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DIFFERENCES IN BODY COMPOSITION AND PREVALENCE FOR POSTURAL DEVIATIONS IN GIRLS FROM TWO RACIAL GROUPS IN SOUTH AFRICA

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ABSTRACT

Little is known about ethnic differences in developing countries such as South Africa, particularly with regard to prevalence of postural deviations and body composition profiles. The aim of this study is to compare the prevalence rate for postural deviations and body composition status among two racial groups in South Africa. The sample (n = 216) consisted of 89 African girls and 127 Caucasian girls. Anthropometric (BMI and percentage body fat) and body posture measurements were performed. A posture grid and the New York Posture test were used for all postural assessments. Independent t-tests and effect sizes demonstrated that in the 11 and 13 year old group the Caucasian group had a significantly higher ($p<0.05$) BMI and percentage body fat than the African group. There were no statistical and practical significant differences in prevalence rate between age groups. The African group had higher prevalence rates in most of the deviations, with winged scapulae, kyphosis, protruding abdomen and lordosis demonstrating a statistical significance ($p<0.05$) and practical significance (large effect) with regard to the Caucasian group. The higher prevalence rate for uneven shoulders in the Caucasian group was statistically significant ($p<0.05$) and also visible (medium effect) with regard to the African group. The higher prevalence rate for pronated feet in the African group was statistically significant ($p<0.05$), and also visible (medium effect) with regard to the Caucasian group. The prevalence rate was high in both groups and the lack of awareness and the results of this study should support the development of more responsible educational and screening programmes in both rural and urban school environments. The identification of postural deviations is important for prevention, to encourage a healthier posture for children and to prevent resulting painful syndromes.

Key words: Postural deviations; BMI; Fat%; Body composition; Ethnic; South Africa.

INTRODUCTION

Posture is the mechanical relationship of the parts of the body to each other and can be divided into static posture (at rest e.g. sitting, lying or standing), and dynamic posture (in action or anticipation of action) (Bloomfield *et al*., 1994; Norris, 2000; Tattersall & Walshaw, 2003; Kendall *et al*., 2005; McEvoy & Grimmer, 2005; Penha *et al*., 2005). Correct upright posture is considered to be an important indicator of musculoskeletal health (McEvoy & Grimmer, 2005). Postural deviations alter the body mechanics, causing uneven pressure on joint surfaces, ligamentous strain and skeletal muscle imbalance (Reigger-Krugh & Keysor, 1996; Hrysomallis & Goodman, 2001; McEvoy & Grimmer, 2005). The body's attempt to compensate for imbalance generally exacerbates the problem and can lead to more serious disability (Norris, 2000).

The environment of children has drastically changed worldwide during the last decades as reflected in unhealthy dietary habits and sedentary behaviours (Ahrens *et al*., 2006). There is a growing concern that the current behaviours of children may accelerate lifestyle-related diseases and result in higher prevalence of postural deviations (Ahrens *et al*., 2006). Children prefer to watch television, surf the Internet and play video games instead of engaging in more physically active leisure activities (Tremblay & Willms, 2000; Salmon *et al*., 2005). Children who spend hours surfing the net or sitting hunched over video games are running a high risk of damaging their backs and developing repetitive strain injuries.

Sedentary lifestyle and poor nutrition are among the reasons given for the sudden increase in childhood obesity (Sherman, 2002). A vast number of studies have indicated that children are becoming more overweight and inactive (Cole *et al*., 2000; Sallis, 2000; Tremblay & Willms, 2000; WHO, 2000; WHO, 2003; Evers *et al*., 2007).

The African children in South Africa in rural areas usually do not have televisions and computers. Most of these children have to walk long distances to school and food intake is usually unbalanced or inadequate and may lead to nutritional stunting or malnutrition. Childhood nutritional stunting has been suggested as a possible factor contributing to the high prevalence rates of obesity in developing countries because of the observed association between stunting and childhood and obesity in adults (Popkin *et al*., 1996; Sawaya *et al*., 1998; Hoffman *et al*., 2000; Mantsena *et al*., 2004). Excessive weight increases loading on the spine and pressure on the discs and other structures of the back, and as result serious back problems may occur (Yip *et al*., 2001). Also, children with adequate nutrition are usually characterized by alert posture, square shoulders, straight spine, firm muscles, straight legs, well arched feet, and proper weight for height and age (Banfield, 2000). However, poor nutrition can lead to sagging posture, round shoulders, scoliosis, poor muscle tone, knocked knees or bow legs and flat feet (Banfield, 2000).

Little is known about ethnic differences in developing countries such as South Africa, particularly with regard to prevalence of postural deviations and body composition profiles. The aim of this study is to compare the prevalence rate for postural deviations and body composition status among 11 to 13 year old rural South African African girls in the North-West Province of South Africa and Caucasian South African girls of the same age from an urban environment.

MATERIALS AND METHODS

Participants

The age group selected was based on the idea that early recognition could lead to preventive measures for more serious conditions. Parental consent was obtained from all participants before participating in the study. Ethical approval was obtained from the Ethics Committee of the North-West University (Project number 05K13). The following groups participated in the study:

African South African group

This study made use of a convenient sample. A letter was sent to three schools in the Potchefstroom area, explaining the importance and purpose of the study and to enquire whether any of these schools were interested in participating in this study. The three schools gave permission to conduct the study at their schools. African girls aged 11 to 13 years from three primary schools in the Potchefstroom area in the North-West Province participated in this study. The sample (n = 89) consisted of 28 eleven year olds, 29 twelve year olds and 32 thirteen year olds. Measurements for this group were conducted during a two month period in 2006.

Caucasian South African group

The Caucasian group formed part of a master's degree study project (Stroebel, 2002) which was conducted in the Western Cape. A letter was sent to 15 schools in urban areas within the Western Cape region, which were chosen randomly from a list provided by the Western Cape Schools Board. Caucasian girls aged 11 to 13 years from four schools participated in the study. The sample (n = 127) consisted of 28 eleven year olds, 43 twelve year olds and 56 thirteen year olds.

Measurement Procedure

In both groups, the first stage of the measurement procedure was conducted with the children separated into groups. Measurement procedure was explained to the children in detail to reduce any uncertainties and anxiety. With help from assistants, the participants completed a questionnaire. The questionnaire included personal details namely, age, gender, language, handedness and contact numbers. Thereafter the anthropometric measurements and postural evaluation were assessed. To ensure complete reliability of the study the researcher, a qualified Biokineticist, administered all the postural evaluations, including the postural evaluations on the Caucasian group. Trained postgraduate Biokinetics students were used for all the anthropometric measurements.

Anthropometric Measurements

The anthropometric measurements chosen are those that could have a functional role in the prevalence of postural deviations. In both groups, all measurements were measured by trained postgraduate Biokinetics students. Measurements were taken according to the standard procedures of the International Society for the Advancement of Kinanthropometry (ISAK) methods (ISAK, 2001). The following measurements were taken:

Stature

Maximum stature was measured to the nearest 0.1 cm with a stadiometer with the child standing upright and the head in the Frankfort plane.

Body mass

The children wore hospital gowns and underwear while their body mass was measured to the nearest 0.1 kg on an electronic scale (Krupps). The scale was calibrated at the beginning of the study with a 20 kg standard calibration weight.

Using stature and body mass measurements, BMI was calculated using the following equation (ACSM, 2006):

$$BMI = \frac{weight(kg)}{height(m)^2}$$

Skinfolds

The triceps and subscapular skinfolds were measured in duplicate to the nearest 0.2 mm with a Harpenden® skinfold caliper with a constant pressure of 10 g/mm^2 (Cambridge Scientific Intruments, Cambridge, MA) and the two values averaged. Sites on the right side of the body were measured and percentage body fat was determined using a 2-site skinfold measurement (Triceps and Subscapular) (Slaughter *et al*., 1988).

$$\Sigma SKF > 35mm{:}\%BF = 0.546(\Sigma SKF) + 9.7$$

$$\Sigma SKF < 35mm{:}\%BF = 1.33(\Sigma SKF) - 0.013(\Sigma SKF)^2 - 2.5$$

ΣSKF = Sum of skinfolds
$\%BF$ = Percentage body fat
mm = millimetre

Postural Evaluation

In both groups, the New York Posture Test (Davis *et al*., 1995; Sherrill, 1993; Bloomfield *et al*., 1994; Reedco, 2001; Magee, 2002; Pankey *et al*., 2004) and a "see-through posture grid" (Davis *et al*., 1995; Arnheim & Prentice, 2000; Kendall *et al*., 2005) were used for evaluation and identification of possible deviations. Each test item is scored on a 5-3-1 basis. The score is based on the criteria and drawings located on the score sheet (5 = normal; 3 = slightly abnormal; 1 = abnormal). The participants were examined from a lateral, posterior and anterior view. The participants stepped down into powdered white chalk and then onto a black board to evaluate flat feet. The "Adam's test" (forward bending test) was used for further scoliosis evaluation. To reduce the degree of subjectivity the following criteria are provided by the New York Posture Test (30) to score uneven shoulders: 5 (0 – 2 degrees); 3 (2.1 – 4 degrees); 1 (> 4 degrees).

The most superior-lateral edge of the acromions was marked with a pencil. Degree of lateral asymmetry is measured by counting the amount of blocks the one shoulder is lower than the other one. A goniometer was used beforehand, to measure the amount of degrees for each block of the posture grid. Subjects with a broader chest (greater bi-acromial width) will exhibit a greater angle of asymmetry. To account for these differences three bi-acromial widths were used. A subject will either be 2, 3 or 4 "large blocks" wide, which will be 25, 37.5 and 50 cm respectively.

The following mathematical calculation was used to determine the reliability of the goniometer measurements. E.g. acromion height difference of "1 block" (2.5 cm) and a bi-acromial width of "3 large blocks" (37.5 cm), where *t* = difference in acromion height and *a* = bi-acromial width (Taylor & Myburgh, 1987).

$$Tan\,\theta = \frac{t}{a}$$

$$= \frac{2.5}{37.5}$$

$$\theta = 4 \text{ degrees}$$

This mathematical measurement was compared to all goniometer measurements. The goniometer measurements correlated well with the mathematical measurements, and thus constitute a reliable method of measurement.

Statistical Analysis

Microsoft Excel Version 7.0 Analysis Tool and Statistica (StatSoft, 2006) were used for all quantitative data analyses. Two-way frequency tables and Chi-square analyses were used to determine whether the difference in prevalence of postural deviations in the two groups was significant on a 5% level ($p<0.05$). It was also used to determine whether there were significant differences in postural deviations between the different age groups ($p<0.05$). As this study made use of a convenience sample, statistical inference and p-values are not sufficient. Instead of only reporting descriptive statistics in this case, effect sizes were determined. Practical significance can be understood as a large enough difference to have an effect in practice (Ellis & Steyn, 2003).

Effect size for the relationship in a two-way frequency table is given by $w = \sqrt{\frac{X^2}{n}}$, where X^2 is the usual Chi-square statistic for the contingency table and *n* is the sample size. Note that the effect size is independent of sample size. Cohen (1988) gives the following guidelines for the interpretation of it in the current case:

(a) small effect: $w \approx 0.1$, (b) medium effect: $w \approx 0.3$, (c) large effect: $w \approx 0.5$

A relationship with $w \approx 0.3$ can be considered to be visible and with $w \approx 0.5$ as practical significant.

Independent t-tests were used to determine whether there was significant difference on a 5% level ($p<0.05$) in BMI and percentage body fat in the two groups. They were also used to determine whether there were significant differences in BMI and percentage body fat for age groups ($p<0.05$). Effect size for the difference between means was used to determine practical significance. This was determined by the following formula:

$$d = \frac{|\bar{x}_1 - \bar{x}_2|}{s_{\max}}$$

Where $|\bar{x}_1 - \bar{x}_2|$ is the difference between $\bar{x}_1$ and $\bar{x}_2$ without taking the sign into consideration and s_{max} is the maximum of s_1 and s_2, the sample standard deviations. Cohen (1988) gives the following guidelines for the interpretation of the effect size in the current case:

(a) small effect: $d \approx 0.2$, (b) medium effect: $d \approx 0.5$ and (c) large effect: $d \approx 0.8$.

It is considered that data with $d \approx 0.8$ is practical significant, since it is the result of a difference having a large effect and with $d \approx 0.5$ as a visible difference but not yet practical significant (Ellis & Steyn, 2003).

RESULTS

BMI

Independent t-tests demonstrated that statistical significant differences ($p<0.05$) in race existed between BMI in the 11 and 13 year old group (table 1). In the 11 year old group the African group had a lower BMI of 17.7 compared to 20.1 in the Caucasian group. The difference was statistical significant ($p<0.05$), and effect sizes demonstrated a medium effect ($d \approx 0.5$), making it a visible difference. In the 13 year old group the African group had a significantly ($p<0.05$) lower BMI of 18.3 compared to 20.9 in the Caucasian group and effect sizes demonstrated a practical significance (large effect, $d \approx 0.8$). There were no statistical or practical significant differences in BMI for the 12 year old group. Comparing the African and Caucasian group as a whole, the African group had visibly (medium effect, $d \approx 0.5$) as well as statistical significant ($p<0.05$) lower BMI than the Caucasian group.

TABLE 1: **THE DIFFERENCE WITH REGARD TO BMI BETWEEN THE AFRICAN AND CAUCASIAN GIRLS (N = 216). VALUES ARE EXPRESSED AS MEANS ± SD AND SAMPLE SIZE (N)**

	BMI (kg/m^2)		**Statistical significance**	**Practical significance**
Age (years)	**African**	**Caucasian**	**p**	**d**
11	17.8±3.85 (28)	20.1±3.96 (28)	0.03	0.6
12	18.8±4.76 (29)	20.3±4.35 (43)	0.17	0.3
13	18.3±3.10 (32)	20.9±3.58 (56)	0.00	0.7
Total group	18.3±3.92 (89)	20.5±3.92 (127)	0.00	0.6

$p < 0.05$
small effect: $d \approx 0.2$; medium effect: $d \approx 0.5$; large effect: $d \approx 0.8$

Percentage body fat

Independent t-tests demonstrated that statistical significant differences ($p<0.05$) in race existed between percentage body fat in the 11 and 13 year old group (table 2). In the 11 year old group the African group had a lower percentage body fat of 19.3 compared to 24.4 in the Caucasian group. Differences were statistical significant ($p<0.05$) and effect sizes demonstrated a medium effect (d≈0.5), making it a visible difference. In the 13 year old group the African group had a statistical significantly ($p<0.05$) lower percentage body fat of 19.6 compared to 24.9 in the Caucasian group and effect sizes demonstrated a practical significance (large effect, d≈0.8). There were no statistical or practical significant differences in percentage body fat for the 12 year old group. Comparing the African and Caucasian group as a whole, the African group had a visibly (medium effect, d≈0.5) as well as statistical significant ($p<0.05$) lower percentage body fat than the Caucasian group.

TABLE 2: **THE DIFFERENCE WITH REGARD TO PERCENTAGE BODY FAT BETWEEN THE AFRICAN AND THE CAUCASIAN GIRLS (N = 216). VALUES ARE EXPRESSED AS MEANS ± SD AND SAMPLE SIZE (N)**

	Percentage body fat (%)		**Statistical significance**	**Practical significance**
Age (years)	**African**	**Caucasian**	**p**	**d**
11	19.3±7.93 (28)	24.4±10.61 (28)	0.04	0.5
12	20.9±9.29 (29)	24.2±9.04 (43)	0.14	0.3
13	19.6±6.27 (32)	24.9±8.13 (56)	0.00	0.7
Total group	20.0±7.82 (89)	24.6±8.96 (127)	0.00	0.5

$p < 0.05$
small effect: *d*≈0.2; medium effect: *d*≈0.5; large effect: *d*≈0.8

Postural deviations

Chi-square analysis and effect sizes revealed no statistical and practical significant differences in prevalence rate between age groups, therefore, to simplify comparisons and increase the power of the analysis, age groups were grouped together. The main postural deviations found in this study were as follows:

For the African group, in the abnormal category (figure 1), lordosis (74%), winged scapulae (63%), protruding abdomen (52%) and kyphosis (47%) were observed most often, with pronated feet (9%), flat feet (9%) and uneven shoulders (8%) demonstrating low prevalence rates and scoliosis (0%) being non-existent. For the Caucasian group, in the abnormal category (figure 1), uneven shoulders (11%), lordosis (9%) and flat feet (5%) were observed most often, while kyphosis (3%), protruding abdomen (2%), winged scapulae (2%), pronated feet (2%) and scoliosis (2%) demonstrated low prevalence rates.

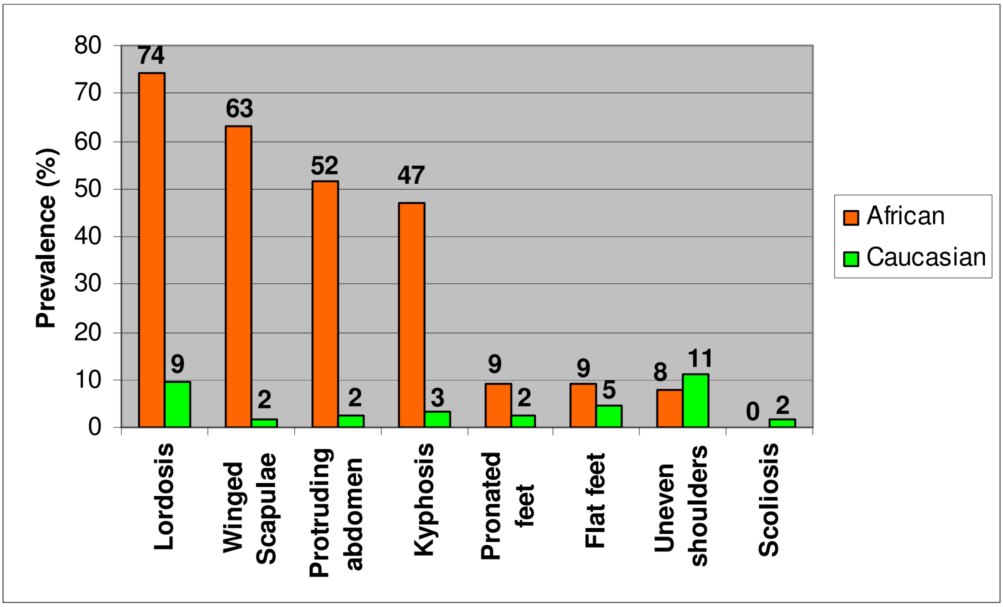

FIGURE 1: **ABNORMAL CATEGORY: COMPARISON OF PREVALENCE RATES FOR POSTURAL DEVIATIONS IN TWO RACIAL GROUPS (N=216)**

For the African group, in the slightly abnormal category (figure 2), pronated feet (48%), kyphosis (45%), protruding abdomen (43%), flat feet (31%) and winged scapulae (31%) were observed most often, with lordosis (21%) and uneven shoulders (16%) observed less often and scoliosis (7%) again demonstrated a very low prevalence rate. For the Caucasian group, in the slightly abnormal category (figure 2), lordosis (54%), kyphosis (50%) and uneven shoulders (48%) demonstrated high prevalence rate, while protruding abdomen (29%), flat feet (26%), pronated feet (20%) and winged scapulae (17%) were observed less often with scoliosis (9%) demonstrating the lowest prevalence rate.

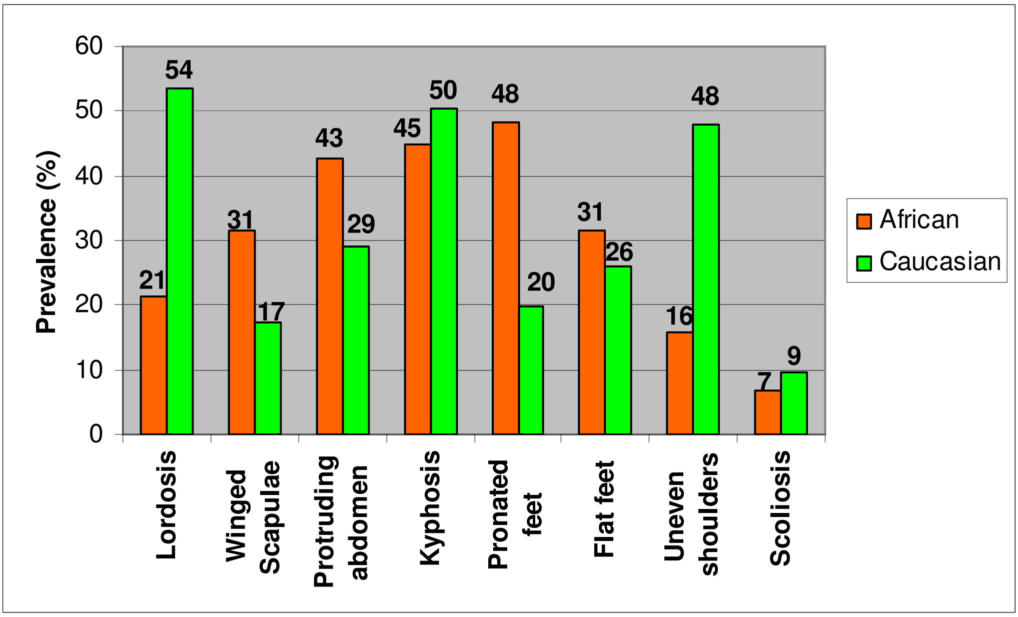

FIGURE 2: **SLIGHTLY ABNORMAL CATEGORY: COMPARISON OF PREVALENCE RATES FOR POSTURAL DEVIATIONS IN TWO RACIAL GROUPS (N=216)**

The African group had higher prevalence rates in most of the deviations with winged scapulae, kyphosis, protruding abdomen and lordosis demonstrating a statistical significance ($p<0.05$) and a practical significance (large effect, $w\approx0.5$) with regard to the Caucasian group. The higher prevalence rate for uneven shoulders in the Caucasian group was statistical significant ($p<0.05$) and also visible (medium effect, $w\approx0.3$) with regard to the African group. The higher prevalence rate for pronated feet in the African group was statistical significant ($p<0.05$), and visible (medium effect, $w\approx0.3$) with regard to the Caucasian group.

It is important to note that the majority of postural deviations in African girls was classified as abnormal, where in the Caucasian girls the majority was classified as slightly abnormal, meaning the degree of deviation in the African children was more severe.

DISCUSSION

Comparisons between studies in the literature are difficult, because of the differences in age groups and gender. In South Africa there is limited information regarding ethnic differences in BMI, percentage body fat and postural deviations.

In the greater Johannesburg metropolitan area a study by McVeigh *et al.* (2004) found no significant difference between BMI and percentage body fat of Caucasian and African children aged 9 to 10 years. The mean BMI for the African group in this study, were slightly higher than the 16.5 measured in rural children from KwaZulu-Natal with the same socio-economic background (Jinabhai *et al.*, 2001). In accordance with this study, an American study (Daniels *et al*., 1997) evaluating 7 to 17 year old children found a higher percentage body fat in Caucasian girls compared to African girls. A study in Britain (Duncan *et al*., 2004) found similar results.

This study stands in contrast to a study in America (Felton *et al*., 2002) that found African-American girls living in rural areas to have a significantly higher BMI than their white counterparts living in urban areas. Several studies reported similar findings (Rebato *et al*., 1998; Fahlman *et al*., 2006; Hanson & Chen, 2007).

With regard to postural deviations, a lack of comparable research analysing the broad spectrum of postural deviations existed. To the researchers of this study's knowledge this is the first musculo-skeletal screening programme to address the differences in prevalence rate of postural deviations in African and Caucasian 11 to 13 year old South African children specifically. The only other study conducted in South Africa was in Johannesburg (Segil, 1974), where the prevalence of scoliosis in the Caucasians was 2.5% and in the Africans 0.03%, which was similar to the present study's findings, in that Caucasian children had a higher prevalence rate (no number of participant were reported). This is in contrast to a similar study done in India (Mittal *et al*., 1987).

In accordance with research (Francis & Bryce, 1987; Loots *et al*., 2001) the prevalence rate for lordosis and kyphosis was high in both races. A study in Lithuania (Mauriciene & Baciuliene, 2005) reported that children with a bigger or smaller than medium weight have a greater possibility for kyphosis, however, height had no influence on lordosis. It can be expected that African children will have some degree of growth deficiencies because of malnutrition or undernutrition, but further research would be necessary to confirm this statement.

Kyphosis can be related to rapid growth, and can occur in children during the growth spurt of puberty, which is very important in girls since there is a tendency to adopt kyphosis as a manner of hiding breast development (Britnell *et al*., 2005; Penha *et al*., 2005).

The African group showed a significantly higher prevalence rate for winged scapulae compared to the Caucasian girls. Poor muscle tone, especially in the serratus anterior or trapezius muscles can cause winged scapulae (Shultz *et al*., 2005) and poor nutrition can lead to sagging posture, round shoulders and poor muscle tone (Banfield, 2000).

The significantly higher prevalence rate for protruding abdomen may stem from the fact that it is a postural deviation related to lordosis. Abdominal protrusion relates directly to lordosis in an attempt to correct the anteroposterior balance that is compromised (Penha *et al*., 2005).

The higher prevalence rate for flat feet in the African group, although not statistical or practical significant, is in accordance with research by a recent study on Congolese children (Echarri & Forriol, 2003). However, this is in contrast to other research (Rao & Joseph, 1992; McCoy & Dickens, 1997).

The significantly higher prevalence rate of uneven shoulders among the Caucasian group may be associated to muscular imbalance caused by carrying heavy backpacks (Chansirinukor *et al*., 1999; Negrini *et al*., 1999; Penha *et al*., 2005; Negrini & Negrini, 2007). One could assume that Caucasian children carry more school material than their rural counterparts, as African children from rural areas cannot afford backpacks, but further research would be necessary to prove this assumption.

One could argue that the time difference between evaluating the two groups might influence the outcomes of this study. However, evolution in posture and body composition is known to take place in decades and centuries (Cintra *et al*., 2007; De Ridder, 2007) which makes the time difference of four years in this study insignificant.

Variations in growth patterns for various ethnic groups could possibly be an explanation for the higher prevalence of postural deviations in the African group. A study in America reported that the mean age of onset of menarche can vary by almost three-quarters of a year between African-American and Caucasian females (Rosenbaum, 2006). Also, malnutrition or undernutrition diminishes the ability to all systems of the body to perform properly, with particularly serious consequences in young children. Studies have demonstrated associations between undernutrition and growth retardation (Caulfield *et al*., 2004), which in effect will influence normal postural development.

CONCLUSION

This study presents important information on ethnic differences between body composition and prevalence of postural deviations. In developing countries environmental constraints such as malnutrition or undernutrition, the high burden of infectious diseases, bad living conditions and lack of educational facilities must be taken into consideration when discussing growth and development in children (Parizkova & Hills, 1998).

Developing postural muscles or stressing proper seating posture may help in correcting postural deviations while children progress through elementary school (Pankey *et al*., 2004). The identification of postural deviations is important for prevention, to encourage a healthier posture for children and to prevent resulting painful syndromes (Penha *et al*., 2005).

In summary the findings suggest that there is a difference in the prevalence of postural deviations and body composition status between African South African and Caucasian South African girls, with a higher prevalence of postural deviations and lower BMI and percentage body fat reported among African girls. Although prevalence of postural deviations was significantly higher in the African girls compared to the Caucasian girls, the prevalence rate remains high in both groups. Future research recommendations would include a similar study in racial groups but from the same socio economic background, as to conclude if this prevalence is due to race or other factors.

The lack of awareness and the results of this study should support the development of more responsible educational and screening programmes in both rural and urban school environments.

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