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Neck Circumference Is Better Associated Than Waist Circumference at Insulin Resistance in Bantu Population from Brazzaville in Republic of Congo

Danny Mafuta-Munganga[1], Reine Freudlendrich Eboka-Loumingou Sakou[2], Benjamin Longo-Mbenza[1, 3, 4], Etienne Mokondjimobe[2, 3], Blaise Makoso Nimi[1, 3, 5]

[1]Department of Internal Medicine, University of Kinshasa, Kinshasa, Democratic Republic of Congo

[2]Faculty of Health Sciences, Marien Ngouabi University, Brazzaville, Republic of Congo

[3]Department of Public Health, Lomo University of Research, Kinshasa, Democratic Republic of Congo

[4]Faculty of Health Sciences, Walter Sisulu University, Mthatha, South Africa

[5]Department of Internal Medecine, University of President Joseph KASA-VUBU, Boma, Democratic Republic of Congo

Email address:

danny.mafuta@gmail.com (D. Mafuta-Munganga), eliahdereine@gmail.com (R. F. Eboka-Loumingou S.), longombenza@gmail.com (B. Longo-Mbenza), mmobet@yahoo.fr (E. Mokondjimobe)

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Abstract: *Background:* it is difficult to measure directly insulin sensitivity in routine practice. An easily measured anthropometric parameter associated with insulin resistance (IR) would be a very useful tool in detecting people at risk. *Objective:* To investigate the association between neck circumference (NC) and Insulin Resistance (IR) in Bantu population. *Methods:* Cross-sectional health screening conducted between February and May 2019, among Bantu population from Brazzaville in Republic of Congo. The analysis included 500 participants, aged ≥ 20 years. Anthropometric indices and blood pressure were measured by standard protocol. Fasting lipid profile, blood glucose and insulin were determined. Triglyceride Glucose index (TyG index) and triglyceride/high density lipoprotein ratio (TG/HDL) were calculated. IR was defined as HOMA-IR ≥ 2. TyG index was calculated by using the formula: Ln [TG (mg/dL) x FPG (mg/dL)/2]. To investigate if there was a statistically association between NC and IR parameters, a correlation was computed. To evaluate the influence of NC on IR parameters, the study population was divided in 3 groups by tertiles of NC in both men and women The diagnostic ability of NC, WC, TyG index and TG/HDL ratio to identify people with IR was determined with the receiver operating characteristic (ROC) curves. *Results:* NC was positively correlated with insulin, TG/HDL, TyG index and HOMA-IR. For all variables, this correlation was stronger in comparison with WC. In all participants, TG/HDL shows the largest AUC for IR detection (0.810, 95% CI: 0.765–0.855) followed by TyG index (0.799, 95% CI: 0.754–0.844), NC (0.624, 95% CI: 0.572–0.677), and WC (0.616, 95% CI: 0.560–0.672) in that order. *Conclusion:* NC is associated with IR. NC is better than WC to identify IR in Bantu population from Brazzaville in republic of Congo.

Keywords: Neck Circumference, Insulin Resistance, Bantu, Brazzaville

1. Introduction

Insulin resistance (IR) is considered as a major cardio-metabolic risk factor. IR can be evaluated directly by invasive methods, including the hyperinsulinemic-euglycemic clamp technique [1-4]. These techniques are not accessible in current medical practice due to their invasiveness and their high cost for the vast majority of patients. Thus, several indexes have been proposed to indirectly measure cells insulin sensitivity. These are the assessment of the homeostasis model for insulin resistance (HOMA-IR) [5], the metabolic score for IR [6] and the triglyceride glucose index (TyG index) as well as TyG linked

[7-9]. The dosage of insulin remains expensive to perform in current practice. It is for this reason; in the present study the objective is to evaluate the association between the neck circumference (NC), an anthropometric parameter easy to measure and the IR parameters (HOMA-IR, TyG index) in the Bantu population in sub-Saharan Africa.

2. 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 [10]. 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. Ethical Consideration

Written informed consents were obtained from all patients. All procedures were in accordance with the Helsinki Declaration of 1975, as revised in 2008.

2.3. 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. 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).

2.4. 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.

2.5. Definition of Variables

1. Insulin resistance was estimated by HOMA-IR using the formula [5]: [Fast insulin (mIU/L) × FPG (mmol/L)]/22.5.
2. Insulin resistance was defined as a HOMA-IR ≥ 2.5
3. The TyG index was calculated as the natural logarithm (Ln) of the product of FPG and TG using the formula [7]: TyG index = Ln [TG(mg/dL) x FPG(md/dL)/2]

2.6. Statistical Analysis

Data analyses were performed with the software package SPSS Statistics, Version 21 (IBM Corporation, Armonk, NY, USA). Kolmogorov–Smirnov test of normality was used to determine the distribution of continuous variables. Normally distributed data were expressed as the means ± SD, whereas continuous variables with a skewed distribution were summarized as the median with interquartile range. Variables that are normally distributed were compared with independent sample t-test, whereas variables that are not normally distributed were compared with the Mann–Whitney test. Spearman's correlation coefficient was employed to test the correlations between different variables. The diagnostic ability of NC, WC, TyG index and TG/HDL ratio to identify people with IR was determined with the receiver operating characteristic (ROC) curves. A P value < 0.05 was considered statistically significant.

3. Results

Five hundred participants were enrolled. The mean of age was 47.2 years. The age, systolic blood pressure (SBP), diastolic blood pressure (DBP) and total cholesterol (TC) were similar in both IR and control groups. Table 1 shows generals characteristics of study population according to the IR status.

Table 2 demonstrated the correlation of NC and WC with IR parameters. To investigate if there was a statistically association between neck circumference and IR parameters, a correlation was computed. The NC was positively correlated with insulin, TG/HDL, TyG index and HOMA-IR in both males and females (all p <0.05). For all variables, this correlation was stronger in comparison with WC.

Table 1. *General characteristics of study participants by the presence of IR.*

Variables	All (n=500)	IR (+) (n=137)	IR (-) (n=363)	*p*
Age, year	47.2 ± 13.6	48.2 ±12.5	46.8± 14.1	0.281
BMI, kg/m^2	26.4 ± 5.1	28.6 ±5.6	25.6± 4.6	<0.001
NC, cm	36.4 ± 2.9	37.4 ±2.7	36.1± 2.9	<0.001
WC, cm	93 (85–103)	98.0 (89.5 – 105.0)	93.0 (85.0 – 101.0)	<0.001
SBP, mm Hg	120 (112 – 130)	120 (110 – 130)	120 (112 – 130)	0.436
DBP, mm Hg	74 (60 – 80)	79 (60 – 81)	70 (60 – 80)	0.667
TC, mg/dl	61.8 (54.9 – 73.4)	65.6 (55.6 – 75.7)	61.8 (54.8 – 71.4)	0.121
HDL, mg/dl	27.4 (21.2 – 31.7)	22.4 (18.5 – 27.4)	29.3 (22.4 – 33.2)	<0.001

Variables	All (n=500)	IR (+) (n=137)	IR (-) (n=363)	*p*
TG, mg/dl	133.2 (108.0 – 155.8)	153.1 (122.1 – 167.3)	122.1 (100.9 – 154.0)	<0.001
TG/HDL	2.14 (1.63 – 2.66)	2.78 (2.36 – 3.32)	1.96 (1.45 – 2.34)	<0.001
FPG, mg/dl	84.0 (76.0 – 98.0)	99.0 (81.0 – 151.5)	82.0 (74.0 – 93.0)	<0.001
Insulin, UI/ml	8.8 (6.9 – 12.0)	14.4 (12.0 – 17.1)	7.8 (6.4 – 9.7)	<0.001
HOMA-IR	1.87 (1.44– 2.69)	3.43 (2.90 – 4.39)	1.63 (1.31 – 2.02)	<0.001
TyG index	8.64 (8.37 – 8.88)	8.91 (8.70 – 9.30)	8.54 (8.26 – 8.75)	<0.001

IR+ presence of insulin resistance, *IR-* absence of insulin resistance, *BMI* body mass index, *WC* waist circumference, *NC* neck circumference, *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, *TyG* triglyceride glucose index

Table 2. *Correlation of IR parameters with neck and waist circumference stratified by gender.*

Variable	Male				Female			
	NC		WC		NC		WC	
	r_s	*p*-value	r_s	*p*-value	r_s	*p*-value	r_s	*p*-value
TG/HDL	0.132	0.047	0.090	0.177	0.222	<0.001	0.193	0.001
TyG index	0.230	0.001	0.153	0.022	0.291	<0.001	0.235	<0.001
Insulin	0.141	0.034	0.132	0.048	0.337	<0.001	0.231	<0.001
HOMA-IR	0.228	0.001	0.157	0.019	0.395	<0.001	0.247	<0.001

rs: Spearman coefficient

To evaluate the influence of NC on IR parameters, the study population was divided in 3 groups by tertiles of NC in both men and women. HOMA-IR and TyG index were significantly higher in the third tertile in comparison with the first and the second tertiles in men (table 3). However, the TG/HDL ratio, HOMA-IR, insulin and TyG index were significantly (all $p<0.001$) highest among the third tertile of NC in women (table 4).

Table 3. *IR parameters according to the tertiles of neck circumference in men.*

Variables	All	T1 (< 37.7 cm)	T2 (37.7 – 39.4 cm)	T3 (> 39.4 cm)	*p*
N	225	75	76	74	
TG/HDL	2.21 (1.62 – 2.66)	2.06 (1.53 – 2.48)	2.26 (1.63 – 2.75)	2.29 (1.65 – 2.91)	0.193
TyG index	8.63 (8.32 – 8.84)	8.53 (8.21 – 8.78)	8.66 (8.32 – 8.95)	8.71 (8.40 – 9.02)	0.010
Insuline (UI/ml)	8.6 (6.5 – 11.7)	7.5 (6.2 – 11.0)	8.7 (6.8 – 12.0)	9.0 (6.7 – 12.8)	0.189
HOMA-IR	1.86 (1.44 – 2.71)	1.74 (1.25 – 2.32)	1.98 (1.50 – 2.89)	2.12 (1.48 – 3.16)	0.005

Table 4. *IR parameters according to the tertiles of neck circumference in women.*

Variables	All	T1 (< 33.5 cm)	T2 (33.5 – 35.1 cm)	T3 (> 35.1 cm)	*p*
N	275	91	93	91	
TG/HDL	2.13 (1.64 – 2.66)	1.97 (1.14 – 2.50)	2.10 (1.46 – 2.40)	2.34 (1.91 – 2.98)	<0.001
TyG index	8.65 (8.41 – 8.89)	8.53 (8.27 – 8.80)	8.64 (8.36 – 8.88)	8.75 (8.59 – 9.04)	<0.001
Insuline (UI/ml)	9.1 (7.1 – 12.3)	8.1 (6.4 – 10.6)	8.4 (7.0 – 10.7)	12.0 (8.5 – 16.5)	<0.001
HOMA-IR	1.87 (1.42 – 2.67)	1.55 (1.30 – 1.94)	1.83 (1.42 – 2.31)	2.76 (1.89 – 3.54)	<0.001

Figure 1A–C shows the ROC curve analyses. Table 5 carries the corresponding AUCs (95% confidence interval, CI). NC, WC, TG/HDL and TyG index significantly identified IR in all participants as well as in both genders. In all individuals, TG/HDL presents the largest AUC for IR identification (0.810, 95% CI: 0.765–0.855) followed by TyG index (0.799, 95% CI: 0.754–0.844), NC (0.624, 95% CI: 0.572–0.677), and WC (0.616, 95% CI: 0.560–0.672) in that order. Gender analysis revealed that NC has large AUC than WC in both men and women, implying that it may better identify IR.

Table 5. *Results of the AUC for NC, WC, TG/HDL and TyG index for IR identification*

Variables	All			Male			Female		
	AUC	95% CI	*p*	AUC	95% CI	*p*	AUC	95% CI	*p*
NC, cm	0.624	0.572 – 0.677	<0.001	0.605	0.525 – 0.685	0.015	0.727	0.656 – 0.797	<0.001
WC, cm	0.616	0.560 – 0.672	<0.001	0.577	0.495 – 0.660	0.042	0.653	0.578 – 0.728	<0.001
TG/HDL	0.810	0.765 – 0.855	<0.001	0.774	0.700 – 0.849	<0.001	0.840	0.786 – 0.895	<0.001
TyG index	0.799	0.754 – 0.844	<0.001	0.803	0.736 – 0.870	<0.001	0.796	0.736 – 0.857	<0.001

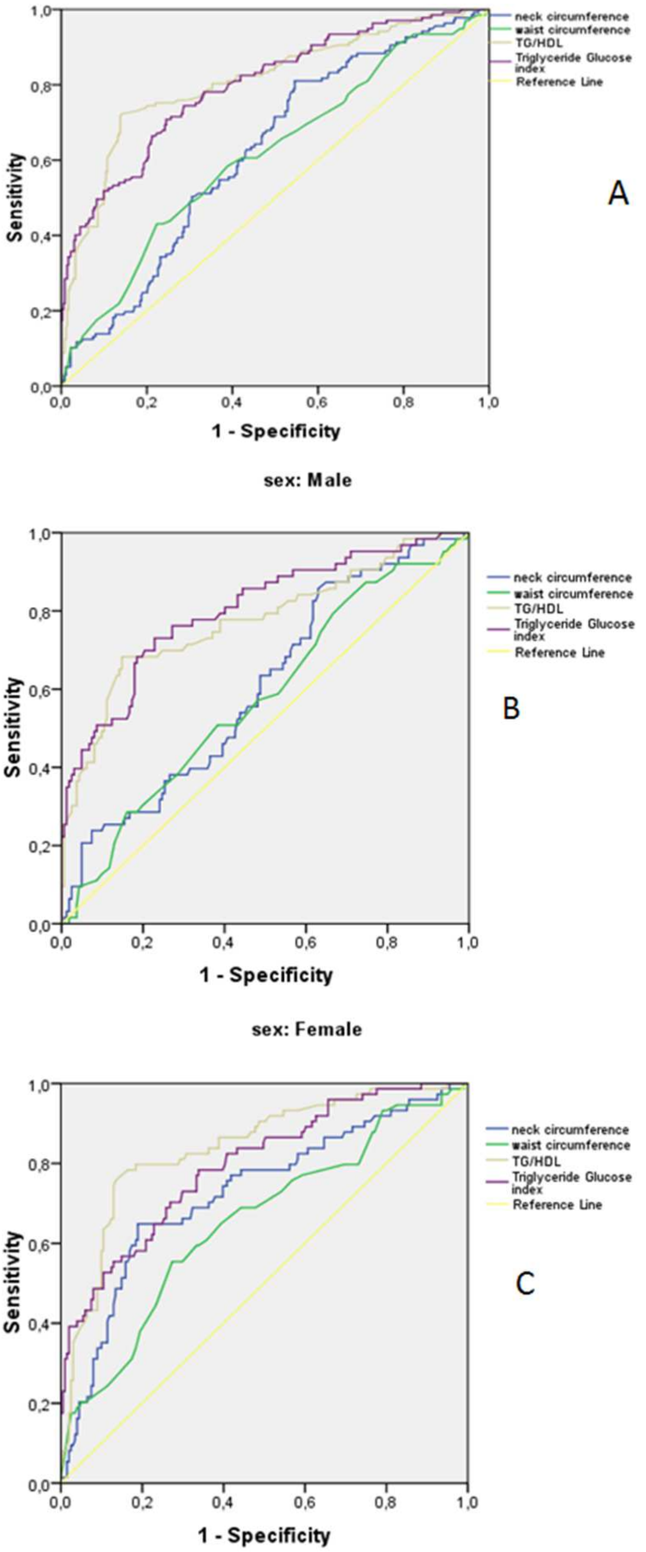

Figure 1. *ROC curves for NC, WC, TG/HDL and TyG index for IR identification in all participants (A), in men (B) and in women (C). IR insulin resistance; ROC, receiver operating characteristic; TyG, triglyceride-glucose; TG/HDL triglyceride high density lipoprotein ratio.*

4. Discussion

This study demonstrated that NC was associated with IR in sub-Saharan Africa population.

However, in IR group, FPG, the fasting insulin, triglyceride, anthropometric indexes (NC, WC and BMI) were highest in comparison with the control group. TG/HDL and TyG index, markers of IR were so higher among insulin resistant individuals than those in the control group. NC had a positive correlation with fasting insulin, TG/HDL ratio, TyG index and HOMA-IR; which corresponded well with previous studies [11]. In comparison with WC, NC had the strongest correlation with IR parameters.

In type 2 Diabetes mellitus, IR is the primordial etiopathogenic mechanism [12, 13]. Thus, individuals at risk must be identified. The invasive character of the glucose clamp technique to identify IR and the expensive measuring of insulin, limited their use in practical experience. Several studies proposed simple and non invasive methods [14 – 17]. Increased TyG index is commonly found in state of IR [7, 8, 18]. We proved that TyG index and HOMA-IR increased with the tertiles of NC.

In this study, the AUC was 0.624 (95% CI: 0.572–0.677) for NC and 0.616 (95% CI: 0.560–0.672) for WC in predicting IR in all participants. Thus, that AUC for NC was higher than for WC, (0.605 [95% CI: 0.525 – 0.685] versus 0.577 [95% CI: 0.495 – 0.660]) and (0.727 [95% CI: 0.656 – 0.797] versus 0.653 [95% CI: 0.578 – 0.728]), respectively in both men and women. This suggests that NC may be better than WC in predicting IR in Bantu population. Comparing to WC, NC is an anthropometric measurement more efficient.

This study has the following limitation. By its cross-sectional nature, associations between NC and IR parameters are not prospective and causal links cannot be inferred. The strength of the study lies in the fact that it is a large population-based study and representative of Brazzaville's adults. We describe, for the first time in Sub-Saharan region, the cross-sectional relationship of NC with insulin resistance.

5. Conclusion

This study verified the association between NC and IR in Bantu population from Brazzaville in republic of Congo. NC is better than WC to identify individuals with IR. Further research, particularly long-term, prospective, is needed in Central Africa region to validate our findings.

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