

The prevalence of hypertension and the relationship with body composition in Grade 1 learners in the North West Province of South Africa

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Abstract

Objective. To determine the prevalence of hypertension in Grade 1 learners in the North West Province of South Africa and to investigate the association between blood pressure (BP) and body composition of these children.

Methods. Data were collected by means of a stratified random sampling procedure from 816 Grade 1 learners (419 boys, 397 girls) with a mean age of 6.78±0.49 years (mean±SD), in the NW-CHILD-study. Height, weight, skinfolds (subscapular, triceps, calf) and waist circumference were measured. The international recommended cut-off values of Cole *et al.* (2000) for body mass index (BMI) were used. Hypertension, defined as the average of two separate BP (BP) readings, where the systolic BP and diastolic BP is >95th percentile for age, sex and height, was determined by means of an Omron 705CP-II.

Results. The overall prevalence of prehypertension and hypertension was 8.5% and 24.9%, respectively. Both systolic and diastolic BP was positively associated with BMI, body fat percentage and waist circumference. Boys and girls showed a similar prevalence of hypertension. A higher percentage of black children were hypertensive compared with whites, although the difference in BP of the groups was not significant. A high percentage of children with normal weight also showed increased levels of BP.

Conclusions. High prevalences of hypertension were found in Grade 1 learners in the North West Province of South Africa. Small practical significant associations existed between BP and body composition. BP screening is therefore considered important in the paediatric population. Interventions which include physical activity are recommended to reduce potential cardiovascular complications and obesity among children. Other contributing factors to high BP amongst young children should also be investigated.

Introduction

High blood pressure (hypertension) is the greatest risk factor for cardiovascular disease,¹ which is responsible for up to 7 million deaths worldwide every year.² The Centres for Disease Control and Prevention (CDC) indicates that 1 in 3 adults in America have hypertension³ and the same trend is found in South Africa, where 55% of adults 30 years and older have hypertension.⁴

Until recently, hypertension was a rare phenomenon amongst children, possibly due to fewer environmental stressors, higher physical activity levels, a lower prevalence of obesity and a healthier life-style.⁵ Chiolerio *et al.*⁶ are of the opinion that the worldwide increase in obesity amongst children over the last two decades probably resulted in an increase in the incidence of hypertension in children.⁶ In this respect, Munter *et al.*⁷ found that the systolic and diastolic BP of children were respectively 1.4 mmHg and 3.3 mmHg higher in 1999 - 2000 than in 1988 - 1994 and attribute this increase in hypertension largely to the increased incidence of overweight children. Whitney and Rolfes⁸ report that obesity contributes to the development of hypertension because additional adipose tissue contains extra capillaries through which the blood has to pump and, consequently, puts extra strain on the heart and veins, which results in increased BP. A South African study on 5-year-old children indicated that 11.6% of these children suffered from hypertension,⁹ while the study of Monyeki *et al.*¹⁰ conducted on 6 - 13-year-old children from rural communities revealed that 1.0 - 5.8% of the boys and 3.1 - 11.4% of the girls had hypertension. In this study there was a direct association between the prevalence of hypertension amongst the children from rural communities and an increased body mass index (BMI).¹⁰

Research evidence indicates that even a moderate increase in BP could have a negative effect on the vascular structure and function of children.¹¹ Children with increased BP could develop target organ damage and retinal abnormalities.¹² Furthermore, such children are also more at risk of hypertension-related illnesses in their adult lives.¹³

Overweight and obesity have increased drastically in children over the last 2 decades.¹⁴ The phenomenon has occurred throughout the world, including in South Africa, and is regarded as a serious health problem as it could have an effect on current and future public health.¹⁵ Statistics in South Africa indicate that in children between the ages of 6 and 13 years, 14.0% and 3.2% of boys are overweight and obese respectively, compared to 17.9% and 4.9% of girls (overweight and obese).¹⁶

Sorof *et al.*¹⁷ further report that hypertension occurs in 33% of children who are obese compared with 11% in those children who are not obese. Various studies also show that overweight children display higher systolic BP than children of normal weight.^{5,18} A study

of 6 - 13-year-old South African children indicated that there is a positive correlation between the BMI and BP of the children, even after adjustments have been made for age, gender and height.¹⁹ The results of this study, however, are only based on children from disadvantaged communities.

Research indicates an increase in child obesity in South Africa and this could possibly contribute to an increased prevalence of hypertension amongst children in South Africa.²⁰ Because of the potential health risks of hypertension, action needs to be taken to address this incidence. However, to develop adequate preventive strategies, it is important to determine the relationship between BP and body composition in South African children. In particular there is a gap in the literature with regard to this relationship within the diverse population of South Africa, and especially the young child population. Only a few studies could be found that examined the relationship of hypertension with overweight in South African child populations,^{10,19} and the studies were mainly relevant to children of disadvantaged communities. Hence, the aim of this study was to determine the prevalence of hypertension in Grade 1 learners and, more specifically, to determine the relationship between the BP and body composition of Grade 1 learners in the North West Province.

Methods

Research group

The research formed part of the NW-CHILD (Child-Health-Integrated-Learning and Development) study. Grade 1 learners in the North West Province of South Africa served as the target population for the study. The total number of participants identified for the study was 880 Grade 1 learners. The research group was selected by means of a stratified random sample in conjunction with the Statistical Consultation Service of the North West University. To determine the research group, a list of names of schools in the North West Province was obtained from the Department of Education. From the list of schools in the North West Province, which are grouped in 4 education districts, each representing 12 - 22 regions with approximately 20 schools (minimum 12, maximum 47) per region, regions and schools were randomly selected with regard to population density and school status (quintile 1, i.e. schools from poor economic sectors to quintile 5, i.e. schools from good economic sectors). Boys and girls in Grade 1 were then randomly selected from each school. Twenty schools, from 4 districts with a minimum of 40 children per school and with an even gender distribution, were involved in the study. The total group that was measured consisted of 816 learners (419 boys and 397 girls) with an average age of 6.78 years and an ethnic distribution of 567 black, 218 white, 20 coloured and 11 Indian learners. Thirteen parents (1.5%) did not consent to participation, while the rest of the selected participants were absent at school on the day of testing or had to be excluded because of incorrect ages that were provided by the schools.

The principals of the various identified schools were asked for permission to collect the data during school hours. If the numbers of learners in the school allowed it, 60 Grade 1 learners were randomly selected and received informed consent forms that had to be completed by their parents. This was done to ensure that informed consent would be granted by the parents of a minimum of 40 learners who needed to be measured at each school. The learners whose parents reacted positively to the above-mentioned forms, underwent the tests.

Ethical approval for the execution of the study was obtained from the Ethics Committee of the NWU (No. NW 00070 09 S1). Permission was also obtained from the Education Department of the North West Province.

Anthropometric measurements

The anthropometric measurements included the following: height (cm), body mass (kg), 3 skinfolds (subscapular, triceps and medial calf) (mm) and waist circumference (cm). These variables measured were measured by trained postgraduate students in Kinderkinetics in accordance with the protocol of the International Society for the Advancement of Kinanthropometry.²¹ Height was measured barefoot to the nearest 0.1 cm by means of a portable stadiometer, and body mass was measured with an electronic scale (BF 511, Omron) to the nearest 0.1 kg. From the height and body mass measurement the body mass index (BMI) was calculated for each participant. Skinfolds were measured with a pair of Harpenden skinfold callipers and each skinfold was measured twice to obtain the average of the two measurements. These skinfold measurements were selected because, according to Meredith and Welk,²² they show the highest correlation with the overall percentage of fat in the bodies of children. Because the BMI of children changes continually as they get older, Cole and co-workers²³ determined age-specific BMI cut-off values to identify obesity in growing children and these were used to categorise the participants into a normal weight, overweight or obese group. The cut-off values for 6-year-old overweight and obese children are $>17.34 \text{ kg/m}^2$ and $>19.65 \text{ kg/m}^2$, while for 7-year-old children they are $>17.75 \text{ kg/m}^2$ and $>20.51 \text{ kg/m}^2$, respectively.²³ Waist circumference, which was measured at the narrowest point between the lower costal (10th rib) border and the crista iliaca, was measured in the standing position with a standard measuring tape (0.1 mm intervals).

Blood pressure

BP was measured with an Omron 705CP-II, (Kyoto, Japan). The width of the cuff (small 17 - 22 cm, medium 22 - 32 cm, large 32 - 42 cm) was adapted to the arm width. BP was measured while the child was seated, with the left arm resting on a table top with the palm turned upwards. Duplicate readings were recorded after the child had rested for 5 minutes. The mean of the two readings was used to determine the BP. Normal BP is defined as systolic and/or diastolic BP less than the 90th percentile for age, gender and height according to the cut-off values of the National High BP Education Program Working Group (NHBPEP) on high BP in children and adolescents;²⁴ prehypertension is defined as systolic and/or diastolic BP greater than or equal to the 90th percentile, but less than the 95th percentile and paediatric hypertension is defined as systolic and/or diastolic BP greater than or equal to the 95th BP percentile for age, gender and height.²⁴

Statistical analyses

Statistica²⁵ was used to analyse the data. A proportionally stratified sample was drawn with regard to ethnicity by making use of the population constitution data from Statistics South Africa²⁶ to ensure that the data could be generalised to children in the North West Province. For the purpose of description, data were analysed on the basis of means, maximum and minimum values and standard deviations (sd). Data were also further analysed by making use of Spearman correlation coefficients to analyse the relationship between BP and body composition. For the interpretation of practical significance, the following guidelines of Cohen²⁷ concerning magnitude of effect were used, namely, $d>0.1$ indicates a small effect; $d>0.3$ indicates a moderate effect and $d>0.5$ indicates a large effect. In addition, use

Table I. Number and percentage of Grade 1 learners according to classification in BMI-groups

	Normal weight		Overweight		Obese		Total
	(n)	(%)	(n)	(%)	(n)	(%)	(N)
Group	721	88.4	64	7.8	31	3.8	816
Boys	378	90.2	27	6.4	14	3.3	419
Girls	343	86.4	37	9.3	17	4.3	397
White	175	80.3	29	13.3	14	6.4	218
Black	517	91.2	34	6.0	16	2.8	567

n = number of participants.

Table II. Prevalence of prehypertension and hypertension amongst Grade 1 learners according to BMI categories

	Normal weight (n=721)		Overweight (n=64)		Obese (n=31)		p for trend	Total	
	(n)	(%)	(n)	(%)	(n)	(%)		(n)	(%)
Prehypertension									
Boys	34	9.0	4	14.8	3	21.4	0.15	41	9.8
Girls	22	6.4	3	8.1	3	17.7	0.02	28	6.8
White	12	5.5	3	1.4	4	1.8	0.08	19	8.7
Black	41	7.2	4	0.7	2	0.4	0.05	47	8.3
Total group	56	7.8	7	10.9	6	19.4	0.008	69	8.5
Hypertension									
Boys	96	25.4	3	11.1	5	35.7	0.07	104	24.8
Girls	82	23.9	11	29.7	6	35.3	0.14	99	24.9
White	40	18.3	4	1.8	3	1.4	0.004	47	21.6
Black	130	22.9	10	1.8	7	1.2	0.47	147	25.9
Total group	178	24.7	14	21.9	11	35.5	0.028	203	24.9

BMI = body mass index; n = number of participants; % = percentage; prehypertension >90th percentile <95th percentile; hypertension >95th percentile.

was made of a one-way analysis of variance to determine significant differences between the groups (normal weight, overweight and obese), and logistic regression was used to determine trends with regards to prevalence of prehypertension and hypertension between the subgroups. Because of the small number of coloured and Indian children that entered the sample, these children were excluded from the analysis of race differences, although their data were considered in the other results.

Results

Table I displays the descriptive statistics of the research group. The table shows that 88.4% of the learners were in the normal weight category, 7.8% into the overweight category and 3.8% into the obese category. The table also shows that a smaller percentage of the boys in comparison with the girls were in the overweight (6.4% compared with 9.3%) and obese (3.3% compared with 4.3%) categories. A smaller percentage of the black learners in comparison with the white learners fell into the overweight (6.0% compared with 13.3%) and obese (2.8% compared with 6.4%) categories.

Table II displays the percentage of learners of the total group, and race and gender separately, that can be classified with prehypertension and hypertension in the various BMI groups. A greater percentage of the research group were in the hypertension group compared with the prehypertension group. It appears that the prevalence of

prehypertension may increase with an increase in BMI. The obese group displayed the highest prevalence of hypertension in comparison with the normal and overweight groups. Boys showed a higher prevalence of prehypertension than the girls (9.8% compared with 6.8%), while the prevalence of hypertension in the boys and the girls was similar (24.8% compared with 24.9%). The prevalence of prehypertension was similar (8.7% compared with 8.3%), in the white and the black children, while black children displayed a higher prevalence of hypertension than the white children (25.9% compared with 21.6%).

Correlation coefficients were used to determine the relationship of systolic and diastolic BP with body composition (BMI, body fat percentage and waist circumference) of the participants. All the correlations were statistically and practically significant. Systolic and diastolic BP had significant ($p < 0.01$) positive correlations with BMI ($r = 0.22$; $r = 0.18$), body fat percentage ($r = 0.17$; $r = 0.16$) and waist circumference ($r = 0.21$; $r = 0.19$), although only with small practical significance ($d\text{-value} > 0.1$). These correlations were further analysed by means of covariance of analysis in Table III where the mean values for the systolic and diastolic BP of the participants were analysed in the group in the 3 different BMI groups and also separately for gender and race. A *t*-test was used to make comparisons between gender and races and significant differences in this regard. These results are shown in the table with a#.

Table III. Mean BP of Grade 1 learners according to BMI categories

Variables	Normal weight (a) (n=721)			Overweight (b) (n=64)			Obese (c) (n=31)			P for trend
	Mean	SD	95%CI	Mean	SD	95%CI	Mean	SD	95%CI	
Systolic BP (mmHg)										
Total group (n=816)	96.8 ^c	14.0	(13.6;14.5)	99.3 ^c	11.1	(9.9;12.6)	106.1 ^{ab}	15.5	(13.2;18.7)	<0.001
Boys (n=419)	98.0 ^c	14.4	(13.8;15.1)	99.7	7.7	(6.4;9.7)	105.6 ^a	17.6	(14.0;23.5)	0.012
Girls (n=397)	95.4 ^{bc#}	13.5	(12.9;14.2)	99.1 ^{ac}	12.6	(10.9;14.8)	106.6 ^{ab}	13.5	(10.8;17.8)	<0.001
White (n=218)	96.9	14.8	(13.4;16.5)	99.6	9.6	(7.6;13.0)	103.2	13.7	(9.9;22.1)	0.21
Black (n=567)	96.9 ^c	14.0	(13.5;14.5)	99.4	11.7	(10.3;13.6)	106.1 ^a	15.8	(13.1;19.8)	<0.001
Diastolic BP (mmHg)										
Total group (n=816)	64.6 ^c	13.1	(12.7;13.6)	67.0 ^c	11.2	(10.0;12.7)	72.0 ^{ab}	14.8	(12.6;17.9)	<0.001
Boys (n=419)	65.1 ^c	13.6	(13.0;14.2)	65.2	10.0	(8.3;12.5)	71.2 ^a	15.0	(12.0;20.0)	0.047
Girls (n=397)	64.0 ^{abc}	12.6	(12.1;13.2)	68.0 ^a	11.8	(10.2;13.8)	72.8 ^a	14.8	(11.9;19.5)	<0.001
White (n=218)	63.9	12.6	(11.4;14.1)	63.7	7.6	(6.1;10.3)	69.3	14.0	(10.2;22.6)	0.28
Black (n=567)	64.6 ^c	13.2	(12.7;13.7)	68.2	12.1	(10.6;14.0)	72.8 ^a	15.3	(12.8;19.2)	<0.001

BMI = body mass index; sd = standard deviation; a = normal weight; b = overweight; c = obese; mean with superscript differed significantly on a 5% level; # p-value <0.05 gender and race differences; CI = confidence interval.

Due to the small number of coloured and Indian children in the sample, these race groups were excluded from the analysis of race differences and only white and black children were compared. The systolic and diastolic mean BP values increased in the group as the BMI of the participants increased. The mean systolic and diastolic BP values of the normal weight and overweight children differed significantly from the obese children. Differences between the groups are indicated with superscripts (a, b & c). Boys in the normal weight group had significantly higher systolic BP values than the girls in this group. On the other hand, the girls in the obese group had higher systolic BP values in comparison with the boys in the obese group (not significant) and the girls in the overweight and obese groups also had higher diastolic BP in comparison with the boys in the overweight and obese group (not significant). An analysis of possible race differences showed that there was a tendency for the diastolic BP values of black children to be higher than those of the white children in all 3 of the different BMI groups (not significant).

Discussion

The aim of this study was to determine the prevalence of hypertension in Grade 1 learners, as well as to determine the possible relationship between the BP and body composition of Grade 1 learners in the North West Province of South Africa.

Our results regarding prehypertension in the group of 6 - 7-year-olds indicate a prevalence of 8.5%. This is similar to the findings of Hansen *et al.*,²⁸ who found a prevalence of 3.4% in a group of 3 - 18-year-old American children. With regards hypertension we showed a prevalence of 24.9%, which is a slightly higher than the 22.3% indicated in a study conducted by Steyn *et al.*⁹ more than 10

years ago in South Africa. Research demonstrates that the prevalence of hypertension has increased over the last decade as a result of the increase in overweight and obesity amongst children.⁶ Monyeki *et al.*,¹⁰ who focused on a relatively small group of black children (n=203) from disadvantaged communities, reported a 3.9% prevalence of hypertension in 6 - 7-year-old children. However, none of the 6 - 7-year-old children fell into the overweight category, which could also possibly contribute to the lower prevalence of hypertension that was reported in the study. The 35.5% prevalence of hypertension that was found in the obese group of children coincides with a study by Sorof *et al.*,¹⁷ who reported a 33.0% prevalence of hypertension in obese children (11.8 years old). However, South Africa lacks literature that reflects the prevalence of prehypertension and hypertension in 6 - 7-year-old children which could be used for comparison purposes.

The results further showed that systolic and diastolic BP had a significantly positive correlation with BMI, body fat percentage and waist circumference, although the practical significance was small. These results concur with the study of Monyeki *et al.*¹⁰ on 6 - 13-year-old children in disadvantaged communities. Waist circumference showed a positive and significant correlation with systolic and diastolic BP and coincides with research by Cuestas *et al.*²⁹ on 2 - 9-year-old children. From the above-mentioned results it would appear that waist circumference could be used as a possible risk marker to identify children at risk of possible high BP.

The obese children had significantly higher systolic and diastolic BP compared with the normal weight and overweight children and an increase in BMI was consequently associated with an increase in BP. These results coincide with studies conducted on children that

found the same trends.^{5,18} Morphological and functional changes that probably occurred in these children, such as arterial stiffness and left ventricular hypertrophy,³⁰ carotid arterial wall thickening³¹ and early activation of vascular endothelium and platelets³² could be cited as possible reasons for this. All the changes associated with high BP that are reported in the literature indicate that the arteriosclerotic process already begins during the early childhood years.

However, the results also show that a large percentage (24.7%, n=178) of the normal weight group (n=721) was also classified with hypertension. The high prevalence of hypertension in this group indicates that other factors, excluding body composition, may also play a role in the increased prevalence of hypertension. Possible reasons that could be given for this include unhealthy dietary habits, such as a reduced intake of fruit and vegetables, a diet high in saturated fats and a high intake of salt.³³ These unhealthy dietary habits of high intake of salt often occur in the South African population, seeing that bread is the staple food of large numbers of this population and it contains high levels of sodium chloride. Environmental stressors, such as violence and economic stressors, for example poverty,⁵ could possibly also have an influence on hypertension in children.

Boys of the normal weight group had significantly higher systolic BP values than girls in the normal weight group. On the other hand, the girls in the obese group had higher systolic BP values compared with the boys in the obese group, although not statistically significant. Girls in the overweight and obese group also displayed higher mean diastolic BP values compared with boys in the overweight and obese group, although also not statistically significant. These results correspond with research by Agyemang *et al.*³⁴ and Monyeki *et al.*¹⁰ which also found that girls had higher BP than boys. A possible reason could be that girls have a higher percentage of fat than boys, which contributes to a higher prevalence of overweight and obesity and, as a result, they display higher systolic and diastolic BP values.

As far as race differences are concerned, the mean diastolic BP values of the black children were higher than those of white children in all three of the different BMI groups, although not statistically significant. These results correspond with other research studies that also found that black children showed higher diastolic BP values than white children.^{9,35,36} These studies, however, did not analyse the different BMI groups separately. Furthermore, the results also show that the mean systolic BP of the black children was only higher than that of the white children in the obese group, although also not statistically significant. The studies of Dekkers *et al.*³⁶ and Cruz *et al.*³⁵ both show that the systolic BP of black children was higher than that of white children. The different BMI groups, however, were also not analysed separately in these studies. Possible reasons that can be given for this are differences in socio-economic status, genetic, endocrine and environmental factors, as well as cardiac function, diet and stress.³⁷⁻³⁹ Seedat³⁷ further demonstrates that black hypertensive patients are more susceptible to cerebral bleeding and malignant hypertension, which is more inclined to give rise to congestive cardiac failure, while coronary cardiac diseases are less common. In contrast to this, coronary cardiac disease is the most important result of hypertension in the white community. These slight differences, although they can only be viewed as trends, could possibly indicate different causes of hypertension in the different race groups, and this speculation needs further research.

The prevalence of hypertension, as well as prehypertension that was found in this study of 7-year-old children is disturbing, especially

when considering the associated health-related problems. A notable relationship was also found between the BP and body composition in the overall group of children, although this relationship could be mediated by high hypertensive percentages that were also found in the normal weight group.

BP during childhood is significantly associated with BP during adulthood.⁶ Therefore it is important to develop intervention programmes, especially those that are aimed at increasing levels of physical activity that would lead to weight loss in overweight and obese children and thus reduce the risk of hypertension. It is also advised that BP must be monitored from early childhood and that BP readings must be incorporated in the clinical evaluation of children on a routine basis so that possible cardiovascular risk factors can thus be monitored, especially in the case of overweight and obese children. This study, however, also shows that other factors besides body composition could have an effect on the prevalence of hypertension in children and follow-up studies are advised to obtain a better understanding of the influence of these factors. Among others, growth retardation is a possible factor that could have an effect on the increased prevalence of hypertension, especially amongst children of normal weight, as height is taken into consideration in BP percentile tables.

A shortcoming of the study was that, although two BP readings were taken five minutes apart, BP could only be taken once. However, most research studies conducted on children report this limitation. Although everything was also done to set the participants at ease with regard to the nature of the BP reading, a child could have been erroneously classified as hypertensive as a result of anxiety. This study is, however, the beginning of a longitudinal study during which follow-up data will be collected on BP status in 2013 and 2016 and baseline BP will consequently be monitored in this way. It has, moreover, also been reported that health workers often underdiagnose hypertension in children as the values for children are not as precise as those for adults, but have to be recorded from BP percentile tables and these tables are not always available in health care clinics.²⁶ Gender differences were indicated, but could not be analysed thoroughly in the race groups due to the limited numbers of children in the different race groups. In spite of these shortcomings, the study brought valuable information to the fore regarding the current prevalence of hypertension amongst Grade 1 learners in the North West Province of South Africa and the effect of body composition, gender and race on the BP of these children.

Conclusion

High prevalences of hypertension were found in Grade 1 learners in the North West Province of South Africa. Small practical significant associations existed between BP and body composition. Screening for BP should therefore not be neglected in these children, especially within the black communities, where the prevalence of hypertension was higher than in the white children. We recommend that interventions, including physical activity, should be introduced to reduce potential cardiovascular complications and obesity among children. Other factors contributing to high BP amongst children should also be investigated.

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