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Appropriate Neck Circumference Cut-off Points for Abdominal Obesity in Bantu Population from Brazzaville in Republic of Congo

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Abstract: *aims*: To investigate the association between neck circumference (NC) and abdominal obesity indicators: waist circumference (WC), waist-to-hip ratio (WHR), waist-to-height ratio (WHtR), Lipid Accumulation Product (LAP), Visceral Adiposity Index (VAI) and Abdominal volume index (AVI), in Bantu population at Brazzaville. *Methods*: A total of 500 subjects (mean age: 47.2±13.6 years) were recruited in Brazzaville to perform anthropometric measurements, including WC and hip circumference (HC), NC, body mass index (BMI), Blood pressure, fasting glucose and insulin, and lipid profile (total cholesterol TC, high-density lipoprotein cholesterol HDL, low-density lipoprotein cholesterol LDL, and triglyceride TG levels) were determined. The LAP, VAI and AVI were calculated as: LAP=[WC (cm) – 65] x TG (mmol/l); VAI=[WC (cm) / 39.68+ 1.88 x BMI (kg/m^2)] x [TG (mmol/l)/1.03) x [1.31/ HDL (cm)] for males and LAP=[WC (cm) – 58] x TG (mmol/l); VAI=[WC (cm) / 36.58+ 1.89 x BMI (kg/m^2)] x [TG (mmol/l)/0.81) x [1.52/ HDL (cm)] for females. For both males and females: AVI=[2 cm x WC^2 (cm)^2 + 0.7 cm x (WC – HC)^2]/1000. *Results*: NC was significantly ($p<0.001$) associated with visceral obesity and those fatness indices evaluating visceral fat distribution, including WC, WHR, WHtR, VAI, LAP and AVI. After applying the ROC analysis, NC ≥ 38 cm in males and 33 cm in females were determined as the best cut-off values to predict visceral obesity. These cut-off values had accuracy for diagnosis of visceral obesity with AUC of 0.944 (95% 0.904, 0.983) for males and 0.886 (95% 0.834, 0.938) for females. *Conclusion*: our findings suggest a positive correlation of NC with abdominal obesity in Bantu population, and could be a useful and accurate tool to identify visceral obesity.

Keywords: Neck Circumference, Abdominal Obesity, Bantu, Brazzaville

1. Introduction

Obesity is a public health problem related to cardiovascular diseases, metabolic syndrome, cancer and other comorbidities [1]. Upper-body distribution of fat is more predictive of metabolic and cardiovascular diseases than whole body obesity. Body mass index (BMI), a traditional anthropometric marker used in majority of the epidemiological studies, is not the best method to evaluate central obesity [2-4]. Computed tomography (CT), magnetic resonance imaging (MRI) and dual-energy X-ray absorptiometry (DEXA) are sophisticated methods to assess visceral adiposity and are impractical in general population [5]. Many anthropometric parameters such waist circumference (WC), waist-to-hip ratio (WHR), waist-to-height ratio (WHtR) and recent indices like the visceral adiposity index (VAI), the lipid accumulation product (LAP) and the abdominal volume index (AVI), were been suggested to estimate visceral obesity [6, 7]. NC a simple and alternative anthropometric measure was proposed as an index of central obesity. NC is associated with other cardiovascular risk factors, such as dyslipidemia, arterial hypertension, hyperuricemia and insulin resistance [8-10]. Therefore, the aim of this study was to investigate the association of NC with the visceral obesity indicators (WC, WHR, WHtR, LAP, VAI and AVI) among Bantu population and to determine cut-off values of NC for identify visceral obesity.

2. Patients and Methods

2.1. Study Population

A cross-sectional survey on the diagnostic performance of the TG/HDL ratio in Insulin resistance in apparently healthy Congolese adults was done in Brazzaville. The details of the study design have been described previously [11]. In brief, the study was performed from February 14 to May 22, 2019. People (aged 20–80 years) who had lived in the community over 10 years, with informed consent were included. All participants under the age of 20, a known Diabetes mellitus (DM), with severe disabilities, hepatic failure, renal failure or goiter were excluded. A total of 500 participants were analyzed in this study.

2.2. Clinical and Anthropometric Evaluation

Waist circumference (WC) was measured using flexible tape between the highest lateral edge of the right and left Ilium. Neck circumference (NC) was measured in the middle of the neck between the mid-cervical spine and the mid-anterior neck at 0.5 cm, so palpable, just below the laryngeal prominence. BMI was calculated as the weight in kilograms divided by the height in meters squared. WHR and WHtR were calculated as waist circumference divided by hip circumference and height, respectively. Blood pressure (BP) was measured 3 times in a sitting position after at least 15 minutes of rest using an electronic type blood pressure monitor (OMRON M3 IT). The average of 3 recorded systolic and diastolic BP values was used in the analysis. The LAP, VAI and AVI were calculated as follows [6, 12, 13]:

Males:

$$LAP=[WC\ (cm) - 65] \times TG\ (mmol/l)$$

$$VAI=[WC\ (cm) / 39.68 + 1.88 \times BMI\ (kg/m^2)] \times [TG\ (mmol/l)/1.03] \times [1.31/ HDL\ (cm)]$$

Females:

$$LAP=[WC\ (cm) - 58] \times TG\ (mmol/l)$$

$$VAI=[WC\ (cm) / 36.58 + 1.89 \times BMI\ (kg/m^2)] \times [TG\ (mmol/l)/0.81] \times [1.52/ HDL\ (cm)]$$

For both males and females: $AVI=[2\ cm \times WC^2\ (cm)^2 + 0.7\ cm \times (WC - HC)^2] /1000$

2.3. Biochemical Measurements

Peripheral venous blood samples were drawn after an overnight fast of at least 8 h. The blood samples for the plasma glucose test were collected into vacuum tubes with the anticoagulant sodium fluoride and centrifuged within 1 h after collection. Plasma fasting concentrations of Glucose (FPG), Total Cholesterol (TC), Triglycerides (TG), high-density lipoprotein cholesterol (HDL) and Uric acid were measured using the standard procedure using a COBAS e411 (Roche Germany). Insulin was detected by the immunochemistry method. Then, insulin resistance was estimated by the homeostatic model assessment (HOMA-IR) index: [FI (mIU/L) × FPG (mmol/L)]/22.5.

2.4. Definition of Variables

Visceral obesity was defined as a waist circumference WC ≥ 81 cm in both males and females [14].

2.5. Statistical Analysis

Data analyses were performed with the software package SPSS Statistics, Version 21 (IBM Corporation, Armonk, NY, USA). Normally distributed data were expressed as the means±SD, whereas continuous variables with a skewed distribution were summarized as the median with interquartile range. To compare the differences between groups, one-way analysis of variance (ANOVA) was used for continuous variables with a Gaussian distribution, and the Mann-Whitney U test was used for variables with a skewed distribution. Spearman's correlation coefficient was employed to test the correlations between different variables. The association of NC (independent variable) with fatness indices including WC, WHR, WHtR, VAI, LAP, VAI and AVI (dependent variables) was assessed by linear regression. Model 1 did not adjust for any factors. Multivariate linear regression was used to determine the influence of visceral adiposity indicators on the NC. The receiver operating characteristics (ROC) curve analysis had allowed determining the optimal threshold of NC to detect the presence of visceral obesity. A P value < 0.05 was considered statistically significant.

2.6. Ethical Consideration

The study design protocol was approved by the Ethics Committee of Lomo University of Research. Written informed consents were obtained from all patients. All procedures were in accordance with the Helsinki Declaration of 1975, as revised in 2008.

3. Results

3.1. General Characteristics of the Study Population

Five hundred participants, including 275 women and 225 men (sex ratio 1.2), were enrolled. The general characteristics of the study population are listed in Table 1. These subjects had the mean or median of age, BMI, WC and NC respectively of 47.2±13.6 years, 25.6 kg/m^2, 93 cm and 36.4±2.9 cm. The visceral adiposity indicators (WC, HC, WHtR, LAP, VAI, AVI), TC and TG were significantly elevated in women. However, men had significantly higher NC (34.5±2.0 cm; p <0.001) and FPG levels.

Table 1. *General characteristic of study participants by sex.*

Variables	All	Male	Female	*p*
N	500	225	275	
Age (y)	47.2±13.6	47.9±13.1	46.6±14.1	0.269
BMI (kg/m^2)	25.6 (22.6–29.3)	24.6 (21.9–26.8)	27.2 (24.0– 38.8)	<0.001
WC (cm)	93 (85–103)	93 (85–100)	108 (85–104)	0.009
HC (cm)	106 (93–113)	103 (92.5–112)	108 (94– 115)	0.008
NC (cm)	36.4±2.9	38.8±1.9	34.5±2.0	<0.001
WHR	0.89 (0.83 – 0.95)	0.89 (0.83 – 0.96)	0.89 (0.84 – 0.95)	0.894
WHtR	0.55±0.09	0.53±0.07	0.58±0.09	<0.001
SBP (mmHg)	120 (112 – 130)	120 (113 – 130)	120 (110 – 130)	0.683
DBP (mmHg)	74 (60 – 80)	70 (60 – 80)	78 (60 – 80)	0.804
FPG (mmol/l)	4.66 (4.21–5.44)	4.83 (4.33 – 5.61)	4.61 (4.16 – 5.39)	0.022
TC (mmol/l)	1.60 (1.42 –1.90)	1.53 (1.40 – 1.88)	1.70 (1.50 – 1.90)	0.003
TG (mmol/l)	1.51 (1.22 – 1.76)	1.38 (1.14 – 1.76)	1.56 (1.29 – 1.76)	0.036
HDL (mmol/l)	0.71 (0.55 – 0.82)	0.68 (0.54– 0.78)	0.73 (0.56 – 0.85)	0.005
LDL (mmol/l)	0.66±0.26	0.65±0.27	0.67±0.24	0.485
Insulin (mIU/l)	8.82 (6.86 –12.05)	8.58 (6.48– 11.67)	9.06 (7.08– 12.25)	0.091
HOMA-IR	1.87 (1.44– 2.69)	1.86 (1.44–2.71)	1.87 (1.42 –2.67)	0.849
LAP	49.3±26.4	39.5±20.8	57.2±27.8	<0.001
VAI	3.41 (2.61– 4.71)	2.20 (2.15 – 3.64)	4.25 (3.09 – 5.38)	<0.001
AVI	17.8±4.8	17.2±4.3	18.3±5.1	0.010

Data were presented as the mean±SD for continuous variables with a normal distribution and as the median (interquartiles range) for continuous variables with a skewed distribution. One–way ANOVA and the Mann-Whitney U test were used to compare the differences between groups, BMI body mass index, WC waist circumference, HC hip circumference, NC neck circumference, WHR waist-to-hip ratio, WHtR waist-to-height ratio, SBP systolic blood pressure, DBP diastolic blood pressure, FPG fasting plasma glucose, HOMA-IR insulin resistance index, TG triglycerides, TC total cholesterol, LDL low-density lipoprotein, HDL high-density lipoprotein, VAI visceral adiposity index, LAP lipid accumulation product, AVI abdominal volume index.

3.2. Correlation Between Neck Circumference and Fatness Indicators

Table 2 demonstrated the correlation between NC and visceral adiposity indicators. The NC was positively correlated with WC, HC, WHtR, LAP and AVI in both males and females (all *p* <0.001).

Table 2. *Correlation between neck circumference and fatness indices by sex.*

Variables	Male		Female	
	rho	*p*	*rho*	*p*
WC (cm)	0.597	<0.001	0.659	<0.001
HC (cm)	0.603	<0.001	0.624	<0.001
WHR	0.021	0.902	0.120	0.047
WHtR	0.630	<0.001	0.723	<0.001
LAP	0.559	<0.001	0.617	<0.001
VAI	0.124	0.063	0.198	0.001
AVI	0.622	<0.001	0.683	<0.001

Data were Spearman's rho correlation coefficients.

3.3. Association of Visceral Adiposity Indicators with NC

Table 3 summarized the results of univariate linear regression models analyzing the association of NC with WC, HC, WHtR, LAP and AVI. In basis model, the NC (independent variable) was associated with all visceral adiposity indicators (dependent variables) in both males and females (all *p* <0.001), excepted for WHR.

Table 3. *Association of NC with visceral adiposity indicators by sex: univariate linear regression.*

Dependent variables	Male				Female			
	β	B (95% CI)	*p*	R^2	β	B (95% CI)	*p*	R^2
WC	0.597	3.889 (3.200 – 4.578)	<0.001	0.357	0.659	4.641 (4.010 – 5.272)	<0.001	0.434
HC	0.603	4.294 (3.545 – 5.044)	<0.001	0.364	0.624	4.486 (3.816 – 5.155)	<0.001	0.389
WHtR	0.630	0.024 (0.020 – 0.028)	<0.001	0.397	0.723	0.035 (0.028 – 0.035)	<0.001	0.523
LAP	0.559	6.097 (4.890 – 7.304)	<0.001	0.313	0.617	8.403 (7.114 – 9.692)	<0.001	0.381
AVI	0.622	1.408 (1.174 – 1.642)	<0.001	0.387	0.683	1.710 (1.492 – 1.928)	<0.001	0.467

R^2 represented the coefficient of determination.

Table 4 shows the multiple linear regression analysis of the relationship between NC (dependent variable) and adiposity indicators. HC (predictive variable) had the best influence on NC in males. In females, WC had the best influence on NC (p <0.001).

Table 4. *Association of visceral adiposity indicators (predictive variables) with NC: multivariate linear regression.*

Predictive variables	Male			Female		
	β	*t*	*p*	β	t	*p*
WC (cm)	0.326	3.99	<0.001	0.439	6.345	<0.001
HC (cm)	0.351	4.30	<0.001	0.286	4.140	<0.001

R^2=0.406 in male and 0.468 in female.

Table 5 shows the summary of nonlinear regression analysis to determine the relationship between NC (independent variable) and visceral adiposity indicators. Comparing the coefficient of determination (R^2), quadratic model was better than the linear model for all dependent variables. All visceral adiposity parameters were significantly associated with NC.

Table 5. *Nonlinear regression analysis (quadratic model) of association between NC with visceral adiposity indicators by sex.*

Dependent variables	Male			Female		
	R^2	B_1	B_2	R^2	B_1	B_2
WC	0.408	43.62	- 0.503	0.472	37.32	- 0.464
HC	0.402	41.73	- 0.474	0.444	44.75	- 0.571
WHtR	0.459	0.278	- 0.003	0.568	0.254	- 0.003
LAP	0.355	67.91	- 0.781	0.395	46.99	- 0.547
AVI	0.433	14.58	- 0.167	0.495	11.69	- 0.142

R^2represented the coefficient of determination.

3.4. Cut-off Value of NC to Detect the Visceral Adiposity

Table 6 demonstrated the results of the receiver operating characteristics (ROC) curve analyze for determining the optimal threshold of NC to detect the presence of visceral obesity. Areas under curve were 0.944 (IC 95% 0.904 to 0.983; p <0.001) and 0.886 (IC 95% 0.834 to 0.938; p<0.001) respectively in males and females. The cut-off values of NC were 37.3 cm and 33.3 cm respectively in males and females, with high sensitivity (81.7% versus 81.4%) and specificity (88.2% versus 82.4%) in both groups.

Table 6. *Results of the ROC curve analyze for identifying optimal cut-off point of NC to detect the presence of visceral obesity (WC ≥ 81 cm).*

Variable	AUC (95% CI)	SE	*p*	Cut-off	Se (%)	Sp (%)	Yi
Male	0.944 (0.904 – 0.983)	0.029	<0.001	37.7	81.7	88.2	0.699
Female	0.886 (0.834 – 0.938)	0.026	<0.001	33.3	81.4	82.4	0.634

AUC area under curve, SE standard error, Se sensitivity, Sp specificity, Yi Youden index.

4. Discussion

The most important advantage of this study is that it is the first study to verify the association between NC and fatness indices in the general Bantu population, particularly at Brazzaville.

This study found that NC was highly correlated with all the anthropometric indices of visceral obesity. After full adjustment for metabolic factors, NC was still significantly associated with visceral obesity and those fatness indices evaluating visceral fat distribution, including WC, WHR, WHtR, VAI, LAP and AVI. In our study, NC is significantly correlated with these visceral adiposity indicators; which corresponded well with previous studies [15-17].

Another interesting finding from our study was that NC had a strong positive correlation with BMI. A cross-sectional study on Indian Type 2 diabetic patients found NC to be highly correlated with BMI [18]. However, BMI can neither distinguish between fat and lean tissues nor identify the anatomic location or function of distinct fat depots [12, 19].

After applying the ROC analysis, NC ≥ 38 cm in males and 33 cm in females were determined as the best cut-off values to predict visceral obesity. These cut-off values had accuracy for diagnosis of visceral obesity with AUC of 0.944 (95% 0.904, 0.983) for males and 0.886 (95% 0.834, 0.938) for females. In previous study, *Thunyarat et al* found cut-off values of 38 cm in males and 32 cm in females [20].

Our study has the following limitations. First, by its cross-sectional nature, associations are not prospective and causal links cannot be inferred. Second, the number of participants in this study was relatively small. Third, because of the sample of subjects living in urban areas, the results cannot be generalized to individuals in rural areas. Future surveys are needed to assess NC in different Congolese populations.

5. Conclusion

Neck circumference was found to be strongly correlated with visceral adiposity indicators. NC $\geq$ 38 cm in males and that $\geq$ 33 cm in females were the best cut-off for identifying subjects with central obesity. Neck circumference could be considered as an alternative to WC measurement in screening of visceral obesity.

Author's Contributions

DMM, RFELS and ANN designed and analyzed the statistical data for the study. BLM, JBKL, EM supervised the study. All authors have read and approved the final and revised version of the manuscript.

Conflict of Interest

The authors declare no conflict of interest.

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References

[1] Mello AC, Engstrom EM, Alves LC. Health-related and socio-demographic factors associated with fraily in elder: a systematic literature review. Cad Sauda Publica 2014; 30: 1143-68.

[2] Calle EE, Thum MJ, Petrelli JM, Rodriguez C, Health Jr. CW. Body mass index and mortality in a prospective cohort of U. S. adults. N Engl J Med 1999; 341: 1097-105.

[3] Perssimoto E, Pisent C, Sergi G, Grigoletto F, Enzi G. anthropometric measurements in the elderly, age and gender differences. Br J Nutr 2002; 87: 177-86.

[4] Wannamethee SG, Shaper AG, Morris RW, Whincup PH, Walker M. Overweight and obesity and the burden of disease and disability in elderly men. Int J Obes Relat Metab Disord 2004; 28: 1374-82.

[5] Zhang M, Zheng L, Li P, Zhu Y, Chang H, Wang X, Liu W, Zhang Y, Huang G. Four-year trajectory of visceral adiposity index in the development of type 2 diabetes: a prospective cohort study. Ann Nutr Metab. 2016; 69: 142–9.

[6] Guerrero-Romero F, Rodriguez-Moran M. Abdominal volume index. An anthropometry-based index for estimation of obesity is strongly related to impaired glucose tolerance and type 2 diabetes mellitus. Arch Med Res. 2003; 34: 428–32.

[7] de Oliveira CC, Roriz AK, Ramos LB, Gomes Neto M. Indicators of adiposity predictors of metabolic syndrome in the elderly. Ann Nutr Metab. 2017; 70: 9–15.

[8] Stabe C, Vasques AC, Lima MM, Tambascia MA, Pareja JC, Yamanaka A, et al. Neck circumference as a simple tool for identify the metabolic syndrome and insulin resistance: results from the Brazilian Metabolic Syndrome Study. Clin Endocrinology (Oxf) 2013; 78: 874-81.

[9] Dai Y, Wan X, Li X, Jin E, Li X. Neck circumference and future cardiovascular events in a high-risk population: a prospective cohort study. Lipids in Health and Disease 2016; 15: 46 https://doi.org/10.1186/s12944-016-0218-3.

[10] Preis SR, Massaro JM, Hoffmann U, D'Agostino Sr. RB, Levy D, Robins SJ, et al. neck circumference as o novel measure of cardiovascular risk: the Framingham Heart study. J Clin Endocrinol Metab 2010; 95: 3701-10.

[11] Eboka-Loumingou Sakou RF, Longo-Mbenza B, GUIE G, Mûnka Nkalla-Lambi A, Mokondjimobe E, Monabeka HG, Tukadila HA, Aliocha Nkodila Natuhoyila. Diagnostic Performance of the TG/HDL-C Ratio in the Prediction of Insulin Resistance in Brazzaville, Republic of Congo. International Journal of Health Sciences and Research. Vol. 10; Issue: 1; January 2020: 135–145.

[12] Khan HS. The lipid accumulation product is better than BMI for identifying diabetes. A population-based comparison. Diabetes care, 2006; 29: 151-3. PMID: 16373916.

[13] Amato MC, Giordano C, Galia M, Criscimanna A, Vitabile S, Midiri M, et al. Visceral adiposity index. A reliable indicator of visceral fat function associated with cardiometabolic risk. Diabetes Care. 2010; 33: 920–922. PMID: 20067971 https://doi.org/10.2337/dc09-1825.

[14] Ekoru K, Murphy GAV, Young EH, Delisle H, Jerome CS, Assah F, Longo–Mbenza B. Deriving an optimal threshold of waist circumference for detecting cardiometabolic risk in sub-Saharan Africa. International Journal of Obesity (2018) 42, 487–494; https://doi.org/10.1038/ijo.2017.240.

[15] Luo Y, Ma X, Shen Y, Xu Y, Xiong Q, Zhang X, et al. Neck circumference as an effective measure for identifying cardio-metabolic syndrome: a comparison with waist circumference. Endocrine. 2017; 55: 822–30.

[16] Dai Y, Wan X, Li X, Jin E, Li X. Neck circumference and future cardiovascular events in a high-risk population–a prospective cohort study. Lipids Health Dis. 2016; 15: 46.

[17] Zhao L, Huang G, Xia F, Li Q, Han B, Chen Y, et al. Neck circumference as an independent indicator of visceral obesity in a Chinese population. Lipids in Health and Disease (2018) 17: 85 https://doi.org/10.1186/s12944-018-0739-z.

[18] Nowreen N, Sangra S, Sachdev S. Neck circumference as an alternative anthropometric measure of obesity in patients of Type 2 Diabetes Mellitus – A Hospital based study. IOSR journal of Dental and Medical Sciences (April 2017) 16 (4): 27-30; https://doi.org/10.9790/0853-1604062730.

[19] Kahn HS. The "lipid accumulation product" performs better than the body mass index for recognizing cardiovascular risk: a population-based comparison. BMC Cardiovasc Disord. 2005; 5: 26.

[20] Thunyarat A, Nakarin S, Sangsule T, Dumrongrat L, Ammarin T. Neck circumference as an Anthropometric indicator of central obesity in patients with prediabetes: A cross-sectional study. Hindawi Biomed Research International (2019), https://doi.org/10.1155/2019/4808541.