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Determinants of Raised Blood Pressure in Urban Uganda: A Community-Based Case-Control Study

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Objective: Rapid urbanization is changing the epidemiology of non-communicable diseases in sub-Saharan Africa. We aimed to identify the determinants of raised blood pressure in urban Uganda to highlight targets for preventive interventions.

Design: Case-control.

Setting: Three community-based sites in Kampala, the capital of Uganda.

Participants: Participants were eligible to enroll if they were aged ≥18 years and not pregnant.

Methods: 450 cases with raised blood pressure were frequency matched by sex and age to 412 controls. Unconditional logistic regression was used to evaluate the association of socio-demographic, lifestyle, anthropometric, and laboratory variables with the outcome of raised blood pressure. Cases currently treated with antihypertensive medication and cases not treated with antihypertensive medication were analyzed separately.

Results: Significantly increased odds of raised blood pressure were associated with overweight body mass index (BMI) (25 kg/m^2 ≤ BMI < 30 kg/m^2), obese BMI (BMI ≥ 30 kg/m^2) and hemoglobin A1c ≥ 6.5%. Significantly decreased odds of raised blood pressure were associated with moderate-to-vigorous work-related physical activity of >4 hours/week. No significant associations were found between raised blood pressure and marital status, education level, car or flush toilet ownership, dietary habits, alcohol consumption, smoking habits, moderate-to-vigorous leisure-related physical activity > 4 hours/week, waist-to-hip ratio, or total cholesterol levels.

Conclusions: Targeted interventions are needed to address the key modifiable risk factors for raised blood pressure identified in this study, namely elevated BMI and regular physical activity, in order to reduce the burden of cardiovascular disease in urban Uganda. *Ethn Dis.* 2017;27(1):15-20; doi:10.18865/ed.27.1.15.

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Introduction

High blood pressure is the leading risk factor globally for premature death and disability as measured in disability-adjusted life years (DALYs).[1] More than one-quarter of the world's adult population has hypertension and this proportion is expected to increase as a result of epidemiological transitions and demographic changes, eg, urbanization, particularly in low- and middle-income countries (LMIC).[2] Hypertension is the leading modifiable risk factor for mortality from cardiovascular disease (CVD) including stroke and ischemic heart disease.[3,4] Age-standardized mortality rates for stroke decreased globally from 1990 to 2013 but did not decline in sub-Saharan Africa (SSA) where deaths from stroke exceeded deaths from ischemic heart disease in 2013.[5] A systematic analysis of cross-sectional studies of hypertension in Africa reported a pooled crude prevalence of 30.8% and a pooled awareness rate of 33.7% in 2010.[6] This analysis included four studies from Uganda reporting crude prevalence rates of hypertension ranging from 20.5% to 30.4%. A national survey of hypertension conducted in 2014 in Uganda found a crude prevalence of 26.4%

and an awareness rate of only 7.7%.[7]

The anticipated rise in the burden of CVD in LMIC can be attenuated by primordial and primary prevention at the population and individual levels.[8] Investigations of the proximal determinants of key risk factors for CVD will empower public health policymakers with the data needed to make informed decisions for program planning and resource allocation for preventive interventions.

A national survey of hypertension conducted in 2014 in Uganda found a crude prevalence of 26.4% and an awareness rate of only 7.7%.[7]

Previous studies have evaluated the risk factors for hypertension in rural, urban, and mixed rural-urban communities in Uganda.[7,9-15] We undertook this study to identify the determinants of raised blood pressure in an exclusively urban population in Kampala, the capital of Uganda.

Methods

Study Population and Setting

Residents of Kampala, the capital of Uganda, aged ≥18 years were recruited from three sites of religious worship in central Kampala: Rubaga Cathedral (Catholic), Namirembe Cathedral (Protestant) and the Old Kampala National Mosque (Muslim). Study recruitment tables were set up during times of worship and individuals were self-referred for participation. Recruitment was conducted on a weekly basis from February to September 2014.

Measurements

Blood pressure (BP) was measured twice (> 2 minutes apart) using a battery-operated automatic blood pressure monitor (Microlife BP3NB1-1X or Homedics BPA-060). A large adult cuff was utilized as needed. Participants were at rest for at least 5 minutes prior to measurement and seated with their forearm resting comfortably on a table and their legs uncrossed. The lower of the two readings was used to determine case status (raised blood pressure present) or control status (raised blood pressure not present and not treated with antihypertensive medication). Raised blood pressure was present if the systolic BP was ≥ 140 mm Hg and/or the diastolic BP was ≥ 90 mm Hg or if the participant was currently treated with antihypertensive medication. Data on sociodemographic characteristics, dietary habits, smoking habits, alcohol consumption, and work-related and leisure-related physical activity of study participants were collected by trained enumerators using standardized questionnaires adapted from the WHO STEPS Instrument.[16] Alcohol intake, smoking status, and regular physical activity were categorized according to the approach employed by the INTERSTROKE study of risk factors for ischemic and hemorrhagic stroke.[17]

Body mass index (BMI) was calculated as weight in kilograms over height in meters squared and categorized as normal (BMI < 25 kg/m^2) overweight (25 kg/m^2 ≤ BMI < 30 kg/m^2) and obese (BMI ≥ 30 kg/m^2). Height was measured to the nearest tenth of a centimeter using a portable stadiometer and recorded as the maximum distance from the floor to the highest point on the head of the barefoot participant standing as fully extended as possible. Well-calibrated scales were used to measure weight to the nearest tenth of a kilogram and adjusted to zero before each measurement. Waist-to-hip ratio (WHR) was used as an indicator of abdominal obesity (≥ .9 for men and ≥ .85 for women). Waist circumference was measured midway between the lowest rib and the iliac crest. Hip circumference was measured at the level of the greater trochanters with the legs close together. Hemoglobin A1c (HbA1c) levels were measured to diagnose diabetes (HbA1c ≥ 6.5%) and pre-diabetes (5.6% < HbA1c < 6.5%). Total cholesterol levels were measured and categorized as high (≥6.2 mmol/L), borderline high (5.0 mmol/L - <6.2 mmol/L), and desirable (<5.0 mmol/L).

Statistical Analysis

Because of the uncertainty of self-reported age, especially for older individuals, we used frequency matching for sex and age band (18-25, 26-35, 36-45, 46-55, 56-65, >65 years) to obtain a similar distribution of cases and controls. Due to differing levels of participation at each site, we were not able to recruit equal numbers of cases and controls from each site. Data analysis was conducted as for an

unmatched case-control study using Stata/IC 11.2. Cases currently treated with antihypertensive medication (n=148) and cases not treated with antihypertensive medication (n=302) were analyzed separately. Continuous variables were expressed as means ± standard deviation while categorical variables were expressed as percentages. Descriptive statistics for all variables were assessed using the two-tailed unpaired Student's t test for continuous variables and the chi-square statistic with Yates' correction for categorical variables. A total of 145 missing values (1% of all values) were imputed by multiple imputation by chained equations (10 imputations).

Unconditional logistic regression with frequency matching variables (age and sex) and recruitment site included as covariates was used to evaluate the association of sociodemographic, lifestyle, anthropometric and laboratory variables with the outcome of raised blood pressure. Backward stepwise selection was employed (P cutoffs; Pr = .05, Pe = .049) to identify variables for inclusion in the multivariable logistic regression model. Additional variables known to be associated with raised blood pressure were forced into the model (education level, HbA1c, WHR, alcohol consumption). Multicollinearity of independent variables was evaluated by examining the variance inflation factor (VIF) of each variable. All VIF values were <1.53. Estimated odds ratios (OR) were reported with 95% confidence intervals (CI) and a two-tailed P=.05 was used as the cutoff point for statistical significance.

Results

Characteristics of Study Participants

We enrolled 450 cases (148 currently treated with antihypertensive medication) and 412 controls at three distinct sites of religious worship in central Kampala: Rubaga Cathedral (202 cases, 130 controls), Namirembe Cathedral (77 cases, 88 controls) and the Old Kampala National Mosque (171 cases, 194 controls). These sites were chosen because of their size and to ensure a diverse sample of study participants representative of the population of Kampala.

Tables 1 and 2 compare the characteristics of the cases (cases treated and cases not treated) and controls. Although we used frequency matching of cases by sex and age band, the mean age of cases exceeded controls due to challenges finding older study participants without hypertension. The lower of two recorded blood pressure readings was used to classify participants as cases or controls in order to reduce the possibility of over-diagnosing raised blood pressure. Average systolic

Table 1. Sociodemographic and lifestyle characteristics of participants

Variable	Prevalence, n (%)		
	Controls, n=412	Cases not treated, n=302	Cases treated, n=148
Age, mean ± SD	42.1 ± 13.5	46.1 ± 13.3 [a]	56.0 ± 13.8 [a]
Sex			
Male	249 (60.4)	208 (68.9) [a]	69 (46.6) [a]
Female	163 (39.6)	94 (31.1)	79 (53.4)
Systolic blood pressure, mean ± SD	122.5 ± 11.3	152.6 ± 17.6 [a]	149.4 ± 20.5 [a]
Diastolic blood pressure, mean ± SD	78.0 ± 7.8	97.1 ± 10.9 [a]	92.2 ± 13.8 [a]
Education			
< Primary/none	46 (11.2)	26 (8.6)	13 (8.8)
Primary completed	99 (24.2)	66 (21.9)	30 (20.3)
≥ Secondary completed	265 (64.6)	209 (69.5)	105 (70.9)
Marital status			
Never married/widowed/divorced	158 (38.3)	94 (31.2)	60 (40.5)
Currently married	254 (61.7)	207 (68.8)	88 (59.5)
Car ownership			
No	339 (82.5)	235 (77.8)	96 (66.2) [a]
Yes	72 (17.5)	67 (22.2)	49 (33.8)
Flush toilet ownership			
No	278 (67.6)	200 (66.7)	79 (54.1) [a]
Yes	133 (32.4)	100 (33.3)	67 (45.9)
Smoking status			
Never	370 (91.4)	256 (84.8) [a]	133 (89.9)
Current (any smoking in past 12 months)	13 (3.2)	14 (4.6)	2 (1.4)
Former (quit > 12 months ago)	22 (5.4)	32 (10.6)	13 (8.7)
Physical activity - work			
Moderate/vigorous ≤ 4 hours/week	243 (59.6)	204 (68.7) [a]	110 (76.9) [a]
Moderate/vigorous > 4 hours/week	165 (40.4)	93 (31.3)	33 (23.1)
Physical activity - leisure			
Moderate/vigorous ≤ 4 hours/week	374 (91.0)	278 (92.1)	142 (95.9)
Moderate/vigorous > 4 hours/week	37 (9.0)	24 (7.9)	6 (4.1)

a. P<.05 compared with controls, chi-square test or t-test (see Methods section)

Table 2. Dietary, anthropometric, and laboratory characteristics of participants

Variable	Prevalence, n (%)		
	Controls, n=412	Cases not treated, n=302	Cases treated, n=148
Alcohol consumption			
None	312 (75.7)	218 (72.4) [a]	99 (66.9)
1-30 drinks/month	82 (19.9)	55 (18.3)	38 (25.7)
>30 drinks/month	18 (4.4)	28 (9.3)	11 (7.4)
Fruit consumption			
≤ 6 servings/week	288 (70.1)	212 (70.2)	96 (65.3)
≥ 7 serving/week	123 (29.9)	90 (29.8)	51 (34.7)
Vegetable consumption			
≤ 6 servings/week	280 (68.1)	217 (71.9)	83 (56.1) [a]
≥ 7 servings/week	131 (31.9)	85 (28.1)	65 (43.9)
Meat consumption			
≤ 3 servings/week	293 (71.6)	227 (75.2)	122 (82.4) [a]
≥ 4 servings/week	116 (28.4)	75 (24.8)	26 (17.6)
Body mass index (BMI)			
< 25 kg/m^2	208 (50.5)	109 (36.7) [a]	42 (28.4) [a]
25 kg/m^2 - < 30 kg/m^2	123 (29.9)	108 (36.3)	54 (36.5)
≥ 30 kg/m^2	81 (19.6)	80 (27.0)	52 (35.1)
Waist-to-hip ratio (WHR)			
< .9 (men)/< .85 (women)	229 (55.9)	139 (47.1) [a]	55 (37.4) [a]
≥ .9 (men)/> .85 (women)	181 (44.1)	156 (52.9)	92 (62.6)
Hemoglobin A1c (HbA1c)			
≤ 5.6%	318 (81.1)	227 (80.2)	99 (68.8) [a]
> 5.6 - < 6.5 %	40 (10.2)	36 (12.7)	19 (13.2)
≥ 6.5%	34 (8.7)	20 (7.1)	26 (18.0)
Total cholesterol			
< 5.0 mmol/L	180 (45.9)	105 (37.1)	50 (34.7) [a]
5.0 - < 6.2 mmol/L	123 (31.4)	105 (37.1)	48 (33.3)
≥ 6.2 mmol/L	89 (22.7)	73 (25.8)	46 (32.0)

a. P<.05 compared with controls, chi-square test or t-test (see Methods section).

and diastolic blood pressures of cases were significantly higher than controls.

Factors Associated with Raised Blood Pressure

We assessed for independent predictors of raised blood pressure using unconditional multivariable logistic regression adjusted for frequency matching variables (age and sex) and recruitment site (Table 3). Cases currently treated with antihypertensive medication and cases not treated with antihypertensive medication were analyzed separately. Significantly higher odds of raised blood pressure were associated with overweight BMI (25 kg/m^2 ≤ BMI < 30 kg/m^2) (cases not treated), obesity BMI (BMI ≥ 30 kg/m^2) (cases treated and cases not treated), and hemoglobin A1c ≥ 6.5% (cases treated). Moderate to vigorous work-related physical activity > 4 hours/week was associated with significantly lower odds of raised blood pressure (cases treated and cases not treated).

Discussion

To our knowledge, this study is the first investigation of the determinants of raised blood pressure in an exclusively urban population in Uganda. We found significantly increased odds of raised blood pressure associated with overweight BMI (25 kg/m^2 ≤ BMI < 30 kg/m^2), obesity BMI (BMI ≥ 30 kg/m^2), and hemoglobin A1c ≥ 6.5%, and significantly decreased odds of raised blood pressure associated with moderate-to-vigorous work-related physical activity of > 4 hours/week. No significant associations were found between raised blood pressure and marital status, education level, car ownership, flush toilet ownership, dietary habits, alcohol consumption, smoking habits, moderate to vigorous leisure-related physical activity >4 hours/week, WHR, or total cholesterol levels. Due to the low prevalence rates in cases and controls, our study may have been underpowered to detect a significant association between moderate-to-vigorous leisure-related physical activity or smoking with raised blood pressure.

Previous studies of risk factors for hypertension in rural, urban, and mixed rural-urban populations in Uganda[7,9-15] also reported significant associations of higher BMI with hypertension while certain studies reported significant associations of random or fasting blood glucose levels,[10,12,15] alcohol consumption,[9,12,15] WHR,[10,15] or education level[9,10] with hypertension. Notably, our study is the first investigation in Uganda to find significantly reduced odds of raised blood pressure with regular physical activity. Since our case-control study design employed frequency matching for age and sex, we could not evaluate the association of these two variables with raised blood pressure. One limitation of our study design is the self-referral of participants, which

Table 3. Predictors of raised blood pressure in study participants

Variable	Cases not treated, OR (95% CI) [a]	P	Cases treated, OR (95% CI) [a]	P
Education				
< Primary/none	1		1	
Primary completed	1.29 (.71 – 2.35)	.408	2.03 (.84 – 4.90)	.114
≥ Secondary completed	1.41 (.81 – 2.45)	.218	2.11 (.93 – 4.81)	.076
Car ownership				
No			1	
Yes			1.63 (.94 – 2.82)	.081
Alcohol consumption				
None	1		1	
1-30 drinks/month	.75 (.48 – 1.18)	.219	1.29 (.71 – 2.34)	.84
>30 drinks/month	1.82 (.92 – 3.59)	.083	1.35 (.50 – 3.59)	.554
Physical activity - work				
Moderate/vigorous ≤ 4 hours/week	1		1	
Moderate/vigorous > 4 hours/week	.69 (.50 – .97)	.030	.47 (.28 – .78)	.004
Body mass index (BMI)				
< 25 kg/m^2	1		1	
25 kg/m^2 - < 30 kg/m^2	1.67 (1.14 – 2.44)	.009	1.59 (.90 – 2.81)	.111
≥ 30 kg/m^2	2.45 (1.55 – 3.87)	<.001	2.81 (1.50 – 5.27)	.001
Waist-to-hip ratio (WHR)				
< .9 (men)/< .85 (women)	1		1	
≥ .9 (men)/≥ .85 (women)	1.19 (.85 – 1.66)	.310	1.30 (.80 – 2.12)	.292
Hemoglobin A1c (HbA1c)				
≤ 5.6%	1		1	
> 5.6% - < 6.5%	1.25 (.76 – 2.08)	.381	1.39 (.67 – 2.86)	.373
≥ 6.5%	.62 (.33 – 1.16)	.133	2.03 (1.03 – 4.00)	.040

a. Adjusted for age, sex, recruitment site, and variables shown (see Methods section).

may have resulted in an indeterminate recruitment bias between cases and controls. Although we recruited participants from three distinct sites of religious worship to obtain a broadly representative sample of study participants, cases and controls were not recruited equally from the three sites. Further, adult residents who do not engage in religious worship were not included in our study sample.

According to the Global Burden of Disease Study 2013, CVD caused more than one million deaths in sub-Saharan Africa (SSA) in 2013, which represents 11.3% of annual deaths from all causes in that region.[5] Deaths from stroke exceeded those from ischemic heart disease by 58%. Age-adjusted mortality rates from CVD in SSA have remained unchanged from 1990 to 2013 in contrast the sharp declines seen in many other regions of the world.[5] Hypertension is the leading risk factor for stroke in SSA and a leading risk factor for ischemic heart disease in SSA.[17,18] The age-standardized prevalence rate of hypertension in SSA in 2010 was 25.9%, a rate comparable to other developing regions of the world.[6] However, rates of awareness, treatment and control of hypertension in SSA are very low due to weak health systems for the management of non-communicable diseases.[2,6] The burden of CVD in SSA is expected to rise as a result of population growth and aging as well as advancing urbanization, which is driving an increased prevalence of the key risk factors for CVD including hypertension.[2,19-21]

Conclusion

Population-level and individual-level interventions are needed to address the key modifiable risk factors for raised blood pressure identified in our study. In particular, interventions to reduce elevated BMI and increase regular physical activity are needed to reduce the prevalence of raised blood pressure and the burden of CVD in urban Uganda. Domestic health sector policies and budgets should include programs for the provision of community-based screening and counseling for raised blood pressure to increase awareness and to promote healthy lifestyle modifications, such as weight reduction, regular physical activity, moderation of alcohol consumption, smoking cessation, and reduced salt intake.

Acknowledgements and Compliance with Ethical Standards

Our research was approved by the Makerere University School of Medicine Research and Ethics Committee and by University of California at Berkeley Committee for Protection of Human Subjects and all procedures followed were in accordance with the ethical standards of the IRB and the Helsinki Declaration of 1975, as revised in 2000. Informed written consent was obtained from each study participant.

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Conflict of Interest

No conflicts of interest to report.

Author Contributions

Research concept and design: Chin, Twinobuhungiro, Sandhu, Kalyesubula; Acquisition of data: Chin, Twinobuhungiro, Sandhu, Hootsmans, Kayima, Kalyesubula; Data analysis and interpretation: Chin; Manuscript draft: Chin, Hootsmans, Kayima, Kalyesubula; Statistical expertise: Chin, Twinobuhungiro; Acquisition of funding: Chin, Kayima; Administrative: Chin, Twinobuhungiro, Sandhu, Hootsmans, Kalyesubula; Supervision: Chin, Kayima, Kalyesubula

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