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Prevalence and factors associated with hypertension among adolescents in Sudan: a cross-sectional school-based study

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ABSTRACT

Objectives There is an increasing rate of elevated blood pressure, or hypertension, in children and adolescents worldwide, including Sub-Saharan Africa (SSA). Only a few data on adolescent hypertension in SSA, including Sudan, have been published. The aim of the present study was to investigate the prevalence and associated factors of hypertension among adolescent schoolchildren (within the ages of 10 to 19 years) in Sudan.

Design A cross-sectional school-based study was conducted from June to September 2022.

Settings Six randomly selected schools in Almatamah, River Nile State, Sudan.

Participants Adolescent schoolchildren (within the ages of 10 to 19 years).

Main outcome measures Sociodemographic information. Anthropometric and blood pressure measurements were performed in accordance with the standard procedures. An adjusted logistic regression analysis was performed.

Results Of the 384 enrolled adolescents, 166 (43.2%) and 218 (56.8%) were boys and girls, respectively. The median (IQR) age and body mass index (BMI) were 15.2 years (14.0–16.4 years) and 18.5 kg/m^2 (16.4–21.5 kg/m^2), respectively. Of the 384 adolescents, 240 (62.5%) and 255 (66.4%) had educated mothers and fathers (≥secondary), respectively. 38 adolescents (9.9%) had hypertension (≥95th percentile). The multivariable logistic regression analysis revealed that age, sex and maternal educational level were not associated with hypertension. Paternal educational level according to secondary education attainment (adjusted OR (AOR), 2.72; 95% CI 1.36–5.46) and increasing BMI (AOR, 1.12; 95% CI 1.02–1.20) were associated with hypertension.

Conclusion 1 in 10 adolescents in northern Sudan was hypertensive. Low paternal educational level and increasing BMI were significantly associated with hypertension. The introduction of interventional nutritional programmes at early ages is needed to ensure that adolescents are healthy in their present and later lives. To sustain such programmes, involving all educational parties at early stage is essential.

STRENGTHS AND LIMITATIONS OF THIS STUDY

⇒ The random sample selection gives the study the power to represent the studied community (Almatamah Locality).
⇒ The cross-sectional nature of the current study limits us to measure the causal association between hypertension among adolescents and the studied variables.
⇒ Conducting a longitudinal study will provide more clarification regarding the association between hypertension and the variables of nutritional status among adolescents.
⇒ No information was collected in the present study regarding dietary patterns and lifestyle practices, which could influence blood pressure.

INTRODUCTION

There is an increasing rates of elevated blood pressure, or hypertension, in children and adolescents worldwide, including Sub-Saharan Africa,[1–3] owing to the potential roles of the increasing incidence of overweight and obesity among these groups.[1 2] The WHO defines adolescence as 'the phase of life between childhood and adulthood, extending from ages 10 to 19 years'.[4] It is a unique/important stage of human development and an important time for the future health.[4] Increased awareness, applying an optimum screening tools, early detection and treatment of hypertensive individuals among adolescents could prevent the development of further hypertension in adulthood and cardiovascular events in later life.[3 5]

The prevalence of hypertension/elevated blood pressure among children and adolescents varies in different populations in Africa.[1 2 6–15] Moreover, several risk factors such as male sex,[16] age,[12 14 15] family history of hypertension, smoking, overweight and obesity[1 2 14 15] are associated with hypertension/elevated blood pressure among children and adolescents. Blood pressure screening at early ages (among adolescents and young adults) provides an opportunity to manage the secondary causes of hypertension, such as renal diseases.[17] This preventive approach is

needed in Africa, especially in Sudan, where resources are limited. According to the estimation of the WHO, more than 20% of the population in Sudan are adolescents.[18]

To attain good health, adolescents' health needs must be addressed at all levels and by all involved parties. The health burden of hypertension/elevated blood pressure among adolescents requires urgent public health action. Therefore, the practical steps to address hypertension and its associated factors in adolescents on a global scale require a thorough understanding of the local context. To achieve this, first, the prevalence of elevated blood pressure among adolescents in the community and its associated factors must be investigated. On the basis of community-based data, appropriate healthcare measures can then be applied accordingly to maintain good health. There is a paucity of studies on the prevalence of elevated blood pressure and its associated factors among adolescents in Sudan in general,[19] and no such studies have been conducted in the proposed area (northern Sudan). Thus, the aim of the present study was to investigate the prevalence and associated factors of hypertension among adolescents in northern Sudan.

METHODS

Patient and public involvement

This cross-sectional school-based study was conducted among 384 adolescents (age 10 to 19 years). Strengthening the reporting of observational studies in epidemiology (STROBE) guidelines were strictly followed.[20]

This study was conducted at public schools in the locality of Almatamah in northern Sudan from June to September 2022. Almatamah, located in the River Nile State, northern Sudan, is approximately 130 km from Khartoum, the capital of Sudan.

Sampling technique and sample size

There are three districts in Almatamah Locality. From these three districts, one district was randomly selected (Wad Hamid). There are 16 schools in Wad Hamid district and all of them are public schools for both boys and girls that is, there is no private school. Six schools (three schools for each gender) were randomly selected from the 16 schools using simple random selection (lottery method). A total of 4931 students were registered in the nominated six schools. A total of 384 students (sample size) was taken from the nominated schools. The probability proportional to size was used to appoint a proportion of the calculated sample size to schools so that schools with a larger number of students contributed more to the sample. In each school, the assigned sample size was selected using a simple random technique (lottery method) from the list of the students in the school.

All adolescents within the ages of 10 and 19 years were included in the study, and those younger or older than these ages were excluded. Those who did not give their consent for participation in the study were excluded. All the participants recruited were apparently healthy, and those who were sick, receiving antihypertensive medications or other medications, pregnant or lactating girls were excluded from the study.

OpenEpi Menu was used to calculate the desired sample size.[21] A sample of 384 adolescents were calculated for this study. There was no previous study in the study area, hence the maximum (50.0%) of the event (hypertension) was assumed to have the optimum sample size using the formula, '$n=Z^2pq/d^2$, in which $q=(1-p)$, $Z1-\alpha$=CI of 95%=1.96, and d=margin of error of 5%=0.05)'.

Variables

After the participants and their guardians signed an informed consent form, the selected students were approached. Data on sociodemographic characteristics, including age in years, sex, parental educational level (<secondary or ≥secondary), maternal occupational status (housewife or employed), smoking habit and family history of hypertension, were collected through a questionnaire. Two medical research assistants were trained by the investigators to collect the information. Blood pressure, weight and height were measured using the standard procedures. The sociodemographic and body mass index (BMI) were considered as secondary outcomes, and hypertension as the primary outcome.

After resting for at least 10 min in a sitting position, the blood pressure was measured twice using a standardised digital blood pressure measuring device '(Omron Digital HEM-907, Tokyo, Japan)', with the arm maintained at heart level. The average of two blood pressure readings was calculated. If the difference between the two readings was >5 mm Hg, measurements were retaken until the reading stabilised. The systolic and diastolic blood pressures were computed according to age and sex, guided by reports on the diagnosis, evaluation and treatment of hypertension in children and adolescents.[22] In this study, hypertension was defined as average systolic and diastolic pressures ≥95th percentile for age, sex and height. The American Academy of Pediatrics 2017 definition,[22] which is widely reported and performed for the diagnosis of hypertension in children and adolescents in Africa,[1 2] was used in this study.

Weight and height measurements

The participants' weights were measured in kilograms using the standard procedures which were well-calibrated scales and were adjusted to zero before each measurement. Weight was measured to the nearest 100 g. The participants stood with minimal movement, with their hands by their sides. Moreover, shoes and excess clothing were removed. Height was measured to the nearest 0.1 cm, with the participant standing straight with the back against the wall and the feet together. BMI was calculated according to the formula of dividing participants' weight in kilograms (kg) by their height in metres (m) squared.[23] To have an accurate estimation of the influence of one unit increase in BMI on blood pressure

among adolescents, in this study, BMI was analysed as a continuous variable, similar to recent studies.[14 24]

Statistical analysis

Data were entered into a computer using the IBM Statistical Product and Service Solutions (SPSS) for Windows (SPSS V.22.0, New York, New York). Continuous data including age and BMI were evaluated for normality using the Shapiro-Wilk test and they were found to be not-normally distributed and were expressed as median (IQR). Initially, we performed a univariate analysis with hypertension as the dependent variable and age, sex, BMI, parental educational level, smoking habit and family history of hypertension as independent variables. Variables with a p value of <0.20 were shifted to build up a multivariable logistic regression model to adjust for covariates. The results of adjusted odds ratios (AORs) with their 95% CIs were calculated and p value of<0.05 was considered statistically significant.

RESULTS

Of the total enrolled adolescents (n=384), 166 (43.2%) and 218 (56.8%) were boys and girls, respectively. The median (IQR) age and BMI were 15.2 (14.0–16.4) years and 18.5 (16.4–21.5) kg/m^2, respectively. Of the 384 participants, 240 (62.5%) mothers had education ≥secondary level and 255 (66.4%) fathers had education ≥secondary. Only 35 (9.1%) of the adolescents' mothers were employed. Of the 384 adolescents, 29 (7.6%) were smokers, and 98 (25.5%) had a family history of hypertension (table 1). The median (IQR) systolic and diastolic blood pressures were 110 mm Hg (100–120 mm Hg) and 70 mm Hg (66–80 mm Hg), respectively.

38 adolescents (9.9%) had hypertension (systolic and diastolic pressures ≥95th percentile). In the univariate analysis, while paternal education (unadjusted OR, 2.72; 95% CI, 1.38–5.37) and increasing BMI (unadjusted OR, 1.09; 95% CI 1.01–1.18) were associated with hypertension, age, sex, maternal education and occupation, smoking habit and family history of hypertension were not associated with hypertension (table 1).

The results of the multivariable logistic regression analysis showed that low paternal educational level (AOR, 2.72; 95% CI, 1.36–5.46) and increasing BMI (AOR, 1.12; 95% CI, 1.02–1.20) were associated with hypertension (table 2).

DISCUSSION

The main finding of the present study was that 9.9% of the adolescents had hypertension. In this study, the prevalence (9.9%) of hypertension is comparable with the results from Tanzania among children aged 6–17 years, of whom 10.8% had hypertension (≥95th percentile).[15] The prevalence rate (9.9%) of hypertension in the present study is higher than those reported in Nigeria, which showed that 4.3% and 4.4% of adolescents had prehypertension and hypertension, respectively.[7] Moreover, the prevalence rate of hypertension in our study was higher than that reported for 600 schoolchildren in Ghana, of whom 8.5% had elevated blood pressure (2.5% had hypertension and 6.0% had prehypertension).[6] Compared with those in other countries, the prevalence of hypertension

Table 1 Characteristics of the studied adolescents in northern Sudan (n=384), 2022

Variable		Total (n=384)	Adolescents with hypertension (38/384=9.9%)	Adolescents without hypertensive (346/384=91.1%)	Unadjusted OR (95% CI)	P value
		Median (IQR)				
Age, years		15.2 (14.0–16.4)	15.4 (13.6–16.5)	15.2 (14.0–16.4)	0.97 (0.78–1.20)	0.752
Body mass index, kg/m^2		18.5 (16.4–21.5)	19.0 (17.9–21.7)	18.4 (16.4–21.4)	1.09 (1.01–1.18)	0.028
		Frequency (proportion)				
Gender	Male	166 (43.2)	21 (55.3)	145 (41.9)	Reference	
	Female	218 (56.8)	17 (44.7)	201 (58.1)	0.58 (0.30–1.15)	0.118
Mother education level	≥secondary	240 (62.5)	21 (55.3)	219 (63.3)	Reference	
	<secondary	144 (37.5)	17 (44.7)	127 (36.7)	1.40 (0.71–2.74	0.333
Parental's education	≥secondary	255 (66.4)	17 (44.7)	238 (68.8)	Reference	
	<secondary	129 (33.6)	21 (55.3)	108 (31.2)	2.72 (1.38–5.37)	0.004
Mother occupation	Employed	35 (9.1)	3 (7.9)	32 (9.2)	Reference	
	House wife	349 (90.9)	35 (92.1)	314 (90.8)	1.19 (0.35–4.08)	0.783
Smoking	No	355 (92.4)	33 (86.2)	322 (93.1)	Reference	0.176
	Yes	29 (7.6)	5 (13.2)	24 (6.9)	2.03 (0.72–5.68)	
Family history of hypertension	No	286 (74.5)	25 (65.8)	261 (74.4)	Reference	0.199
	Yes	98 (25.5)	13 (34.2)	85 (24.6)	0.62 (0.30–1.27)	

Table 2 Multivariable logistic regression analysis of factors associated with hypertension among adolescents in northern Sudan (n=384), 2022

Variable		Adjusted OR (95% CI)	P value
Body mass index, kg/m^2		1.12 (1.02–1.20)	0.015
Gender	Male	Reference	0.195
	Female	0.63 (0.32–1.27)	
Father education	≥secondary	Reference	0.005
	<secondary	2.72 (1.36–5.46)	
Smoking	No	Reference	
	Yes	1.75 (0.58–5.26)	
Family history of hypertension	No	Reference	0.511
	Yes	0.77 (0.36–1.65)	

in our study was higher than the prevalence of hypertension previously reported in Uganda (3.1%).[9] Data from a recent systematic review meta-analysis that included 41 studies with a total of 52918 participants aged 3 to 19 years from 10 African countries showed that the prevalence of hypertension ranged from 0.2% to 38.9%. The pooled prevalence of hypertension was 7.45%; elevated blood pressure, 11.38%; and combined hypertension/elevated blood pressure, 21.74%.[1]

On the other hand, the prevalence (9.9%) of hypertension in this study was lower than that previously reported in Tunisia (15.4%)[10] and Nigeria, which ranged from 12.7% to 19.0%.[11] In their meta-analysis that included 25 studies and 54196 participants aged 2–19 years, Noubiap *et al* showed that the pooled prevalence rate of elevated blood pressure (systolic or diastolic blood pressures ≥95th percentile) was 5.5%, whereas that of slightly elevated blood pressure (systolic or diastolic blood pressure ≥90th and <95th percentiles) was 12.7%.[2] On the other hand, a systematic review and meta-analysis showed a high prevalence rate of hypertension (12.6%) and prehypertension (13.9%) across the Arab countries.[5] The prevalence rates were almost four times higher in high-income countries such as Saudi Arabia than in middle-income countries such as Egypt and Tunisia. In addition, the prevalence rate was higher among studies based on adolescents with high BMI.[5] In Arab countries, the prevalence of hypertension in adolescents varies across countries, with rates ranging from 4% to 26%.[5]

In the present study, low paternal educational level was associated with adolescent hypertension. Consistent with the present result, a study by Kwok *et al* revealed that low paternal educational level is a risk factor of hypertension in adolescents.[25] Furthermore, a study by Suh *et al* indicated that low parental educational level, rather than one's own educational level, is significantly associated with prevalent hypertension among young adults.[26] Suh *et al* attributed this to young adults with low parental educational levels being prone to higher intakes of sodium.[26]

The lack of maternal education could be explained by the low quality of education among mothers and the low impact of maternal education on the workforce (only 9.1% of mothers were employed in the present study). Our previous work documented a low maternal employment rate in eastern Sudan.[27]

Our result showed adolescent with an increase of one BMI kg/m^2 was 1.12 times at risk of developing hypertension, that is, increase in one BMI kg/m^2 contributed by 12% of developing blood pressure among adolescents. Similar to our study, other studies have shown a positive association between adolescent hypertension and increasing BMI.[10 14 24 28 29] In South Africa, a study included 1665 schoolchildren and adolescents (846 boys and 819 girls) aged 5 to 15 years showed an increase of one BMI kg/m^2 was associated with 1.198 times and 1.23 times risk of developing systolic and diastolic hypertension, respectively.[24]

Another study in South Africa included 876 schoolchildren aged 9 to 14 years showed increase in BMI was significantly associated with elevated blood pressure in children (AOR=1.06, 95% CI=1.02–1.11).[14]

In a recent large cross-sectional study that enrolled 1385 Tunisian adolescents, hypertension was associated with overweight and obesity.[10] In a recent meta-analysis, children with obesity in Africa had a 5.5 higher risk of having an elevated blood pressure.[2]

Our study shows no association between adolescent sex and hypertension. This is consistent with several previous studies that showed no association between adolescent sex and elevated blood pressure in different African countries.[2 14 15] However, in Nigeria[7] and Cameroon,[12] female sex was associated with hypertension. By contrast, Azupogo *et al* reported that in Ghana, men were 1.9 times more likely to have elevated blood pressure than women.[13]

Our results should be cautiously compared with the findings of other studies. First, while our study used the WHO cut-off age (10–19 years), other studies used different ages of adolescents (early adolescent, late adolescent or both adolescent and children). Second, differences in sociodemographic characteristics such as smoking habit and alcohol consumption in different settings must be considered. For example, a recent study in Nigeria, Ayogu and Nwodo reported that the likelihood of adolescents to

have hypertension was three times higher among those who smoked any substance and almost three times higher among those who consumed alcohol.[11]

The current results have implications on improving adolescents' health since the identified factors (BMI and low paternal educational level) are modifiable factors. Moreover, the study recommendations including interventional nutritional programmes at early ages and improving education are essential to maintain adolescents' health in present and later lives. These recommendations will be communicated with the decision makers to be integrated into the existing policies.

Strengths and limitations of the study

The current study has several strengths. To the best of the authors' knowledge, it is the first study of its kind that addressed the prevalence of blood pressure and its associated factors among adolescents in northern Sudan. The current results add to the existing paucity of knowledge on elevated blood pressure among adolescents in Sudan in general.[19] In addition, the recommendations proposed above can be implemented to improve adolescents' health. However, this study has some limitations that must be mentioned. This was a cross-sectional study. A longitudinal study will provide more clarification regarding the association between hypertension and the variables of nutritional status among adolescents. This study was conducted in northern Sudan, thus limiting the generalisation of the findings to adolescents in Sudan. Moreover, no information was collected in the present study regarding dietary patterns and lifestyle practices, which could influence blood pressure.[8]

CONCLUSION

1 in 10 adolescents in northern Sudan were hypertensive. BMI and low paternal educational level were significantly positively associated with hypertension. Introducing interventional nutritional programmes at early ages is needed to ensure that adolescents are healthy in their present and later lives. To sustain such programmes, involving all educational parties at early stage is essential.

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Contributors AAH and IA conceptualised the study; AAN and AA supervised the work, guided the analysis and critically reviewed the manuscript; AAH and IA prepared the analysis plan, performed the data analysis and wrote the first draft of the paper; and AAN and AA supervised the data collection. All authors reviewed and approved the final manuscript. Guarantor, IA.

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Competing interests None declared.

Patient and public involvement Patients and/or the public were not involved in the design, or conduct, or reporting, or dissemination plans of this research.

Patient consent for publication Not applicable.

Ethics approval This study involves human participants and was approved by the ethical board of the Faculty of Medicine, University of Khartoum, Sudan, with reference no. 9, 2021. This study was conducted in accordance with the Declaration of Helsinki. All participants and their guardians signed written informed consent forms. The authors followed all measures to ensure the privacy and confidentiality of the participants, such as excluding personal identifiers during data collection. Participants gave informed consent to participate in the study before taking part.

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Data availability statement Data are available upon reasonable request.

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