015;38(8):827-34. doi: 10.1007/s40618-015-0338-z
28. Simonenko VB, Goriutskii VN, Dulin PA. The role of insulin resistance in pathogenesis of arterial hypertension. Klin Med (Mosk). 2014;92(9):27-33.
29. Assyov Y, Gateva A, Tsakova A, Kamenov Z. A comparison of the clinical usefulness of neck circumference and waist circumference in individuals with severe obesity. Endocr Res. 2017;42(1):6-14. doi:10.3109/07435800.2016.1155598