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Research Article

BLOOD PRESSURE-TO-HEIGHT RATIOS, AGING AND NECK CIRCUMFERENCE IN BANTU POPULATION FROM A WESTERN PORT CITY IN DEMOCRATIC REPUBLIC OF CONGO

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Abstract

Background: Blood pressure-to-height ratios (BPHR) were proposed as simple tool to identify hypertension among children and adolescents. **Objective**: To investigate the relationship between BPHR and anthropometric parameters. **Methods**: A population-based cross-sectional study was conducted among 3290 participants aged 18 years or more in Boma, from March 1st to April 15th 2018. Systolic blood pressure-to-height ratio (SBPHR) was calculated as systolic blood pressure (SBP) in mmHg devised by height in centimeter. Diastolic blood pressure-to-height ratio (DBPHR) was calculated as diastolic blood pressure (DBP) in mmHg devised by height in centimeter. Spearman correlation tests, univariate and multiple linear regression analysis were used to measure the association between BPHR, age and anthropometric parameters. **Results**: The median value of SBPHR was 0.71(0.65–0.78) mmHg/cm in men and 0.73(0.66–0.81) mmHg/cm in women. The median value of DBPHR was 0.47(0.41–0.52) mmHg/cm and 0.49(0.44–0.55) mmHg/cm respectively in men and in women. Neck circumference (NC), waist circumference (WC) and hip circumference (HC) had the median value of 37.1 cm, 77 cm and 83 cm in men respectively, and 32.3 cm, 80 cm and 93 cm in women. BPHR were positively correlated with age, NC, WC and HC. Age followed by NC had the best influence on BPHR in both men and women. **Conclusion**: BPHR is associated at age and neck circumference.

Keywords: Blood pressure-to-height ratios, Age, Neck circumference, Bantu, DR Congo.

INTRODUCTION

The prevalence of hypertension in developing countries is rising (Mittal and Singh, 2010). Associations between hypertension and age, height and weight were known (Patel *et al.,* 2008; Xi *et al.,* 2014). It is established that body size influences blood pressure (Kahn *et al.,* 1986; Regnault *et al.,* 2014; LA de Hoog *et al.,* 2012). However, blood pressure-to-height ratios (BPHR) had been proposed as a simple tool for screening hypertension and prehypertension in childhood and adolescents (Ejike *et al.,* 2011; Lu *et al.,* 2011; Rabbia *et al.,* 2011; Guo *et al.,* 2013; Mourato *et al.,* 2015). Therefore, the aim of this study was to investigate the relationship between systolic blood pressure-to-height ratio (SBPHR), diastolic blood pressure-to-height ratio (DBPHR) and anthropometric parameters as neck circumference (NC), waist circumference (WC) and hip circumference (HC) among Bantu population.

METHODS

Participants

A population-based cross-sectional survey on undiagnosed hypertension among residents of Boma, a western port city in Democratic Republic of Congo was done. The details of the study design have been described previously (Makoso *et al.,* 2020). In brief, the study was performed from March 1 to April 15, 2018. Participants aged 18 years or more, with informed consent were included.

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For this purpose, both a detailed medical history and a complete physical examination were performed before the study. A total of 3290 participants were analyzed in this study.

Measurements

The anthropometric measurements (weight, neck circumference, waist circumference, hip circumference, and height) and blood pressure were collected by well-trained Medical students. Blood pressure was measured using digital blood pressure meters (OMRON MIT5 Connect, Kyoto, Japan). The average of the two measures was used in the final analysis. The height was measured, in a standing position, in a participant without shoes, using a flexible measuring tape (Hemostyl, Sulzbach, Germany). Weight was also measured with individuals wearing light clothing or standing without shoes using a digital weighing scale (Deluxe GBS-721; Seca Deutschland, Hamburg, Germany). Body mass index (BMI) was computed as weight in kilograms divided by height in meters squared (Kg/m^2). 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.

Definitions

Hypertension was defined as systolic blood pressure (SBP) above 140 mm Hg and/or diastolic blood pressure (DBP) above 90 mm Hg (Lemogoum *et al.,* 2000). The following equations for blood pressure-to-height ratio (BPHR) were used:

- Systolic blood pressure-to-height ratio (SBPHR) = SBP (mmHg)/height (cm)
- Diastolic blood pressure-to-height ratio (DBPHR) = DBP (mmHg)/height (cm).

The nutritional status was defined according to the specific thresholds of BMI (Kasiam *et al.,* 2007):

Table 1. Definition of levels of cardio metabolic risk by BMI in both sex

Nutritional status	Local cut-off points of BMI	Cardio-metabolic risk
Denutrition	< 15	Undetermined
Normal weight	15 – 22.9	Reference
Overweight	23 – 26.9	Light
Obesity		
Grade I	27 – 29.9	Moderate
Grade II	30 – 33.9	High
Grade III	≥ 34	Very high

Statistical analysis

All analyses were performed using the SPSS 21 statistical software (SPSS for Windows; SPSS, Inc., Chicago, IL, USA). Numerical variables were reported as the medians and inter quartile ranges. Categorical variables were reported as number and percentage. Comparisons were performed between groups using non parametric tests and Pearson Chi-Square tests. The Spearman coefficient was used to measure the correlation between BPHR (SBPHR, DBPHR), age and anthropometric parameters (NC, WC and HC). Univariate linear regression analysis was used to measure the strong of the association between BPHR, age and anthropometric parameters. Multiple linear regression analysis was used to measure the influence of age and anthropometric parameters on BPHR. The *p*-value <0.05 was considered to be statistically significant.

Ethical consideration

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

RESULTS

Clinical characteristics of study population

Data was generated from 1351 men and 1939 women of identical age. The prevalence of hypertension was 26.3%. The prevalence of hypertension was similar in men and women, 27.2 and 25.7% respectively (p=0.342). In this study, 9.4% were obese and an additional 26.0% were overweight. Table 1 presents the clinical characteristics of the study participants by sex. The median value of height, weight, SBP, NC and WHR were higher in men than in women (p<0.001). The median value of SBPHR and DBPHR were 0.72 and 0.48 mmHg/cm respectively in overall group. The levels of BMI, WC, HC, WHtR, SBPHR and DBPHR were higher in women than in men (p<0.001).

Correlation between BPHR and anthropometric parameters

SBPHR was positively correlated with age. This correlation was much strong in women than in men (r=0.352, p<0.001 for women and r=0.270, p<0.001 for men). The correlation between DBPHR and age was significantly positive (r=0.300, p<0.001 for men and r= 0.325, p<0.001 for women). In both men and women, SBPHR and DBPHR were positively correlated with NC, WC and HC.

Table 2 Clinical characteristics of the study participants by sex

Variable	All (n=3290)	Male (n=1351)	Female (n=1939)	*p*-value
Age, year	31 (23 – 45)	31 (24 – 46)	32 (23 – 44)	0.615
Height, m	1.63 (1.57 – 1.70)	1.69 (1.63 – 1.74)	1.60 (1.55 – 1.64)	<0.001
Weight, kg	58 (52 – 65)	60 (55 – 66)	56 (50 – 64)	<0.001
BMI, kg/m^2	21.6 (19.7 – 24.1)	21.1 (19.3 – 23.2)	22.0 (19.9 – 24.7)	<0.001
SBD, mmHg	118 (107 – 130)	120 (110 – 132)	117 (106 – 129)	<0.001
DBP, mmHg	78 (70 – 88)	79 (70 – 88)	78 (70 – 88)	0.832
SBPHR, mmHg/cm	0.72 (0.66 – 0.80)	0.71 (0.65 – 0.78)	0.73 (0.66 – 0.81)	<0.001
DBPHR, mmHg/cm	0.48 (0.43 – 0.54)	0.47 (0.41 – 0.52)	0.49 (0.44 – 0.55)	<0.001
NC, cm	34.0 (32.1 – 36.8)	37.1 (36.3 – 38.1)	32.3 (31.5 – 33.4)	<0.001
WC, cm	79 (73 – 87)	77 (72 – 84)	80 (73 – 89)	<0.001
HC, cm	91 (86 – 98)	89 (84 – 94)	93 (87 – 100)	<0.001
WHR	0.85 (0.81 – 0.90)	0.86 (0.82 – 0.91)	0.85 (0.80 – 0.90)	<0.001
WHtR	0.48 (0.44 – 0.54)	0.46 (0.43 – 0.50)	0.50 (0.46 – 0.56)	<0.001
HTN	865 (26.3)	367 (27.2)	498 (25.7)	0.342
Overweight	856 (26.0)	300 (22.2)	556 (28.7)	<0.001
Obesity	308 (9.4)	70 (5.2)	238 (12.3)	<0.001
Origin				<0.001
Urban	844 (25.7)	391 (28.9)	453 (23.4)	
Rural	2446 (74.3)	960 (71.1)	1486 (76.6)	

BMI body mass index, *SBP* systolic blood pressure, *DBP* diastolic blood pressure, *SBPHR* systolic blood pressure-to-height ratio, *DBPHR* diastolic blood pressure-to-height ratio, *NC* neck circumference, *WC* waist circumference, *HC* hip circumference, *WHR* waist-to-hip ratio, *WHtR* waist-to-height ratio, *HTN* hypertension,

Table 3 Spearman correlation between SBPHR, DBPHR and other parameters by sex

Men / Women	SBPHR (mm Hg/cm)	DBPHR (mm Hg/cm)	Age (year)	NC (cm)	WC (cm)	HC (cm)
SBPHR (mm Hg/cm)	-	0.712*	0.270*	0.312*	0.166*	0.097*
DBPHR (mm Hg/cm)	0.751*	-	0.300*	0.290*	0.242*	0.094*
Age (year)	0.352*	0.325*	-	0.231*	0.337*	0.218*
NC (cm)	0.235*	0.229*	0.234*	-	0.487*	0.437*
WC (cm)	0.179*	0.236*	0.330*	0.608*	-	0.414*
HC (cm)	0.119*	0.141*	0.260*	0.619*	0.481*	-

*p<0.001

Table 4. Association between SBPHR with anthropometric parameters: Univariate linear regression

Variable	Men				Women			
	β	B (95% IC)	R^2	*p*	β	B (95% IC)	R^2	*p*
Age	0.386	0.0029 (0.0025 – 0.0033)	0.149	<0.001	0.490	0.0046 (0.0042 – 0.0050	0.240	<0.000
NC	0.300	0.0256 (0.0215 – 0.0302)	0.090	<0.001	0.220	0.0246 (0.0198 – 0.0295)	0.048	<0.000
WC	0.191	0.0024 (0.0017 – 0.0031)	0.037	<0.001	0.191	0.0025 (0.0019 – 0.0031)	0.037	<0.000
HC	0.151	0.0019 (0.0012 – 0.0021)	0.023	<0.001	0.120	0.0015 (0.0009 – 0.0021)	0.014	<0.000

β: standardized coefficient, B: unstandardized coefficient, R^2 : coefficient of determination.

Table 5. Association between DBPHR with anthropometric parameters: univariate linear regression

Variable	Men				Women			
	β	B (95% IC)	R^2	*p*	β	B (95% IC)	R^2	*p*
Age	0.304	0.0016 (0.0013 – 0.0019)	0.093	<0.001	0.391	0.0024 (0.0021 – 0.0026)	0.153	<0.001
NC	0.288	0.0176 (0.0145 – 0.0207)	0.083	<0.001	0.231	0.0167 (0.0136 – 0.0199)	0.053	<0.001
WC	0.227	0.0020 (0.0016 – 0.0025)	0.052	<0.001	0.226	0.0019 (0.0016 – 0.0023)	0.051	<0.001
HC	0.132	0.0012 (0.0007 – 0.0016)	0.017	<0.001	0.142	0.0012 (0.0008 – 0.0015)	0.020	<0.001

β: standardized coefficient, B: unstandardized coefficient, R^2 : coefficient of determination.

This correlation was much strong with NC, excepted for DBPHR in women as reported in table 3.

Association between BPHR and anthropometric parameters

Table 4 summarizes the results of univariate linear regression models analyzing the association of SBPHR with age, neck circumference, waist circumference and hip circumference. In both men and women, the relationship between SBPHR and anthropometric parameters was much strong with age followed by NC, WC, and HC in this order. Thus, age, NC, WC and HC explained respectively 15.0%, 9.0%, 4.0% and 2.3% of the variability of SBPHR in men. Whereas in women, age its self explained 24% of this variability ($p<0.001$). Concerning the univariate linear regression analysis of the relationship between DBPHR and anthropometric parameters as reported in table 5, age followed by NC were much associated at DBPHR in both men and women.

Table 6 shows the multiple linear regression analysis of the relationship between SBPHR (dependent variable) and anthropometric parameters. Age had the best influence (β=0.36, $p<0.001$) on SBPHR followed by neck circumference (β=0.27, $p<0.001$) in men. The same result was found among women.

Table 6 Association between SBPHR with anthropometric parameters: multivariate linear regression

Variables	Men			Women		
	β	t	*p*	β	t	*p*
Age	0.358	14.054	<0.001	0.476	23.477	<0.001
NC	0.266	9.156	<0.001	0.193	6.961	<0.001
WC	-0.054	-1.829	0.068	-0.024	-0.942	0.346
HC	0.008	0.295	0.768	-0.064	-2.692	0.007

R^2= 0.209 in men and 0.263 in women.

Table 7 Association between DBPHR with anthropometric parameters: multivariate linear regression

Variables	Men			Women		
	β	t	*p*	β	t	*p*
Age	0.258	9.790	<0.001	0.358	16.774	<0.001
NC	0.235	7.830	<0.001	0.160	5.494	<0.001
WC	0.038	1.219	0.223	0.048	1.802	0.072
HC	-0.019	-0.671	0.502	-0.029	-1.180	0.238

R^2= 0.152 in men and 0.184 in women.

The multiple linear regression analysis of the relationship between DBPHR (dependent variable) and anthropometric parameters is resumed in table 7. In both me and women, age followed by neck circumference had the best influence on DBPHR ($p<0.001$).

DISCUSSION

In this study we demonstrated for the first time the association between BPHR, age and neck circumference among Bantu population from a western port city in Democratic Republic of Congo (DRC). In fact, several studies proposed BPHR as a simple tool for identifying Hypertension and Prehypertension in children and adolescents (Ejike, 2011; Lu *et al.,* 2011; Rabbia *et al.,* 2011; Guo *et al.,* 2013; Mourato *et al.,* 2015). In this study, the median value of SBPHR and DBPHR is 0.72 and 0.48 mm Hg/cm respectively in whole group. Previous studies had found similar results (Lu *et al.,* 2011; Rabbia *et al.,* 2011). The prevalence of hypertension in this study is 26.3%. The similar prevalence was found by previous studies (Sumaili *et al.,* 2009; Muchanga *et al.,* 2016; Whanghi *et al.,* 2019). *Masimango et al* in a recent study from South Kivu in DRC found a low prevalence of 20.2% (Masimango *et al.,* 2020). It is established that visceral obesity is a major risk factor of insulin resistance, diabetes milletus and cardiovascular events. Several studies demonstrated the strong relationship between bioclinical markers of visceral obesity and neck circumference (Mafuta-Munganga *et al.,* 2020). In 2007, a large population study in Kinshasa-Hiterland determinated local thresholds of body mass index and waist circumference defining overweight/general obesity (Kasiam *et al.,* 2007). The prevalence of overweight and obesity in this study is 26.0% and 9.4% respectively. The median value of neck circumference in our finding is 37.1 cm and 32.3 cm, respectively in males and females. This result corroborates previous studies (Mafuta-Munganga *et al.,* 2020). In this study, BPHR were positively correlated with age. Those correlations were much strong in women than in men. Concerning anthropometric parameters, neck circumference have strongest correlation with BPHR followed by waist circumference and hip circumference in both men and women. Additionally, age followed by neck circumference have significantly the best influence on BPHR in both men and women. The strength of the present study was that we first examined this method among adults based on a representative population using a relatively large sample size. Second, participants in the study were sufficiently ethnically diverse to facilitate extrapolation to all ethnic groups. However, there is a limitation to the present study by its cross-sectional nature. Associations are not prospective and causal links cannot be inferred.

Conclusion

The present study confirmed the relationship between BPHR (SBPHR, DBPHR), age and neck circumference. Therefore, we suggest prospective study to establish the part of BPHR for detecting people at cardio metabolic risk.

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