THE ASSOCIATION OF FAT PATTERNING WITH BLOOD PRESSURE IN RURAL SOUTH AFRICAN CHILDREN: THE ELLISRAS LONGITUDINAL GROWTH AND HEALTH STUDY

DR KD Monyeki

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Prof Han Kemper and Dr KD Monyeki in Ellisras area

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LIST OF ABREVIATIONS

ELS:	Ellisras longitudinal growth and health study
BMI:	Body mass index
BP:	Blood pressure
SBP:	Systolic blood pressure
DBP:	Diastolic blood pressure
CHD:	Coronary heart disease
SPIL:	Supraspinale skinfold
SSCP:	Subscapular skindfold
TRCP:	Triceps skinfold
BCP:	Biceps skinfold
S4SK:	Sum of four skinfold
S/T ratio:	Subscapular/triceps
S/ST:	Subscapular/subscapular +triceps
SS/SSBT:	Subscapular + suprailiac / subscapular+ suprailiac + biceps + triceps

ABSTRACT

Background Hypertension is one of the major causes of death in developed and underdeveloped nations. Essential hypertension and obesity may have their inception in childhood, with little data in African children to support these findings. Objectives were to determine the prevalence of overweight and hypertension in rural children in South Africa. Additionally, the association between fat-patterning ratios and blood pressure was investigated.

Methods Data were collected from 1884 subjects (967 boys and 917 girls), aged 6 - 13 years, participating in the Ellisras Longitudinal Study. Height, weight, triceps, biceps, subscapular and suprailiac skinfolds were measured according to the International Society for the Advancement of Kinanthropometry. Skinfold ratios were used as an indicator of a central pattern of body fat. Internationally recommended cut-off points for body mass index (BMI) were used. Hypertension, defined as the average of three separate blood pressure (BP) readings where the systolic or diastolic BPs are greater than or equal to the 95th percentile for age and sex, was determined.

Results The prevalence of hypertension ranged from 1-5.8% for boys and 3.1-11.4% for girls, and that of overweight from 1.1-2.9% for boys and 0.6-4.6% for girls. The association between high systolic BP and high BMI was -0.30, while that for high diastolic BP and high BMI was -0.68.

Conclusions The prevalence of hypertension is evident from age 6 years for girls, while that of overweight was low. Overweight became evident from age 10-13 years for both sexes. A significant association between high diastolic BP and high BMI was noted, while children with low BMIs were less likely to be hypertensive. Investigating habitual physical activity, fitness and dietary patterns will shed more light on the association of fat patterning and BP in this population.

INTRODUCTION

Hypertension is one of the major causes of death in developed and underdeveloped nations (Levi, 1979; Simpson et al., 1983; Seedat et al., 1981; Steyn et al., 1986). The causes of hypertension are generally unknown, and high blood pressure (BP) of unknown origin is usually referred to as "essential" hypertension. Prevalence studies in childhood have the important advantage that they may lead to the prevention of high BP before its harmful sequence occurs (Seedat et al., 1981).

The prevalence of arterial hypertension in children varies widely among different reports, ranging from 1-13%, depending mainly on the methodology (WHO, 1983). The highest prevalence rates are found in studies that drew data from one single visit (van Lenthe et al.,1998a). When the BP is measured several times, as recommended for the diagnosis of hypertension, the prevalence rate tends to fall to nearly 1% (National High Blood Pressure Education Program working Group on High Blood Pressure in children and Adolescents, 2004). Several longitudinal studies have demonstrated that the child with elevated BP levels, even within the normal limits, tends to show a progression during life, with higher levels than other individuals and a greater probability of becoming an adult with hypertension. This concept, known as tracking of hypertension, is very important because a pediatrician can identify children at high risk of becoming an adult with hypertension, thus allowing time to initiate preventive measures at an early age (Morgenstern, 2002). It could be beneficial for the rural South African population if research could be geared towards tracking this phenomenon in early life.

One of the most important parameters for doing hypertension studies in children is the definition of reference values to be adopted. For the adult population the definition of hypertension is epidemiological, and the cut-off point is determined according to the population at risk of developing morbid events (Anand & Tandon, 1996). However, for children and adolescents the definition usually followed reference values that are statistically obtained from clinical practice as reported by the American Board of Experts (National High Blood Pressure Education Program Working Group on High Blood Pressure in Children and Adolescents, 2004).

Overweight and hypertension are common conditions in the South African black adult population. Overweight has been reported to be 34% in urban black women in Cape Town (Steyn et al., 1991), and 28-32% in rural women (de Villers et al., 1988; Walker et al., 1989; Steyn et al., 1994; Beilin, 1994). Obesity is known to be one of the most important risk factors contributing to hypertension, which has been reported in 19-35% of black men studied in Durban and Cape Town (Steyn K, et al., 1992; Seedat & Seedat, 1982; Castelli, 1983; Fritz, 1995). Although reliable statistics on stroke are sparse and difficult to obtain in black South Africans, recent studies have indicated that the incidence is higher in the black than the white population, i.e. 244/100 000 in the 55-64-year-old group (Seedat & Seedat, 1982; Seedat et al., 1992; Fritz, 1995; Kotani et al., 1997; van Lenthe et al., 1998b). However, no published data on overweight, fat patterning and BP in rural South African children exist to support these findings.

LITERATURE REVIEW

Definition of obesity and overweight in children

Overweight for children was defined as body mass index (BMI) >85th percentile by the National Health and Nutrition Examination Survey (Cameron & Getz, 1997; Monyeki et al., 1999) during the past decades. The sum of triceps subscapular was used as an indicator of over-fatness with the cut-off point being greater than the 85th percentile for the National Health and Nutrition Examination Survey (Cameron & Getz, 1997). Recently, the relationship between childhood body fat and adult obesity has led to the development of cut-off points for BMI in children, which are able to classify children as obese >30 kg/m^2 and or overweight >25kg/m^2 for specific age and sex (Cole et al., 2000).

Definition of blood pressure in children

Standardisations and norms of BP in children were reported in the publication of the 1987 Report of the Second Task force on BP control in children (National High Blood Pressure Education Program Working Group on Hypertension Control in Children and Adolescents, 1996; National High Blood Pressure Education Program Working Group on High Blood Pressure in Children and Adolescents, 2004; Morgenstern, 2002). In this report it was recommended that children of 3 years and older should have their BP recorded during health maintenance and emergency visits. It should mostly be measured with a standard clinical sphygmomanometer using the stethoscope placed over the brachial artery pulse, proximal and medial to the cubital fossa and below the bottom edge of the cuff approximately 2 cm above the cubital fossa. The cuff that is approximately to the size of the child's upper right arm should be used. In order to measure BP in children 3 years and older, three different cuff sizes, the standard adult cuff, a large adult cuff and a thigh cuff should be available. The BP should be measured in a control led environment after 3 to 5 minutes of rest in the seated position with the cubital fossa supported at heart level. The BP should be recorded twice on each occasion and the average of each systolic (SBP) and diastolic blood pressure (DBP) measurement be used.

SBP is determined by the onset of the tapping Korotkof sound. The definition of DBP has been more controversial. The American Heart Association has recently established the disappearance of sounds (the fifth Korotkoff sound) as the DBP in children of all ages (National High Blood Pressure Education Program Working Group on Hypertension Control in Children and Adolescents, 1996; National High Blood Pressure Education Program Working Group on High Blood Pressure in Children and Adolescents, 2004 Morgenstern, 2002). In children, Korotkoff sounds can be heard to 0mmHg.

The second Task Force report of 1987 presented the BP distribution curve that was adjusted for age and height. Although increase in BP is associated with obesity and height the association with weight is believed to be a causal one. The 1996 updated BP tables included data from the 1987 Second Task Force Report that were reanalysed to determine BP percentiles based on height to determine age, sex and height specific SBP and DBP percentiles (Morgenstern, 2002). More recently, data were obtained from the National Health and Nutrition Examination Survey III that screened 61206 children from 1988 to 1991 (National High Blood Pressure Education Program Working Group on Hypertension Control in Children and Adolescents, 1996; National High Blood Pressure Education Program Working Group on High Blood Pressure in Children and Adolescents, 2004). BP varies widely throughout the day in children and adults because of normal diurnal fluctuation, changes in physical activity, emotional stress and other factors. This variation can make the diagnosis of hypertension difficult.

Normal BP is defined as SBP and DBP less than the 90th percentile for age and sex; high normal BP is defined as an average SBP and DBP of greater than or equal to 90th percentile but less than the 95th percentile, and hypertension is defined as an average of SBP or DBP greater than or equal to the 95th percentile for age and sex measured on at least three separate occasions (National High Blood Pressure Education Program Working Group on Hypertension Control in Children and Adolescents, 1996; National High Blood Pressure Education Program Working Group on High Blood Pressure in Children and Adolescents, 2004 Morgenstern, 2002). A more precise characteristic of individual BP is found when averaging multiple measurements taken over weeks and months.

High BP and overweight or obesity

Overweight is a well established risk factor for cardiovascular disease (CVD) onset diabetes and stroke (Kemper et al., 1997; van Lenthe et al., 1998b). The relationship between body fat patterning and BP has been recognised for many years. A number of recent investigators have concluded that among many relevant factors, BMI and skinfold ratios are associated with high BP (Menash et al., 1999; Morgenstern, 2002). Although ethnicity and genetics have long been known to influence the distribution of BP levels within a population, these factors seem to have less bearing on the differences in BP levels between populations (Kaufman et al., 1997; He et al., 1994). Luke et al. (1997) have shown that BMI was strongly related to BP, and that its effect is similar to those across surveys conducted in the United States and within sex and racial groups. Kaufman et al. (1997) who investigated the prevalence of hypertension in black populations in Africa, Caribbean and the United States, suggested that mean BMI and urinary sodium-potassium ratio account for 70% of the geographic variation in the hypertension prevalence. They further reported that the prevalence of hypertension was stronger and more consistent than that of the sodium-potassium ratio. In these studies children were not included.

In the INTERSALT study, Dyer et al. (1989) after adjusting for age, alcohol intake, smoking and sodium and potassium excretion, reported that BMI was positively related to SBP and DBP among men and women. It is clear that male and female levels of BP were similarly affected by adipose measures. Various genetic and environmental hypotheses have been offered to relate growth and body size to BP to untangle patterns observed in adults. Sections examining the relationship among childhood and adolescent BP measure with that of adults` BP, and among body size, BP and puberty are presented. Sex differences in BP are explored through the relation of body size and menopause.

In the United States, about 25% of the adult population has hypertension; although the prevalence is low in children and adolescents, the concept is that the root of essential hypertension extends back to childhood (Kaufman et al., 1997). Longitudinal studies and familial studies of BP showed that a link existed between genetic and environment of essential hypertension (Kemper et al., 1999). During the preschool years, BP begins to follow a pattern, i.e. children at a given percentile of BP distribution tend to maintain that approximate value relative to their peer group, as they grow older. This pattern continues from adolescence to adult life with a tracking correlation of 0.55 SBP and 0.44 for DBP (van Lenthe et al., 1998a; Kemper et al., 1997).

Several factors known to be associated with hypertension in adults correlate with high BP in children and adolescents. A direct relationship between weight and BP has been documented at the age of 5 years and was more prominent in the second decade (Kemper et al., 1999; van Lenthe et al., 1998b). The association of fat patterning and obesity and hypertension was believed to be a causal one wherein obesity contributes not only to higher BP in children and adolescents, but has been shown to have a significant predictive value for its association with the cardiovascular risk factors, such as cholesterol levels and serum lipoprotein ratios (Kemper et al., 1999). Between 13% and 36% of 12-17-year-old American adolescents are obese, while 4-12% may be considered super obese (Sidiropoulos et al., 1996). In South Africa, the national average for obesity was reported as 4% and for overweight 17.2% in children, though its association with BP for these children was not investigated (Reddy et al., 2003).

Cardiovascular effect of hypertension

Elevated BP accelerates the development of coronary arteries and contributes significantly to the pathogenesis of cerebrovascular accidents, heart failure and renal failure. The Amsterdam Growth and Health study relate BP in childhood to cardiovascular risk factor in adulthood (Kemper et al., 1999). A direct relationship exists between BP and left ventricular size in normotensive children, and cardiac size increases with increasing percentiles of BP suggesting a continuous threshold effect. In a study of normotensive children, Munger et al. (1998) and St George et al. (1990) found increased left ventricular mass index in the offspring of two hypertensive parents.

The adverse effect of hypertension on cardiovascular function is confounded by the presence of obesity. Appropriate normalization of the left ventricular mass is necessary for each study population and left ventricular hypertrophy caused by obesity begins in childhood (Kemper et al., 1999).

Cardiovascular risk factors tend to aggregate and usually appear in combination. This clustering of risk factors is evident in childhood and persists into young adulthood (Kemper et al., 1999). Epidemiological studies have established that multiple risk factors increase the probability of cardiovascular events because cardiovascular risk factors tend to reinforce each other in their influence on morbidity and mortality. The risk factors associated with clinical cardiovascular disease in adults are also associated with the pathologic evidence of atherosclerotic disease in children and young adults (Kemper et al., 1999; Twisk et al., 1994).

The effect of multiple risk factors on coronary arteriosclerosis gives further justification for the evaluation of the cardiovascular risk in young people and provides a rationale for both prevention and intervention early in life.

Body fat and sex differences in blood pressure

Many studies have reported the relationship between adiposity measures and BP, although few have examined whether the association holds for men and women separately (Gerber et al., 1995, Kaufman et al., 1997). It has been reported that the relationship between BP and body fat does not differ for the different sexes (Garrison & Kannel, 1993; Freedman et al., 1995). Gerber et al. (1995) reported a significant association between various adiposity measures and BP for men and women separately. Adiposity was measured in many studies by BMI, waist to hip ratios, sum of skinfolds and skinfold ratios, with further complications in the analysis of the adiposity relationship to BP that made it difficult for these studies to be compared.

Garrison and Kannel (1993) in the Framingham Offspring study, which was conducted in white men and women, aged 20 to 39 years reported a significant regression coefficient between adiposity as seen in the skinfold thickness, BMI, and BP of both men and women. In the Chinese population, He et al. (1994) reported a significant relationship between BMI and BP for men compared to women even after adjusting for age, heart rate, smoking, alcohol intake and physical activity.

In summary, most studies reported a significant association between adiposity measures and BP for men and women. Few studies suggested that these relationships are different between men and women, although a small number reported age modification or non-linearity for women in the relationship between BMI and BP but not for men.

Relationship between body size, blood pressure and puberty

The onset of puberty is associated with increases in BP. An individual with a larger body mass generally commences puberty at an earlier age than their smaller counterparts. Daniels et al. (1996) reported that racial differences in BP of pre-pubertal and pubertal girls are explained by stage of sexual maturation and body fatness or body size. This was evident from the findings of Higgins (1990), who mentioned that the greater prevalence of hypertension among black women contributes to this group's high rate and risk of cardiovascular morbidity and mortality. Among black and white girls aged 9-10 years, the black girls were taller, heavier and had thicker skinfolds than white girls did, with SBP and DBP being significantly greater in black girls compared to white girls of the same age (Daniels et al., 1996). In applying a multiple regression analysis, to evaluate the relationship of race, sexual maturation, height, and sum of skinfold thickness on SBP and DBP, Daniels et al. (1996), found height to be the predictor of both SBP and DPB. It was clear that linear growth as measured for height should be taken into account when evaluating DBP differences by race or sexual maturation stages, whereas SBP, body fatness and height appears to be important in children.

Age at menarche is strongly related to fatness (Garn et al., 1986). In determining the relationship between diet, physical activity and early menarche age, it was clear that the girls were significantly heavier, taller and had greater abdominal and suprailiac skinfold than pre-menarcheal girls (Moisan et al., 1990). Weight had the strongest association with early menarche. It has been reported that greater weight leads to greater skinfold thickness that exhibits a high association with both SBP and DBP, particularly in girls who experience early menarche.

In summary, body size and body mass measured in various studies as height, weight and skinfold thickness influence timing and sexual maturation and the level of BP. Skeletal age and stage of sexual maturation, as seen using the Tanner scale, predicts BP and seems to be largely dependent on body size.

MOTIVATION FOR THE STUDY

Elevated arterial BP is a strong predictor of cardiovascular and renal disease. Cardiac output and systematic vascular resistance determines the level of arterial BP (WHO, 1983). It is not known whether the increase in BP occurring early in life is a result of increased cardiac output (Hohn, 1994). In children, high cardiac output plays a part in the early pathogenesis of hypertension (van Lenthe et al., 1998b).

Several factors have been suggested to be related to the BP level in children. These include genetic factors, maturation, obesity and low physical activity, body size, endocrine and renal factors, dietary factors (particularly high sodium intake), oral contraceptives, and noise, psychological and social influences (Hohn et al., 1994; van Lenthe et al., 1998a; Harshfield & Treiber, 1999; Kemper et al., 1999; Freedman et al., 1995). The role of any of these factors on the level or change of BP during childhood and adolescence has still to be determined in rural South African children.

It has been recognised that overweight which starts early in life and persists into adulthood, increases the risk of overweight-related conditions, such as hypertension later in life (van Lenthe et al., 1998a,b). Adolescence is also known to be an important stage to develop central patterning of body fat, which predisposes to CHD at a later age (Kemper et al., 1999). Furthermore, essential hypertension may have its inception in childhood (van Lenthe et al., 1998b).

MAIN OBJECTIVES FOR THE STUDY

The main objectives of this study were to determine the prevalence of overweight and hypertension in the initial cross-sectional sample of children, aged 6-13 years, participating in Ellisras Longitudinal Study (ELS). Additionally, the association of fat patterning and BP was investigated.

METHODS

Geographical area

Ellisras is a deep rural area situated within the north-western area of the Limpopo Province, South Africa. The population is about 50 000 people residing in 42 settlements (Sidiropoulos et al., 1996). These villages are approximately 70 km from the Ellisras town (23° 40S 27° 44W), now known as Lephalale, adjacent to the Botswana border. The Iscor coal mine and Matimba electricity power station are the major sources of employment for many of the Ellisras residents, whereas the remaining workforce is involved in subsistence farming and cattle rearing, while a minority is in education and the civil service.

Sample

The ELS followed a cluster sampling method initially (Monyeki et al., 2000). In brief, the study was undertaken at 22 schools (10 pre-school and 12 primary schools) randomly selected from 68 schools within the Ellisras area. Birth records were obtained from the principals of each school. Only those records that were verified against health clinic records were used to determine the age of each potential participant. Each of the 22 selected schools was assigned a grade with the expectation that most of the children in a particular age category (i.e. 3,4,...9,10) would be found in that grade.

In May 2000, medical students from VU University, Amsterdam included the BP parameter in the ongoing anthropometric measurements of the ELS. Measurements were done on 967 boys and 917 girls (n = 1884), aged 6-13 years. The Ethics Committee of the University of the North granted ethical approval prior to the survey, and the parents or guardians provided informed consent.

Anthropometry

All children underwent a series of anthropometric measurements. Weight was measured on an electronic scale to the nearest 0.1 kg, and a Martin anthropometer was used to measure height to the nearest 0.1 cm. Skinfolds (suprailiac-SPIL, subscapular-SSCP, triceps-TRCP, and biceps-BCP) were measured using a Slim Guide skinfold caliper. All training and measurements were done in accordance with the standard procedures of the International Society for the Advancement of Kinanthropometry (Norton & Olds, 1996). To achieve technical error of measurement within the accepted limits, the fieldworkers underwent testing for reliability of measurements as part of their training (Norton & Olds, 1996).

Fat patterning

The sum of the four skinfolds (SPIL+SSCP+TRCP+BCP) (S4SK) was used as an indicator of total body fatness. The proportion body fat on the trunk relative to that on the limbs was used as an indicator of a central pattern of body fat (visceral fat). This was calculated by three equations (Kemper et al., 1999; Cameron & Getz, 1997).

1). S/T ratio: $\frac{\text{Subscapular}}{\text{Triceps}}$

2). S/ST ratio: $\frac{\text{Subscapular}}{\text{Subscapular + triceps}}$

3). SS/SSBT ratio: $\frac{\text{Subscapular + Suprailiac}}{\text{Subscapular + Suprailiac+ Biceps + triceps}}$

Blood pressure

Using an electronic Micronta monitoring kit, at least three BP readings were taken after the child had been seated for 5 minutes or longer (National High Blood Pressure Education Program Working Group on Hypertension Control in Children and Adolescents, 1996; National High Blood Pressure Education Program Working Group on High Blood Pressure in Children and Adolescents, 2004). The bladder of the device contains an electronic infrasonic transducer that monitors the BP and pulse rate, displaying these 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 mercury sphygmomanometer.

Statistical analyses

Data were expressed as median and inter-quartiles. BMI was calculated for each participant as: weight divided by height (in meters) squared. The non-parametric t-test was applied to test the significance level ($P < 0.05$) between sexes. Internationally recommended cut-off points for BMI in children were used (Cole et al., 2000). Hypertension, defined as the average of three separate BP readings where the SBP or DBP is greater than or equal to the 95^{th} percentile for age and sex (National High Blood Pressure Education Program Working Group on Hypertension Control in Children and Adolescents, 1996; National High Blood Pressure Education Program Working Group on

High Blood Pressure in Children and Adolescents, 2004). Fisher's exact test was used to test for a significant association in the overweight and hypertension groups. Linear regression models were used to assess the relationship between BP and other fat patterning variables adjusted for age and sex. Logistic regression analysis was applied to determine whether subjects falling within the high body fat categories are more likely to have hypertension than those with lower body fat. All the statistical analyses were done using the Statistical Package for the Social Sciences (SPSS). The statistical significance was set at $P < 0.05$.

RESULTS

Figures 1 and 2 present the median and inter-quartile BP by age group. Boys and girls exhibited a gradual increase in the median SBP throughout the age range, with girls having a significantly higher median SBP than boys at age 12 ($P < 0.05$) and 13 (P 0.018) (Figure 1). There was a gradual increase over age, with 12-year-old (P 0.040) and 13-year-old (P 0.027) girls having a significantly higher DBP than boys (Figure 2).

Table 1. The prevalence of hypertension and overweight in Ellisras rural children age 6–13 years.

			Hypertension[a]		Overweight[b]	
	Boys	Girls	Boys	Girls	Boys	Girls
Age (years)	N		%		%	
6	33	26	0	3.8	0	0
7	79	65	2.5	7.5	0	0
8	97	85	1	3.4	0	0
9	117	110	5.8	4.5	0	0
10	175	177	2.8	4.5	1.1	0.6
11	216	214	3.7	6.0	0	2.8
12	172	183	2.3	11.4	2.9	3.8
13	91	62	4.3	3.1	2.2	4.6

[a] The average systolic blood pressure and diastolic blood pressure greater than or equal to the 95^{th} percentile for age and sex measured at least three separate occasions (National High Blood Pressure Education Program Working Group on Hypertension Control in Children and Adolescents, 1996; National High Blood Pressure Education Program Working Group on High Blood Pressure in Children and Adolescents, 2004)
[b] Internationally recommended body mass index cut-off points in children, Cole *et al.* (2000)

The prevalence of hypertension starts at age 7 for boys (2.5%) and age 6 for girls (3.8%) and range from 1% to 5.8% for boys and 3.4% to 11.4% for girls (Table 1). Although a high prevalence of hypertension was found in girls at age 12, and in 9-year-old boys, this was not statistically significant. The prevalence of overweight is evident in this sample at age 10 and older, ranging from 1.1% to 2.9% for boys and 0.6% to 4.6% for girls. The 12-year-old boys (2.9%) and 13-year-old girls (4.6%) had the highest prevalence of overweight.

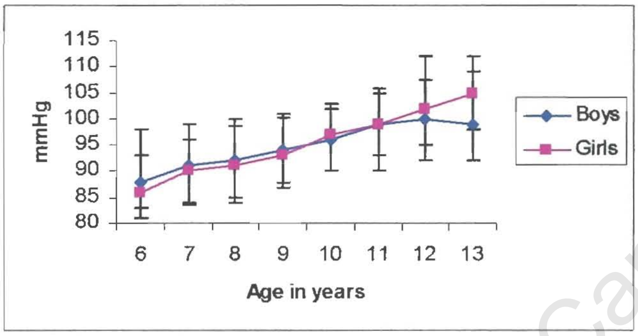

Figure1. Median systolic blood pressure for Ellisras rural children age 6–13 years (N=967 boys, 917 girls)

Girls showed higher BMIs at age 11 onward and reached a statistically significant level ($P < 0.05$) at age 13 compared to boys (Figure 3). The median S4Sk for girls was significantly higher than in boys ($P < 0.01$ to < 0.001) throughout the age range (Figure 4). The median S/T ratio was significantly higher for boys than girls ($P < 0.05$ to < 0.001) (Figure 5a). The median S/ST and SS/SSTB ratios for boys were significantly higher than for girls ($P < 0.05$ to 0.0001) throughout the age range (Figures 5b and 5c).

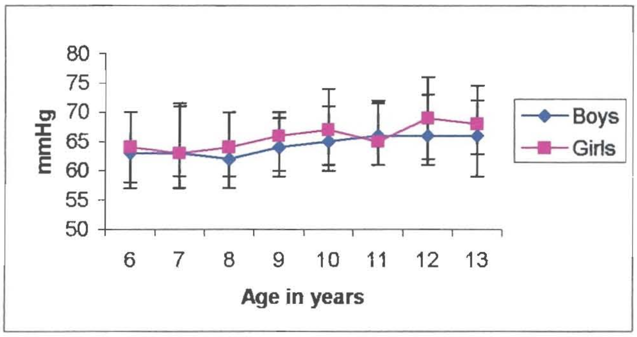

Figure 2. Median diastolic blood pressure for Ellisras rural children age 6–13 years (N=967 boys, 917 girls)

The regression analysis showed a positive significant association for the variables BMI, the S/ST and SS/SSBT ratios, and the sum of the skinfolds with SBP ($P < 0.001$) (Table 2). No significant association is seen between the fat-patterning variables and DPB. High SBP was related to high BMI (Table 3) although the association was not significant. However, a significant ($P < 0.05$) association was observed between high DBP and high BMI (Table 3). Contrary, there is a high significant inverse association between low BMI and both systolic (crude -4.15 and -7.23 adjusted for age and sex) and diastolic (crude -2.45 and -3.01 adjusted for age and sex) blood pressure (Table 3).

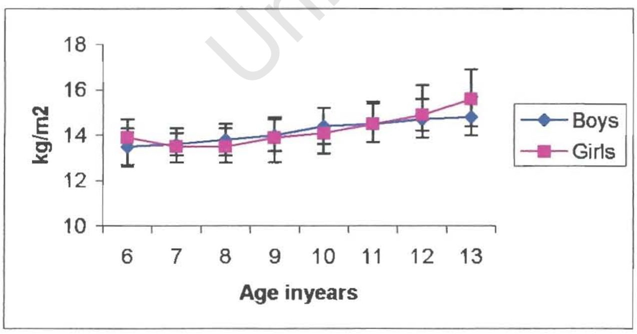

Figure 3. Median body mass index for Ellisras rural children age 6–13 years (N=967 boys, 917 girls)

Table 2. Regression coefficient, 95% confidence interval and *P*-value in the association of fat-patterning variables and blood pressure in the Ellisras rural children (N=967 boys, 917 girls)

Fat-patterning variables	Systolic blood pressure								Diastolic blood pressure							
	Crude				Adjusted (for age and sex)				Crude				Adjusted (for age and sex)			
	ß	*P*-value	95% CI		ß	*P*-value	95% CI		ß	*P*-value	95% CI		ß	*P*-value	95% CI	
Body mass index	0.04	0.001	0.03	0.05	0.03	0.000	0.02	0.03	0.002	0.97	-0.01	0.01	0.002	0.57	-0.01	0.01
S/T ratio	0.001	0.870	-0.001	0.001	0.001	0.807	-0.07	0.009	0.000	0.94	-0.001	0.001	0.002	0.76	-0.001	0.001
S/ST ratio	0.04	0.001	0.03	0.05	0.03	0.000	0.02	0.04	-0.003	0.67	-0.02	0.01	-0.03	0.61	-0.02	0.01
SS/SSBT ratio	0.18	0.001	0.14	0.21	0.11	0.000	0.07	0.15	-0.02	0.51	-0.06	0.03	-0.01	0.54	-0.06	0.03
Sum of skinfolds	0.15	0.001	0.12	0.19	0.10	0.000	0.06	0.13	-0.003	0.90	-0.05	0.44	-0.004	0.86	-0.05	0.04

S/T: subscapular/triceps; S/ST: subscapular/subscapular+triceps; SS/SSBT: subscapular+suprailiac/subscapular+suprailiac+biceps+triceps skinfolds

The most valid and reliable method for the assessment of fat patterning in children is the dual-energy X-rays absorptiometry, not used in our study. However, height, weight and skinfold thickness that were used to determine the BMI, central pattern and general adiposity have measurement validity. More importantly, these measurements in children and adolescents have been associated with future development of increased BP (Mensah et al., 1999). In our sample, we performed the regression analysis for BP with age corrected for S4SK for boys and girls separately (Table 4). The increase in the SBP and DBP was partly because of the increased fat around the arm with increasing age as reported earlier (Law et al., 2001).

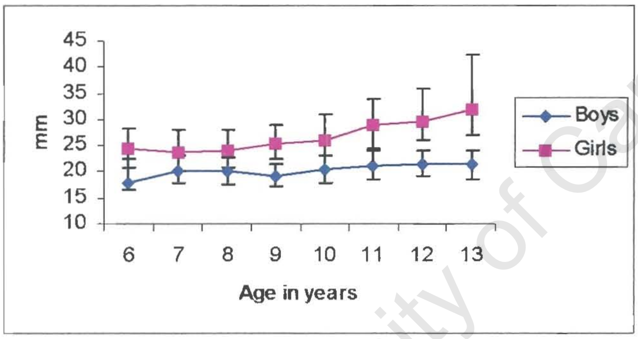

Figure 4. Median sum of skinfolds for Ellisras rural children age 6–13 years (N=967 boys, 917 girls)

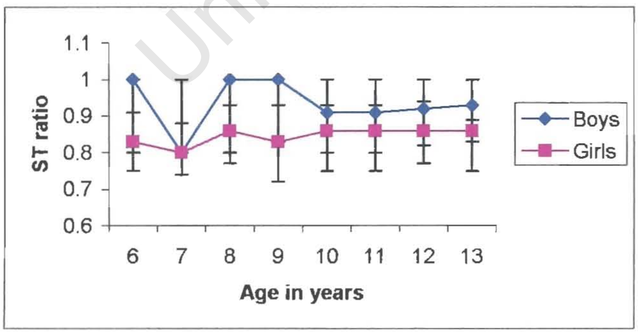

Figure 5(a). Median subscapular/triceps skinfold ratio for Ellisras rural children age 6–13 years (N=967 boys, and 917 girls)

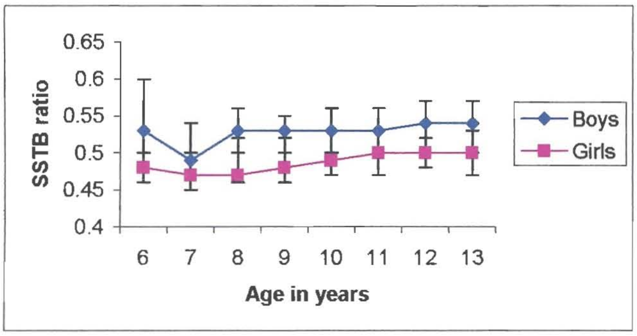

Figure 5(b). Median subscapular + suprailiac/subscapular + suprailiac + biceps + triceps skinfold ratio for Ellisras rural children age 6–13 years (N=967 boys, 917 girls)

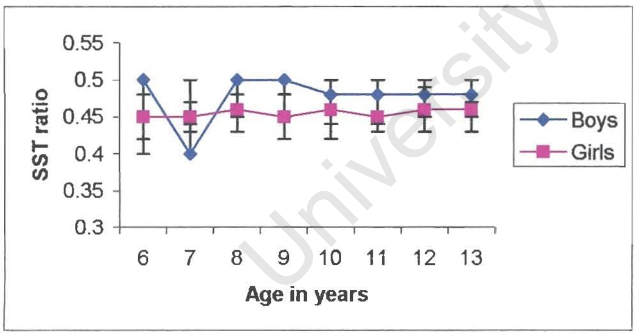

Figure 5(c). Median subscapular/subscapular + triceps skinfold ratio for Ellisras rural children age 6–13 years (N=967 boys, 917 girls)

Table 3. Regression coefficient, 95% confidence interval and *P*-value in the association of high blood pressure (systolic and diastolic) and high and low body mass index (BMI) of Ellisras rural children (N=967 boys, 917 girls)

	Crude				Adjusted (for age and sex)			
	ß	*P*-value	95% CI		ß	*P*-value	95% CI	
High Systolic								
High BMI	-0.30	0.27	-0.89	3.19	-6.28	0.369	-1.12	3.02
Low BMI	-4.15	0.000	-4.51	-3.78	-7.23	0.00	-9.99	-4.46
High Diastolic								
High BMI	-0.68	0.00	1.03	2.88	1.05	0.00	1.02	2.90
Low BMI	-2.65	0.00	-2.83	-2.47	-3.01	0.00	-4.19	-1.82

Table 4. Regression coefficient, 95% confidence interval and *P*-value for blood pressure (systolic and diastolic) and age and the sum of the four skinfolds (S4Sk) of Ellisras rural children (N=967 boys, 917 girls)

	Boys				Girls			
	ß	*P*-value	95% CI		ß	*P*-value	95% CI	
Systolic								
Age	1.62	0.00	1.26	1.98	2.19	0.000	1.75	2.63
S4Sk	0.20	0.002	0.07	0.32	0.21	0.000	0.13	0.30
Diastolic								
Age	0.61	0.00	0.30	0.92	0.71	0.000	0.35	1.06
S4Sk	0.01	0.001	-0.1	0.12	0.12	0.000	0.05	0.19

DISCUSSION

In this study, cross-sectional results of fat patterning and BP measurements of children from Ellisras rural area in South Africa are presented. The prevalence of hypertension is evident from a younger age group among girls in this sample, while that of overweight was low. Overweight became evident from age 10-13 years for girls and boys. Hypertension in the present study was observed in 48 boys (4.8%) and 77 (5.1%) girls aged 6–13 years, while in the West Indies this was observed in only 23 (0.46%) aged 5 to 17 years (Anand & Tandon, 1996). The number of hypertensive children in the West Indies study dropped from 160 to 23 following the re-evaluation of hypertensive children (Anand & Tandon, 1996).

Elevated BP must be confirmed on repeated visits before characterising an individual as having hypertension (National High Blood Pressure Education Program Working Group on Hypertension Control in Children and Adolescents, 1996; National High Blood Pressure Education Program Working Group on High Blood Pressure in Children and Adolescents, 2004). A more precise characteristic of an individual's BP level is an average of measurements taken over weeks or months (National High Blood Pressure Education Program Working Group on Hypertension Control in Children and Adolescents, 1996; National High Blood Pressure Education Program Working Group on High Blood Pressure in Children and Adolescents, 2004; Morgenstern, 2002). Therefore, a follow-up of the present study might yield different results among these hypertensive children, as was the case with children in the West Indies study (Anand & Tandon, 1996). However, this study provided valuable information on hypertension in rural South African children, and could be followed by an intervention study to uproot this particular public health problem in rural South African communities. BP measurements between the 90^{th} and 95^{th} percentile are high and warrant further observation and consideration of other risk factors, since this level of BP could relate to disease in adulthood (National High Blood Pressure Education Program Working Group on Hypertension Control in Children and Adolescents, 1996; National High Blood Pressure Education Program Working Group on High Blood Pressure in Children and Adolescents, 2004; Morgenstern, 2002).

The longitudinal data are not yet available to allow an assessment of the extent of the prevalence of hypertension in this study. Other epidemiological studies reported that elevated BP was associated with overweight (National High Blood Pressure Education Program Working Group on Hypertension Control in Children and Adolescents, 1996; National High Blood Pressure Education Program Working Group on High Blood Pressure in Children and Adolescents, 2004; Morgenstern, 2002). In the present study, elevated DBP was significantly associated with a high BMI, while the association for SBP with a high BMI was not significant. Additionally, there is a high significant inverse association between low BMI and both systolic and diastolic BP. However, obesity in terms of overweight was reported to be low in this population (Monyeki et al., 1999), with the prevalence of malnutrition being high in the older age group (Monyeki et al., 2000).

Although no empirical data are available on nutritional intake and food practices in these villages, one of the current authors (KDM) lived in this area throughout childhood and reports that girls spend their time in and around the house, and would be likely to obtain food they, their mothers, grandmothers or other female siblings prepare. The capability of boys to become independent goat and cattle herders coincides with their school attendance. They will return from school each afternoon to carry out their herding chores. During this time, their nutritional intake is likely to deteriorate because they are distanced from the preparation and source of food, which is unlikely to be kept for them on their return. The boys, usually aged about 7-15 years, rely on gathering vegetable foods (berries etc.), trapping rabbits and hares, and/or killing birds, which they cook and eat during the day. Therefore, they do not have a guaranteed daily nutritional intake. The staple family diet is porridge (mealie-meal/maize) which is prepared daily in the most families by female siblings or parents. This porridge remains in the cooking pot for members of the family to serve themselves when they are hungry. In common with the data on Pedi children reported by Steyn NP, et al. (1992) it may be that these children, who are mainly from Tswana origin, have two meals a day with very low energy intake. While the above description is anecdotal and may be viewed as having little scientific basis, such reports of dietary behaviour regarding children in Southern Africa are rare in the literature and, therefore, should not be ignored as a possible explanation of rural South African nutritional intake.

Furthermore, elevated BP was associated with the degree of physical fitness and physical activity (National High Blood Pressure Education Program Working Group on Hypertension Control in Children and Adolescents, 1996; National High Blood Pressure Education Program Working Group on High Blood Pressure in Children and Adolescents, 2004; Morgenstern, 2002). Though the physical activity and physical fitness level of the present sample was not part of our analysis, Monyeki et al. (2003) reported low physical activity patterns among girls compared to boys. In this study, the measurement estimates of height and weight were associated with poorer performance in physical fitness tests (Monyeki et al., 2003).

One would expect a statistically significant association between BP and fat-pattern ratio over age, which is not the case in this sample (Steyn et al., 1992; Seedat & Seedat, 1982; Seedat et al., 1992; Castelli, 1983; van Lenthe et al., 1998a,b). Furthermore, Stalloness et al. (1982) reported a statistically significant association between central fat patterning and SBP in 12-17-year-old white males, and a weaker association in 13-17-year-old females in the Bogalusa Heart Study. Van Lenthe et al. (1996) reported a significant association of BP with fat-pattern ratios in girls who showed signs of early menarche. Girls in this study currently report their age at menarche as ranging from 9.56-13.13 years.

CONCLUSIONS

Hypertension and overweight are evident in the present sample, although the number of affected children is very small. A significant association between high DBP and high BMI is noted in this population. Investigation of the habitual physical activity, physical fitness and dietary patterns will shed more light on the association of the fat pattern and BP in this population.

KEY MESSAGES

- The prevalence of hypertension was evident from younger age groups in the Ellisras rural population of South Africa.
- Overweight occurred during the adolescence for boys and girls although the prevalence was very low.
- A positive significant association between body mass index, subscapular /subscapular + triceps, susbscapular +suprailiac / suprailia + subscapular + biceps + triceps and the sum of four skinfold with systolic blood pressure exists.
- No significant association between the fat patterning ratios and diastolic blood pressure exists.
- There was a significant association between high diastolic blood pressure and high body mass index.

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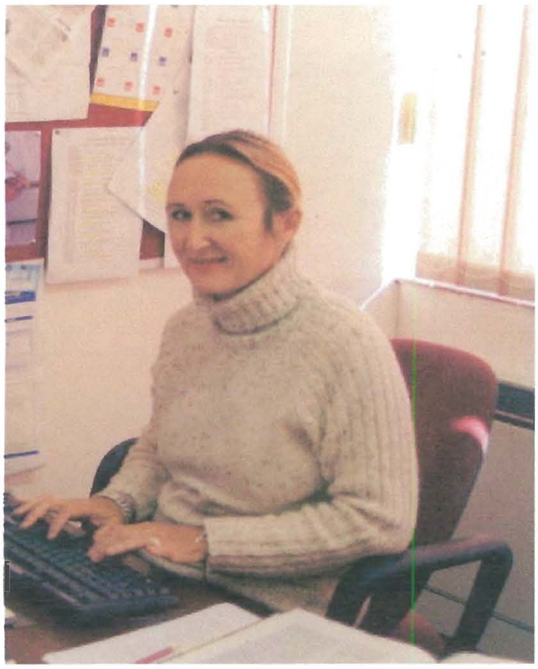

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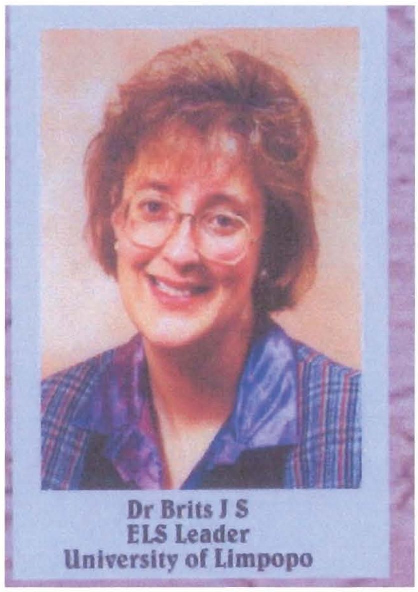

Dr Huub van Erve, SGB Heckenberg, R Schouten (Fourth year Vu Medical University Center Students), Dr LAS du Plessis and University of Limpopo ELS field workers.

ELLISRAS RURAL COMMUNITY ANTHROPOMETRIC PROJECT

			WIDTH MEASURMENTS						GIRTH MEASUREMENTS													HEIGHT MEASUREMENTS				
NUMBER	EXAMDATE	WEIGHT	BIACROMIAL	A-P CHEST	TRANSVERSE CHEST	BIILIOCRISTAL	HUMERUS	FEMUR	HEAD	NECK	ANKLE	CALF	THIGH	GLUTEAL	WAIST	CHEST	WRIST	FOREARM (MAX. REFLEX)	ARMGIRTH (FLEXED)	ARMGIRTH R	ARMGIRTH L	HEIGHT	SITTING HEIGHT	ARM SPAN	TROCHAN TERION	COMMENTS

[illegible] RURAL COMMUNITY ANTHROPOMETRIC PROJECT

SUBJECT: DATE OF BIRTH: GENDER:

SUBJECT NUMBER: NAME OF THE SCHOOL / PRE-SCHOOL:

NUMBER	EXAM DATE	TRICEPS L			BICEPS			SUBSCAPULAR			SUPRASPINALE			TRICEPS R			ABDOMINALE			FRONT THIGH			MEDIAL CALF			COMMENT

ELLISRAS LONGITUDINAL STUDY
Blood pressure

Subject:________________ Date of birth:________ Gender:________________

Subject number: ____________ School name:________ School number:____________

Exam Date	Systole	Diastole	Pulse rate	Systole	Diastole	Pulse rate	Systole	Diastole	Pulse rate

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CONSENT FORM:

1. I voluntarily agree to participate in a research study of the of anthropometric and blood pressure measurements. I understand that the purpose of this research is to invesigate the growth and health status of rural children in Ellisras rural area.
2. The procedures involved have been fully explained to me by the investigator. The measurements session will not take more than 30 minutes.
3. I will receive no direct benefits from participating in this research study, although the results of the study will contribute to the general knowledge on my growth and health status
4. There are no costs to me for participating in this study only incentive will be provided which will be in the form of juice and biscuit.
5. I understand that participation is voluntary, and that I may withdraw and discontinue participation at any time without penalty to me, or loss of compensation.
6. I also understand that I will not be identified in any presentation of the information obtained from this study. All information collected will be kept confidential excepts as may be required by law. I will receive a copy of this consent form for my records if I need it. I understand that all data collected for the study will be archived for possible further analysis and maintained in a locked file cabinet.
7. I may contact the principal investigator at any time during the course of this study to answer any additional questions regarding the purpose, procedures and risks involved.
8. I have read the information given above. I understand the meaning of this information. I hereby consent to participate in the study.

PART:A:(To be used by adults and fully conscious persons):
I (NAME IN FULL)..have understood the information I have been given/ I have read.
I, ... agree to take part in the study.

Signature...

Date ....

Witness (NAME AND SIGNATURE)...

Signature...

Date...

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ASSENT FORM

An assessment of EFFECTS OF MALNUTRITION ON MOTOR COORDINATION IN PR-ADOLESCENCE AND ADOLESCENCE IN RURAL SOUTH AFRICA

[*The following is the text/script for the verbal assent procedure to be used. The language will be appropriate for the child's age, maturity and cultural context*]

Who are we?
I [*identify by name and profession*] am from the university of the North

What is it that we are doing?

We are doing an investigation in the in physical growth and health status by applying antrhopometric instruments to your body parts and also the blood pressure as part of the ongoing Ellisras Longitudinal Study. The purpose of this research is to evaluate the growth and health status of rural South African children

What do we want you to do?
We would like you to participate in our study on anthropometry and blood pressure as part of the ongoing Ellisras Growth and Health Study. We will measure your body limb segments weight, stature and blood pressure. The measurements will not take more 30 minutes to complete.

Can you say no?
Of course you can say no to the whole study or any part that you do not want us to do. Even if you say "yes" now you can change your mind (answer) at any time. No one (parents, the researcher, teacher or friends) will be upset with you.

What about your parents?
Your parents first have to say OK to you taking part in the study; we have spoken to them already. But, only you can decide if you agree to take part and we will measure you.

What about your teacher and friends at school?
Your friend and your teacher will not be told about your results so you can not have to worry. Whether you take part or not will not affect your school work.

Are you willing to take part in our study?

[Child's reply is noted. Only a define yes is taken as assent. Delete that which is not applicable]

Yes / No

Child: ______________________________ Age ______________

Witness: ______________________________ Capacity: ______________