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Research Article

High Rate of Obesity-Associated Hypertension among Primary Schoolchildren in Sudan

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Cardiovascular disease (CVD) frequently has roots in childhood, including following childhood-onset hypertension. Incidence of CVD has increased in developing countries in East Africa during recent urbanization. Effects of these shifts on childhood hypertension are unclear. Our objectives were to (1) Determine the prevalence of hypertension among primary schoolchildren in Khartoum, Sudan; (2) Determine whether hypertension in this setting is associated with obesity. We performed a cross sectional study of 6-12y children from two schools randomly selected in Khartoum, Sudan. Height, weight, BMI, BP and family history of hypertension were assessed. Age-, height- and gender-specific BP curves were used to determine pre-hypertension (90–95%) and hypertension (>95%). Of 304 children, 45 (14.8%) were overweight; 32 (10.5%) were obese; 15 (4.9%) were pre-hypertensive and 15 (4.9%) were hypertensive. Obesity but not family history of hypertension was associated with current hypertension. In multiple logistic regression, adjusting for family history, children who were obese had a relative-risk of 14.7 (CI 2.45-88.2) for systolic hypertension compared to normal-weight children. We conclude that overweight and obesity are highly prevalent among primary schoolchildren in urban Sudan and are strongly associated with hypertension. That obesity-associated cardiovascular sequelae exist in the developing world at young ages may be a harbinger of future CVD in sub-Saharan Africa.

1. Introduction

The prevalence of childhood obesity has been increasing at unsettling rates across the globe [1]. In addition to striking the developed world, this pattern has also been noted in developing countries undergoing rapid epidemiological transitions, including those in East Africa [2]. In Sudan, a study of children in secondary school in the capital Khartoum found that rates of overweight and obesity were 28.5% and 5.6%, respectively [3]. Rates of obesity for younger schoolchildren in East Africa remain unclear, though obesity at younger ages may carry greater importance because younger children possess improved potential for early intervention [4].

Hypertension, a notable sequela of obesity, was already common in sub-Saharan Africa [5] but has been reported to be worsening in prevalence in recent years [6]. Hypertension often goes underdiagnosed in children, in part because its accurate diagnosis requires the use of standardized growth charts specific for age, gender, and height, with hypertension defined as a systolic and/or diastolic blood pressure > 95th percentile and pre-hypertension defined as systolic and/or diastolic blood pressure 90–95th percentile. Underdiagnosis of hypertension may be even more common in developing countries, where medical care is limited to symptomatic diseases, and childhood hypertension has been overlooked in lieu of more urgent disease.

Given the importance of childhood hypertension and pre-hypertension in determining adult cardiovascular disease outcomes [7], our goal was to determine the prevalence of hypertension and pre-hypertension among urban school children in Sudan and to determine whether hypertension was associated with obesity in this population. These data serve to alert providers in developing and developed countries to the extent of the current obesity epidemic.

2. Methods

2.1. Study Area. Sudan is in East Africa, bordering Egypt on the north, Ethiopia on the east, Kenya, Uganda, and Congo on the south, and Central African Republic, Chad, and Libya

on the west. Sudan has 2.5 million square kilometers and 37 million inhabitants, of whom 5–7 million live in the capital of Khartoum. Traditionally an impoverished country, Sudan has experienced an economy that has expanded rapidly with oil exportation over the past 10 years, with Khartoum being the epicenter of economic activity.

2.2. Study Design and Subjects. This was a cross-sectional study using a sample of 304 children aging six through twelve years from two schools randomly selected in Khartoum, the capital of Sudan. All students were given a questionnaire to be filled out by their parents, which asked for signed consent for their child to participate in the study, in addition to other demographic and health information. Ethics approval was obtained from the University of Medical Sciences and Technology (Khartoum, Sudan) Research Ethics Board.

2.3. Data Collection. Questionnaires sent to parents inquired regarding the child's age, gender, and health conditions, both previous and current. The questionnaire also asked whether there was a medical diagnosis of hypertension, diabetes, or heart disease among blood-related family members and which family members were affected. The child was classified as having a positive family history only if disease was present in a first-degree relative.

2.4. Measurements. Measurements taken for each student were body weight, height, and blood pressure. Measurements were taken by trained volunteers in a consistent, standardized manner. Body weight was measured to the nearest tenth of a kilogram on a calibrated digital scale, with the child's shoes removed. Height was measured with the child standing with shoes removed, measured in centimeters to the nearest millimeter. Blood pressure was measured twice, once manually and once digitally, using an appropriate cuff size, based on arm circumference, and the mean was taken and used for analysis.

Body mass index (BMI), defined as body weight in kilograms divided by the square of height in meters (kg/m^2), was used as the measure of obesity in this study. BMI is an accepted measure of obesity in clinical practice, and its use in children has been supported internationally by the International Obesity Task Force (IOTF), which agreed that it provides a reasonable index of adiposity [8] and in that it is a simple and inexpensive measure. It provides reliable estimations, with the exceptions of extremes of age, height, and musculature [9].

BMI was categorized according to the Centers for Disease Control and Prevention (CDC) age- and sex-specific growth charts [10]. The following categories were used: underweight <5th percentile; normal weight, 5th to 85th percentile; overweight, 85th to 95th percentile; obese, >95th percentile.

Blood pressure was categorized according to BP tables from the Fourth Report on the Diagnosis, Evaluation, and Treatment of High Blood Pressure in Children and Adolescents [11], using age and height percentiles, with normotension defined as a BP under the 90th percentile, prehypertension 90th to 95th percentile, and hypertension greater than 95th percentile or an absolute systolic BP (SBP) of ≥120 mm Hg or diastolic BP (DBP) of ≥80 mm Hg. Children were also classified as hypertensive if they were taking antihypertensive medication or had been diagnosed with hypertension previously.

2.5. Statistical Analysis. Descriptive statistics were calculated for gender, family history, and BMI and BP categories. Analyses were performed using the chi-squared test for association, and multinomial logistic regression to investigate the odds of systolic and diastolic prehypertension and hypertension with overweight or obesity, controlling for family history of hypertension. Analyses were conducted using STATA 10.0 (2008 StataCorp LP, College Station, TX).

3. Results

Complete data on height, weight, BP, and family history were available for the entire sample ($n = 304$). The average age of participants was 7.8 years, with a median age of 9 years (range 6–12 years). All were of Sudanese nationality, and the gender distribution was 236 female (77.6%) and 68 male (22.4%).

The number of children who were overweight was 45 (14.8%), and 32 were obese (10.5%). Females had a nonsignificant trend toward higher rates than males of overweight (14.0% versus 11.8%) and obesity (11.0% versus 5.9%, $P > .05$). These frequencies are examined further by age and gender in Table 1.

Prehypertension was detected in 15 (4.9%) participants and additional 15 (4.9%) had hypertension, all on the basis of BP measurement, as none were taking antihypertensives or had a previous diagnosis of hypertension. The rate of elevated BP (prehypertension and hypertension combined) in males and females was 13.2% versus 8.9%. A family history of hypertension was reported for 64 (21.1%) of the participants overall, including 20.1% of children with a normal blood pressure, 20.0% of those with pre-hypertension, and 40.0% of hypertensive children (Table 2). Though there is a higher rate of family history with hypertension compared to normal BP or prehypertension, this difference was not significant by chi-square test ($P > .05$).

Regarding the association between BMI and BP, 31.2% of obese children had hypertension, versus 17.8% of overweight children and 5.3% of normal BMI children. These results were found to be highly statistically significant by Pearson chi-squared test ($P < .001$). Further classification of prehypertension and hypertension into systolic and diastolic is stratified by BP category in Table 3 for descriptive purposes.

Results of multinomial logistic regression analysis are shown in Table 4. The results are given as the relative risk of being in a certain BP category by weight category compared to children with a normal BMI, adjusting for gender and family history. After adjustment for these factors, Sudanese children who were obese had a relative risk of systolic hypertension of 14.7 compared to their normal-weight counterparts ($P < .01$).

Table 1: Age and gender by BMI status.

Characteristic	Normal BMI *n* (%)	Overweight *n* (%)	Obese *n* (%)
Gender			
Male	56 (82.4)	8 (11.8)	4 (5.9)
Female	177 (75.0)	33 (14.0)	26 (11.0)
Age			
6 yrs	34 (82.9)	7 (17.1)	0 (0.0)
7 yrs	40 (80.0)	5 (10.0)	5 (10.0)
8 yrs	42 (77.8)	6 (11.1)	6 (11.1)
9 yrs	54 (75.0)	10 (13.9)	8 (11.1)
10 yrs	19 (63.3)	5 (16.7)	6 (20.0)
11 yrs	19 (73.1)	5 (19.2)	2 (7.7)
12 yrs	25 (80.6)	3 (9.7)	3 (9.7)

Table 2: Gender and family history of hypertension by blood pressure category.

Characteristic	Normotensive *n* (%)	Prehypertension *n* (%)	Hypertension *n* (%)
Gender			
Male	59 (86.8)	2 (2.9)	7 (10.3)
Female	215 (91.1)	13 (5.5)	8 (3.4)
Family History			
Positive	55 (85.9)	3 (4.7)	6 (9.4)
Negative	219 (91.3)	12 (5.0)	9 (3.7)

Table 3: Blood pressure classification according to BMI category.

	Normal BP	Systolic Pre-HT	Diastolic Pre-HT	Systolic HT	Diastolic HT
BMI					
Normal	215 (94.7)	4 (1.8)	5 (2.2)	3 (1.3)	0 (0.0)
Overweight	37 (82.2)	1 (2.2)	2 (4.4)	1 (2.2)	4 (8.9)
Obese	22 (69.0)	2 (6.3)	1 (3.1)	3 (9.4)	4 (12.5)

Table 4: Relative risk of hypertension by BMI category (adjusted for gender and family history).

Blood pressure	Relative risk*	Confidence interval
In overweight children:		
Systolic pre-hypertension	1.44	0.15–13.34
Diastolic pre-hypertension	0.94	0.11–8.03
Systolic hypertension	2.23	0.22–22.86
Diastolic hypertension	1.24	0.14–11.23
In obese children:		
Systolic pre-hypertension	5.65	0.92–34.85
Diastolic pre-hypertension	1.39	0.15–13.13
Systolic hypertension	**14.69**	**2.45–88.2**
Diastolic hypertension	3.61	0.58–22.52

* Compared to risk of normal BP.

4. Discussion

We found a high rate of overweight and obesity among 6–12-year-old primary schoolchildren in urban Sudan, with 14.8% of the children overweight and 10.5% obese. Despite moderate rates of hypertension reported previously among children in sub-Saharan Africa—up to 11% in rural children, suggesting an underlying genetic predisposition [12]—we found that obesity and not family history was the factor most strongly associated with hypertension in our sample. Obese children carried a relative risk of 14.7 for systolic hypertension after adjustment for family history, while family history of hypertension was not significantly associated. That obesity was so highly correlated with hypertension in a part of the world more commonly linked to undernutrition underscores the pervasiveness of the obesity epidemic and its sequelae throughout the world.

Rates of hypertension in sub-Saharan Africa have been noted to be increasing among adults [5, 6, 13] concurrent with rising rates of obesity in urban areas [2]. Prior studies to demonstrate these effects among children in East Africa have been lacking, however. The appearance of early cardiovascular sequelae of obesity at these young ages suggests that urban areas in the developing world may begin to face increasing health concerns in children related to the obesity epidemic.

As in other sub-Saharan African nations, these high rates of obesity in Sudan are felt to be due to the epidemiological transition that has come with Westernization [2]. Increased television viewing and internet surfing have contributed to a more recent sedentary lifestyle. While food availability has improved, dietary habits have shifted away from traditional agricultural choices to an increase in processed foods as seen in Western countries. The appearance of obesity-associated hypertension in children may signal that developing countries are likely to face similar difficulties as developed countries in overcoming lifestyle choices.

Similar reports of obesity have been reported from other less-developed nations outside of Africa. A study of schoolchildren in Beijing, China, reported that approximately 20% of children were overweight or obese [14]. In Karachi, Pakistan, an almost identical prevalence of 25% of children had a high BMI, with 6% of children overweight and 19% obese [15]. In Iran, 8.8% were overweight, and 4.5% were obese [16]. Rates of hypertension in other populations are less clear, although increasing BMI has been consistently associated with increased blood pressure throughout childhood [17–19].

This study had several strengths and weaknesses. The total number of children involved was relatively small (304 subjects), particularly with respect to boys (68 subjects). We collected complete data, including family history of hypertension on all participants. In contrast to many studies of blood pressure in African children that did not determine rates of hypertension based on normal ranges for height, age, and gender [20], we determined blood pressure status for each of our participants, dividing children into normotensive, pre-hypertensive, and hypertensive categories.

In common with other studies [20, 21], we used the average of blood pressure measurements at a single time

point for each subject, acknowledging that measuring blood pressure on separate occasions is necessary for the diagnosis of hypertension on a clinical basis [11]. It is possible that the prevalence of hypertension in our sample would be lower were three measurements used to determine hypertension [22].

In addition, we used BMI as the sole measure of obesity. Other measurements estimating adiposity (waist circumference, bioelectrical impedance, and MRI) are more specific to the amount of fat mass. Nevertheless, for population-based studies BMI correlates well with these other measures and remains widely used as a definition of obesity in hypertension research [23–25].

5. Conclusion

In conclusion, primary schoolchildren in urban Sudan exhibited a high degree of overweight and obesity, and hypertension among these children was more closely linked to obesity than to family history. That obesity-associated cardiovascular sequelae exist in the developing world at such young ages is a harbinger of worsened cardiovascular outcomes in sub-Saharan Africa in the future. To overcome these trends, children in urban settings in Africa are likely to require similar dietary and activity lifestyle adjustments as needed by their counterparts in developed nations.

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