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Research Article

The Relationship Between Mid-Upper Arm Circumference and Blood Pressure of Private School Children Aged 6-13 Years, In Polokwane, Limpopo Province, South Africa

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Abstract

Objectives: The prevalence of obesity and hypertension in sub-Saharan Africa are increasing to higher levels, even amongst children and adolescents.The aim of the study was to determine the relationship between Mid-upper arm circumference (MUAC), as a measure of obesity, and elevated blood pressure (BP) among Polokwane private school children.

Study Design: A total of 1629 subjects (boys=821 and girls=808) aged 6-13 years attending three private schools in Polokwane participated in the survey. The receiver operating characteristics curve was used to discriminate children with high BP. Linear regression was used to assess the relationship between BP and MUAC.

Results: The prevalence rate recorded for hypertension was 12.9% for girls and 9.3% for boys, whereas overweight was recorded as 47.9% for girls and 26.7% for boys. Area under curve (AUC) for hypertension, high systolic blood pressure (SBP) and high diastolic blood pressure (DBP) were significantly ($P<0.05$) higher in girls than boys. Linear regression showed a significant association for MUAC and BP (SBP, $\beta=1.6$, 95% CI 3.0-7.0; DBP, $\beta=1.2$, 95% CI 2.3-4.7) after adjusted for age and gender.

Conclusion: Polokwane private school girls showed higher prevalence of overweight and hypertension than boys. There was a significant relationship between MUAC and BP. Thus MUAC can be used as an inexpensive and easy risk marker for the presence of hypertension in children. An investigation into the physical activity level of these children will assist in uprooting the dynamics of cardiovascular diseases.

INTRODUCTION

Obesity and hypertension are modifiable risk factors for stroke, myocardial infarction, renal disease and cardiovascular diseases [1]. The prevalence of obesity and hypertension in sub-Saharan Africa seems to be increasing to higher levels, even amongst children and adolescents [2-4]. Consequently, the South African National Demographic Survey and National Food Consumption Survey suggested that screening for high blood pressure (BP) and obesity be frequently done to individuals visiting primary health care settings [5,6].

Several anthropometric indicators for obesity have been used as markers of high BP in children [7,8]. Most circumference measurements (waist circumference, neck circumference and Mid-upper arm circumference (MUAC)) are commonly used indicators of central obesity [9,10]. Fewer studies have explored the association of MUAC with high BP. The measurement of MUAC is simple, inexpensive, quick, practical (requires minimum effort from the examiner and examinee) and can be easily applied as screening tool during epidemiological surveys or in low resource settings. It has good inter and intra-rater reliability in children [8,9,11]. Dalili et al. [12] showed that BP in Indian children is closely related to MUAC. Little is known about the relationship between BP and MUAC of children in sub Saharan Africa. Thus, the objectives of the study were to determine 1) the prevalence of hypertension and overweight, 2) the tendency of MUAC to

discriminate children with elevated BP, 3) the relationship between MUAC and elevated BP among Polokwane private school children aged 6-13 years.

MATERIALS AND METHODS

Study population

A total of 1629 subjects (821 boys and 808 girls) aged 6-13 years attending three private schools in Polokwane, a city in the Limpopo Province of South Africa, participated in the survey in September 2000. Generally, children attending private schools in South Africa fall within the middle and upper socio-economic groups of the population. All children who were present at school on the days of the survey participated in the study. Parents and/or guardians gave informed consent prior to the survey, and ethical approval for the study was obtained from the Ethics Committee of the University of the North, currently the University of Limpopo-Turfloop Campus.

Anthropometric measurements

MUAC was measured in all children, in accordance with the standard procedures of the International Society for the Advancement of Kinanthropometry [13]. The absolute and relative values for intra and inter-tester technical error of measurements (% TEM) for Mid-upper arm circumference measurements ranged from 0-3.4 cm (0-4%) during the training.

Blood pressure

Using an electronic Micronta monitoring kit, at least three BP readings of Systolic BP (SBP) and Diastolic BP (DBP) were taken at intervals of 5 min after the child had been seated for 5 min or longer [14,15]. The bladder device contains an electronic infrasonic transducer that monitors the BP and pulse rate, displaying those concurrently on the screen. This versatile instrument has been designed for research and clinical purposes. In a pilot study, conducted before the survey, a high correlation (r=0.93) was found between the readings taken with the automated device and those taken with a conventional Sphygmomanometer.

Statistical analysis

Descriptive statistics were done for BP and MUAC measurements. Student's t-test was applied to test the significance difference between the genders. MUAC of overweight children was classified according to age and gender using Mazicioglu et al [16] cut-off points. All children were classified as overweight and obese according to Cole et al. [17] cutoff point. The international cut-off points for thinness (grade one, two, and three) by sex for exact ages defined to pass through BMI of 16, 17, and 18 kg/m^2 were used [18,19]. Hypertension was defined as the occurrence of SBP and DBP levels greater than or equal to the 95th percentile of height and sex adjusted reference levels. We produced gender-specific receiver operating characteristic curves and used the corresponding area under curve (AUC) to identify children with elevated BP. The receiver operating characteristic (ROC) curve is a plot of true positive rate (sensitivity) against false-positive rate (1-specificity) [20,21]. Linear regression models were used to assess the relationship between BP and MUAC adjusted and unadjusted for age and gender. Logistic regression was used to determine whether subjects who are overweight and obese were more likely (odds ratio) to be hypertensive. All statistical analyses were conducted using the Statistical Package for the Social Sciences (SPSS) and the level of significance was set at $P<0.05$.

RESULTS

Table 1 shows descriptive statistics for MUAC and BP, As well as the prevalence of overweight and hypertension among boys and girls aged 6-13 years. There was significantly higher mean MUAC for girls than boys aged 6-13 years. Boys and girls showed a gradual increase in the mean SBP throughout the age range, with girls having a significantly ($P<0.002$-0.039) higher mean SBP than boys at ages 10, 12 and 13 years. Mean DBP of girls was significantly ($P<0.000$-0.015) higher than boys at ages 6, 12 and 13 years. The prevalence of hypertension ranged from 0.9-12.9% and that of overweight 0-22.6% using both BMI and MUAC across the age range. The prevalence of underweight was ranging from 0 to 30.2% (n = 1948) where's majority of Children were classified as having mild underweight ranging from 14-30.2% (Table 2). Table 3 shows the gender-specific ability of an anthropometric indicator of overweight to correctly identify children with high BP, using ROC analysis. The AUC for hypertension (0.812), high SBP (0.777) and high DBP (0.659) were significantly higher in girls compared to boys. Linear regression showed a significant ($P<0.000$ and 0.05) association for MUAC and both SBP (SBP, $\beta=1.6$, 95% CI 1.4-1.8) and DBP (DBP, $\beta=1.2$, 95% CI 0.9-1.4) after adjusted for age and gender. Table 4 showed odds ratio, P-value and 95% CI of hypertension among Polokwane private school children. A significant odds ratio (OR=4.9, 95% CI 2.9-8.3) was found in the current study for private school children aged 6-13 years in Polokwane, South Africa.

DISCUSSION

The relationship between MUAC and elevated BP is crucially important in evaluating both the public health and clinical impact of the hypertension and overweight epidemic that has its roots in the prevalence of childhood overweight and hypertension. In this study we found BP to be significantly associated with MUAC. In identifying high BP among children, AUC showed hypertension, high SBP and high DBP to be significantly higher in girls than boys. The risk of becoming hypertensive was significant among Polokwane private school children.

There was a significantly higher mean MUAC and BP among Polokwane private school girls compared to boys aged 10 and 12 years. Similar results were found by Pier et al. [22] among Italian girls aged 11-14 years. The high prevalence of overweight (9.4–47.9%) and hypertension (0.9–12.9%) in this population is cause for concern. However, low prevalence of overweight (0.4%) was reported among Nigerian Children aged 10-17 years [23-25], though the sample was not from private school children as it is the case in our current study. Private school children are characterized by families from higher socio-economic status in South Africa. Gradual adoption of western lifestyle including reduction in physical activity, and increased childhood hypertension are associated with higher socio-economical status population in developing countries [23,26,27]. Furthermore, the South African rural population is moving to the cities in large numbers and consuming fast foods predisposing them to high

Table 1: Descriptive statistics for mid-upper arm circumference, BP parameters,Weight, Height and BMI of Polokwane private school children from age 6 to 13 years.

	N		Mid-Upper Arm Circumference		Systolic BP		Diastolic BP		Weight		Height		BMI	
Age (Years)	Boys	Girls	Boys	Girls	Boys	Girls	Boys	Girls	Boys	girls	Boys	girls	Boys	girls
			M(sd)	M(sd)	M(sd)	M(sd)	M(sd)	M(sd)	M(sd)	M(sd)	M(sd)	M(sd)	M(sd)	M(sd)
6	74	94	16.7	17.1	87.6	90.3	60.3*	63.5*	21.7	21.0	122.8	121.6	14.3	14.2
			(1.4)	(1.6)	(9.7)	(10.3)	(9.3)	(9.7)	(3.1)	(3.1)	(5.4)	(5.8)	(1.3)	(1.7)
7	118	122	17.1	17.4	95.0*	92.3*	65.2	64.4	24.3	23.5	126.8	126.2	15.0	14.7
			(2.0)	(1.6)	(11.4)	(9.8)	(10.4)	(9.0)	(4.0)	(3.8)	(6.0)	(7.5)	(1.8)	(1.8)
8	116	117	18.2	18.3	100.1*	96.9*	69.2*	66.5*	27.3	27.6	131.5	131.7	15.7	15.9
			(2.5)	(2.3)	(12.0)	(11.1)	(9.3)	(9.2)	(5.6)	(5.9)	(6.9)	(5.2)	(2.4)	(3.1)
9	106	106	18.0*	19.5*	100.9	102.9	67.9	68.7	28.9*	31.5*	136.1	137.5	15.5*	16.5*
			(1.8)	(3.3)	(11.1)	(11.2)	(8.4)	(8.3)	(4.9)	(7.3)	(6.9)	(6.6)	(2.0)	(3.1)
10	117	104	18.8*	20.1*	100.3*	104.9*	68.3	69.9	33.0*	35.3*	142.1	144.0	16.2*	16.9*
			(2.4)	(3.3)	(10.1)	(14.4)	()10.5	(9.9)	(6.3)	(8.5)	(6.0)	(6.8)	(2.5)	(3.2)
11	140	140	19.7	20.8*	106.2	107.4	71.3	70.3	36.0*	39.4*	146.6*	150.0*	16.7	17.4
			(2.7)	(3.1)	(13.0)	(14.1)	(12.5)	(10.5)	(7.7)	(9.0)	(6.6)	(7.7)	(3.2)	(3.2)
12	104	93	20.0*	21.4*	106.6*	112.4*	70.1*	75.9*	38.9	43.6	151.2	155.7	16.9	17.9
			(2.9)	(3.6)	(13.0)	(12.3)	(9.6)	(12.7)	(10.0)	(117)	(8.2)	(7.2)	(3.3)	(3.9)
13	71	43	21.1*	22.6*	109.8	115.3	70.5	75.1	43.1*	49.1*	156.3	160.0	17.6*	19.1*
			(2.6)	(3.6)	(13.2)	(14.1)	(9.3)	(9.9)	(8.0)	(11.0)	(7.3)	(7.0)	(2.5)	(4.0)

Table 2: The prevalence of thinness, overweight/obesity and hypertension amongst Polokwane private school children from age 6 to 13 years.

			BMI[@]										MUAC[$]		Blood Pressure[#]					
			Thinness						Overweight/Obesity											
	N		Severe		Moderate		Mild		Overweight		Obesity		Overweight		High Systolic		High Diastolic		Hypertension	
Age (Yrs)	Boys	Girls	Boys %(n)	Girls %(n)	Boys %(n)	Girls %(n)	Boys %(n)	Girls %(n)	Boys %(n)	Girls %(n)	Boys %(n)	Girls %(n)	Boys %(n)	Girls %(n)	Boys %(n)	Girls %(n)	Boys %(n)	Girls %(n)	Boys %(n)	Girls %(n)
6	74	94	17.6	13.8	29.7	2.1	21.6	28.7	1.4	1.1	1.4	-	16.7	17.1	1.4	1.1	4.1	12.8	-	1.1
			(13)	(13)	(22)	(2)	(16)	(27)	(1)	(1)	(1)	-	(3)	(1)	(1)	(1)	(3)	(12)	-	(1)
7	188	122	5.9	9.0	19.5	-	23.7	23.8	11.9	0.8	1.7	0.8	17.0	17.4	5.9	0.8	12.7	13.9	4.2	-
			(7)	(11)	(23)	-	(28)	(29)	(14)	(1)	(2)	(1)	(11)	(2)	(7)	(1)	(5)	(17)	(5)	-
8	166	117	4.3	5.1	14.7	13.7	27.6	21.4	6.0	2.6	6.0	4.3	18.2	18.3	4.3	6.8	10.3	9.4	0.9	3.4
			(5)	(6)	(17)	(16)	(32)	(25)	(7)	(3)	(7)	(5)	(13)	(8)	(5)	(8)	(12)	(11)	(1)	(4)
9	106	106	5.7	2.8	10.4	11.3	30.2	23.6	3.8	10.4	2.8	6.6	18.0	19.5	5.7	11.3	5.7	13.3	0.9	3.6
			(6)	(3)	(11)	(12)	(32)	(25)	(4)	(11)	(3)	(7)	(7)	(18)	(6)	(12)	(6)	(14)	(1)	(4)
10	117	104	1.7	2.9	9.4	12.5	23.9	21.2	6.0	15.4	1.7	3.8	18.8	20.1	4.3	11.5	8.5	16.3	2.6	6.7
			(2)	(3)	(11)	(13)	(28)	(22)	(7)	(16)	(2)	(4)	(9)	(20)	(5)	(12)	(10)	(17)	(3)	(7)
11	140	140	2.9	1.4	18.6	15.7	20.7	16.4	4.3	13.6	4.3	2.9	19.7	20.8	12.9	20.7	16.4	20.7	9.3	8.6
			(4)	(2)	(26)	(22)	(29)	(23)	(6)	(19)	(6)	(4)	(12)	(22)	(18)	(23)	(23)	(29)	(13)	(12)
12	104	93	4.8	5.4	20.2	8.6	19.2	15.1	5.8	6.5	1.9	4.3	20.0	21.4	6.7	18.3	10.6	30.1	1.9	12.9
			(5)	(5)	(21)	(8)	(20)	(14)	(6)	(6)	(2)	(4)	(8)	(10)	(7)	(17)	(11)	(28)	(2)	(12)
13	71	43	5.6	7.0	9.9	14.0	18.3	14.0	9.9	20.9	-	2.3	21.1	22.6	11.3	23.3	11.3	16.3	5.6	9.3
			(4)	(3)	(7)	(6)	(13)	(6)	(7)	(9)	-	(1)	(7)	(10)	(8)	(10)	(8)	(7)	(4)	(4)

N= sample size; MUAC = Mid-upper arm circumference; BMI= Body mass index,, #= Hypertension was defined as the occurrence of SBP and DBP levels greater than or equal to the 95th percentile of height, age and sex [14,15], $=Mid-upper arm circumference of overweight children was classified according to age and gender [16], [@]=All children were classified as overweight and obese according to Cole et al.[17] cutoff point. The international cut-off points for thinness (grade one, two, and three) by sex for exact ages defined to pass through BMI of 16, 17, and 18 kg/m^2 were used [18].

Table 3: Gender-specific areas under the receiver operating characteristic curves showing the ability of anthropometric measures to identify children with high blood pressure (HBP).

	Mid-upper arm circumference		Body Mass Index	
ROC analysis	**AUC**	**95% CI**	**AUC**	**95% CI**
Hypertension in boys	0.648	0.524-0.772	0.615	0.497-0.732
High SBP in boys	0.670	0.590-0.749	0.622	0.537-0.707
High DBP in boys	0.613	0.543-0.684	0.577	0.509-0.646
Hypertension in girls	0.812	0.740-0.885	0.681	0.586-0.775
HighSBP in girls	0.777	0.723-0.831	0.650	0.579-0.720
High DBP in girls	0.659	0.605-0.712	0.579	0.523-0.635

*AUC: area under curve (all AUC significant p<0.05), ROC: receiver operating curve, SBP: systolic blood pressure, DBP: diastolic blood pressure

Table 4: Odds Ratio, P-value and 95% confidence intervals of hypertension among Polokwane Private School children aged 6 and 13 years.

	Unadjusted				Adjusted for age and gender			
	Odds ratio	**P-value**	**95%CI**		**Odds ratio**	**P-value**	**95%CI**	
High systolic	4.4	0.000	2.9	6.5	4.6	0.000	3.0	7.0
High Diastolic	3.2	0.000	2.3	4.6	3.3	0.000	2.3	4.7
Hypertension	4.8	0.000	2.8	8.0	4.9	0.000	2.9	8.3

levels of obesity [28,29]. People of African descent have a strong tendency towards salt sensitivity, resulting in hypertension when the sodium chloride levels in the diet increases [29]. Thus urbanization with the associated westernization can possibly explain the high prevalence of overweight and hypertension in these urban South African children.

The odds of having hypertension among Polokwane private school children in the present study was significant (p<0.05) (OR=4.8, 95% CI 2.8-8.0) even after adjusting for age and gender (OR=4.9, 95% CI 2.9-8.3). Similar results were reported among Mexican and Indian children [30-32]. Furthermore, Freedman et al. [33] reported that overweight children in the Bolagusa heart study were 4.5% times likely to be hypertensive than normal weight children. The higher risk of hypertension seen among Indian children might be explained by factors such as diet during early childhood, sedentary lifestyle and family history of hypertension [34]. The same may apply to this study population.

There was a significant (P<0.05) relationship between MUAC and elevated BP among Polokwane private school children aged 6-13 years. Pier et al. [22]. Found similar results among Italian children. Furthermore, Mazicioglu et al. [16] reported that MUAC was significantly related to BP among children aged 11-17 years from Turkey. The differences in patterns of increase in BP between boys and girls are probably related to certain physiological factors. Muscle mass is greater among boys and this is why the relationship of MUAC among boys is weaker than girls, which have a greater component of fat in their MUAC [22]. Furthermore, Gortmaker et al. [35] reported that growth and fat storage characteristics of children may have an effect on MUAC wideness.

In our study, we did not consider the socio-economic status of the children's families, physical activity, dietary intake and number of siblings. Furthermore, even though the data of the study was collected in 2000, it is possible that the prevalence of overweight and obesity has increased even in public school children, at present time, due to developments and changes in South Africa [29,36].

CONCLUSION

Polokwane private school children showed a higher prevalence of overweight and hypertension. There was a significant relationship between MUAC and BP among private school children in Polokwane. The risk of having hypertension among Polokwane private school children was significant even after adjusting for age and gender. The results of this study suggest that MUAC may be used as a risk marker for hypertension in children aged 6–13 years when other measures of BP are not available, which is often the case in low resource settings. Research into the physical activity level of these children will assist in uprooting the dynamics of cardiovascular diseases.

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