The prevalence of postural deformities and body composition status of 11 to 13 year old African South African children in selected schools in the North West Province

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Dedication

To my parents, Hennie and Susan Stroebel

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I wish to express my sincere thanks and appreciation to the following people and organisations for their assistance in this research project. The completion of this study would have not been possible without their help.

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Author's Contribution

The principle author of this thesis is Ms. S. Stroebel. The contribution of each of the co-authors involved in this study are summarised in the following table:

Co-Author	Contribution
Prof. J.H. de Ridder	Promoter. Co-reviewer, assistance in writing of manuscripts, selection of studies, data extraction, design and planning of manuscripts, interpretation of results.
Prof. C.J. Wilders	Co-promoter. Assistance in writing of manuscripts, general recommendations.
Dr. S.M. Ellis	Data analysis and statistics. Assistance in writing manuscripts, general recommendations (Chapters 4, 5 and 6).

The following is a statement from the co-authors confirming their individual role in each study and giving their permission that the manuscripts may form part of this thesis.

I declare that I have approved the above mentioned manuscripts, that my role in the study, as indicated above, is representative of my actual contribution and that I hereby give my consent that they may be published as part of the Ph.D. thesis of Suzanne Stroebel.

Prof. J.H. de Ridder

Prof. C.J. Wilders

Dr. S.M. Ellis

Abstract

The prevalence of postural deformities and body composition status of 11 to 13 year old African South African children in selected schools in the North West Province

Prolonged poor posture induces abnormal stress on supporting structures of the spinal column and can cause chronic back pain, which usually develops while standing, walking or doing other activities of daily living. Children in rural areas are exposed to hard physical labour and food intake in rural areas is mostly unbalanced or inadequate. If a relationship exists between overweight and the prevalence of postural deformities, the high rate of overweight children reported in the literature appears to be cumbersome. Also, it is apparent that the condition of being overweight co-exists with being stunted (underweight) in many developing countries, which will be a cause of great concern if a high prevalence of postural deformities is found among stunted children. Research on African South African children living in rural areas which focuses on the prevalence of postural deformities and the influence of body composition on the prevalence rates for postural deformities will provide an opportunity to understand the role of undernutrition and malnutrition in the normal development of posture in rural children and the importance thereof.

This thesis is comprised of seven chapters of which five chapters (2, 3, 4, 5 and 6) can be read independently as they are written in the form of research articles.

Main findings

The first purpose of the study was to conduct a literature review on aspects such as: the definition and concept of good posture, normal postural development, postural deformities, influence of bone growth, incidence rates of postural deformities and influence of body composition on postural deformities. The literature review was done to gain more insight regarding postural deformities, normal growth and development of children and the role that body composition plays in the development of postural deformities. The importance of these aspects are highlighted and discussed in Chapter 2.

The second purpose of this study was to determine the prevalence of postural deformities among 11 to 13 year old African South African children in selected schools in the North West Province (Chapter 3). A total of 168 children (79 boys and 89 girls) were evaluated. Results showed a high prevalence rate of postural deformities, especially in lordosis, winged scapulae, protruding abdomen, kyphosis and pronated feet. Most of the postural deformities were classified as abnormal, meaning the degree of deviation was severe.

The third purpose of the study was to compare the prevalence rate of postural deformities and body composition status of 11 to 13 year old African South African girls from the North West Province with girls of the same age from a different ethnic group and sosio-economic environment (Chapter 4). A total of 216 girls (89 African and 127 Caucasian) were evaluated. The African South African girls showed a significantly higher prevalence rate for winged scapulae, kyphosis, protruding abdomen, lordosis and pronated feet, and a significantly lower prevalence rate for uneven shoulders with regard to Caucasian South African girls. The majority of postural deformities 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. With regard to Body Mass Index (BMI), in the 11 and 13 year old group, the African girls demonstrated a significantly lower BMI compared to the Caucasian girls. With regard to percentage body fat, in the 11 and 13 year old group, the African girls demonstrated a significantly lower percentage body fat, compared to the Caucasian girls.

The fourth purpose of the study was to compare the prevalence rate of postural deformities and body composition status of 11 to 13 year old African South African boys from the North West Province with boys of the same age from a different ethnic group and sosio-economic environment (Chapter 5). A total of 219 boys (79 African and 140 Caucasian) were evaluated. The African South African boys showed a significantly higher prevalence rate for winged scapulae, protruding abdomen, lordosis, kyphosis, pronated feet and flat feet and a significantly lower prevalence rate for uneven shoulders with regard to Caucasian South

African boys. The majority of postural deformities in African boys was classified as abnormal, where in the Caucasian boys the majority was classified as slightly abnormal, meaning the degree of deviation in the African children was more severe. With regard to BMI in all three age groups, the African boys demonstrated a significantly lower BMI compared to the Caucasian boys. With regard to percentage body fat in all three age groups, the African boys demonstrated a significantly lower percentage body fat compared to the Caucasian boys.

The fifth purpose of the study was to determine to what extent body composition contributes to the prevalence of postural deformities in 11 to 13 year old African South African children from the North West Province (Chapter 6). A total of 168 children (79 boys and 89 girls) were evaluated. In boys, results demonstrated a statistical significant association between protruding abdomen and BMI, and also for the association of winged scapulae and protruding abdomen with percentage body fat. A large practical significant difference in BMI and percentage body fat was demonstrated between the different categories of winged scapulae and lordosis. In girls, results demonstrated a statistical significant association between BMI and percentage body fat with winged scapulae, protruding abdomen and flat feet. A large practical significant difference in BMI was demonstrated between the different categories of winged scapulae and flat feet and also in percentage body fat with regards to the different categories of flat feet.

Chapter 7 includes a general discussion, conclusion, limitations and recommendations for schools, practices, parents as well as for future research.

It can be concluded that the prevalence of postural deformities in African South African children in the North West Province is high and that ethnicity and body composition have an influence on the prevalence rates for postural deformities. Furthermore, recommendations are made about the implementation of school-screening programmes in rural areas, the role of the government, parents and teachers, and the importance of adequate food intake.

Opsomming

Die voorkoms van postuurafwykings en liggaamsamestelling van 11- tot 13-jarige swart Suid-Afrikaanse kinders in geselekteerde skole in die Noordwes-Provinsie

Langdurige swak postuur gee aanleiding tot abnormale druk op ondersteunende strukture van die werwelkolom en kan chroniese rugpyn veroorsaak, wat gewoonlik ontwikkel terwyl die persoon staan, loop of ander daaglikse lewensaktiwiteite uitvoer. Kinders in landelike gebiede word blootgestel aan harde fisieke arbeid en die voedselinname in daardie gebiede is meestal ongebalanseerd of onvoldoende. Indien daar 'n verband bestaan tussen oorgewig en die voorkoms van postuurafwykings, wil dit voorkom asof die hoë oorgewigsyfer onder kinders wat in die literatuur vermeld word, kommerwekkend is. Daarby is dit ook duidelik dat die verskynsel van oorgewig in talle ontwikkelende lande sy aan sy met belemmerde groei voorkom, wat kommer wek indien 'n hoë voorkoms van postuurafwykings onder kinders met belemmerde ontwikkeling gevind word. Navorsing oor swart Suid-Afrikaanse kinders in landelike gebiede wat fokus op die voorkoms van postuurafwykings en die invloed van liggaamsamestelling op die voorkomssyfers vir postuurafwykings, kan bydra tot 'n beter begrip vir die rol wat onder- of wanvoeding in die normale ontwikkeling van postuur in landelike kinders speel en ook die belangrikheid daarvan.

Hierdie tesis bestaan uit sewe hoofstukke waarvan vyf hoofstukke (2, 3, 4, 5 en 6) onafhanklik van mekaar gelees kan word, aangesien dit in die vorm van navorsingsartikels geskryf is.

Belangrikste bevindinge

Die eerste doel van die studie was om 'n literatuuroorsig te verkry oor aspekte soos: die definisie en konsep van goeie postuur, normale postuurontwikkeling, postuurafwykings, invloed van beengroei, voorkomssyfers van postuurafwykings, en die invloed van liggaamsamestelling op postuurafwykings. Die literatuuroorsig is gedoen om 'n breër insig te

verkry in postuurafwykings, normale groei en ontwikkeling van kinders en die rol wat liggaamsamestelling in die ontwikkeling van postuurafwykings speel. Die belangrikheid van hierdie aspekte is in Hoofstuk 2 uitgelig en bespreek.

Die tweede doel van hierdie studie was om die voorkoms van postuurafwykings onder 11- tot 13-jarige swart Suid-Afrikaanse kinders in geselekteerde skole in die Noordwes-Provinsie (Hoofstuk 3) te bepaal. Altesaam 168 (79 seuns en 89 meisies) is geëvalueer. Resultate het gedui op 'n hoë voorkomssyfer van postuurafwykings, veral wat betref lordose, gevleuelde skapulas, uitstaan buik, kifose en voetpronasie. Die meeste van die postuurafwykings is geklassifiseer as abnormaal, wat beteken dat die graad van afwyking ernstig was.

Die derde doel van die studie was om die voorkomssyfer van postuurafwykings en die liggaamsamestelling van 11- tot 13-jarige swart Suid-Afrikaanse meisies uit die Noordwes-Provinsie te vergelyk met dié van meisies van dieselfde ouderdom uit 'n verskillende etniese groep en sosio-ekonomiese omgewing (Hoofstuk 4). Altesaam 216 meisies (89 swart en 127 Kaukasies) is geëvalueer. In vergelyking met die Suid Afrikaanse Kaukasiërmeisies het die swart Suid-Afrikaanse meisies 'n betekenisvolle hoër voorkomssyfer van gevleuelde skapulas, kifose, uitstaan buik, lordose en voetpronasie getoon en 'n betekenisvolle laer voorkomssyfer van ongelyke skouers. Die meerderheid postuurafwykings by swart meisies is as abnormaal geklassifiseer, terwyl die meerderheid daarvan in die geval van die Kaukasiërmeisies as effens abnormaal geklassifiseer is, wat beteken dat die graad van afwyking in die swart kinders ernstiger was. Wat die Liggaamsmassa Indeks (LMI) betref het die swart meisies, in die 11- en 13-jarige groep, 'n betekenisvolle laer LMI getoon in vergelyking met die Kaukasiërmeisies. In die geval van die persentasie liggaamsvet het die swart meisies in die 11- en 13-jarige groep 'n betekenisvolle laer persentasie liggaamsvet getoon in vergelyking met die Kaukasiërmeisies.

Die vierde doel van die studie was om die voorkomssyfer van postuurafwykings en die liggaamsamestelling van 11- tot 13-jarige swart Suid-Afrikaanse seuns uit die Noordwes-Provinsie te vergelyk met dié van seuns van dieselfde ouderdom uit 'n verskillende etniese groep en sosio-ekonomiese omgewing (Hoofstuk 5). Altesaam 219 seuns (79 swart en 140 Kaukasies) is geëvalueer. In vergelyking met die Suid-Afrikaanse Kaukasiërseuns het die swart Suid-Afrikaanse seuns 'n betekenisvolle hoër voorkomssyfer van gevleuelde skapulas, uitstaan buik, lordose, kifose, voetpronasie en plat voete getoon en 'n betekenisvolle laer voorkomssyfer van ongelyke skouers. Die meerderheid postuurafwykings by swart seuns is as abnormaal geklassifiseer, terwyl die meerderheid daarvan in die geval van die Kaukasiërseuns as effens abnormaal geklassifiseer is, wat beteken dat die graad van afwyking by die swart kinders ernstiger was. Wat die LMI betref, het die swart seuns in al drie ouderdomsgroepe 'n betekenisvolle laer LMI getoon in vergelyking met die Kaukasiërseuns. In die geval van die persentasie liggaamsvet by al drie ouderdomsgroepe het die swart seuns 'n betekenisvolle laer persentasie liggaamsvet in vergelyking met die Kaukasiërseuns getoon.

Die vyfde doel van die studie was om te bepaal tot watter mate liggaamsamestelling bydra tot die voorkoms van postuurafwykings by 11- tot 13-jarige swart Suid-Afrikaanse kinders uit die Noordwes-Provinsie (Hoofstuk 6). Altesaam 168 kinders (79 seuns en 89 meisies) is geëvalueer. In seuns, het die resultate 'n statistiese betekenisvolle assosiasie getoon tussen uitstaan buik en LMI, en so ook vir die assosiasie van gevleuelde skapulas en uitstaan buik met persentasie liggaamsvet. In meisies, het die resultate 'n statistiese betekenisvolle assosiasie getoon tussen LMI en persentasie liggaamsvet met gevleuelde skapulas, uitstaan buik, en plat voete.

Hoofstuk 7 het 'n algemene bespreking, gevolgtrekking, beperkinge en aanbevelings vir skole, ouers en toekomstige navorsing ingesluit.

Daar kan tot die gevolgtrekking gekom word dat die voorkoms van postuurafwykings by swart Suid-Afrikaanse kinders in die Noordwes-Provinsie hoog is en dat etnisiteit en liggaamsamestelling wel 'n invloed het op die voorkomssyfer van postuurafwykings. Verder is aanbevelings gemaak oor die implementering van skoolevalueringsprogramme in landelike gebiede, die rol van die regering, ouers en onderwysers, en die belangrikheid van voldoende voedselinname.

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List of Abbreviations

BMI: Body Mass Index

Fat%: Percentage body fat

LMI: Liggaamsmassa indeks

ACSM: American College of Sports Medicine

WHO: World Health Organisation

ROM: Range of motion

SD: Standard deviation

n: Sample size

kg: kilogram

m: metre

mm: millimetre

Chapter 1

Problem statement and aim of the study

1.1 PROBLEM STATEMENT

The attainment of human uprightness has long excited the attention of anatomists and kinesiologists studying the body's ability to maintain a functional musculoskeletal balance between the forces of gravity and muscular imbalances (Loots, 1999:12; Kendall *et al.*, 2005:51). The mechanics of posture consist of balances and counter-balances. Variation in the angles at any weight-bearing joints (spine, hip, knee, or ankle) displaces the bodyweight, and will result in an equal and opposite displacement in another joint to compensate for the deviation (Barker, 1985:25). Poor posture can cause a downward pressure on the internal organs which can produce a broad range of health problems namely, fatigue, abdominal pain, breathlessness, palpitations, faintness, kidney and bladder problems, and constipation to name just a few (Banfield, 2000:49). Although some postural deformities are congenital, more are acquired (Francis & Bryce, 1987:1221). Postural deformities include scoliosis, kyphosis, lordosis, winged scapulae, uneven shoulders, pronated, flat feet etc.)

Posture means that the body as a whole or in part is held in a certain position (Schrecker, 1971:3). This definition for posture is indicative in several languages, e.g. in German "*haltung*", Afrikaans "*houding*", and French "*tenue*". The Latin word "*positura*" implies the same idea as it describes a state of having been "placed" or "arranged" (Schrecker, 1971:3). *Orthopedics* is Greek for "straight child," emphasizing the significance society places on deformity as well as the functional impact it may have on the child (Boachie-Adjei & Lonner, 1996:883).

Already in 1945, "*The White House Conference on Child Health and Protection*" made the statement that 75% of the youth in the United States exhibit grades of body mechanics which are imperfect (Hansson, 1945:947). There is a growing concern that the current behaviour patterns of children may accelerate lifestyle-related diseases and result in higher incidence of postural deformities (Tremblay & Willms, 2000:1429). Loots *et al.* (2001:37) stated that postural deformities are pandemic in modern society and that 70% to 95% of children up to the age of 18 years are affected by this condition.

Any abnormal increase in the spinal curve will produce extra strain on the supporting ligaments, which may cause discomfort and pain. 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. Television, video entertainment, computers, internet, motorized transportation, fast food and lack of regular physical activity contribute to the poor physical condition of children (Tremblay & Willms, 2000:1429). A editorial published in *JOPERD* stated the following:

> *"Sedentary lifestyle (watching television, using computers, playing video games) and poor nutrition (too much "junk food") are among the reasons given for this sudden increase in childhood overweight (Sherman, 2002:9)".*

It is believed that back pain probably coincides with bad postural habits. Banfield (2000:92) stated the following:

> *"Backaches seem to be rather common among civilised people, probably because of their more sedentary ways of life".*

According to Banfield (2000:92) they are still developing their bone structure and muscle tension, therefore, bad posture could cause debilitating pain for life. The Australian

Physiotherapy Association is concerned about the number of children seeking physiotherapy treatment for back, neck and shoulder pain caused by poor posture (Fullarton & Emmerson, 1999). Most of the aches and pains of adults are not the result of injuries, but the long-term effects of distortion in posture that have their origins in childhood (Fullarton & Emmerson, 1999).

The Scandinavian study identified the prevalence of back pain in a group of 1 174 school children to be 51% (Fysh, 2001). Children who watched television for extended periods were also more likely to suffer from back problems. A *Medical World News* release stated that four out of five adult Americans do suffer, will suffer, or have suffered from lower back pain (Francis & Bryce, 1987:1225). A study by Leboeuf-Yde and Kirsten (1998:228) found that low back pain in Danish school children increased during the teen years and by the ages of 18 years (girls) and 20 years (boys), more than 50% experienced low back pain. The extent of this problem in South Africa is not known at present. The only South African figures found were that of Delport *et al.* (1985:109) that reported a low back pain prevalence rate of 21.7% among males aged between 40 and 60 years and Loots *et al.* (2001:37) that reported a high incidence of postural deformities among male executives (97.7%) and primary school boys (92%). According to Loots *et al.* (2001:43), lack of body awareness, modern sedentary lifestyles, stress, and poor use of body mechanics was to be blamed for this unfortunate state of affairs. Also, a recent study by Stroebel (2002:64) involving primary schools of the Western Cape reported prevalence rates as high as 70% for lordosis/ hollow back, and 57% for kyphosis/hunch back.

At present, a lack of physical activity shadows life and as a result, formerly unknown, postural problems now appear (Saunders *et al.*, 1995:156). Physical activity is essential for good posture and strong, flexible antigravity muscles to maintain skeletal balance. A prolonged lack of dynamic exercise results in the degeneration of bone tissue in the skeleton, primarily at the spinal column (Junghanns & Hager, 1990:165). According to Saunders *et al.* (1995:156), a sedentary lifestyle is often seen in conjunction with poor posture, joint hypermobility and poor use of body mechanics. The steepest decline in physical activity is during the teen years and when children reach high school, only a minority of them are meeting health-related activity guidelines (Sallis, 2000:31). To make matters worse schools have reduced the amount of time allocated to physical education lessons. In some cases, only one hour a week is devoted to physical education, which is inadequate when compared to the recommended minimum of 20 minutes per day (Andersen, 1996:39; Laventure, 2000:7). Physical activity is vital for weight control and excess weight around the waist, for example, can put additional stress on the posture muscles of the lower back. According to Banfield (2000:69), obese children with a heavy abdomen are more likely to develop an accentuated lumber curvature and a compensatory stoop in their shoulders. Wang (2001:1129) stated that at present, one-quarter of children in the United States are obese or overweight. A study in Canada determined that the prevalence of obesity among children aged 7 to 13 years increased from 5% in 1981 to 13.5% in 1996. The prevalence of obesity has doubled over that period (Tremblay & Willms, 2000:1429). Tremblay and Willms (2000:1429) also assessed changes in BMI over a 15-year period (1981-1996), using representative samples of Canadian children and youth. For children aged 11 to 13 years the average BMI increases were 1.38 and 0.58 for boys and girls respectively. Given that the study spanned over a 15-year period, the average increase is nearly 0.1 of a BMI unit per year. Moreover, the results indicate that BMI has increased from 1981 to 1996. According to the American Obesity Association, obesity increased from 7% in 1980 to 13% in 1999 for children aged 6 -11 years and from 5% to 14% in the 12-19 years age group. Obesity is not only increasing in industrialized countries, but in developing countries as well (WHO, 2000:16; Wang, 2001:1133). With the improvement in socio-economic status and increasing changes due to rapid urbanization, the prevalence of obesity among some groups of black women has risen to levels exceeding those in populations in industrialized countries (WHO, 2000:21). The World Health Organisation estimated that already in 1990 approximately 44% of African women in the Cape Peninsula, age 15 to 64 years, were obese (WHO, 2000:21). A South African demographic health survey (Puoane *et al.*, 2002:1043) determined prevalence of obesity in 15 year old girls in 1998 to be 30.5% in Africans, 28.3% in mixed cultures, 20.2% in Asian and 24.3% in whites. The highest rate of obesity for 15 year old boys was found among whites, with a prevalence rate of 19.8%.

Currently, a number of researchers are focusing on children that are living sedentary life styles namely, watching television, playing video games, eating too much fatty foods and low levels of physical activity (Leupker, 1999:S12; Van Mil *et al.*, 1999:S41; Chopra *et al.*, 2002:952; WHO, 2003:10). A vast number of studies have indicated that children are becoming more overweight and inactive (Cole *et al.*, 2000:1240; Sallis, 2000:31; Tremblay & Willms, 2000:1429; WHO, 2000:32; WHO, 2003:10; Evers *et al.*, 2007:219). Unfortunately, the focus of researchers has not included African South African children. Cole *et al.* (2000:1242) commented on the lack of data from Africa, and called for further research on the children of Africa.

Most of the African children in rural areas do not have access to television and computers. These children usually have to travel long distances by foot and the food intake is mostly inadequate and unbalanced, which in effect can result in malnutrition and stunting. According to Hoffman *et al.* (2000), childhood nutritional stunting has been suggested as one factor contributing to high rates of obesity in developing countries because of the observed association between stunting and childhood and adult obesity (Popkin *et al.*, 1996:3009; Sawaya *et al.*, 1998:S415). Recent research by Hoffman *et al.* (2000:1029) showed that stunted children have a lower fasting fat oxidation rate, a factor that strongly predicts excess gain in weight. A study by Mantsena *et al.* (2004:154) including 6 to 13 year old rural South African children in the Ellisras region, determined that stunted children exhibited a high percentage of body fat at an early stage and this may clearly depict that stunting at an early age can be associated with overweight in later life. However, a South African study by Jinabhai *et al.* (2003:57) that included primary school children from a rural community in KwaZulu-Natal, found no clear measure of association between being stunted and overweight.

Stunting is one of the two most important indicators of a child's well-being used throughout the world. The assessment of stunting is important to public health, clinical and research workers in many fields concerned with the well-being and growth and development of children (Frongillo, 1999:529). According to Steyn *et al.* (1989:21), in South Africa, stunting remains by far the most common nutritional disorder affecting nearly one out of five children. According to Banfield (2000:129), good nutrition is usually characterized by alert posture, square shoulders, straight spine, firm muscles, straight legs, well arched feet and proper weight for height and age. As a result it is suggested that stunted children are likely to have sagging posture, round shoulders, curved spine, poor muscle tone, knocked knees and flat feet (Banfield, 2000:129).

If a relationship exists between overweight and the prevalence of postural deformities, the high rate of overweight children reported in the literature appears to be cumbersome. Also, it is apparent that the condition of being overweight co-exists with being stunted (underweight) in many developing countries, which will be a cause of great concern if a high prevalence of postural deformities is found among stunted children. There is a lack of sufficient data in this regard, as the prevalence of postural deformities among African South African children is not known. An investigation into the relationship between body composition and postural deformities among African South African children can clarify the condition among children in South Africa. An important consequence of such a study would be that more appropriate prevention and intervention strategies could be developed.

It is in the light of the literature background that the following research questions are proposed. Firstly, what is the prevalence rate of postural deformities among 11 to 13 year old African South African children in selected schools in the North West Province? Secondly, how does the prevalence rate of postural deformities and body composition status among 11 to 13 year old African South African girls in the North West Province compare to girls of the same age from a different ethnic group and socio-economic environment? Thirdly, how does the prevalence rate of postural deformities and body composition status among 11 to 13 year old African South African boys in the North West Province compare to boys of the same age from a different ethnic group and socio-economic environment? Finally, to what extent does body composition contribute to the prevalence of postural deformities in African South African children from the North West Province?

1.2 AIMS OF THE STUDY

The aim of this study is:

- To determine the prevalence of postural deformities among 11 to 13 year old African South African children in selected schools in the North West Province;

- To compare the prevalence rate of postural deformities and body composition status of 11 to 13 year old African South African girls from the North West Province with girls of the same age from a different ethnic group and socio-economic environment;
- To compare the prevalence rate of postural deformities and body composition status of 11 to 13 year old African South African boys from the North West Province with boys of the same age from a different ethnic group and socio-economic environment;
- To determine to what extent body composition contributes to the prevalence of postural deformities in African South African children from the North West Province.

1.3 HYPOTHESIS

- The prevalence of postural deformities among 11 to 13 year old African South African children in selected schools in the North West Province will be high.
- The prevalence rate for postural deformities and body composition status will differ in the 11 to 13 year old African South African girls from the North West Province compared to girls of the same age from a different ethnic group and socio-economic environment.
- The prevalence rate for postural deformities and body composition status will differ in the 11 to 13 year old African South African boys from the North West Province compared to boys of the same age from a different ethnic group and socio-economic environment.
- Body composition will have a significant influence on the prevalence of postural deformities in 11 to 13 year old African South African children from the North West Province.

1.4 STRUCTURE OF THE THESIS

The results of this thesis will be presented in the format of four individual research articles. Each article will consist of unique aims and conclusions. All the articles will be presented for publication in accredited scientific journals, which will be chosen depending on the title of the article.

Chapter 1 is the introductory chapter where the problem statement, aim and hypotheses of the study are stated. The list of references is proposed at the end of the chapter according to the regulation of the Harvard method.

Chapter 2 is a review article and aims to define the concept of good posture, analyze normal postural development and postural deformities, discuss the influence of bone growth, report incidence rates and discuss the influence of body composition on postural deformities. This article will be presented for publication in the *Health SA Gesondheid* Journal. The list of references at the end of the chapter will be proposed according to the regulation of this journal, which will be attached as Appendix A (Guidelines for authors) at the end of the thesis.

Chapter 3 is an article that investigates the prevalence of postural deformities in 11 to 13 year old African South African children from the North West Province. This article is published in the *African Journal for Physical, Health Education, Recreation and Dance. Dance* (AJPHERD) 2007 September (Supplement), pp. 38-48, and will be presented in the format in which it was published. The regulation of this journal will be attached as Appendix B (Guidelines for authors) at the end of the thesis.

Chapter 4 is an article that compares the prevalence rate of postural deformities and body composition status of 11 to 13 year old African South African girls from the North West Province with girls of the same age from a different ethnic group and socio-economic environment. This article will be presented for publication in the *Journal of Health, Population and Nutrition*. The list of references at the end of the chapter will be proposed according to the regulation of this journal, which will be attached as Appendix C (Guidelines for authors) at the end of the thesis.

Chapter 5 is an article that compares the prevalence rate of postural deformities and body composition status of 11 to 13 year old African South African boys from the North West Province with boys of the same age from a different ethnic group and socio-economic environment. This article will be presented for publication in the *South African Journal for Research in Sport, Physical Education and Recreation*. The list of references at the end of the chapter will be proposed according to the regulation of this journal, which will be attached as Appendix D (Guidelines for authors) at the end of the thesis.

Chapter 6 is an article that will determine to what extent body composition contributes to the prevalence of postural deformities in African South African children from the North West

Province. This article will be presented for publication in the *International Council for Health, Physical Education, Recreation, Sport and Dance Journal of Research*. The list of references at the end of the chapter will be proposed according to the regulation of this journal, which will be attached as Appendix E (Guidelines for authors) at the end of the thesis.

Chapter 7 consists of a general discussion, conclusion and recommendations of all the results in the individual chapters. The list of references is proposed at the end of the chapter according to the regulations of the Harvard method.

The method and results of this study will be incorporated in Chapters 3, 4, 5 and 6. Therefore, no separated method and results chapter will be presented in this thesis.

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Chapter 2

Postural deformities in children: a review

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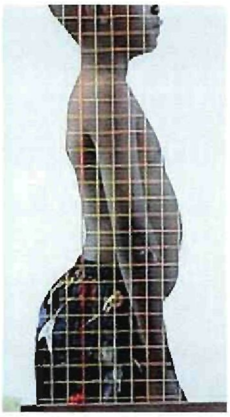
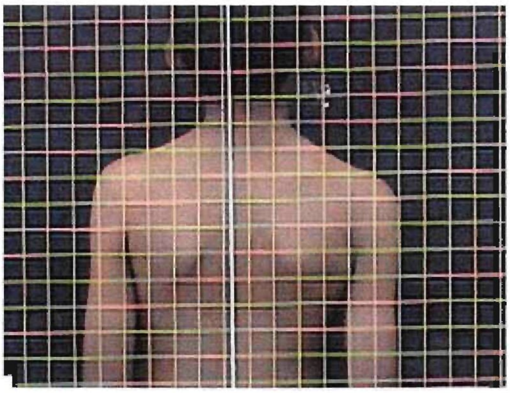
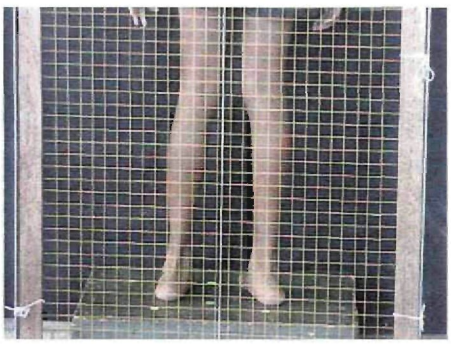
Short title: Postural deformities among South African children







ABSTRACT

Postural deformities are a commonly encountered problem among children. Most of the aches and pains of adults are the result, not of injuries, but of the long-term effects of distortions in posture or alignment that have their origins in childhood or adolescence. Television, video entertainment, motorized transportation, fast food and lack of regular physical activity contribute to the poor physical condition of children. Childhood obesity has increased dramatically in the past decade. Countries in economic transition from underdeveloped to developed, such as South Africa, are particularly affected and have an increasing prevalence of obesity across all economic levels and age groups. In a developing country like South Africa, where overweight/obesity co-exists with undernutrition, there is an urgent need to prevent unhealthy trends in diet and physical activity. School screening is mandated in schools in 26 states of the United States (US) for children between 10 and 16 years of age. Previous studies conducted in the US found that 160 out of 1000 people suffer from scoliosis (Boachie-Adjei & Lonner, 1996). This means that scoliosis is as prevalent as hypertension or diabetes mellitus. Identification of postural deformities at an early stage makes early treatment possible, which may, in future, prevent serious postural abnormalities. The aim of this review article is to define the concept of good posture, analyze normal postural development and postural deformities, and discuss some of the developmental factors affecting posture.

Key words: posture; postural deformities; obesity; physical activity; stunted; malnutrition, scoliosis

INTRODUCTION

Posture is a concept that goes back as far as the early Greek times, when emphasis was already laid on "good posture" (Solberg, 1993:8). In the last Victorian half century (1850–1902) it was common for physical educators to be preoccupied with "posture". If postural deformities were simply an aesthetic problem the concern about them might be limited to appearance. However, it must be recognized that postural faults that persist into adulthood may cause discomfort, pain or a permanent deformity (Kendall, Mccreary, Provance, Rodgers & Romani, 2005:51).

During malalignment, muscles are resting in a shortened or lengthened position and eventually, adaptive shortening or lengthening may result (Reigger-Krugh & Keysor, 1996:164; Hrysomallis & Goodman, 2001:385). The body's attempt to compensate for imbalance generally exacerbates the problem and can lead to more serious disability (Norris, 2000:94). Considerable deviations from normal posture may be aesthetically unpleasant, adversely influence muscle efficiency, and predispose individuals to muscoloskeletal conditions (Hrysomallis & Goodman, 2001:385; Kendall *et al.*, 2005:51). The National Institute for Occupational Safety and Health review found neck and shoulder musculoskeletal disorders to be strongly associated with poor posture (Murphy, Buckle & Stubbs, 2004:114). Already in 1740, Nicholas Audry taught that many illnesses in children had their origin in imperfect body mechanics (Hansson, 1943:947).

POSTURE DEFINED

There are innumerable concepts as to what human posture is and innumerable interpretations as to their significance. The concept of posture is employed in many ways, yet its exact definition is elusive. Different definitions may be found in the literature pertaining to posture.

Posture is defined as the relative arrangement of the parts of the body (Bloomfield, Ackland & Elliott, 1994:96; Norris, 2000:134; Kendall *et al.*, 2005:51; Penha, Joao, Casarotto, Amino & Penteado, 2005:9). Static posture refers to the alignment and maintenance of body segments in certain positions such as standing, lying or sitting (Hrysomallis & Goodman, 2001:385; Moss, 2001:38; Kendall *et al.*, 2005:51). Roaf (1977:2) argued that it is impossible to define bad or abnormal posture. He preferred to define posture as the position the body assumes in preparation for the next movement. According to Roaf (1977:2), mere uprightness, which is static, is not true posture. Psychologists have contributed to the moving concept, describing posture as an adjustment mainly in the erect position, which does not necessarily mean standing as it pertains to problems of locomotion, manipulation and gestural communications. The researcher recommends the following definition as it pertains both to static and dynamic features of posture. Posture is species adjustment to the environment, and applies both to the maintained and the changing relations of different parts of the body to each other and to the surrounding media or surfaces (Schrecker, 1971:3; Norris, 2000:135).

NORMAL POSTURE

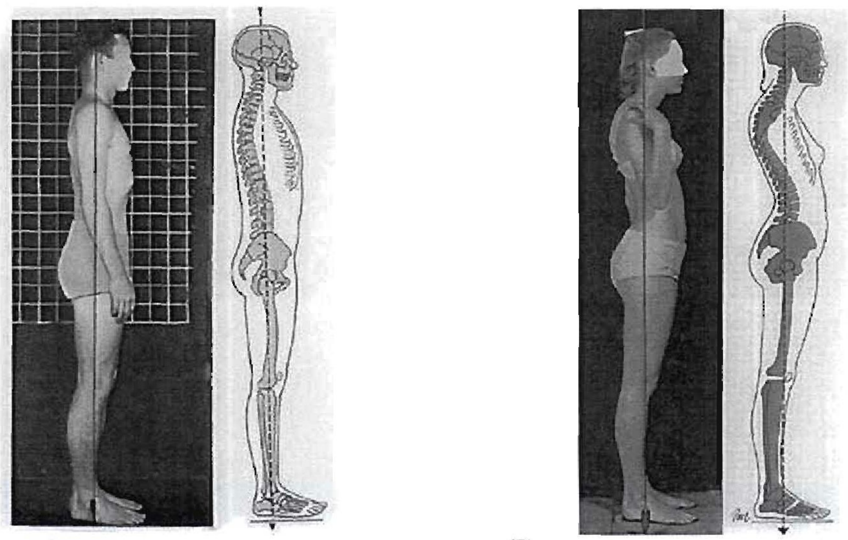
In order to recognize postural deformities one needs to have a clear understanding of what "normal" or "good" posture is (Norris, 2000:134). The importance of normal upright posture has been proposed since the early 1900's when it was described as a state of balance requiring minimal muscular effort to maintain (Griegel-Morris, Larson, Mueller-Klaus & Oatis, 1992:26). Views and ideas concerning correct posture have changed a great deal. The physical educators and hygienists were once dogmatic about it, and rigid standards were established (Watson & Lowrey, 1962:98). A definition given in 1947 by the Posture Committee of the American Academy of Orthopaedic Surgeons describes good posture as that state of muscular and skeletal balance which protects the supporting structures of the body against injury or progressive deformity (Norris, 2000:134). Kendall *et al.* (2005:59) describe a "standard posture" and refer to an "ideal" posture rather than an average posture.

In the standard posture the spine presents the normal curves and the bones of the lower extremities are in ideal alignment for weight bearing. The "neutral" position of the pelvis is conducive to good alignment of the abdomen and trunk and that of the extremities below. The chest and upper back are in a position that favours optimal function of the respiratory organs. The head is erect in a well-balanced position that minimizes stress on the neck musculature (Griegel-Morris *et al.*, 1992:27; Kendall *et al.*, 2005:73).

Bloomfield *et al.* (1994:96) described normal posture as "a state of muscular and skeletal balance which protects the supporting structures of the body against progressive deformity or injury". According to Mackenzie, Sampath, Kruse and Sheir-Neiss (2003:79), efficient erect posture is believed to reflect the least amount of physical activity required to maintain body position in space, and which minimizes anti-gravity stresses on body tissues. Therefore, the body is in a position that is both mechanically functional and economical (Bloomfield *et al.*, 1994:97).

Skeletal malalignment can alter the joint load distribution and, therefore, joint contact pressure distribution of adjacent or distant joints. Optimal posture combines both minimal muscle work and minimal joint loading, distributing force over a larger area by optimizing segmental alignment and, therefore, reduces joint surface compression and lessens the risk of degenerative changes to a joint (Norris, 2000:134).

Magee (2002:873) described ideal posture as a straight line (plumbline) that passes through the ear lobe, the bodies of the cervical vertebrae, the tip of the shoulder, midway through the thorax, through the bodies of the lumbar vertebrae, slightly posterior to the hip joint, slightly anterior to the axis of the knee joint, and just anterior to the lateral malleolus. In this position the minimum stress is applied to each joint (Figure 2.1).



A B

Figure 2.1: Ideal posture (A); Poor posture (B) (Kendall *et al.*, 2005:60,66).

Balance is the motivating force in good posture, whether static or in motion. Posture has long been thought of in terms of standing and sitting, but posture should be considered as the sum total of the positions and movements of the body throughout life. It is with body in motion that posture becomes most important and effective as posture has a direct relation to the comfort, mechanical efficiency and physiologic functioning of the individual (Saunders, Saunders, Kraus & Woerman, 1995:154; Kendall *et al.*, 2005:59).

In the 1940's Howarth (1946:1401) described good posture as follows:

"The use of the body or its parts in the simplest and most effective way, using muscle contraction and relaxtion, balance, coordination, rhytm and timing, as well as gravity, inertia and momentum to optimum advantage".

Feldenkrais (1985:54) brought a specific emotional state to the definition of good posture:

"The common association of good posture with poise – that is, mental or emotional tranquillity – is in fact an excellent criterion of good posture. Neither excessive muscular tension nor emotional intensity is compatible with good posture. Good posture means acting fast but without hurry; hurry means generally heightened activity that results not in faster action, but only in increased muscular contraction. Good posture means using all the power one possesses without enacting any parasitic movements" (Feldenkrais, 1985:54).

Notwithstanding the above, posture-awareness has become a fundamental concern in almost every part of daily activities. This researcher contends, therefore, that there is value in making efforts to understand some mechanical aspects of good body alignment.

Chukuka, Enwemeka, Bonet, Jayanti, Prudhithumrong and Ogbahon (1986:237) and Straker, Briggs and Greig (2002:245) found that the tension in the upper portion of the trapezius muscle was significantly greater in a mechanically inefficient "forward head" position. Wells and Luttgens (1976:403-405) concluded that the skeletal structure should be architecturally and mechanically sound so that there is a minimum of strain on the weight bearing joints, and pressure within the joints equalizes. In the growing scoliotic spine, the loss of mechanical stability directly affects the vertebral bodies, the facet, and the growth endochondral zones at intervertebral load-transfer areas (Harrington, 1977:17).

Gluckman (1995) stated that correct segmental alignment allows the body to move fluidly and efficiently. The bones move in such a way that gravitational force is evenly distributed across joint surfaces. Proper segmental alignment permits the internal organs to function properly. Overall, good posture allows the body to perform its daily functions with less effort and energy (Gluckman, 1995).

A recent study by Bullock, Foster and Wright (2005:29) suggested that an increased thoracic curvature combined with a slouched posture may influence scapular kinematics and cause a reduction in the sub-acromial space. An exaggerated thoracic kyphosis adversely influences length-tension relationships of the shoulder girdle muscles which, in turn, may cause mal-tracking of the humeral head within the glenoid fossa (Wilk & Arrigo, 1993:368; Lewis, Wright & Green, 2005:83). Bullock *et al.* (2005:36) investigated the effect of slouched versus erect sitting posture on shoulder ROM in subjects with impingement syndrome and found that the maintenance of and erect sitting posture significantly increase the range of shoulder motion and consequently, a moderate improvement of upper limb function may result. Sitting with a slouched posture increases the spinal load and intradiscal pressure, resulting in decreased nutrition to the disc (Wilke, Neef, Hinz, Seidel & Claes, 2001:S114; Cardon, De Clercq, De Bourdeaudhuij & Breithecker, 2004:133). Ludewig and Cook (1996:154) evaluated the effect of cervical position on scapula orientation and results indicated that increased cervical flexion prevented upward rotation and posterior tilt, impeding optimal scapular kinematics.

According to Dowler, Kappes, Fenaughty and Pemberton (2001:76), during sitting posture static muscular tension, combined with prolonged shoulder elevation, has been demonstrated to produce significant pain. Dowler *et al.* (2001:76) studied the effects of neutral posture on muscle tension during computer use and found that participants experienced an almost immediate reduction in muscle activity in the neutral posture. Therefore, the results of placing the body in a posture that requires less muscle activity to support its own weight will have an overall influence on muscle activity during work (Dowler *et al.*, 2001:76).

A study by Snijders, Hermans, Niesing, Spoor and Stoeckart (2004:323) found backward rotation of the pelvis combined with flexion, i.e. slouching, results in backward rotation of the sacrum with respect to the ilium, dorsal widening of the intervertebral disc L5-S1 and strain on the iliolumbar ligaments when protection from back muscles against lumbar flexion is absent.

Postural effects are exaggerated following sustained loading because compressive forces squeeze water from the intervertabral discs and reduce the separation of vertebrae by 1-2mm. Large stress concentration in innervated tissues arising from relatively small changes in posture suggest that bad posture could conceivably lead to spinal pain, even in the apparent absence of degenerative changes in the affected areas (Adams & Dolan, 2005:1972).

From the above it is clear that most of postural deformities are usually associated with other changes within the body. Normally the downward gravitational pull on any part of the body is caused by the segment below, but if any segment deviates from its normal vertical alignment, its weight must be compensated for by the deviation of another segment in the opposite direction. Therefore, postural deformities must be seen from a total body perspective (Bloomfield *et al.*, 1994:99).

NORMAL POSTURAL DEVELOPMENT

When an initial assessment is made by a health care professional, careful consideration is needed when concerns are raised about a child's posture. Parents can be overwhelmed by differing opinions, complicated by different types of intervention offered by a range of health professionals. Therefore, to diagnose postural deformities, a clear understanding of the normal range op spinal curvatures and alignment, as well as postural characteristics at different ages are necessary (Lincoln & Suen, 2003:312).

Normal curvatures and angles

In the coronal or frontal plane, represented by an anteroposterior radiograph, no deviation from the midline should be present. There is a wider range of normal curvature in the sagittal plane represented by a radiograph of the spine. Moreover, the degree of curvature varies within regions of the spine so that thoracic kyphosis, for example, changes, depending on levels of the spine measured (Junghanns & Hager, 1990:33; Boachie-Adjei & Lonner, 1996:884).

The normal range of thoracic kyphosis is 20 – 45 degrees, and the range for lumbar lordosis, 25 – 60 degrees (Fon, Pitt & Thies, 1980:982; Stricker, 2002:135). Harrison, Janik, Troyanovich and Holland (1996:667) found the normal range of lumbar lordosis to be 16.5-66 degrees and cervical lordosis an average of 34 degrees and Sahrmann (2002:52) reported similar values. At the junction of the thoracic and lumbar spine, there should be a straight spine, or only slight kyphosis. The apex of thoracic kyphosis normally lies at the T6-7 (thoracic vertebrae 6 to 7) level, and the apex of lumbar lordosis generally falls at the L3-4 (lumbar vertebrae 3 to 4) level (Cailliet, 1975:21; Bernhardt & Bridwell, 1989:717).

Mac-Thiong, Berthnnaud, Dimar, Betz and Labelle (2004:1642) studied the sagittal alignment of the spine during growth and found the mean thoracic kyphosis and lumbar lordosis to be 43 degrees and 41.2 degrees respectively. The Scoliosis Research Society has defined the range of thoracic kyphosis as 20 – 40 degrees in the growing adolescent (Wenger & Frick, 1999:2630).

Normally, there should be minimum or no rotation of the spine, which is assessed by viewing the location of the pedicles on an anteroposterior radiograph of the spine. Each pedicle should be located at the lateral margins of the vertebral body (Nash & Moe, 1969:228; Boachie-Adjei & Lonner, 1996:884).

Age-related changes in posture

Each phase of life from birth to death has its classical posture picture and, therefore, should be considered in their order of growth and development (Figure 2.2) (Lincoln & Suen, 2003:312).

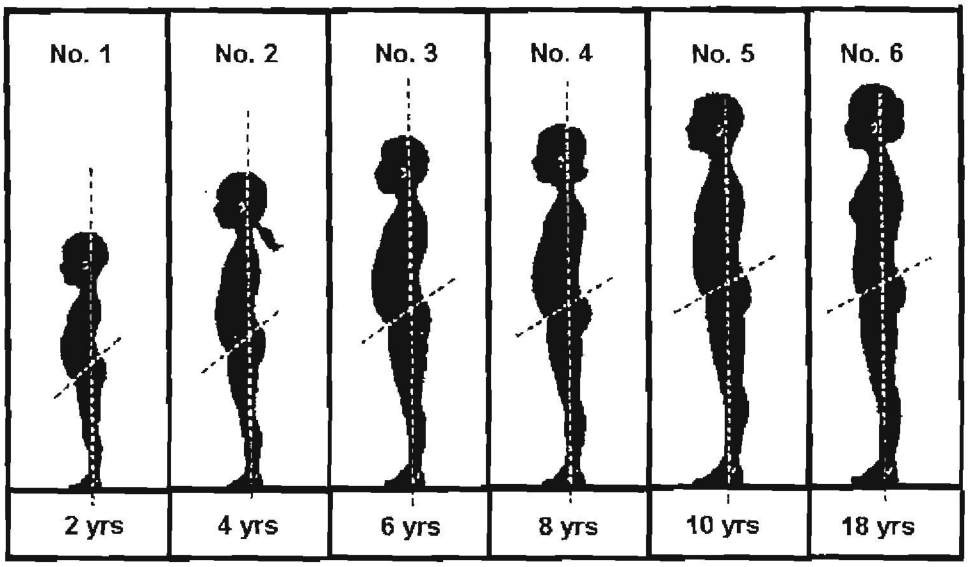


Figure 2.2: Posture at different ages (Magee, 2002:874).

Infants

During several weeks of neonatal life, when a hormonal influence persists, physiologic relaxation of ligaments and musculotendinous structures are pronounced. The infant posture is characterised by a "slackjointed" posture namely, long heel cords, hips and knees flexed, hips easily overabducted, feet turned in and greatly relaxed, and a marked toe-grasping reflex (Scougall, 1977:21). According to Lincoln and Suen (2003:313), it is normal for infants to have a average hip internal rotation of forty degrees and external rotation of seventy degrees.

Curves that are found at birth are called primary curves, which include the thoracic spine and sacrum (Bloomfield *et al.*, 1994:96; Magee, 2002:873). These curves maintain the original position found during birth and thereafter during child growth secondary curves develop that are convexed forward or extended (Magee, 2002:873; Dickson, 2004:411). At birth the entire presacral column is extremely flexible, and has the shape of a single C curve (Watson & Lowrey, 1962:99; Sherrill, 1993:371). At the age of three months the supine-conditioned, long single C curve is lost when the infant is old enough to hold up the head, developing a convexed forward cervical spine that constitutes a cervical lordosis and the infant is able to sit up at six months (Bloomfield *et al.*, 1994:96; Magee, 2002:873).

Toddlers

In the lumbar spine, at about age six to eight months, when the child sits up and starts walking, the secondary curve develops (lumbar lordosis) (Bloomfield *et al.*, 1994:96; McCoy & Dickens, 1997; Magee, 2002:873). Young children with disabilities that prevent upright locomotion, characteristically have flat backs. This condition is normal during the months when the toddler is gaining confidence in walking and running, however, a flat back that persists beyond the toddler stage it is considered a postural deformity (Sherrill, 1993:371; Magee, 2002:874). The toddler stands and walks with a wide base of support, knees and hips slightly flexed and arms held forward over the head for balance. There are usually bowed legs, which are externally rotated for stability, the feet are flat and lumbar lordosis is evident (Scougall, 1977:22; McCoy & Dickens, 1997; Magee, 2002:873). The toddler stage persists to the end of age two, when ninety-seven percent of children are able to run (McCoy & Dickens, 1997).

Preschool age

At ages two to five years, the lower limbs start to show a posture of knock knees (genu valgum) (Watson & Lowrey, 1962:99; Sharrard, 1976:826; Bloomfield *et al.*, 1994:96; McCoy & Dickens, 1997).

The normal preschool child has an exaggerated lumbar curve (excessive lumbar lordosis) that may persist throughout elementary school (Sherril, 1993:378). This accentuated curve is due to the presence of large abdominal contents (protruding abdomen) and weakness of the abdominal muscles and the small pelvis is a normal feature at this age (Watson & Lowrey, 1962:99; Magee, 2002:874; Kendall *et al.*, 2005:98). The centre of gravity is at the level of the T12 vertebra and as the child grows older, the centre of gravity drops to reach the level of the second vertebra. (Magee, 2002:873).

By four to five years, most children develop a medial longitudinal arch in their feet and are no longer flat-footed (Scougall, 1977:22; Magee, 2002:874). However, fifteen percent of Caucasian children remain flat-footed, based on familial patterns, where African children often present with flat feet which are culturally and genetically normal for them (McCoy & Dickens, 1997).

According to McCoy and Dickens (1997) and Sharrard (1976:827), the knock knee posture corrects by the age of seven to eight years. According to Bloomfield *et al.* (1994:96) and Magee (2002:873), by the age of six the legs should naturally straighten. However, Cahuzac, Vardon and Sales De Gauzy (1995:732) found genu valgum and varum changes to occur until the last two years of growth. Sharrard (1976:827) stated that children with knock-knees of late onset usually have a heavy build, and are taller and heavier compared to the mean for their age.

School ages

According to Brower and Nash (1999:58), between ages six and nine years, most children grow about 5 cm a year and gain approximately 10 percent of their total body weight each year. This growth will be affected by factors such as heredity, environment and health status (Brower & Nash, 1999:58).

At age six to nine years children's legs have a "spindly" and "knobbed knee" appearance as fat and muscle are not fully developed (Brower & Nash, 1999:58). The slimming-down process continues until age ten, when girls increase in weight and stature at a faster rate. The dominant side will show a slightly depressed shoulder and a slightly higher hip, which leads to mild asymmetry and should not be confused with the symptoms of scoliosis (Kendall *et al.*, 2005:76). This is in contrast with Brower and Nash (1999:60) who stated that symmetry does not change with growth. Also, a study by Nissinen, Heliovaara, Seitsamo and Poussa (1993:11) found that all kinds of trunk or extremity asymmetry at the prepubertal stage predicted scoliosis.

According to Magee (2002:874), apparent kyphosis at ages six and eight years is due to scapular winging. This may be due to the fact that winged scapulae are usually accompanied by round shoulders (Kendall *et al.*, 2005:79). This may alter the normal mechanics of the neck and back, resulting in a possible kyphosis (Arnheim & Prentice, 2000:708). According to Kendall *et al.* (2005:79), scapular winging is normal for children of about eight years. Widhe (2001:119) also established an increase in kyphosis and lordosis in this stage.

At ages nine to twelve years, children's proportions are much like an adult's, and their posture is erect, with square shoulders (McCoy & Dickens, 1997; Brower & Nash, 1999:60). The pelvis begins to tilt posterior, lessening lordosis and flattening the abdomen (Brower & Nash, 1999:58). At this stage boys are usually taller than girls, but this trend reverses at age eleven or twelve years, when girls reach puberty and begin growing taller than boys (Brower & Nash, 1999:58). Females enter puberty between eight en fourteen years of age, and this lasts for about three years, while males enter puberty between ten and sixteen years of age and it lasts up to five years (Magee, 2002:875). It is during this period that differences arise between girls and boys, with boys tending toward longer leg and arm length, broader shoulders, smaller hip width, and greater overall skeletal size and height than girls (Magee, 2002:875). Because of this rapid growth spurt, children, especially boys, may appear ungainly, and poor postural habits and changes are more likely to occur (Magee, 2002:875).

BONE GROWTH

Bone is a complex heterogeneous tissue which has two often opposing roles namely, it supports the musculature and thus its growth and development are intimately connected with overall body growth and it also serves as a calcium and phosphorus reservoir (Loveridge & Noble, 1994:75). The growth of the skeleton determines the size and proportions of the body. The bony skeleton begins to form about six weeks after fertilization, when the embryo is approximately 12 mm long. During subsequent development, the bones undergo a tremendous increase in size. Bone is a dynamic structure that perpetually remodels and responds to alterations in mechanical loads (Whiting & Zernicke, 1998:21). The mechanical factors which influence longitudinal growth the most and which are essential for normal growth are weight bearing and movement (Golding, 1994:S178). Therefore, there is value in understanding how mechanical factors and physical activity influence bone growth.

Biomechanics

The idea that mechanical factors can influence bone growth has been accepted from the earliest of times which accounts for the ancient Chinese custom of binding the feet of aristocratic girls. This produced a marked reduction in longitudinal and lateral growth as an aid to beauty and social status (Golding, 1994:S178).

Wolf's (as cited in Golding, 1994:S179) results indicated that the internal structure of deformed bone was considerably changed as a response to the static forces acting on it. A normal bone will alter to meet a change in its function and if such change in the mechanical environment is rectified, the bone will resume its former structure (Hall, 1999:98). Wolf's law finally presented as follows:

"*Every change in the form and the function of a bone or of its function alone is followed by certain definitive changes in its internal architecture and equally definite secondary alteration in its external conformation*" (Golding, 1994:S179). Murphy (as cited in Golding, 1994:S179) simplified Wolf's law with the following phrase:

"*The amount of growth in a bone depends upon the need for it*" (Golding, 1994:S179).

According to Golding (1994:S179), correct posture will be associated with a change of cranial length as the centre of gravity of the cranium is required to rest over the feet. Thus, mechanical factors will even play a part in bones that do not bear weight.

According to Golding (1994:S179), cultural differences can play an integral role. African women tend to carry their babies on their backs, which is rather uncommon amongst European cultures. The back-carry produces a constant valgus, external torsion pressure on the lower leg and feet against the mother's pelvis, which can result in a permanent knock-kneed posture. Excessive compression, therefore, can result in thickening of the weight-bearing bone and eventually the slowing of growth along the growth plate (Golding, 1994:S179).

Leivseth and Drerup (1997:409) studied spinal shrinkage (loss in stature) in middle aged men and women during work in a sitting posture compared to work in a standing posture and found the greatest loss in stature during work in a standing position. Fowler, Rodacki and Rodacki (2006:133) studied the changes in stature and spine kinematics in healthy middle aged males during a loaded walking task and found a loss in stature double that observed in the unloaded condition. Also, lateral bending of the spine increased by 12 degrees. This is further evidence to suggest that mechanical changes in bone continue to occur, even when past the growth stage.

Physical Activity

As a result of increased growth rate the skeleton is most sensitive to mechanical loading during childhood and adolescence (Janz, Burns, Tomer, Levy, Paulos, Willing & Warren, 2004:1128). This means that physical activity's contribution to bone health is critical during this time period. According to Bass and Kerr (2000), peak bone mineral density (BMD) is the maximal lifetime amount of bone tissue accrued in the skeleton during growth. It can be a more important determinant of low BMD in older people than age-related bone loss. Maximizing the attainment of peak bone mass is considered to be an important component of osteoporosis prevention. Bass and Kerr (2000) state that physical activity and diet may be the most important modifiable environmental factors that can increase peak BMD in both children and adults.

Torun and Viteri (1994:S189) studied the effect of physical activity on the linear growth of children recovering from protein-energy malnutrition and found the physical active group's increase in linear growth to be double that of the physical inactive group.

Habitual physical activity has been recognized as an important component of a healthy lifestyle (Sallis, 2000:31; Sherman, 2000:8; Janz, Levy, Burns, Torner, Willing & Warren, 2002:563). Exercise is known to increase bone development in teenagers (Junghanns & Hager, 1990:165; Haywood, 1993:80; Whiting & Zernicke, 1998:99). According to Turner (2004), the strengthening effect of exercise is efficient because cellular mechanosensors within bone direct new bone growth to where it is most needed to improve bone strength and bone mass.

Long-term physical activity, short of strenuous labour, promotes bone density and might increase the diameter of bones. Bone adapts favourably to the stimulation that physical activity provides (Haywood, 1993:80). In some tropical countries the mothers exercise their children's legs and encourage infants to stand and walk at a very early age and not wearing shoes and clothes also facilitates ambulation (Torun & Viteri, 1994:S188). The question is raised whether this could be a possible reason for Africans having longer legs than Europeans. However, Torun and Viteri (1994:S189) commented that legs are not only loaded when they are weight bearing and arms when heavy loads are lifted. There is some strain on all of the bones most of the time and thus mechanical factors could not be site specific.

A sustained level of activity leads to greater peak bone mass, as demonstrated by a 15-year longitudinal study in the Netherlands in which physical activity over time was correlated with the lumbar bone mineral density at the age of 27 years (Welten, Kemper, Post, Ban Mechelen, Twisk, Lips & Teule, 1994:1095). According to Rodrigues *et al.* (1988:1059), immobility during fetal development, which may result from neuromuscular diseases, leads to reduced skeleton size with smaller bone cross-section. A study by Lloyed *et al.* (2000:43) concluded that the amount of exercise a teenage girl gets between the ages of 12 and 18 years is an important determinant in the density and strength of the proximal femur, and thus a crucial factor in the prevention of hip fractures due to osteoporosis in postmenopausal women. Kemper *et al.* (1976:324) studied the effect of a 5 versus 3-lesson-a-week physical education programme on the physical development of 12 and 13 year old schoolboys. Achievement in physical education and performance in handgrip were the only variables that showed a significant increase. The effects of two extra lessons of physical education could not be confirmed.

Janz, Burns, Tomer, Levy, Paulos, Willing and Warren (2001:1392) examined the effects of low-impact everyday activities on bone density in children. High motion levels and physical activity ratings were associated with higher bone density and mineral content in both boys and girls. Comparisons showed a 12% greater hipbone content in the most active children, compared to children in the least active group. Also, girls who watched more television tended to have lower bone densities than those who watched less. Boys showed a greater level of total physical and vigorous activity than girls, which may account for their higher bone densities. A further study by Janz *et al.* (2004:1124) concluded that everyday activity predicts bone geometry in children.

According to Twisk (2001:621), adults indicate that particularly vigorous physical activity can prevent osteoporosis and evidence by Welten *et al.* (1994:1095) has demonstrated that this is probably also the case for children and adolescents. A study by Sherman (2001:6) suggested that a high intensity jumping programme has positive effects on young children's hip and lumbar spine bone mineral content. Ward, Roberts, Adams and Mughal (2005:1018) proved that peripheral and axial skeleton geometry and density of pre-pubertal gymnasts increased due to high levels of physical activity. However, Kujala, Taimela and Viljanen (1999:325) found that vigorous physical activity during adolescence may cause acute or stress injuries to the developing musculoskeletal system and higher occurrence of apophyseal pains. In accordance with Kujulas findings, Schmorl and Junghanns (1971:348) made the following statement:

"*If these spines are exposed to heavy physical labour, or if the youth participates in sports where the spine is exposed to stress or to considerable shock (motor cycle riding, etc.) then the thin cartilaginous plates become fissured and disc tissue prolapses into the spongiosa of adjacent vertebral bodies*" (Schmorl & Junghanns, 1971: 348).

Children's skeletal systems show pronounced adaptive changes to intensive physical training. Adolescents are particularly vulnerable to injuries as there are significant changes in the biomechanical properties of bone during this age. Injuries during childhood affect both growing bone and soft tissues, and could result in damage of the growth mechanisms with subsequent life-lasting damage (Maffulli & Baxter-Jones, 1995:139).

It is clear that physical activity plays an integral role in bone growth, however, there is still controversy as to the amount and intensity of physical activity required for optimum growth. Evidence suggests that a given exercise programme will not have the same effect on all children and also, its effect may vary from one development stage to another (Cohen, Beaton & Mitchell, 1979:176; Bass & Kerr, 2000).

POSTURAL DEFORMITIES

Considerable effort by clinicians, therapists, parents and the children themselves can be put into the prevention of postural deformities by maintaining a good posture (Bergström, Short, Frankel, Henderson, & Jones, 1999:838). No disease is known to be caused by poor posture alone, but it is well known that prolonged disturbances in function may lead to pathologic changes which are recognized as a disease. Postural deformities frequently occur in growing children who have had bad posture for a long period of time. Most changes occur slowly, and usually years are required to produce permanent deformities. This can be seen best in the spinal column and less often in the other components of the thoracic cage and much less commonly in the extremities (Kuhns, 1962:64). The most extensively screened postural deformity is scoliosis and most screening programmes are for the detection of scoliosis only (Sells & May, 1974:60; Shtern, 1975:761; Lonstein, 1977:33; Drummond, Rogala, & Gurr, 1979:751; Willner & Udén, 1982:233; Francis & Bryce, 1987:1222; Mittal, Aggerwal & Sarwal, 1987:335; Bunnell, 1993:1572; Nissinen *et al.*, 1993:8; Karachalios, Sofianos, Roidis, Sapkas, Korres, & Nikolopoulos, 1999:2318; Loveless, 1999:227; Yawn, Yawn, Hodge, Kurland, Shaughnessy, Llstrup & Jacobsen, 1999:1427; Bunnell, 2005:40). School-based screening programmes for scoliosis are mandated in 26 states in United States (Yawn *et al.*, 1999:1427)

Already in 1974 the American Academy of Orthopaedic Surgeons made the following statement, further emphasizing the importance of school screening programmes (Lonstein, 1977:35):

"*The American Academy of Orthopaedic Surgeons hereby gives its official recommendation to any program of routine examination of school children for the detection of scoliosis and other crippling spine deformities. The Academy recognizes that by early detection more appropriate treatment can be given and a better total treatment of this disabling health problem can be carried out*" (Lonstein, 1977:35).

Although there are numerous causes of postural deformities in children, scoliosis, postural roundback, Scheuermann's kyphosis and lumbar lordosis account for most of these conditions (Boachie-Adjei & Lonner, 1996:883). A clear understanding of the presentation, initial examination, differential diagnosis and potential treatment for these deformities is essential for appropriate care given by health professionals (Loveless, 1999:227). Some less commonly encountered types of postural deformities will be mentioned briefly.

Scoliosis

Scoliosis, a term of antiquity first used by Hippocrates (460 – 377 BC), which implies abnormal curvature of the spine (Cailliet, 1975:1). It is a general term used to describe any lateral curvature of the spine (Roaf, 1977:41; Whiting & Zernicke, 1998:235; Arnheim & Prentice, 2000:709; Stedman, 2000:1606; Brox, 2003:647; Kendall *et al.*, 2005:107; Zabjek, Leroux, Coillard, Rivard, & Prince, 2005:483). Intensive research is being carried out throughout the world, but the etiology and pathogenesis of scoliosis remain unknown. In 80 – 85% of people the cause of scoliosis is unknown (Anon, 1998).

Scoliosis is evidently a complex disorder in which expression of the defect is variable. Causes of curves are classified as either non-structural or structural (Loveless, 1999:228; Magee, 2002:880; Brox, 2003:649). Non-structural scoliosis is defined as a structurally normal spine that appears curved. This is a temporary, changing curve. There is no bony deformity and it is not progressive. The scoliotic curve will disappear on forward flexion. This type of scoliosis is usually found in the cervical, lumbar, or thoracolumbar area (Magee, 2002:880). According to Arnheim and Prentice (2000:709), the causes include postural habits, muscle imbalances, pelvic and spinal misalignments and subluxations, and leg length discrepancies. In children and adolescents by far the most common type of non-structural scoliosis is the pelvic tilt scoliosis caused by leg length inequality. This scoliosis is found in the lumbar region and is confirmed by the presence of the sacrum as being the bottom of the curve (Dickson, 2004:411).

In structural scoliosis the deformity cannot be corrected by change in posture (Brox, 2003:649). Structural scoliosis can be caused by neuromuscular diseases (such as cerebral palsy, poliomyelitis, or muscular dystrophy), birth defects (such as hemivertebra in which one side of a vertebra fails to form normally before birth), injury, certain infections, tumors, metabolic diseases, connective tissue disorders, rheumatic diseases, or unknown factors (Anon, 1998). Structural scoliosis has the ability to progress considerably during growth and is usually associated with spinal rotation (Dickson, 2004:412). The most common cause of structural scoliosis is idiopathic scoliosis (Dickson, 2004:412; Loveless, 1999:228). Idiopathic scoliosis is defined as a lateral curvature of the spine with rotation in the absence of any other problem such as a congenital spinal abnormality or associated musculoskeletal condition (Brox, 2003:649; Dickson, 2004:415). Idiopathic scoliosis may present at various age groups namely infantile (0-3 years), juvenile (3-10 years) and adolescent (>10 years) (Dickson, 1994:415; Boachie-Adjei & Lonner, 1996:883; Loveless, 1999:228). Adolescent scoliosis is the most common form of spinal deformity evaluated and referred by a primary health care professional (Dickson, 1994:415; Loveless, 1999:228). In idiopathic scoliosis the lateral curvature remains on forward flexion and produces a rib hump, better known as a positive sign for a forward bending test (Brox, 2003:666). Zabjek *et al.* (2005:483) demonstrated that postural abnormalities are evident during quiet standing in idiopathic scoliosis patients.

Giakas, Baltzopoulos, Dangerfield, Dorgan and Dalmiro (1996:2235) found poor gait patterns in scoliotic patients compared to healthy individuals. Chen, Wang, Tsuang, Liao, Huang and Hang (1998:S52) found poor postural stability control in idiopathic scoliosis patients, but gait patterns were similar to that of normal subjects. These studies suggest that gait asymmetry could well be the underlying cause of the balance and coordination problems that result in a curved spine.

Wu (2004:109S) found lower bone mineral density in patients with adolescent idiopathic scoliosis compared to healthy children and this finding may suggest that the osteopenia in adolescent idiopathic scoliosis may be a possible aetiology of the disease. Gender also seems to play a role as a recent study by Helenius, Remes, Yrjönen, Ylikoski, Schlenzka, Helenuis and Pousa (2005:466) has shown that adolescent idiopathic scoliosis requiring treatment is primarily associated with females. The ratio of females to males with curves measuring 30 degrees or more was 10 to 1.

Research in etiology continues with basic science studies. The most exciting avenue of research is the effect of melatonin (a hormone that regulates the sleep-wake cycle) on scoliosis (Hillibrand, Blakemore, Loder, Greenfield, Farley, Hensinger & Hariharan, 1996:1140). Chickens and bipedal rats had their pineal gland removed with a dramatic increase in the incidence of scoliosis. Upon administration of melatonin the development of the scoliosis appeared to decrease significantly (Hillibrand *et al*, 1996:1140; Loveless, 1999:228).

Since no consistent, confirmed cause is currently known for idiopathic scoliosis and not all the mechanisms of the better-known causes are understood, diagnosis of scoliosis remains a clinical one.

Kyphosis

Kyphosis is commonly used to refer to excessive curvature in the thoracic spine from a lateral view. It is associated with round shoulders, protracted scapulae and a hump back (Davis, Kimmet & Auty, 1995:130; Boachie-Adjei & Lonner, 1996:885; Loveless, 1999:228; Arnheim & Prentice, 2000:708; Stricker, 2002:135; Kendall *et al.*, 2005:G-3).

According to Dommisse (1998:49), most types of abnormal kyphosis can be entered into one of the three following categories:

Postural kyphosis

Postural kyphosis is a non-structural, functional deformity with onset during the late juvenile period, usually nine to 12 years. Postural kyphosis does not involve the centers of ossification of the vertebral bodies (Dommisse, 1998:49). The cause of postural kyphosis is purely postural. Slouching and poor posture can stretch spinal ligaments, thus increasing the natural curve of the spine. Postural kyphosis bears a clinical resemblance to Scheuermann's disease in the form of a hyperkyphotic thoracic spine, but the radiological appearances of the vertebrae are within normal limits. According to Sherrill (1993:384), a flattened appearance of the anterior thoracic wall (flat chest) usually accompanies postural kyphosis. Postural kyphosis is usually not progressive and is easily corrected (Sherrill, 1993:374; Dommisse, 1998:49; Stricker, 2002:136).

Congenital kyphosis

This category of spinal deformity refers to an abnormal development in the spine. The bones may not form as they should, or a bone bar may develop between two vertebrae and cause progressive kyphosis as the child grows. Children born with spina bifida usually have severe kyphosis (Boachie-Adjei & Lonner, 1996:885; Dommisse, 1998:49).

Scheuermann's disease / Juvenile kyphosis

Juvenile kyphosis was a poorly understood disease until 1920, when Holger Scheuermann first outlined the radiographic manifestations of this deformity. Since then, Juvenile kyphosis became better known as Scheuermann's disease (Murray, Weinstein & Spratt, 1993:236;

Boachie-Adjei & Lonner, 1996:883; Stricker, 2002:135). This disease is related to the abnormal development of the vertebrae in the spine, which leads to wedge-shaped, instead of rectangular-shaped vertebral bodies. Scheuermann's disease involves the secondary ossification centers of the vertebral bodies, usually at mid-thoracic and thoracolumbar levels, which appear at puberty and develop during the adolescent years, the period of the normal "growth spurt" (Dommisse, 1998:49). It is a structural deformity defined by anterior vertebral wedging greater than 5 degrees that involves three or more contiguous thoracic vertebrae (Wenger & Frick, 1999:2630; Loder, 2001:226). According to Stricker (2002:135), the majority of evidence suggests that Scheuermann's disease is caused by mechanical and genetic factors. Mechanical factors are suspected due to a higher incidence in heavy labourers, and because the deformity is partially reversed by bracing. Wenger and Frick (1999:2631) state that the changes noted radiographically are altered remodeling responses to abnormal biomechanical stresses, and not secondary to an underlying disease process. The kyphosis appears first, and the anterior vertebral body is subjected to increased forces that suppress anterior growth and perpetuate the deformity. Adolescents with Scheuermann's disease usually complain of progressive poor posture or easy fatiqueability in the back. Mild scoliosis is seen in one-third of children with Scheuermann's disease, and increased lumbar lordosis may occur to compensate for thoracic kyphosis (Wenger & Frick, 1999:2631; Stricker, 2002:136).

A clinical impression that kyphosis increases with age, especially in women, is widespread (Milne & Lauder, 1974:327). In 1974 Milne and Lauder (1974:327) found an increase in kyphosis, including 20 to 90 year old men and women, and a recent study by Hinman (2004:413) including 25 to 88 year old women reported similar results. According to Wenger and Frick (1999:2630), the average thoracic kyphosis increases with age, from 20 degrees in childhood, to 25 degrees in adolescents, to 40 degrees in adults.

Of the deformities which may develop during childhood and adolescence, kyphosis is one of the most frequent, and also one of the most frequently neglected. Most screening programmes are instituted mainly to detect scoliosis (Shtern, 1975:761; Willner & Udén, 1982:233; Francis & Bryce, 1987:1222; Bunnell, 1993:1572; Nissinen *et al.*, 1993:8;

Karachalios *et al.*, 1999:2318; Loveless, 1999:227; Yawn *et al.*, 1999:1427), and children with Scheuermann's disease vertebral changes and kyphosis are most likely to be missed.

Lordosis

Kendall *et al.* (2005:70) define lordosis as an increased anterior curve of the spine, usually found in the lumbar region and associated with an anterior pelvic tilt. Lordosis, also called swayback or hollow back, is an exaggeration of the normal posterior concave curve in the lumbar region. It not only affects the five lumbar vertebrae but also throws the pelvis out of correct alignment (Schrecker, 1971:29; Sherrill, 1993:375). Davis *et al.* (1995:129) defines lordosis as an exaggerated hyperextension of the lumbar spine. Occasionally, lordosis is seen in the dorsal spine. The cervical spine position is similar to a lordosis in cases of round upper back with compensatory forward position of the head. According to Arnheim and Prentice (2000:708), when lordosis is combined with kyphosis and a forward head posture, it is referred to as a kypho-lordotic posture. In general, lordosis is associated with an exaggeration of the lumbar curvature (Arnheim & Prentice, 2000:708).

Lordosis is characterised by weak abdominal muscles that allows the pelvis to tilt downward anteriorly; weak gluteal muscles and hamstrings, which cannot counteract this anterior tilt; overly tight lumbar extensors, which contribute to an anterior tilt, and over developed hip flexors, which cause anterior tilt (Sherrill, 1993:375; Magee, 2002:876). The degree of anterior pelvic tilt is often associated with marked shortness of the iliopsoas (hip flexor) muscles, e.g. the weakness of the anterior abdominal muscles and shortness of hip flexors causes a muscle imbalance, which could result in an anterior pelvic tilt (Kendall *et al.*, 2005:70). There is some controversy about the relationship between lumbar lordosis, pelvic tilt and abdominal muscle performance. Two studies concluded that the magnitude of the lumbar lordosis and pelvic inclination in standing is not associated with the force production of the abdominal muscles (Levine, Whittle & Hood, 1996:74; Youdas, Garrett, Egan & Therneau, 2000:261). According to Magee (2002:876), lordosis commonly occurs in obese people with weak back muscles and heavy abdomens and may also develop in pregnant women.

Faulty conditioning may contribute to the development of lordosis. Sit-ups and straight-leg leg-lifts are often used to strengthen the abdominal muscles. The main effect is actually on the iliopsoas and it is well known that these exercises tend to cause lordosis (Watson, 1983:231).

It has also been thought that participating in certain sport can cause lordosis. According to Junghanns and Hager (1990:291), lumbar lordosis plays a considerable part in many sport and gymnastic disciplines. The lordotic posture in some figures in thousands of training hours is constantly repeated and is deliberately gradually increased through relaxation of the intervertebral motor segments in the lumbar area. This posture is not physiological since it results in a strong pressure on the posterior portions of the lumbar intervertebral discs (Junghanns & Hager, 1990:291). A study by Watson (1983:231) investigating posture and participation in sport found the incidence of lumbar lordosis to be significantly higher in individuals who specialized in soccer, football and rugby. In a separate study it was shown that the degree of lumbar lordosis in a group of soccer players and footballers increased during 21 months of participation in these activities (Watson, 1983:231). Also, a further study by Watson (2001:224) concluded that posture defects are an intrinsic risk factor for the development of sport injuries.

Abdominal protrusion is normal in the young child and usually accompanied by lordosis (Davis *et al.*, 1995:129). This posture defect is almost always present in adolescents and adults who lead sedentary lifestyles, especially if they are overweight. The protruding abdomen also characterizes paralysis or muscle weakness that result from spinal cord injuries. (Schrecker, 1971:30; Sherrill, 1993:377).

Incidence

As this study is mainly concerned with the prevalence of postural deformities among children, the review of the literature will include the prevalence rates of school-aged children only. There is a lack of comparable research completed in the broad spectrum of postural deformities. Thus, the researcher makes no attempt to compare the incidence of the various deformities among the population. For scoliosis, however, this data is obtained easily and, therefore, the following incidence rates are applicable to scoliosis:

Wynne-Davies (1968:24) conducted a screening programme in Edinburgh and estimated the incidence as 0.39% for adolescent females. A study by Brooks, Azen, Brooks and Chan (1975:968) in Los Angeles found a prevalence rate of 13.6%. Grant, Fearnow, Hebertson and Henderson (1973:520) found a prevalence rate of 13.4% in El Paso, Texas, which is similar to the finding of Brooks *et al.* (1975:968).

Kane and Moe (1970:216) conducted a study in Minnesota and found a prevalence rate of at least 0.13% for scoliosis requiring referral to an orthopedist. The ratio of positive rotational prominences of female to male was 1.5 to 1. The study by Brooks *et al.* (1975:968) found a ratio of 1.25 to 1. This gives a nearly equal prevalence rate in boys and girls. Sells and May (1974:60) conducted a study in the Shoreline Public School, Washington and found a prevalence rate of 1.6%.

In certain areas the prevalence varies with different populations screened. Segil (1974:393) reported a prevalence of 2.5% in South African whites but 0.03% in South African blacks. Span, Robin and Makin (1976:379) reported that the prevalence in Orthodox Jewish schools in Jerusalem was twice that found in Jerusalem's public schools. Mittal *et al.* (1987:335) conducted a study in India and found a higher incidence rate (0.4%) in adolescents from a low socio-economic status compared to the higher income groups.

Willner and Udèn (1982:233) conducted a prospective prevalence study of scoliosis in Southern Sweden for children aged between seven and 16 years. Among the girls there was prevalence of 4.3% and among the boys 1.2%. Bunnell (1993:1573) conducted a spinal screening programme for children aged 10 years in schools in the United States and reported a prevalence rate of 3% and found no difference among boys and girls. A two-year prospective study by Soucacos, Soucacos, Zacharis, Beris and Xenakis (1997:1498) in North Western and Central Greece assessed the prevalence of scoliosis in schoolchildren nine to 14 years old. The prevalence of scoliosis was 1.7%. The ratio of boys to girls was 1:2.1. A study by Karachalios *et al.* (1999:2323) on the island of Somoa reported an incidence rate of 1.18 % in children age 8 to 16 years and rates were equal for boys and girls. Yawn *et al.* (1999:1427) conducted a population based scoliosis screening study in Rochester, Minnisota for children aged 11 years and found a prevalence rate of 2.8 %. Except for the high rates reported by Brooks *et al.* (1975:968) and Grant *et al.* (1973:520) the prevalence rate for scoliosis generally falls between 2.5% and 4%.

It is clear that incidence studies have shown a wide variation. This can be due to different definitions of scoliosis, to different techniques of screening (with or without x-rays), to the "know how" of screening or to a true deviation of the frequency of scoliosis in different populations. Also different degrees of curvature have been chosen as the limit of scoliosis.

Francis and Bryce (1987:1221) reviewed 43 published articles on postural screening programmes dating back to 1970. They found only one study by Maloney and Hildebrand (as cited in Francis & Bryce, 1987:1221) that screened other postural deformities. Francis and Bryce (1987) screened 18 postural deformities in school children grade six to nine. Lordosis was the most common postural deformity (45%), and torticollis (lateral curvature in cervical spine) was noted least commonly (0%). Scoliosis was noted in 7% of the total population, with a girl-boy ratio of 2:1. The other deformities screened were not considered for statistical purposes.

Kasper, Robbins, Root, Peterson and Allegrante (1993:126) conducted a musculoskeletal outreach screening programme for urban minority children in medically underserved areas of New York. The most frequent diagnoses were for those disorders affecting the foot or ankle (29 %) of which 20% were for flat feet alone and scoliosis (13%). Lordosis and Scheuermann's disease showed lower prevalence rates of 1.1%.

Stroebel (2002:64) screened 13 categories of deformities for children aged 11 to 13 years in selected schools in the Western Cape and found the following prevalence rates: Lordosis (70%); Kyphosis (57%); Uneven shoulders (55%); Inclined trunk (43%); Winged scapulae (42%); Pronated feet (30%); Flat feet (30%); Flat chest (29%); Forward head (28%); Protruding abdomen (28%); Uneven hips (11%); Scoliosis (10%), and Twisted head (1%).

Body Composition

Childhood overweight and obesity are increasing in prevalence at an alarming rate worldwide, both in developed and developing countries (Belizzi & Dietz, 1999:173S;

Fernàndez, Heo, Heymsfield, Pierson, Pi-Sunyer, Wang, Wang, Hayes, Allison & Gallagher, 2003:71; Laitinen, Näyha & Kujala, 2005:697). Obesity is a risk factor for serious pathologies in adults, namely diabetes, high cholesterol, hypertension, increased adult morbidity and mortality. It may likewise be the cause of physical, metabolic and psychological complications in children as well (Guillaume, 1999:126S; Bini, Celi, Berioli, Bacosi, Stella, Giglio, Tosti & Falorni, 2000:214; Riddiford-Harland, Steele, & Storlien, 2000:541). Moreover, an obese child is likely to become an obese adult (Bini *et al.*, 2000:214).

Excessive weight increases the weight on the spine and pressure on the discs and other structures of the back. The center of gravity shifts forward, increasing lordosis and tension on the back (Yip, Ho & Chan, 2001:887). Past studies have reported an association between low back pain and weight. However, the findings concerning this relationship have been conflicting, with some studies revealing a strong association (Fairbank, Pynsent, Van Portvliet & Phillips, 1984:461; Mellin, 1987:464; Grimmer & Williams, 2000:343) and others not reporting such an association (Merriam, Burwell & Mulholland, 1983:153; Pope, Bevins, Wilder & Frymoyer, 1985:644; Biering-Sorensen & Thomsen, 1986:720; Kovacs, Gestoso, Del Real, López, Mufraggi & Mèndez, 2003:259).

Bernard, Geraci, Hue, Amato, Seynnes and Lantieri (2003:184) studied the influence of obesity on postural capacities of teenagers and found a decrease in postural control in obese children. However, the effects of fat distribution on postural control could not be verified. Similar results were reported by Goulding, Jones, Taylor, Piggot and Taylor (2003:136) supporting the view that overweight adolescents have poorer postural control than those of healthy weight. The morphologic somatotype seems to be related to postural stability (Allard, Nault, Hinse, Leblanc & Labelle, 2001:631). Allard *et al's*. (2001:631) results revealed that scoliotic adolescent girls are to be significantly more ectomorphic and less mesomorphic. Specific morphologic somatotypes have been associated with spinal deformity (Allard *et al.*, 2001:631). Chen *et al.* (1998:S52) and Zabjek *et al.* (2005:483) both found marked postural instability in adolescent idiopathic scoliosis. The results from the study by Allard *et al.* (2001:631) showed an increased instability in the ectomorphic group of similar age as the scoliotic subjects. The increase body sway and postural instability in scoliotic girls may be associated to the high ectomorphic component in addition to their postural deformity (Allard *et al.*, 2001:631).

Górniak and Poplawska (2004) evaluated body composition of Polish rural girls aged 7 – 19 with a right body posture and those with a low degree of functional scoliosis and with structural scoliosis. The girls with a right body posture were heavier, presented higher level of fatty tissue, had their arm and calf circumferences bigger than their peers with a lateral spinal curvature, both functional and structural ones. Cheung (2003:2152) studied abnormal peri-pubertal anthropometric measurements and growth pattern in adolescent Idiopathic scoliosis and found body mass index of scoliotic children to be significantly lower than the control group with no spinal deformity. However Grivas, Arvaniti, Mazlotouk, Manesioti and Fergadi (2002:47) found no statistical difference between the body mass index of children with scoliosis and their nonscoliotic counterparts, regardless of curve type and site. Mauriciene and Baciuliene (2005:28) found that height had no statistical significant influence on lumbar lordosis, but it was connected with thoracic kyphosis in boys. Their study also confirmed that the children with bigger or smaller than medium height have a greater possibility for scoliosis or kyphosis development.

Mauno (2003:288) evaluated the height of Finnish girls age 9-24 years with adolescent idiopathic scoliosis. The height of the girls with idiopathic scoliosis was significantly greater than the height of average girls at the age of 11-15, but after maturation the girls with idiopathic scoliosis were not significantly taller than the average girls.

Bordin, De Giorgi, Mazzocco and Rigon (2001:7) evaluated the association between the incidence of flat feet and overweight among children age 8 to 10 years and found a high percentage of children suffering from flat feet to be obese or overweight. This may be due to the increased stress placed on the feet by the need to bear excessive mass (Riddiford-Harland *et al.*, 2000:541). Riddiford-Harland *et al.* (2000:544) concluded that excess body mass had a significant effect on the foot structure of prepubescent children. Foot discomfort associated with these structural changes in the obese foot could further decrease the participation of obese children in physical activity (Riddiford-Harland *et al.*, 2000:544).

In a study by Tüzün, Yorulmaz, Cinda and Vatan (1999:308) both lumbar lordosis and sacral inclination were increased with body mass index. In accordance with this study Murrie, Dixon, Hollingworth, Wilson and Doyle (2003:144) reported similar results, with lumbar lordosis being more prominent in women with a higher body mass index.

De Souza, Faintuch, Valezi, Sant'Anna, Gama-Rodriques, de Batista and de Melo (2005:1013) studied the postural changes in morbidly obese individuals and found seriously altered posture in obese individuals.

It is clear that obesity is increasing at an alarming rate, and if there is a close association between obesity or overweight and postural deformities, the current trends of obesity appear to be cumbersome. Research literature examining the possible association between postural deformities and obesity is lacking.

CONCLUSION

Advances in technology continue to remove habitual physical activity from everyday life. The mechanization of the workplace and the development of labour saving devices in the home have been followed by advances in technology, which further reduced daily energy expenditure. More of a concern is the suggestion that these levels of inactivity among children are the consequence of an inactive adult society, where inactive role models increasingly restrict young people's freedom.

Screening for many postural deformities can become preventive in the sense that early detection and early treatment prevents the progression of the deformity. In a society where many juveniles and adolescents are treated vigorously for acne, have expensive orthodontic treatment for realignment of tooth and jaw abnormalities, and are increasingly concerned with body image and fashion, the importance of external appearance should not be considered lightly (Wenger & Frick, 1999:2633). To disregard the need for a compulsory postural screening programme in light of these findings and other research would be to forego the opportunity of early detection of progressive postural deformities that could require corrective treatment.

Further studies should be conducted to evaluate not only the prevalence of postural deformities, but also to evaluate treatment protocols and preventive measures for children with postural deformities.

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Chapter 3

The prevalence of postural deformities among black South African children aged 11 - 13 years

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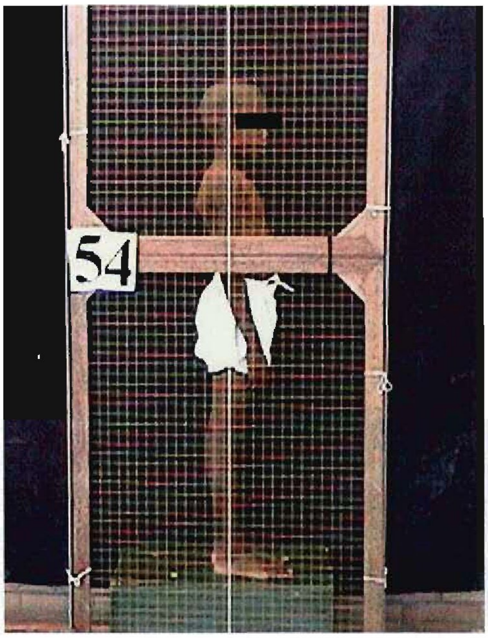

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THE PREVALENCE OF POSTURAL DEFORMITIES AMONG BLACK SOUTH AFRICAN CHILDREN AGED 11-13 YEARS

S. Stroebel, J.H. de Ridder and C.J Wilders

ABSTRACT

The aim of the study was to determine the prevalence of postural deformities among black South African children aged 11 to 13 years in selected schools in the Potchefstroom area in the North West Province. Black South African children 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 = 168) consisted of 47 eleven year olds, 58 twelve year olds and 63 thirteen year old school children. Of the total number of students examined (168), 79 were boys, and 89 were girls. A posture grid and the New York Posture test were used for all postural assessments. In the abnormal category, lordosis (79.8%), winged scapulae (60.1%), protruding abdomen (54.2%), kyphosis (35.1%) and pronated feet (14.3%) were observed most often. Uneven shoulders (8.9%) and flat feet (7.7%) were noted less often with scoliosis (0%) being non-existent. In the slightly abnormal category kyphosis (54.8%), pronated feet (48.8%), protruding abdomen (36.9%), winged scapulae (34.5%) and flat feet (32.7%) were most often observed. Lordosis (16.1%), uneven shoulders (14.3%) and scoliosis (6%) were noted less often. Except for kyphosis, no statistical difference ($p<0.05$) was observed for gender. The prevalence of kyphosis in the slightly abnormal category was much higher in boys (66%) compared to 45% in girls with the greatest difference being in the abnormal category with girls having a prevalence rate of 47% compared to 22% in boys. This study indicated high incidences of postural deformities in black South African school children. Early detection and treatment programmes targeted at children, designed to prevent postural diseases from subsequently becoming chronic adult disabilities, should be an important health strategy for the young population.

Key words: postural deformities, African children, growth, South Africa.

INTRODUCTION

Posture is often defined as the relative arrangement of body parts and a good posture is the state of muscular and skeletal balance that protects the body structures against injury and progressive deformity, independent of the condition in which these structures are working or resting (Penha, Joao, Casarotto, Amino & Penteado, 2005).

Anatomists and kinesiologists have focused for a long time on the body's ability to maintain a functional musculoskeletal balance between the forces of gravity and the muscular imbalances that normally occur in the human body. Skeletal imbalance can alter the load distribution on the joints which may lead to articular cartilage degeneration (Reigger-Krugh & Keysor, 1996). Postural education and assessment forms part of physical therapy and clinical practice. The importance of normal upright posture was proposed in the early 1900's when it was described as a state of balance requiring minimal muscular effort to maintain (Griegel-Morris, Larson, Mueller-Klaus & Oatis, 1992).

Postural deformities frequently occur in growing children who have had bad posture for a long period of time. Most changes occur slowly and usually years are required to produce permanent deformities. This can be seen best in the spinal column and less often in the other components of the thoracic cage and much less commonly in the extremities (Kuhns, 1962). The most extensively screened postural deformity is scoliosis and most screening programmes are for the detection of scoliosis only (Sells & May, 1974; Lonstein, 1977; Drummond, Rogala & Gurr, 1979; Willner & Uden, 1982; Bunnell, 1993; Karachalios, Sofianos, Roidis, Sapkas, Korres & Nikolopoulos, 1999; Loveless, 2002; Yawn, Yawn, Hodge, Kurland, Shaughnessy, Llstrup, 1999). School-based screening programmes for scoliosis are mandated in 26 states in the United States (Yawn *et al.*, 1999).

There are intrinsic and extrinsic factors that can influence posture namely, heredity, the environment or physical conditions, socio economic level, emotional factors, and physiologic changes due to human growth and development (Penha *et al.*, 2005). Lack of body awareness and modern sedentary lifestyle has been proposed as the main reason for children having postural deformities.

However, most of the black children in rural areas do not have access to television and computers. These children usually have to travel long distances by foot and the food intake is mostly inadequate and unbalanced, which in effect can result in malnutrition and stunting. Good nutrition is 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). As a result it is suggested that stunted children are likely to have sagging posture, round shoulders, curved spine, poor muscle tone, knocked knees and flat feet (Banfield, 2000).

The identification of the postural habits adopted by children and the postural deformities that often result are important for prevention, to encourage a healthier posture and to prevent resulting painful conditions. The extent of this problem in black South African children is not known at present. Therefore, the main objectives of this study were to determine the prevalence of postural deformities in children aged 11 to 13 years and to provide information to parents and teachers about this health threat.

MATERIALS AND METHODS

Subjects

The schools were selected purposefully, because learners/pupils attending these schools are from living areas where the lowest income per household could be expected. Many people in these communities live in informal housing and some even without water supply and electricity. It is thus likely that some of the children would be chronically undernourished and could be stunted. Black South African children 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 = 168) consisted of 47 eleven year olds, 58 twelve year olds and 63 thirteen year old children. Of the total number of students examined (168), 79 were boys and 89 were girls. The age distribution for boys and girls is shown in Figure 3.1. Parental consent was obtained from all subjects before participating in the study. Ethical approval was obtained from the Ethics Committee of the North-West University.

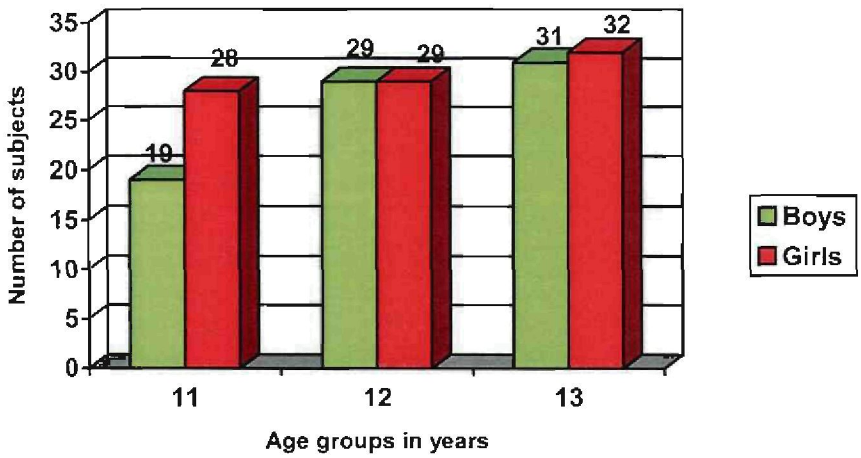

Figure 3.1: Age distribution for males and females (n=168).

Procedure

The procedure was to classify the children into groups according to class and gender. Measurement procedure was explained to children in detail to reduce any uncertainties and anxiety. With the help of assistants, the subjects completed a questionnaire which included personal details namely, age, gender, language, handedness and contact numbers. On completion of this the postural evaluation followed.

Boys and girls were evaluated separately and individually. Privacy was considered to be essential for reducing the children's anxiety. The New York Posture Test was used for evaluation and identification of possible deformities (Sherrill, 1993; Bloomfield, Ackland & Elliott, 1994; Davis, Kimmett & Auty, 1995; Magee, 2002). The New York Posture Test was also used by a well recognized company in the United States that manufactures anatomical measuring devices (Reedco Inc, 2001). The test battery comprises of thirteen items. 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 with: 5 = normal; 3 = slightly abnormal; 1 = abnormal. A subject with a score of 3 or 1 was considered to have a postural deformity.

A "transparent posture grid" was used for postural assessments. The "posture grid" comprises 12.5cm "large blocks", which is further subdivided into 2.5cm "small blocks". The vertical and horizontal strings were attached onto a frame. The vertical lines were at right angles to the horizontal lines. A plumb line was dropped from the top to bottom of the frame. These lines provided reference points for ascertaining the alignment of body parts. The use of gridlines to evaluate posture is well supported in the literature (Davis *et al.*, 1995; Arnheim & Prentice, 2000; Kendall, McCreary, Provance, Rodgers & Romani, 2005).

Normal posture as defined by Kendall *et al.* (2005) is a vertical line passing through the lobe of the ear, the seventh cervical vertebra, the acromial process, the greater trochanter, just anterior to the midline of the knee, and slightly anterior the lateral malleolus. The subjects were examined from a lateral, and posterior (side and back) view. The following deformities were assessed from the lateral view: forward head, flat chest, winged scapulae, kyphosis, inclined trunk, protruding abdomen, and lordosis.

The subjects then stepped down into powdered white chalk and onto a black board to screen for foot abnormalities (e.g. flat feet). After this they stood with their backs towards the posture grid for the evaluation of twisted head, uneven shoulders, scoliosis, uneven hips and foot pronation. The "Adam's test" (forward bending test) was used for additional evaluation of scoliosis. To reduce the degree of subjectivity the following criteria were provided by the New York Posture Test (Reedco Inc, 2001) to score uneven shoulders: the most superior-lateral edge of the acromions should be marked with a pencil; the degree of lateral asymmetry should be measured by counting the amount of blocks by which the one shoulder is lower than the other one; and by using a goniometer, the number of degrees for each block was measured beforehand. 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 could either be 2, 3 or 4 "large blocks" wide, which would be 25, 37.5 and 50 cm respectively. For example, a bi-acromial width of 37.5 cm (3 large blocks) the deviations were noted as follows: ½ block deviation = 2 degrees; 1 block deviation = 4 degrees; 1½ block deviation = 6 degrees; 2 blocks deviation = 8 degrees.

According to the New York Posture Test, uneven shoulders are scored as follows: 5 (0 – 2 degrees); 3 (2.1 – 4 degrees); 1 (> 4 degrees). For example, a subject with an acromion height difference of "1 block" and a bi-acromial width of approximately "3 large blocks wide" will have an angular deviation of 4 degrees, and thus a score of 3. The mathematical calculation in Figure 3.2 was used to determine the reliability of the goniometer measurements (Taylor & Myburgh, 1987).

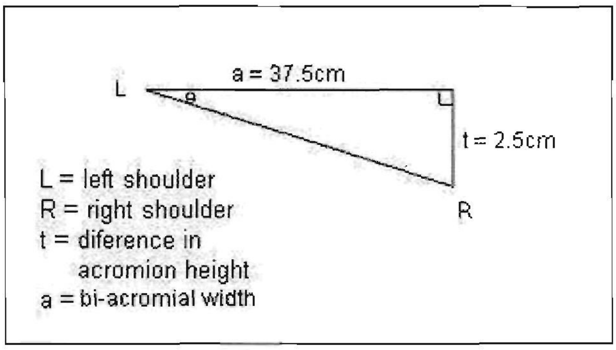

Figure 3.2: Asymmetry of acromial height (Taylor & Myburgh, 1987).

Tan θ = t/a, where t = difference in acromion height; a = bi-acromial width.

E.g. acromion height difference of "1 block" (2.5 cm) and a bi-acromial width of "3 large blocks" (37.5 cm):

$$Tan\theta = \frac{t}{a}$$
$$= 2.5cm / 37.5cm$$

θ = 4 degrees (rounded to nearest whole number)

Data Analysis

Quantitative data were analyzed, using Microsoft Excel Version 7.0 Analysis Tool and Statistica (Statsoft, 2001). Frequency and percentages were used to determine the prevalence of postural deformities in the three age groups. Chi-square analysis was used to determine whether the difference in prevalence of postural deformities in the three age groups was significant ($p<0.05$). Chi-square analysis was also used to determine whether there was a relationship between prevalence of postural deformity and gender ($p<0.05$).

RESULTS

Based on Kendall *et al's*. (2005) criteria for normal posture the majority of the subjects (n=168) had some degree of postural abnormality (Figure 3.3). The main postural deformities found in this study were as follows: In the abnormal category, lordosis (79.8%), winged scapulae (60.1%), protruding abdomen (54.2%), kyphosis (35.1%) and pronated feet (14.3%) were observed most often. Uneven shoulders (8.9%) and flat feet (7.7%) were noted less often, with scoliosis (0%) almost being non-existent. In the slightly abnormal category kyphosis (54.8%), pronated feet (48.8%), protruding abdomen (36.9%), winged scapulae (34.5%) and flat feet (32.7%) were most often observed.

Lordosis (16.1%), uneven shoulders (14.3%) and scoliosis (6%) were noted less often. The reason for lordosis scoring not as high in the slightly abnormal category may stem from the fact that the majority of children scored an abnormal score for this deformity. Chi-square analysis revealed no statistical difference in the prevalence rate between age groups for each postural category ($p<0.05$). Further analysis, including chi-square analysis and frequency counts used in graphing were, therefore, performed, grouping the data for all three age groups to increase the power of analysis. Except for kyphosis, no statistical difference ($p<0.05$) was observed for gender.

The prevalence rate for kyphosis in the slightly abnormal category was much higher in boys (66%) compared to 45% in girls with just the opposite in the abnormal category with girls having a prevalence rate of 47% compared to 22% in boys (Figure 3.4). Although chi-square analysis revealed no statistical difference in the prevalence rate between age groups, the highest percentage of subjects with a slightly abnormal kyphosis was observed in the 13 year old age group, with a prevalence of 65% compared to the 53% and 45% for the 11 and 12 year old group respectively (Figure 3.5).

DISCUSSION

There was a lack of comparable research analysing the broad spectrum of postural deformities. For scoliosis, however, sufficient data could be obtained. To the researchers' knowledge this study is the first musculo-skeletal screening programme to address the prevalence of postural deformities in black 11 to 13 year old South African children living in rural areas specifically. The only other study conducted in South Africa was that by Segil (1974) who researched the incidence of scoliosis in some black and white population groups in Johannesburg. The prevalence of scoliosis in the white group was 2.5% and in the black group 0.03% which was very similar to the results in this study (0% abnormal and 6% slightly abnormal). Kasper, Robbins, Root, Peterson & Allegrante (1993) conducted a musculoskeletal outreach screening, treatment and education programme for African-American urban minority children in medically underserved areas of New York City. The majority of referrals were for scoliosis (17%) which was much higher than in the present study. High prevalence rates for scoliosis were reported by Brooks, Azen, Brooks & Chan (1975) and Penha *et al.* (2005), but the prevalence rate in the literature generally ranges beteen 2.5% and 4% (Willner & Uden, 1982; Bunnell, 1993; Soucacos, Soucacos, Zacharis, Beris & Xenakis, 1997; Karachalios *et al.*, 1999; Yawn *et al.*, 1999) which is similiar to the findings of the present study. In accordance with previous research (Loots, Loots & Steyn, 2001) the prevalence rate for lordosis and kyphosis was the highest. Loots *et al.* (2001) reported 100% for kyphosis and 70% for lordosis. The present study shows prevalence rates of 79.8% (abnormal) and 35.1% (abnormal) for lordosis and kyphosis respectively.

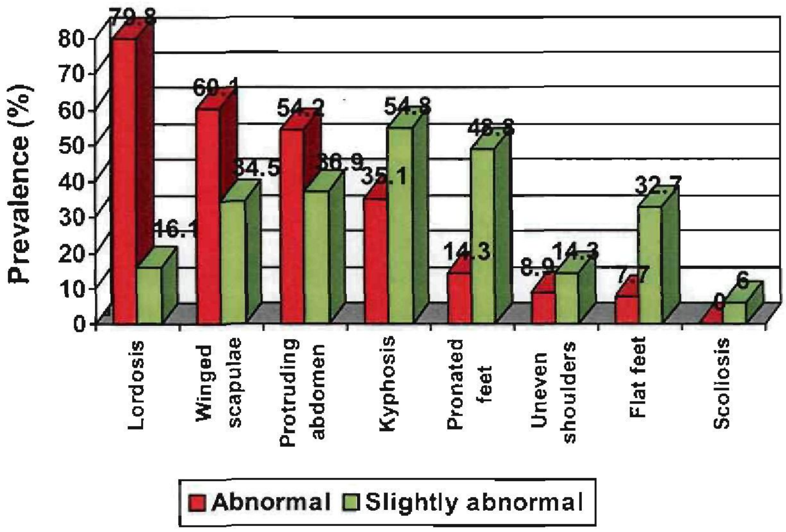

Figure 3.3: Prevalence of postural deformities for the total group (n=168).

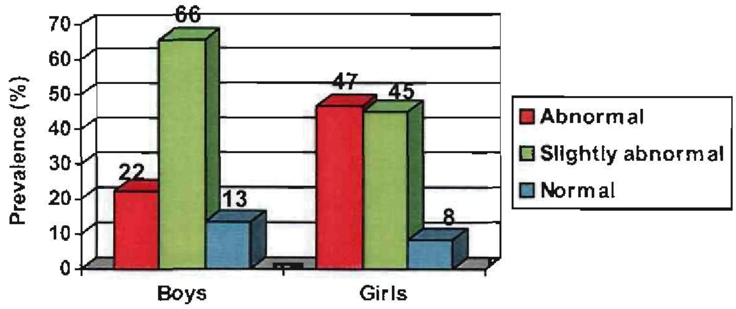

Figure 3.4: Prevalence of kyphosis in boys and girls (n=168).

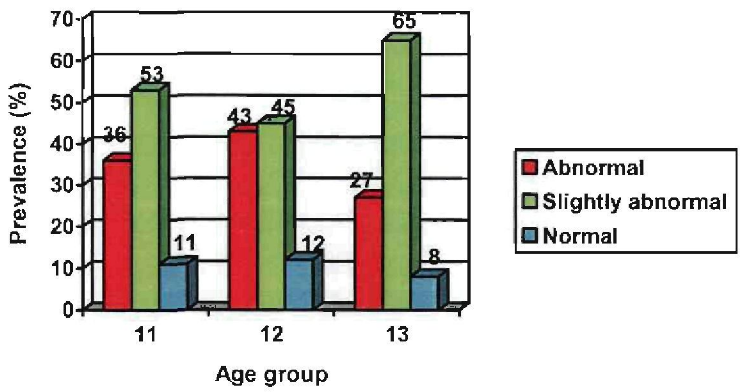

Figure 3.5: Prevalence of kyphosis in the three different age groups (n=168).

Compared to Loots *et al.* (2001), the present study demonstrated a higher prevalence for lordosis, but a much lower prevalence for kyphosis. Nevertheless, these two deformities remain the most prevalent.

The low prevalence rate for flat feet is in accordance with research by Rao and Joseph (1992) who stated that walking barefoot decreases the chances of having flat feet, as children in rural areas walk barefoot most of the time. However, a recent study on Congolese children (Echarri & Forriol, 2003) comparing urban children who wore shoes more often than children from rural areas showed a greater prevalence rate of flat feet in the rural children. Age was the primary predictive factor for flat feet (Echarri & Forriol, 2003). According to Sherrill (1993), flat feet can be the result of pronated feet which contradicts this study's finding in that pronated feet (abnormal – 14.3%; slightly abnormal – 48.8%) had a much greater prevalence rate than flat feet (abnormal – 7.7%; slightly abnormal – 32.7%).

In agreement with previous research (Banfield, 2000) that poorly nourished children suffered round shoulders and a sagging posture, which are usually characterised by winged scapulae (Sherrill, 1993), this deformity showed high prevalence rates in the present study (abnormal – 60.1%; slightly abnormal - 34.5%). The high prevalence rate for protruding abdomen is supported by the fact that this deformity is a well known characteristic of undernourished children (Barclay, 2005) as most of children in rural areas have an unbalanced diet as well as inadequate food intake.

CONCLUSION

This study showed high prevalence rates of postural deformities in black South African children aged 11 to 13 years. Considerable effort by clinicians, therapists, parents and the children themselves should be put into the prevention of postural deformities by maintaining a good posture (Bergström, Short, Frankel, Henderson & Jones, 1999). Although no disease is known at present to be caused by poor posture alone, it is accepted that prolonged disturbances in function may lead to pathologic changes. Despite what is known about the prevalence of postural deformities, prevention has only recently become a focus.

Early detection and intervention programmes targeted at these children, designed to prevent postural deformities from subsequently becoming chronic adult disabilities, should be an important public health strategy especially for communities in rural areas, commonly deprived from education and health services (Kasper *et al.*, 1993).

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Chapter 4

Differences in body composition status and prevalence of postural deformities in South African girls from different ethnic groups

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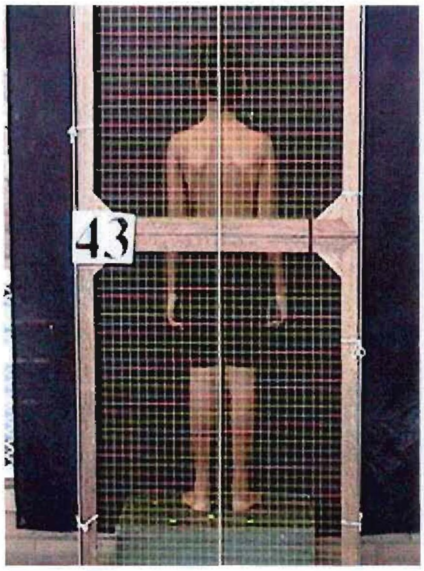
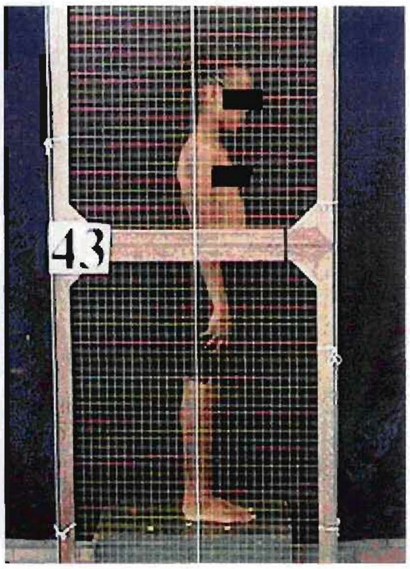
Short title: Body composition and postural deformities in South African girls





ABSTRACT

There are intrinsic and extrinsic factors that can influence children's posture, such as heredity, the environment or physical conditions in which children live, socio-economic environment, emotional factors, and physiologic alterations due to human growth and development. Little is known about ethnic differences in developing countries such as South Africa, particularly with regard to prevalence of postural deformities and body composition profiles. The aim of this study is to compare the prevalence rate for postural deformities and body composition status among 11 to 13 year old African South African girls in the North West Province and Caucasian South African girls of the same age from a different socio-economic environment. 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 deformities, 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.

Key words: postural deformities, 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) (1-6). Correct upright posture is considered to be an important indicator of musculoskeletal health (5). Postural deformities alter the body mechanics, causing uneven pressure on joint surfaces, ligamentous strain and skeletal muscle imbalance (5,7,8). The body's attempt to compensate for imbalance generally exacerbates the problem and can lead to more serious disability (2).

The environment of children has drastically changed worldwide during the last decades as reflected in unhealthy dietary habits and sedentary behaviours (9). There is a growing concern that the current behaviours of children may accelerate lifestyle-related diseases and result in higher prevalence of postural deformities (9). Children prefer to watch television, surf the Internet and play video games instead of engaging in more physically active leisure activities (10,11). 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 (12). A vast number of studies have indicated that children are becoming more overweight and inactive (10,13-17). Unfortunately, the focus of researchers has not included the African children of South Africa. Two studies namely Cole *et al.* (15) and McVeigh *et al.* (18) commented on the lack of data from Africa and called for further research on the children of Africa.

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 (19-22). 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 (23). However, poor nutrition can lead to sagging posture, round shoulders, scoliosis, poor muscle tone, knocked knees or bow legs and flat feet (23).

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

The schools were selected purposefully, because learners/pupils attending these schools are from living areas where the lowest income per household could be expected. Many people in these communities live in informal housing and some even without water supply and electricity. It is thus likely that some of the children would be chronically undernourished and could be stunted. 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.

Caucasian South African group

The Caucasian group formed part of a master's degree study project (24) which was conducted in the Western Cape. A letter was sent to 15 schools in 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.

Anthropometric Measurements

The anthropometric measurements chosen are those that could have a functional role in the prevalence of postural deformities. 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 (25). 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 (26):

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

Skinfolds

The triceps and subscapular skinfolds were measured in duplicate to the nearest 0.2mm 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) (27).

$$\Sigma SKF > 35mm{:}\%BF = 0.546(\Sigma SKF) + 9.7$$
$$\Sigma SKF < 35mm{:}\%BF = 1.33(\Sigma SKF) - 0.013(\Sigma SKF)^2 - 2.5$$

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

Postural Evaluation

In both groups, the New York Posture Test (1,28-32) and a "see-through posture grid" (3,28,33) were used for evaluation and identification of possible deformities. 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. 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.

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 (34).

$$
\begin{aligned}
Tan\theta &= \frac{t}{a} \\
&= \frac{2.5}{37.5} \\
\theta &= 4 \text{ degrees}
\end{aligned}
$$

Statistical Analysis

Microsoft Excel Version 7.0 Analysis Tool and Statistica (35) 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 deformities 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 deformities 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 (36).

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 (37) 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 (37) 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 (36).

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 4.1). 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≈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≈0.5) as well as statistical significant ($p<0.05$) lower BMI than the Caucasian group.

Table 4.1: The difference with regard to BMI between the African and Caucasian girls (n = 216).

	African		Caucasian		Statistical significance	Practical significance
Age	**Mean**	**SD**	**Mean**	**SD**	**p**	**d**
11	17.8	3.85	20.1	3.96	0.03	0.6
12	18.8	4.76	20.3	4.35	0.17	0.3
13	18.3	3.10	20.9	3.58	0.00	0.7
Total group	18.3	3.92	20.5	3.92	0.00	0.6

$p < 0.05$
small effect: *d*≈0.2; medium effect: *d*≈0.5; large effect: *d*≈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 4.2). 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 4.2: The difference with regard to percentage body fat between the African and the Caucasian girls (n = 216).

	African		Caucasian		Statistical significance	Practical significance
Age	**Mean**	**SD**	**Mean**	**SD**	**p**	**d**
11	19.3	7.93	24.4	10.61	0.04	0.5
12	20.9	9.29	24.2	9.04	0.14	0.3
13	19.6	6.27	24.9	8.13	0.00	0.7
Total group	20.0	7.82	24.6	8.96	0.00	0.5

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

Postural deformities

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 deformities found in this study were as follows:

For the African group, in the abnormal category (Figure 4.1), 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 4.1), 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.

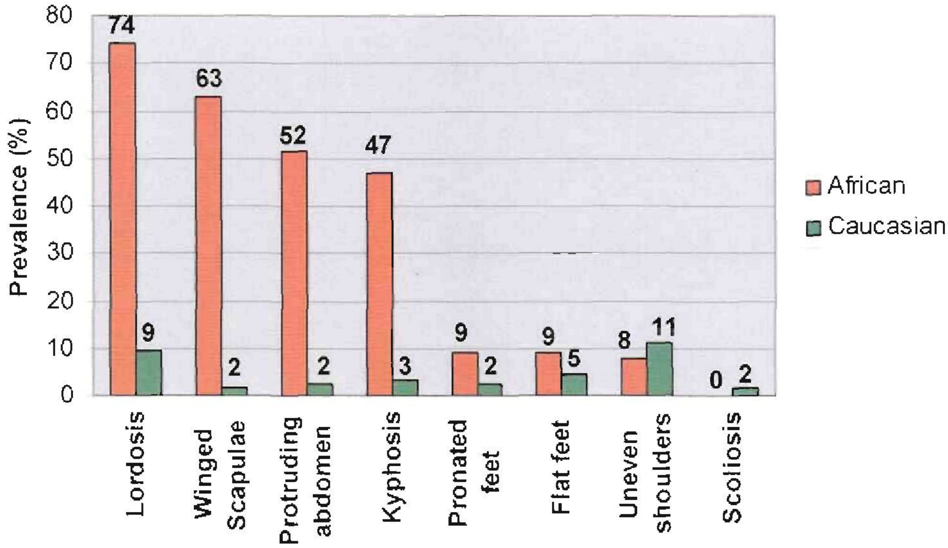


Figure 4.1: Abnormal Category: Comparison of prevalence rate for postural deformities in two ethnic groups (n=216).

For the African group, in the slightly abnormal category (Figure 4.2), 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 4.2), 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.

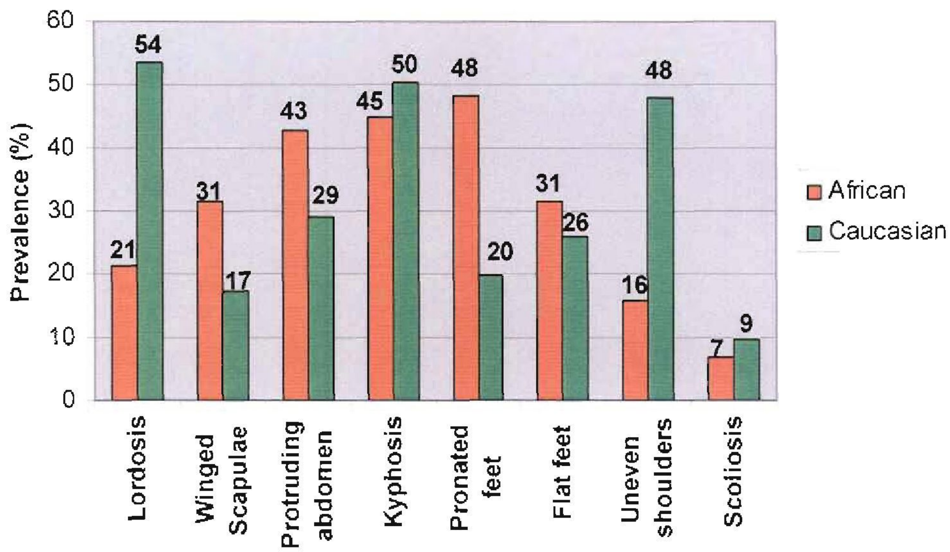


Figure 4.2: Slightly abnormal category: Comparison of prevalence rate for postural deformities in two ethnic groups (n=216).

The African group had higher prevalence rates in most of the deformities 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 deformities 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 difference in age groups and gender. In South Africa there is limited information regarding ethnic differences in BMI, percentage body fat and postural deformities.

In the greater Johannesburg metropolitan area a study by McVeigh *et al.* (18) 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 (38). In accordance with this study, an American study (39) evaluating 7 to 17 year old children found a higher percentage body fat in Caucasian girls compared to African girls. A study in Britain (40) found similar results.

This study stands in contrast to a study in America (41) 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 (42-44).

With regard to postural deformities, a lack of comparable research analysing the broad spectrum of postural deformities 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 deformities in African and Caucasian 11 to 13 year old South African children specifically. The only other study conducted in South Africa was in Johannesburg (45), 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 (46).

In accordance with research (47,48) the prevalence rate for lordosis and kyphosis was high in both races. A study in Lithuania (49) 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.

One can assume that rural African children are exposed to heavy physical labour as they have to travel far distances by foot and carry firewood and water from a very young age. In spines that are exposed to heavy physical labour, the thin cartilaginous plates become fissured and disc tissue prolapses into the spongiosa of adjacent vertebral bodies (50). In effect this can cause kyphosis with a compensating lordosis (33). 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 (6,51)

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 (52) and poor nutrition can lead to sagging posture, round shoulders and poor muscle tone (23).

The significantly higher prevalence rate for protruding abdomen in the African group may be attributed to the fact that the African group most probably were undernourished or malnourished. Lacking sufficient protein can lead to illnesses such as kwashiorkor (53) which in effect will cause a protruding abdomen (54). Abdominal protrusion relates directly to lordosis in an attempt to correct the anteroposterior balance that is compromised (6).

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 (55). However, this is in contrast to other research (56,57).

The significantly higher prevalence rate of uneven shoulders among the Caucasian group may be associated to muscular imbalance caused by carrying heavy backpacks (6,58-60). 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 (61,62) which makes the time difference of 4 years in this study insignificant.

Variations in growth patterns for various ethnic groups could possibly be an explanation for the higher prevalence of postural deformities 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 (63). 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 (64), which in effect will influence normal postural development.

CONCLUSION

This study presents unique information on ethnic differences between body composition and prevalence of postural deformities. 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 (65).

Developing postural muscles or stressing proper seating posture may help in correcting postural deformities while children progress through elementary school (32). The identification of postural deformities is important for prevention, to encourage a healthier posture for children and to prevent resulting painful syndromes (6).

In summary the findings suggest that there is a difference in the prevalence of postural deformities and body composition status between African South African and Caucasian South African girls, with a higher prevalence of postural deformities and lower BMI and percentage body fat reported among African girls. Although prevalence of postural deformities was significantly higher in the African girls compared to the Caucasian girls, the prevalence rate remains high in both groups. 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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Chapter 5

Differences in body composition status and prevalence of postural deformities in South African boys from different ethnic groups

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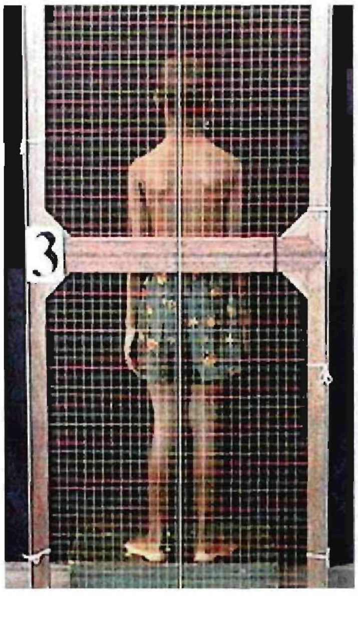
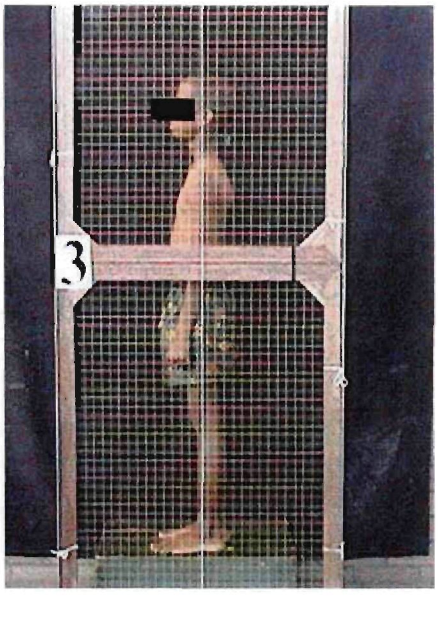
Short title: Body composition and postural deformities in South African boys





ABSTRACT

Asymmetric body posture and overweight are lately more and more often diagnosed among adolescents. Little is known about ethnic differences in developing countries such as South Africa, particularly with regard to prevalence of postural deformities and body composition profiles. The aim of this study is to compare the prevalence rate for postural deformities and body composition status among 11 to 13 year old African South African boys in the North West Province and Caucasian South African boys of the same age from a different socio-economic environment. The sample (n = 219) consisted of 79 African boys and 140 Caucasian boys. 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 ($p<0.05$) and effect sizes demonstrated that in all three age groups the Caucasian group had a significantly higher BMI and percentage body fat compared to the African group. There were no statistical and practical significant differences in prevalence rate between age groups ($p<0.05$). The African group had higher prevalence rates in most of the deformities with winged scapulae, protruding abdomen and lordosis demonstrating a statistical significance ($p<0.05$) and a practical significance (large effect) with regard to the Caucasian group. The higher prevalence rate for kyphosis and pronated feet in the African group were statistical significant ($p<0.05$), and visible (medium effect) with regard to the Caucasian group. The higher prevalence rate for flat feet in the African group was statistical significant ($p<0.05$), but demonstrated a small effect which is not visible. The higher prevalence rate for uneven shoulders in the Caucasian group was statistical significant ($p<0.05$) and also visible (medium effect) with regard to the African group. The results of this study should support the development of more responsible education and screening programmes in both rural and urban school environments.

Key words: postural deformities, BMI, fat%, body composition, ethnic, South Africa

INTRODUCTION

Prolonged poor posture induces abnormal stress on supporting structures of the spinal column and can cause chronic back pain, which usually develops while standing, walking or doing other activities of daily living (Reigger-Krugh & Keysor, 1996; Hrysomallis & Goodman, 2001; Miyakoshi *et al.*, 2003; McEvoy & Grimmer, 2005; Penha *et al.*, 2005; Brukner & Khan, 2007:373). Kendall *et al.* (2005:51) emphasized the relationship between posture, impairments and pain. Kendall *et al.* (2005:51) describe an ideal posture and deviations from this ideal posture can lead to characteristic patterns of musculoskeletal impairments and pain (Mueller & Maluf, 2002).

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 a lack of time and space, safety considerations, and competition with television, video games and computers are all resulting in sedentary lifestyles (Pica, 1999; 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 resulting in postural deformities.

Numerous studies have reported that children are becoming more overweight and physically inactive (Sallis, 2000; Tremblay & Willms, 2000; Cole *et al.*, 2000; WHO, 2000:32; WHO, 2003:10; Evers *et al.*, 2007). Unfortunately, these studies have not included the African children of South Africa. Cole *et al.* (2000) and McVeigh *et al.* (2004) commented on the lack of data from Africa, and called for further research on the children of Africa.

Caucasian South African children and African children in South Africa in rural areas have different lifestyles when looking at the availability of televisions and computers. Also, children in rural areas live far from school and transportation is mainly by foot. 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 overweight 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). Banfield (2000:129) stated that 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. However, poor nutrition can lead to sagging posture, round shoulders, scoliosis, poor muscle tone, knocked knees or bow legs and flat feet (Banfield, 2000:129).

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

The schools were selected purposefully, because learners/pupils attending these schools are from living areas where the lowest income per household could be expected. Many people in these communities live in informal housing and some even without water supply and electricity. It is thus likely that some of the children would be chronically undernourished and could be stunted. African boys 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 = 79) consisted of 19 eleven year olds, 29 twelve year olds and 31 thirteen year olds.

Caucasian South African group

The Caucasian group formed part of a master's degree study project (Stroebel, 2002:51) which was conducted in the Western Cape. A letter was sent to 15 schools in the Western Cape region which were chosen randomly from a list provided by the Western Cape Schools Board. Caucasian boys aged 11 to 13 years from four schools participated in the study. The sample (n = 140) consisted of 34 eleven year olds, 52 twelve year olds and 54 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.

Anthropometric Measurements

The anthropometric measurements chosen are those that could have a functional role in the prevalence of postural deformities. 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, 2006:58):

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

Skinfolds

The triceps and subscapular skinfolds were measured in duplicate to the nearest 0.2mm 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).

$$\Sigma SKF > 35mm{:}\%BF = 0.783(\Sigma SKF) + 1.6$$
$$\Sigma SKF < 35mm{:}\%BF = 1.21(\Sigma SKF) - 0.008(\Sigma SKF)^2 + I*$$

For Africans ($I*$ = -5.2) and for Caucasians ($I*$ = -3.4)

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

Postural Evaluation

In both groups the New York Posture Test (Davis *et al.*, 1995:136; Sherrill, 1993:368; Bloomfield *et al.*, 1994:320; Reedco Inc. 2001; Magee, 2002:893; Pankey *et al.*, 2004) and a "see-through posture grid" (Davis *et al.*, 1995:135; Arnheim & Prentice, 2000:708; Kendall *et al.*, 2005:60) were used for evaluation and identification of possible deformities. 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 check for 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 (Reedco Inc. 2001) 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. 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.

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, 1987:369).

$$\begin{aligned} Tan\theta &= \frac{t}{a} \\ &= \frac{2.5}{37.5} \\ \theta &= 4 \text{ degrees} \end{aligned}$$

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 deformities 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 deformities 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 (1988:222-225) 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 $w \approx 0.5$ is considered as practical significant.

Independent t-tests were used to determine whether there was significant difference in BMI and percentage body fat in the two groups on a 5% level (p<0.05). 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 (1988:20-27) 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 significant differences in race ($p<0.05$) existed between BMI in all three age groups (Table 5.1). In the 11 year old group the African group had a lower BMI of 15.7 compared to 19.3 in the Caucasian group. The difference was statistical significant ($p<0.05$) and practical significant (large effect, $d\approx0.8$) with regard to the Caucasian group. In the 12 year old group the African group had a significantly ($p<0.05$) lower BMI of 16.8 compared to 18.3 in the Caucasian group. However, effect sizes demonstrated a medium ($d\approx0.5$) or visible effect. In the 13 year old group the African group had a lower BMI of 16.6 compared to 19.3 in the Caucasian group. Differences were statistical significant ($p<0.05$) and practical significant (large effect, $d\approx0.8$) with regard to the Caucasian group. Comparing the African and Caucasian group as a whole, differences in BMI are statistical significant ($p<0.05$) and practical significant (large effect, $d\approx0.8$) with regard to the Caucasian group.

Table 5.1: The difference with regard to BMI between the African and Caucasian boys (n = 219).

	African		Caucasian		Statistical significance	Practical significance
Age	**Mean**	**SD**	**Mean**	**SD**	**p**	**d**
11	15.7	1.64	19.3	4.20	0.00	0.9
12	16.8	1.60	18.3	3.19	0.02	0.4
13	16.6	2.29	19.3	2.83	0.00	0.9
Total group	16.5	1.94	18.9	3.36	0.00	0.7

$p < 0.05$
small effect: $d\approx0.2$; medium effect: $d\approx0.5$; large effect: $d\approx0.8$

Percentage body fat

Independent t-tests demonstrated that statistical significant differences in race ($p<0.05$) existed between BMI and percentage body fat in all three age groups (Table 5.2). In the 11 year old group the African group had a lower percentage body fat of 10.1 compared to 19.8 in the Caucasian group. The difference was statistical significant ($p<0.05$) and practical significant (large effect, $d\approx0.8$) with regard to the Caucasian group. In the 12 year old group the African group had a significantly ($p<0.05$) lower percentage body fat of 10.3 compared to 17.8 in the Caucasian group and effect sizes demonstrated a practical significance (large effect, $d \approx 0.8$). In the 13 year old group the African group had a lower percentage body fat of 10.9 compared to 16.7 respectively. The differences were statistical significant ($p<0.05$) and practical significant (large effect, $d \approx 0.8$) with regard to the Caucasian group. Comparing the African and Caucasian group as a whole, the difference in percentage body fat is statistical significant ($p<0.05$) and practical significant (large effect, $d \approx 0.8$) with regard to the Caucasian group.

Table 5.2: The difference with regard to percentage body fat between the African and the Caucasian boys (n = 219).

	African		Caucasian		Statistical significance	Practical significance
Age	**Mean**	**SD**	**Mean**	**SD**	**p**	**d**
11	10.1	5.16	19.8	12.37	0.00	0.8
12	10.3	2.98	17.8	11.29	0.00	0.7
13	10.9	5.33	16.7	7.55	0.00	0.8
Total group	10.5	4.52	17.9	10.31	0.00	0.7

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

Postural deformities

Chi-square analysis and effect sizes revealed no statistical and practical significant differences in prevalence rate between age groups ($p<0.05$), therefore, to simplify comparisons and increase the power of the analysis, age groups were grouped together. The main postural deformities found in this study were as follows:

For the African group in the abnormal category (Figure 5.1), lordosis (86%), winged scapulae (57%) and protruding abdomen (57%) were observed most often. Kyphosis (22%) and pronated feet (20%) were observed less often with flat feet (6%) and uneven shoulders (10%) demonstrating low prevalence rates and scoliosis (0%) being non-existent. For the Caucasian group in the abnormal category (Figure 5.1), lordosis (13%) and winged scapulae (8%) were observed most often with kyphosis (6%), uneven shoulders (6%), protruding abdomen (3%), pronated feet (1%), flat feet (1%) and scoliosis (0%) demonstrated low prevalence rates.

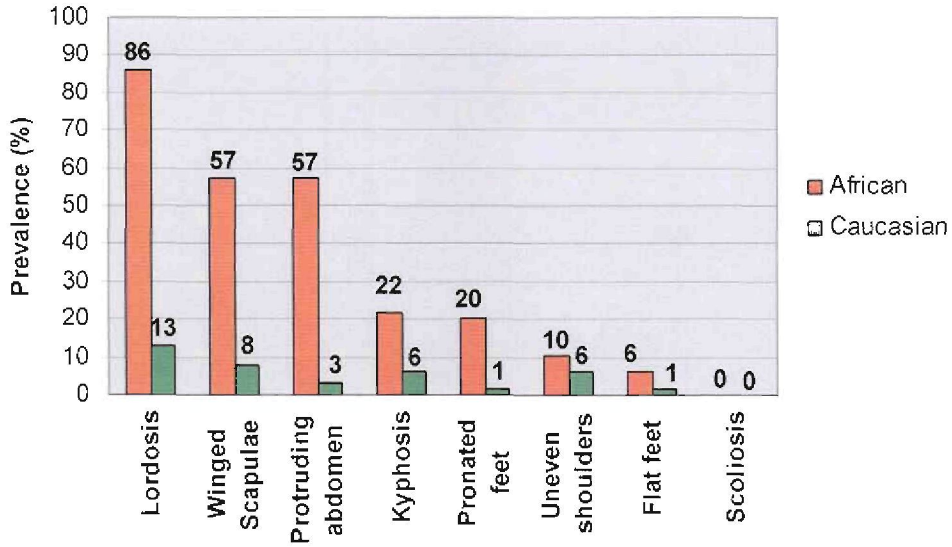


Figure 5.1: Abnormal Category: Comparison of prevalence rate for postural deformities in two ethnic groups (n=219).

For the African group in the slightly abnormal (Figure 5.2) category, kyphosis (66%), pronated feet (49%), winged scapulae (38%), flat feet (34%) and protruding abdomen (30%) were observed most often with uneven shoulders (13%), lordosis (10%) and scoliosis (5%) demonstrating low prevalence rates. For the Caucasian group in the slightly abnormal (Figure 5.2) category, lordosis (61%), winged scapulae (53%), kyphosis (52%) and uneven shoulders (46%) were observed most often, with pronated feet (34%), flat feet (25%) and protruding abdomen (23%) demonstrating lower prevalence rates and again scoliosis (6%) almost being non-existent.

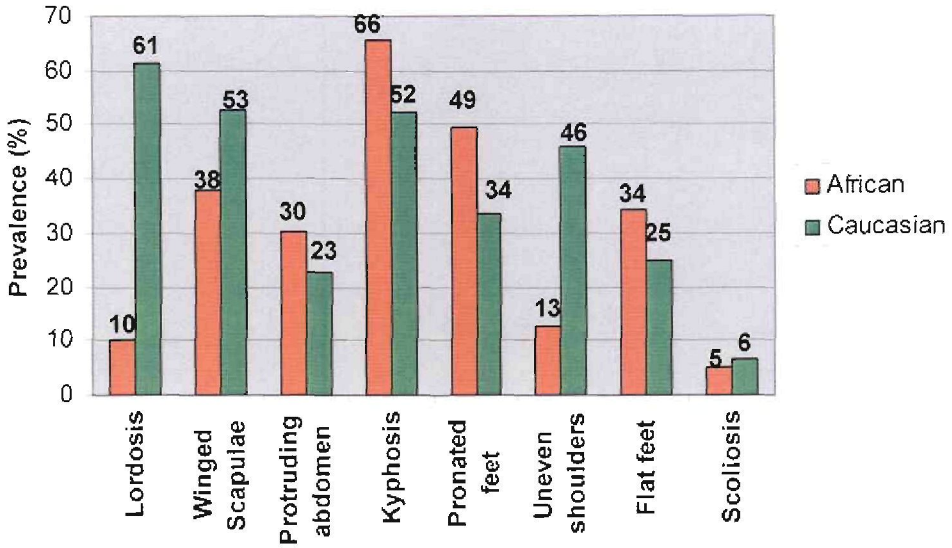


Figure 5.2: Slightly abnormal category: Comparison of prevalence rate for postural deformities in two ethnic groups (n=219).

The African group had higher prevalence rates in most of the deformities with winged scapulae, 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 kyphosis and 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. The higher prevalence rate for flat feet in the African group was statistical significant ($p<0.05$), but demonstrated a small effect ($w\approx0.1$) which is not visible. 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.

DISCUSSION

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

In the greater Johannesburg metropolitan area, McVeigh *et al.* (2004) found no significant difference between BMI and percentage body fat between Caucasian and African boys aged 9 to 10 years. The mean BMI for the African group in this study, was slightly lower than the 16.7 measured in rural children from KwaZulu-Natal (Jinabhai *et al.*, 2001).

In accordance with this study, an American study by Daniels *et al.* (1997) evaluating 7 to 17 year old children found a higher percentage body fat in Caucasian boys compared to Negro boys. Two studies in Britain reported similar results (Duncan *et al.*, 2004; Taylor *et al.*, 2005)

In contrast with the present study's findings, a recent study by Hanson and Chen (2007) reported that adolescents from lower socio-economic backgrounds and from minority groups had a significantly higher BMI. According to Rebato *et al.* (1998), this trend also appears in samples in Guatemala and India, which again are in contrast with the present study's findings.

With regard to postural deformities a lack of comparable research analysing the broad spectrum of postural deformities existed. To the researchers of this study's knowledge this study is the first musculo-skeletal screening programme to address the differences in prevalence rate of postural deformities 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 with the findings of Mittal *et al.* (1987).

In accordance with research (Francis & Bryce 1987; Loots *et al.*, 2001) the prevalence rate for lordosis and kyphosis was very high in both races. Mauriciene and Baciuliene (2005) confirmed 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.

One can assume that rural African children are exposed to heavy physical labour as they have to travel far distances by foot and carry firewood and water from a very young age.

According to Schmorl and Junghanns (1971:348) in spines that are exposed to heavy physical labour, the thin cartilaginous plates become fissured and disc tissue prolapses into the spongiosa of adjacent vertebral bodies. In effect this can cause kyphosis with a compensating lordosis (Arnheim & Prentice, 2000:708).

The African group showed significantly high prevalence rates for winged scapulae. Poor muscle tone, especially in the serratus anterior or trapezius muscles can cause winged scapulae (Shultz *et al.*, 2005:242) and according to Banfield (2000:129), poor nutrition can lead to sagging posture, round shoulders and poor muscle tone.

The significantly higher prevalence rate for protruding abdomen in the African group may be attributed to the fact that the African group most probably was undernutrition or malnourished and according to Whitney *et al.* (1998:199), lacking sufficient protein can lead to illnesses such as kwashiorkor, which in effect will cause a protruding abdomen. In a study by Post *et al.* (1999) stunted children showed larger protruding abdomens and head and thoracic circumferences in relation to their stature than non-stunted children. According to Penha *et al.* (2005), abdominal protrusion relates directly to lordosis in an attempt to correct the anteroposterior balance that is compromised.

The significantly higher prevalence rate for flat feet in the African group, although not practical significant, is in accordance with research in a recent study on Congolese children (Echarri & Forriol, 2003). However, this is in contrast with Rao and Joseph (1992) who stated that walking barefoot decreases the chances of having flat feet, as children in rural areas walk barefoot most of the time. According to McCoy and Dickens (1997), children of African descent often present with flat feet, which is genetically and culturally normal for them. The significantly higher prevalence rate of uneven shoulders among the Caucasian group may be associated with muscular imbalance caused by carrying heavy backpacks (Negrini *et al.*, 1999; Chansirinukor *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 (De Ridder, 2007; Cintra *et al.*, 2007) which makes the time difference of 4 years in this study insignificant.

Variations in growth patterns for various ethnic groups could possibly be an explanation for the higher prevalence of postural deformities in the African group (Nelson *et al.*, 1997). Nelson *et al.* (1997) found significant differences in whole body bone mineral content and bone mineral density between African and Caucasian children. Also, malnutrition or undernutrition diminishes the ability of all systems of the body to perform properly, with particularly serious consequences in young children (Caulfield *et al.*, 2004). Studies have demonstrated associations between undernutrition and growth retardation (Caulfield *et al.*, 2004), which in effect will influence normal postural development.

CONCLUSION

This study provides important information about ethnic differences between body composition status and prevalence of postural deformities. In developing countries environmental constraints such as malnutrition or undernutrition, 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). Teachers and school-based health professionals can promote changes in school education and screening programmes by designing health programmes that are sensitive to race and individual needs.

In conclusion, there is a difference in the prevalence of postural deformities and body composition status between African South African and Caucasian South African boys, with a higher prevalence of postural deformities and lower BMI and percentage body fat reported among African boys. In light of these findings, to disregard the need for a compulsory postural screening programme in both rural and urban school environments would be to forego the opportunity of early detection of progressive postural deformities that could require corrective treatment.

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Chapter 6

Influence of body composition on the prevalence of postural deformities in 11 to 13 year old African South African children in the North West Province

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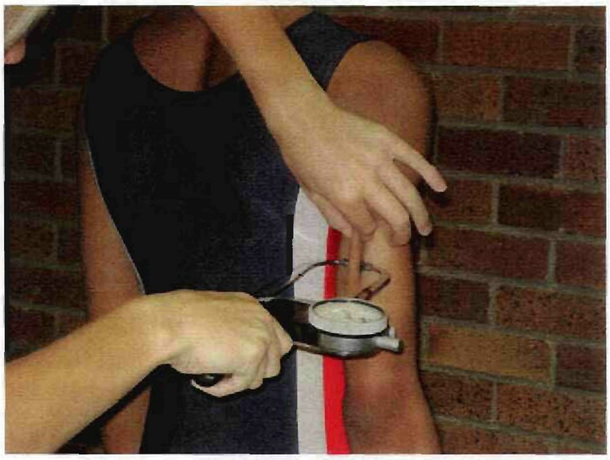
Short title: Influence of body composition on postural deformities in African children



ABSTRACT

The aim of this study is to investigate the influence of body composition on the prevalence of postural deformities among African South African children aged 11 to 13 years in selected schools in the Potchefstroom area in the North West Province. The sample (n = 168) consisted of 47 eleven year olds, 58 twelve year olds and 63 thirteen year old school children. Of the total number of students examined (168), 79 were boys, and 89 were 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. In boys, Spearman Rank Order Correlations demonstrated a statistical significant ($p<0.05$) association between protruding abdomen and BMI, and also for the association of winged scapulae and protruding abdomen with percentage body fat. A large practical significant difference ($d \approx 0.8$) in BMI and percentage body fat was demonstrated between the different categories of winged scapulae and lordosis. In girls, Spearman Rank Order Correlations demonstrated a statistical significant association ($p<0.05$) between BMI and percentage body fat with winged scapulae, protruding abdomen and flat feet. A large practical significant difference ($d \approx 0.8$) in BMI was demonstrated between the different categories of winged scapulae and flat feet and also in percentage body fat with regards to the different categories of flat feet. In summary the findings suggest that, winged scapulae and lordosis in boys, and flat feet in girls, are the postural deformities with the strongest association with BMI and percentage body fat. This study illustrates the need for a further investigation of more profound studies investigating factors such as BMI and percentage body fat.

Keywords: postural deformities, BMI, fat%, body composition, South Africa

INTRODUCTION

Good posture is considered to be a measure of good musculoskeletal health (Banfield, 2000; McEvoy & Grimmer, 2005). Bad posture can alter the joint load distribution and the loading on these joints that are not normally aligned can lead to articular cartilage degeneration and can as a result lead to more serous postural deformities (Riegger-Krugh & Keysor, 1996; Norris, 2000).

The proportion of overweight and obese children is increasing at an alarming rate worldwide, both in developed and developing countries (Belizzi & Dietz, 1999; Fernàndez, Heo, Heymsfield, Pierson, Pi-Sunyer, Wang et al., 2003; Laitinen, Näyha & Kujala, 2005; Evers, Arnold, Hamilton & Midgett, 2007). 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 (Segell, 1998; Yip, Ho & Chan, 2001). According to Segell (1998), a high ratio of muscles to body fat ensures adequate support for the spine. Studies have reported an association between low back pain and weight (Fairbank, Pynsent, Van Portvliet & Phillips, 1984; Mellin, 1987; Grimmer & Williams, 2000). However, other studies reported no association (Merriam, Burwell & Mulholland, 1983; Pope, Bevins, Wilder & Frymoyer, 1985; Biering-Sorensen & Thomsen, 1986; Kovacs, Gestoso, Del Real, López, Mufraggi & Mèndez, 2003)

Countries in economic transition from underdeveloped to developed, such as South Africa, are particularly affected and have an increasing prevalence of obesity across all economic levels and age groups. Food intake in rural areas is mostly unbalanced or inadequate and chronic malnutrition and undernutrition has been suggested as a contributory factor to elevated rates of obesity, because of the observed association between stunting and childhood and obesity in adults (Popkin, Richards & Montiero, 1996; Sawaya, Grillo,Verreschi, Carlos Da Silva & Roberts, 1998).

It is clear that obesity is increasing at an alarming rate, and if there is a close association between obesity or overweight and postural deformities, the current trends of obesity appear to be cumbersome. Research examining the possible association between postural deformities and body composition is lacking. The aim of this study is to investigate the influence of body composition on the prevalence of postural deformities in 11 to 13 year old African South African children in the North West Province.

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 schools were selected purposefully, because learners/pupils attending these schools are from living areas where the lowest income per household could be expected. Many people in these communities live in informal housing and some even without water supply and electricity. It is thus likely that some of the children would be chronically undernourished and could be stunted. African South African children 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 = 168) consisted of 47 eleven year olds, 58 twelve year olds and 63 thirteen year old children. Of the total number of students examined (168), 79 were boys, and 89 were girls.

Measurement Procedure

The first stage of the measurement procedure was conducted with the children separated into groups according to class and gender. Measurement procedure was explained to 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.

Anthropometric Measurements

The anthropometric measurements chosen are those that could have a functional role in the prevalence of postural deformities. 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 with 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 0.2mm 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 by trained postgraduate Biokinetics students. Percentage Body Fat was determined using a 2-site skinfold measurement (Triceps and Subscapular) (Slaughter, Lohman, Boileau, Horswill, Stillman, Van Loan & Bemben, 1988).

Boys:

$$\Sigma SKF > 35mm{:}\%BF = 0.783(\Sigma SKF) + 1.6$$

$$\Sigma SKF < 35mm{:}\%BF = 1.21(\Sigma SKF) - 0.008(\Sigma SKF)^2 + I*$$

Girls:

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

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

For Africans ($I*$ = -5.2) and for Caucasians ($I*$ = -3.4)

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

Postural Evaluation

The New York Posture Test (Sherrill, 1993; Bloomfield, Ackland & Elliott, 1994; Davis, Kimmet & Auty, 1995; Reedco Inc. 2001; Magee, 2002; Pankey, Woosley, & Glendenning, 2004) and a "see-through posture grid" (Davis et al., 1995; Arnheim & Prentice, 2000; Kendall, McCreary, Provance, Rodgers, & Romani, 2005) were used for evaluation and identification of possible deformities. 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 check for 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 (Reedco Inc. 2001) 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 are measured by counting the amount of blocks the one shoulder is lower than the other one. 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.

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).

$$Tan\theta = \frac{t}{a}$$
$$= \frac{2.5}{37.5}$$
$$\theta = 4 \text{ degrees}$$

Statistical Analysis

Spearman Rank Order Correlations (r_S) were used to determine whether there was a statistical association ($p < 0.05$) between BMI and percentage body fat with prevalence of postural deformities. As this study made use of a convenience sample, statistical inference and p-values are not relevant. 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). Correlation is in itself an effect size or measure of the strength of association between two interval scale variables (Steyn, 2006). Cohen (1988) gives the following guidelines for the interpretation of the effect size in the current case: small effect: $|r_S| \approx 0.1$, medium effect: $|r_S| \approx 0.3$. large effect: $|r_S| \approx 0.5$. It is considered that data with $|r_S| \approx 0.5$ is practical significant, since it is the result of a difference having a large effect and $|r_S| \approx 0.3$ as a visible difference but not yet practical significant (Ellis & Steyn, 2003).

As a further investigation into these associations, the difference in mean BMI and percentage body fat was also determined for the different categories of postural deformities. Effect size for the difference between means was used to determine practical significance. This was determined by the following formula:

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

Where $|\overline{x}_1 - \overline{x}_2|$ is the difference between the means, $\overline{x}_1$ and $\overline{x}_2$, 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 practically significant, since it is the result of a difference having a large effect and $d \approx 0.5$ as a visible difference but not yet practical significant (Ellis & Steyn, 2003).

RESULTS

No practical significant association between age and the prevalence of deformities were found and thus the data of different age groups were grouped together to simplify comparisons and increase the power of the analysis. The effect of BMI and percentage body fat on the prevalence of postural deformities will be discussed separately.

Effect of BMI on prevalence rate

Boys with abnormal winged scapulae and lordosis (Figure 6.1) demonstrated to have in practice a lower BMI (large effect, $d \approx 0.8$) than those who are normal. For uneven shoulders, boys in the abnormal category have a visibly lower BMI (medium effect, $d \approx 0.5$) than normal ones. For protruding abdomen and pronated feet, boys in the abnormal category have a visibly higher BMI (medium effect, $d \approx 0.5$) than normal ones. For flat feet, boys in the slightly abnormal category have a visibly higher BMI (medium effect, $d \approx 0.5$) than normal ones. Spearman Rank Order Correlations demonstrated a statistical significant association ($p<0.05$) between BMI and the prevalence of protruding abdomen ($r_s \approx 0.3$), where boys with a higher BMI showed a significantly higher prevalence rate for this deformity.

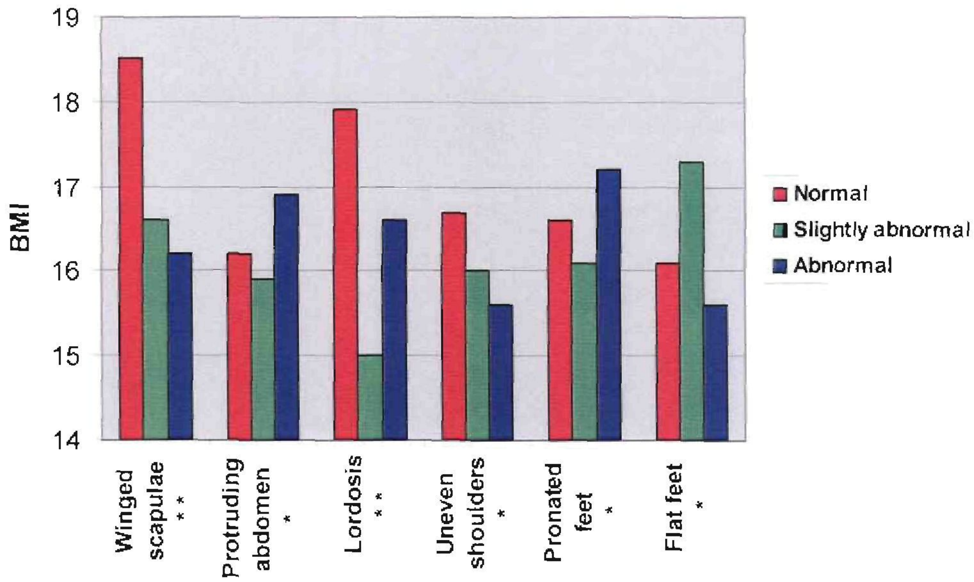


Figure 6.1: The effect of BMI on the prevalence of postural deformities on 11 to 13 year old African South African boys (* * large and * medium practical significance) (n = 79).

For winged scapulae, girls in the abnormal category (Figure 6.2) have a visibly lower BMI (medium effect, d≈0.5) than normal ones. For protruding abdomen and pronated feet, girls in the abnormal category have a visibly higher BMI (medium effect, d≈0.5) than normal ones. Girls with abnormal flat feet demonstrated to have in practice a higher BMI (large effect, d≈0.8) than those who are normal. Spearman Rank Order Correlations demonstrated a statistical significant association ($p<0.05$) between BMI and the prevalence of winged scapulae ($r_s \approx 0.3$), protruding abdomen ($r_s \approx 0.3$) and flat feet ($r_s \approx 0.3$). Girls with a higher BMI showed a significantly higher prevalence rate for protruding abdomen and flat feet, where girls with a lower BMI showed a significantly higher prevalence rate for winged scapulae.

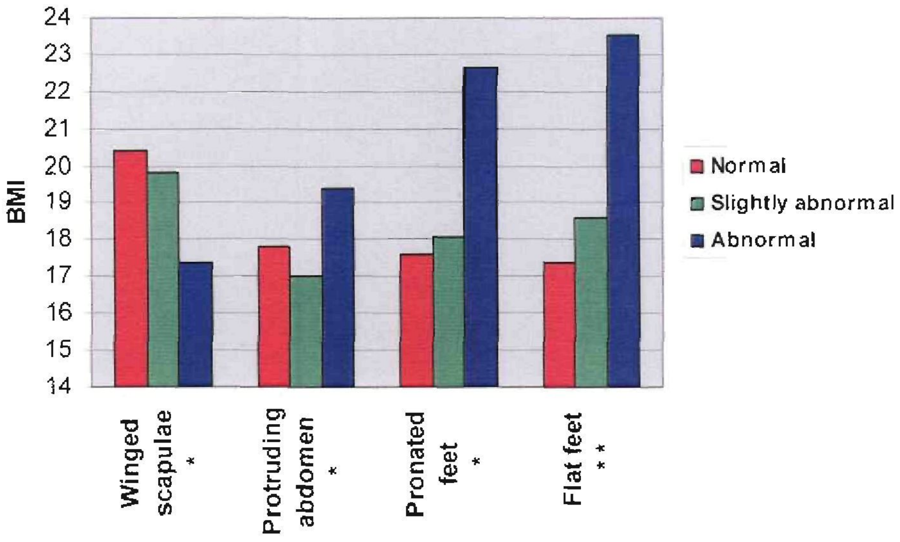


Figure 6.2: The effect of BMI on the prevalence of postural deformities on 11 to 13 year old African South African girls (* * large and * medium practical significance) (n = 89).

Effect of percentage body fat on prevalence rate

Boys with abnormal winged scapulae and slightly abnormal lordosis (Figure 6.3) demonstrated to have in practice a lower percentage body fat (large effect, d≈0.8) than those who are normal. Boys with abnormal uneven shoulders demonstrated to have a visibly lower percentage body fat (medium effect, d≈0.5). For protruding abdomen and pronated feet, boys in the abnormal category have a visibly higher percentage body fat (medium effect, d≈0.5) than normal ones. Spearman Rank Order Correlations demonstrated a statistical significant association ($p<0.05$) between percentage body fat and the prevalence of winged scapulae ($r_s \approx 0.3$) and protruding abdomen ($r_s \approx 0.3$). Boys with a higher percentage body fat showed a significantly higher prevalence rate for protruding abdomen, where boys with a lower percentage body fat showed a significantly higher prevalence rate for winged scapulae.

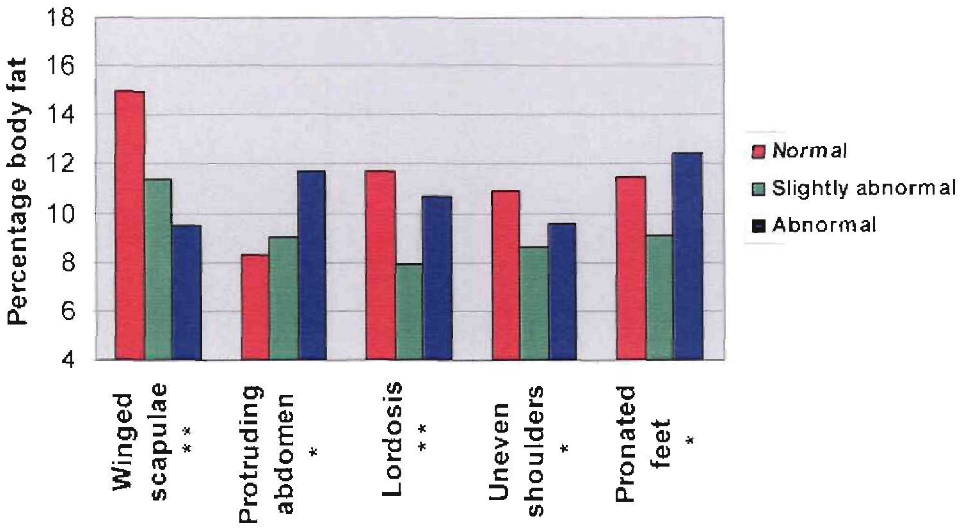


Figure 6.3: The effect of percentage body fat on the prevalence of postural deformities on 11 to 13 year old African South African boys (* * large and * medium practical significance) (n = 79).

For winged scapulae, girls in the abnormal category (Figure 6.4) have a visibly lower percentage body fat (medium effect, d≈0.5) than normal ones. Girls with abnormal flat feet demonstrated to have in practice a higher percentage body fat (large effect, d≈0.8) than those who are normal. For protruding abdomen and pronated feet, girls in the abnormal category have a visibly higher percentage body fat (medium effect, d≈0.5) than normal ones. Spearman Rank Order Correlations demonstrated a statistical significant association ($p<0.05$) between percentage body fat and the prevalence of winged scapulae ($r_s \approx 0.3$), protruding abdomen ($r_s \approx 0.3$) and flat feet ($r_s \approx 0.3$). Girls with a higher percentage body fat showed a significantly higher prevalence rate for protruding abdomen and flat feet, where girls with a lower percentage body fat showed a significantly higher prevalence rate for winged scapulae.

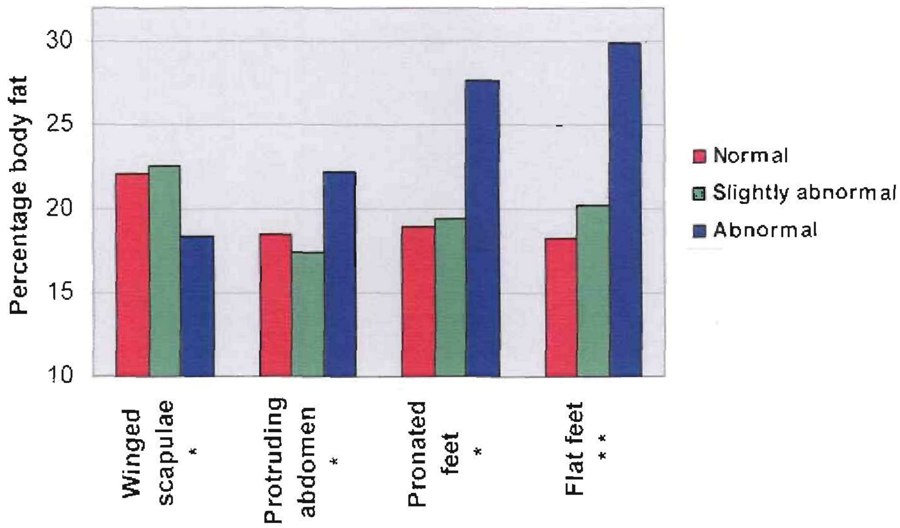


Figure 6.4: The effect of percentage body fat on the prevalence of postural deformities on 11 to 13 year old African South African girls (* * large and * medium practical significance) (n = 89).

DISCUSSION

The research literature examining the possible association between postural deformities and body composition is lacking, especially with regards to African children.

Górniak and Poplawska (2004) evaluated Polish rural girls age 7 to 19 years and found girls with a right body posture to be heavier and have a higher percentage body fat, than those with a postural deformity. This is in accordance with the present study's findings in that girls with a higher percentage body fat and BMI had a lower prevalence rate for winged scapulae.

Cheung (2003) found BMI of adolescents with scoliosis to be significantly lower than the control group with no spinal deformity. This finding could not be confirmed in the present study, where no significant association was found between BMI and scoliosis. This is in accordance with a study by Grivas, Arvaniti, Maziotouk, Manesioti and Fergadi (2002) who found no statistical difference between the BMI of children with scoliosis and their nonscoliotic counterparts.

In accordance with the present study's findings Bordin, De Giorgi, Mazzocco and Rigon (2001) found a high percentage of children with flat feet to have a higher BMI and percentage body fat. Riddiford-Harland, Steele and Storlien (2000) concluded that body mass had a significant effect on the foot structure of children. This may be due to the increased stress placed on the feet by the need to bear excessive weight. A recent study by Irving, Cook, Young and Menz (2007) concluded that a high BMI is associated with pronated foot posture and chronic plantar heel pain.

The present study's findings demonstrated a significant association between percentage body fat, BMI and the prevalence of protruding abdomen, flat feet and pronated feet, where children with a higher percentage body fat and BMI showed a significant higher prevalence rate for these deformities. These findings are supported by the literature (Post, Victora & Barros, 1999; Riddiford-Harland et al., 2000; Bordin et al., 2001; Irving et al., 2007).

It is clear that boys with a high prevalence rate for winged scapulae, lordosis and uneven shoulders demonstrated a lower BMI and percentage body fat, where girls with a high prevalence rate for winged scapulae demonstrated a lower BMI and percentage body fat. In contrast with the present study's findings Tüzün, Yorulmaz, Cinda and Vatan (1999) and Murrie, Dixon, Hollingworth, Wilson and Doyle (2003) found lumbar lordosis to increase with an increase in BMI. However, Stroebel (2002) found a higher prevalence rate for winged scapulae and lordosis in children with a lower BMI and percentage body fat. According to Banfield (2000), poor nutrition can lead to sagging posture, round shoulders and poor muscle tone. Poor muscle tone, especially in the serratus anterior or trapezius muscles can cause winged scapulae (Shultz, Houglum & Perrin, 2005). Also, an increase in the prevalence for winged scapulae in leaner subjects, as in the present study, may be explained by the fact that this deformity is more easily identified in leaner children.

Although the present study reported an association between body composition and prevalence of postural deformities, it is important to note that in girls, only flat feet demonstrated a large practical significance with regards to BMI and percentage body fat. In boys, only winged scapulae and lordosis demonstrated a large practical significance with regards to BMI and percentage body fat. However, care must be taken in interpreting the results of the present study as the majority of children in this study were underweight or of normal weight and thus, associations might not have been observed because of the restricted range of the body composition data. A follow up study investigating African children that are more westernized and overweight, may give a more accurate indication of the association between body composition and the prevalence of postural deformities.

CONCLUSION

In summary the findings suggest that winged scapulae and lordosis in boys and flat feet in girls are the postural deformities with the strongest association with BMI and percentage body fat.

If a clear association can be established between body composition and postural deformities, screening can be implemented in schools to identify those children at risk for developing problematic postural deformities. In the researchers' opinion this study illustrates the need for further investigation of more profound studies investigating factors such as BMI and percentage body fat.

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We would like to thank the pupils and teachers of the various schools that participated in the study and the students of the North-West Univesity (Pochefstroom Campus) who assisted in this study. The financial assistance of the North-West University (Potchefstroom Campus) is also hereby acknowledged.

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Chapter 7

Summary, Conclusion, Limitations and Recommendations

7.1 SUMMARY

The purpose of this study is to determine the body composition status and prevalence of postural deformities in 11 to 13 year old African South African children in the North West Province.

In Chapter 1 the problem statement, aim and hypotheses of the study are stated and the structure of the study is explained. In Chapter 2 a literature review is presented to define the concept of good posture, analyze normal postural development and postural deformities, discuss the influence of bone growth, report incidence rates and discuss the influence of body composition on postural deformities. From the literature review it is clear that the concept of good posture has been the focus of many researchers in the past decade. According to researchers the incidence rate of postural deformities is increasing at a alarming rate and body composition profiles showed an increase in overweight in many countries, especially in developing countries. The literature review also demonstrated a definite influence of body composition on postural deformities.

In Chapter 3 the results investigating the prevalence rate of postural deformities in 11 to 13 year old African South African children are reported. Results showed a high prevalence rate of postural deformities, especially in lordosis, winged scapulae, protruding abdomen, kyphosis and pronated feet. Most of the postural deformities were classified as abnormal, meaning the degree of deviation was severe.

In Chapter 4 the results are reported that compared the prevalence rate of postural deformities and body composition status of 11 to 13 year old African South African girls with girls of the same age from a different ethnic group and socio-economic environment. The African South African girls showed a significantly higher prevalence rate for winged scapulae, kyphosis, protruding abdomen, lordosis and pronated feet, and a significantly lower prevalence rate for uneven shoulders with regard to Caucasian South African girls. The majority of postural deformities 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. With regard to BMI, in the 11 and 13 year old group, the African girls demonstrated a significantly lower BMI compared to the Caucasian girls. With regard to percentage body fat, in the 11 and 13 year old group, the African girls demonstrated a significantly lower percentage body fat, compared to the Caucasian girls.

In Chapter 5 the results are reported that compared the prevalence rate of postural deformities and body composition status of 11 to 13 year old African South African boys with boys of the same age from a different ethnic group and socio-economic environment. The African South African boys showed a significantly higher prevalence rate for winged scapulae, protruding abdomen, lordosis, kyphosis, pronated feet and flat feet and a significantly lower prevalence rate for uneven shoulders with regard to Caucasian South African boys. The majority of postural deformities in African boys was classified as abnormal, where in the Caucasian boys the majority was classified as slightly abnormal, meaning the degree of deviation in the African children was more severe. With regard to BMI, in all three age groups the African boys demonstrated a significantly lower BMI compared to the Caucasian boys. With regard to percentage body fat, in all three age groups the African boys demonstrated a significantly lower percentage body fat, compared to the Caucasian boys.

In Chapter 6 the results are reported that investigated the influence of body composition on the prevalence of postural deformities in 11 to 13 year old African South African children. In boys, results demonstrated a statistical significant association between protruding abdomen and BMI, and also for the association of winged scapulae and protruding abdomen with percentage body fat. A large practical significant difference in BMI and percentage body fat was demonstrated between the different categories of winged scapulae and lordosis. In girls, results demonstrated a statistical significant association between BMI and percentage body fat with winged scapulae, protruding abdomen and flat feet. A large practical significant difference in BMI was demonstrated between the different categories of winged scapulae and flat feet and also in percentage body fat with regards to the different categories of flat feet.

7.2 CONCLUSION

The conclusion of this study is derived from the stated hypotheses.

7.2.1 Hypothesis 1

Hypothesis 1 states that the prevalence of postural deformities among 11 to 13 year old African South African children in selected schools in the North West Province will be high.

According to the results, the prevalence of postural deformities is high with regard to a majority of the postural deformities. Lordosis, winged scapulae, protruding abdomen, kyphosis, pronated feet, flat feet and uneven shoulders showed high prevalence rates. Hypothesis 1 is, therefore, accepted.

7.2.2 Hypothesis 2

Hypothesis 2 states that the prevalence rate for postural deformities and body composition status will differ in the 11 to 13 year old African South African girls from the North West Province compared to girls of the same age from a different ethnic group and socio-economic environment.

According to the results the African South African girls showed a significantly different prevalence rate for postural deformities compared to the Caucasian South African girls, with the African girls demonstrating a significantly higher prevalence rate in winged scapulae, protruding abdomen, kyphosis, lordosis, and pronated feet and a significantly lower prevalence rate for uneven shoulders compared to the Caucasian girls. The African girls in the 11 and 13 year old group demonstrated a significantly lower BMI and percentage body fat compared to the Caucasian girls. Hypothesis 2 is, therefore, accepted.

7.2.3 Hypothesis 3

Hypothesis 3 states that the prevalence rate for postural deformities and body composition status will differ in the 11 to 13 year old African South African boys from the North West Province compared to boys of the same age from a different ethnic group and socio-economic environment.

According to the results the African South African boys showed a significantly different prevalence rate for postural deformities compared to the Caucasian South African boys, with the African boys demonstrating a significantly higher prevalence rate in winged scapulae, protruding abdomen, kyphosis, lordosis, pronated feet, flat feet and uneven shoulders compared to the Caucasian boys. The African boys in all three age groups demonstrated a significantly lower BMI and percentage body fat compared to the Caucasian boys. Hypothesis 3 is, therefore, accepted.

7.2.4 Hypothesis 4

Hypothesis 4 states that body composition will have a significant influence on the prevalence of postural deformities in 11 to 13 year old African South African children from the North West Province.

In boys, results demonstrated a statistical significant association between protruding abdomen and BMI, and also for the association of winged scapulae and protruding abdomen with percentage body fat. In girls, results demonstrated a statistical significant association between BMI and percentage body fat with winged scapulae, protruding abdomen, and flat feet. Hypothesis 4 is, therefore, accepted.

7.3 LIMITATIONS AND RECOMMENDATIONS

The study has demonstrated that postural deformities do exist in public schools as well as rural schools. Also, although the effect of sedentary behaviour on children has become the main focus of many researchers, this study has shown that the other extreme, namely underweight, can even result in a greater amount of postural problems.

There are limitations and recommendations in this study that could improve the outcomes of further research.

7.3.1 There is a lack of clarity of definitions of what normal posture is. It has taken researchers many years to come to a unified understanding of what is normal and several attempts have been made to develop the optimal criteria, but to date there is still controversy concerning the correct criteria for what seems to be optimal or normal posture. Thus it is unlikely that the researcher is now in a position to define a generalized normal posture that is applicable to a wide variety of children.

7.3.2 The children selected were limited to a small geographic location and as a result of time constraints, children were selected purposely and not randomly, which could have influenced the outcomes of the study.

7.3.3 The total number of children detected with postural deformities and the high level of bad posture that was reported in this study, demonstrates the need for a uniform, nationwide screening programme for postural deformities in rural as well as urban environments.

7.3.4 Parents and teachers should be made more aware of the consequences of bad posture and be educated in terms of the identification of postural problems and what corrective measures to take in order to correct these problem. By educating parents and teachers they can constantly make children aware of their bad postural habits.

7.3.5 Growing children require an adequate amount of nutrients in order to ensure normal development. Food intake in rural areas is mostly inadequate thus, government interventions by providing schools with subsidies for adequate meals during school time can drastically improve normal postural development.

7.3.6 Providing medical aid subsidies for the treatment of postural deformities could lead to more effective treatment. Treatment could reduce conditions such as back pain and as a result decrease the economic burden caused by this condition. Not only do parents spend a large amount of money on medical treatment, but also, it costs the government millions of rands. By tackling this problem effectively it would result in enormous savings and less pressure on health budgets.

7.3.7 Further studies should be conducted to evaluate not only the prevalence of postural deformities, but also to evaluate treatment protocols and preventive measures for children with postural deformities. These studies should essentially also include African South African children as limited research on postural deformities is done on African children.

Appendix A

Guidelines for Authors

Health SA Gesondheid

Health SA Gesondheid

Requirements to which the authors of articles must conform

Nature of the publication

Health SA Gesondheid is an accredited interdisciplinary research journal that publishes only selected articles of the highest scientific standard, with human health as main theme. The journal accepts research and review articles on this theme. Journal articles express the authors' views and are not necessarily the views of Health SA Gesondheid. Articles may be written in either Afrikaans or English.

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Authorship

Authorship should be based only on substantial contribution to: (i) conception and design, or analysis and interpretation of data; (ii) drafting the article or revising it critically for important intellectual content; and (iii) final approval of the version to be published. All three of these conditions must be met. All contributors who do not meet the criteria for authorship should be listed in an acknowledgments section. The following statement should be typed on a separate piece of paper and signed by ALL the authors:

"I have participated sufficiently in the conception and design of this work, the data analysis (when applicable), and the writing of this article to take public responsibility for it. I have reviewed the final version of the article and approve it for submission for possible publication".

An explanation for the addition or removal of an author(s) name must be provided with direct verification from the added/removed author(s).

Review

Each article shall be reviewed on a double-blind basis by at least two reviewers. Articles written by any editorial members will also be subjected to a double-blind peer review. Articles will not be reviewed by colleagues or editorial board members from the same institution as the author. The editor reserves the right to withdraw an article from the publishing process at any time.

Article preparation

Body text paragraphs should be in double spacing, **not** indented, left aligned (not justified) and an open (empty) paragraph after each text paragraph.

Body text font type and size should be Arial size 10.

Article must be submitted in MS Word format or recent compatible software format.

Abstracts in English and Afrikaans of no more than 200 words must be included in the article. The abstract must accurately reflect the content of the article.

Five keywords describing the contents of the article should be submitted.
The article itself may not compromise more than 20 pages (including abstract and reference list; excluding figures and tables) and authors must supply a word count. In exceptional cases longer articles may be accepted.

The journal has a policy of anonymous peer review. Authors' names are withheld from the referees, but it is the authors' responsibility to ensure that any identifying material is removed from the article.

The article must be ready for the press, in other words, it must have been revised for grammar and style. The author must provide a letter from a language editor confirming this.

The article must be written in clear English (South African/UK style) or in Afrikaans.

All abbreviations should be written out when first used in the text and thereafter used consistently.

All references to source books must be acknowledged according to the revised Harvard method (see examples at the end of the author guidelines).

It is the author's responsibility to verify references from the original sources.

All illustrations, figures and tables must be numbered and provided with titles. Each illustration, figure and table must, in addition, appear on a separate page and must be graphically prepared (be press ready). Illustrations, figures and tables must be black and white - **NOT in colour.** The author is responsible for obtaining written permission from the author(s) and publisher for the use of any material (tables, figures, forms or photographs) previously published or printed elsewhere. Original letters granting this permission must be forwarded with the final article.

Headings are **not** numbered. Their order of importance is indicated as follows: Main Headings in **CAPITALS** and bold print; sub-headings in UPPER and lower case and bold letters; sub-sub headings in upper and lower case, bold and italic letters (see examples at the end of the author guidelines).

Refer to articles in recent issues for guidance on the presentation of headings and subheadings.

Requirements for publication

Articles should preferably be submitted via email to lviljoen@uj.ac.za

If the article is not submitted electronically, one printout of the article must be submitted.

In addition to the above-mentioned printout, a cd containing the full article must also be submitted. The latter disc must clearly be marked with the name of each author and co-author and the name of the file.

A further copy of the article should be retained by the corresponding author.

The article must be accompanied by a cover letter.

The title page must be submitted on a separate page and must give the following particulars:

- The title of the article.
- The surname, first name and, if any, the other initials of the author(s) and co-author(s).
- The academic and professional qualifications of the author(s) and co-author(s).
- The capacity in which author(s) and co-author(s) is acting and the name of the organisation/institution they are attached to.
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DE VOS, AS; STRYDOM, H; FOUCHE, CB; POGGENPOEL, M & SCHURINK, W 1998: Research at grass roots. A primer for the caring professions. Pretoria: Van Schaik Academic.

DURRHEIM, K 1997: Social constructionism, discourse and psychology. **South African Journal of Psychology**, 27(3):175-182.

FOUCAULT, M 1984: Nietzsche, genealogy, history. (**In:** Rainbow, P ed. 1984: The Foucault reader. Harmondsworth: Penguin, pp 76-100).

HOLMES, A 1998: Greenpeace wins media war. Available from: **http://www.independent.co.uk/international/green25.htm** (Accessed 25 November 1998).

Examples of text references:

The ethical measures adhered to during this research process are those set out by DENOSA (Democratic Nurses Association of South Africa, 1998:3-7).

Stein, Brailowsky and Will (1995:105), however, note that points of divergence are seen even within rodents of the same species. Yet sex differences do occur both in response to injury and in recovery of function, female rats in normal oestrus showing less oedema following frontal cortical contusions than males, and more severe oedema than females who are not in oestrus (Stein *et al.* 1995:105).

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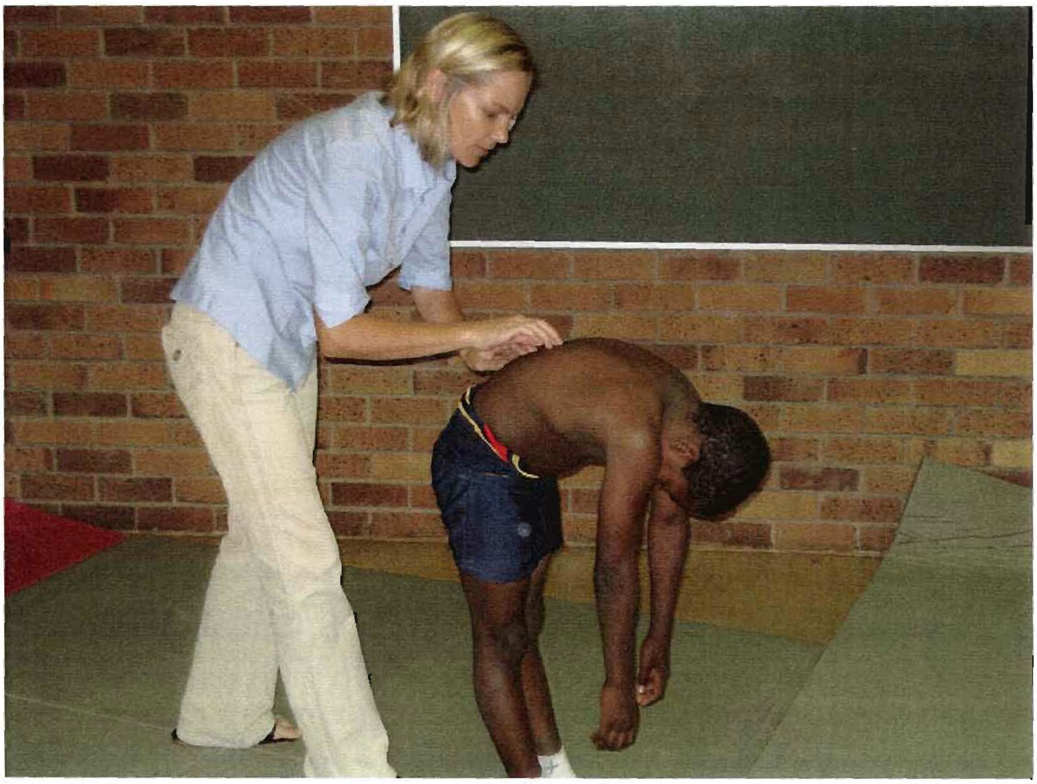
Appendix B

Guidelines for Authors

African Journal for Physical, Health Education, Recreation and Dance (AJPHERD)



African Journal for Health Education, Recreation and Dance

Author Guidelines

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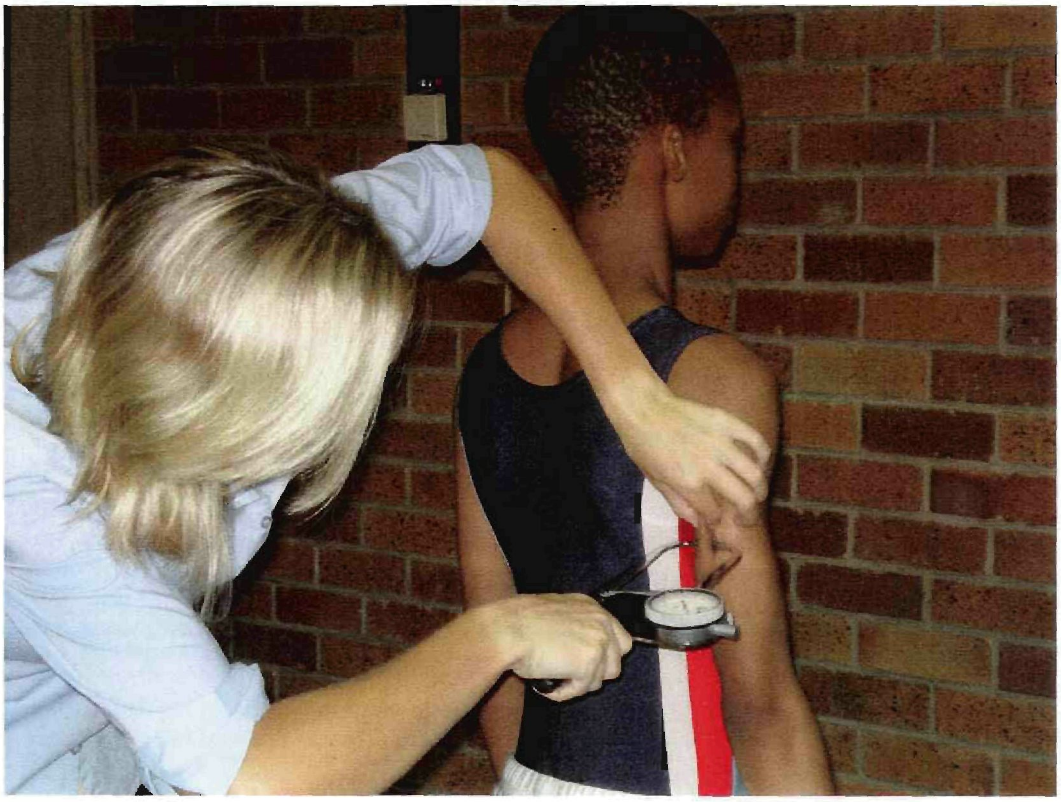
Journal of Health, Population and Nutrition



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The mission of the Journal of Health, Population and Nutrition is to provide a forum for rapid publication of new findings on issues pertinent to maternal, child and family health and related issues of population and nutrition. The articles in the Journal do not deal primarily with child-survival issues but encompass all age-groups and stages of life, with emphasis on family health and development.

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The Journal puts emphasis on speedy publication. Most articles are published within 4-6 months of acceptance. There is no absolute rule against articles primarily dealing with industrialized countries; however, preference is given to the articles dealing with issues of developing countries.

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In principle, a review article should not generally exceed 8,500 words, and an original research article should also not exceed 6,500 words, including the abstract, tables, references, and other appendices. A commentary should not exceed 4,000 words. A short report should not exceed 2,500 words, including abstract, tables, and references. Letters should be brief (around 1,500 words) and to the point; tables can be included, but graphs and illustrations will not normally be used. References must be kept to a minimum.

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Abstract and key words

The abstract of no more than 150 words should state the purposes of the study or investigation; basic procedures (selection of study subjects; observational and analytical methods); main findings (give specific data and their statistical significance, if possible); and the principal conclusions. Emphasize new and important aspects of the study or observations. Use only approved abbreviations.

Below the abstract, provide and identify as such 3 to 10 key words or short phrases that will assist indexers in cross-indexing the article and may be published with the abstract. Key words or short phrases should be sufficient to describe the content of the text. Use terms from the Medical Subject Headings (MeSH) list of the Index Medicus, published by the U.S. National Library of Madicine (NLM), USA; if suitable MeSH terms are not yet available for recently-introduced terms, present terms may be used.

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The text should be divided into sections with the following headings: Introduction, Materials and Methods, Results, and Discussion.

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Include general descriptions of methods in the Materials and Methods section. When data are summarized in the Results section, specify the statistical methods used for analyzing them. Restrict tables and figures to those needed to explain the argument and to assess its support. Use graphs as an alternative to tables with many entries; do not duplicate data in graphs and tables. Avoid non technical uses of technical terms in statistics, such as 'random' (which implies a randomizing device), 'normal,' 'significant,' 'correlations,' and 'sample.' Define statistical terms, abbreviations, and most symbols used.

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Rahman MM, Alvarez JO, Mahalanabis D, Wahed MA, Islam MA, Unicomb L *et al.* Effect of vitamin A administration on response to oral polio vaccination. *Nutr Res* 1998;18:1125-33.

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World Health Organization. Scientific Working Group. Rotavirus and other viral diarrhoeas. *Bull World Health Organ* 1980;58:183-98.

(3) No author given

Defining the limits of public health (editorial). *Lancet* 2000;355:587.

(4) Journal supplement

Hebbelinck M, Clarys P, De Malsche A. Growth, deve-lopment, and physical fitness of Flemish vegetarian children, adolescents, and young adults. *Am J Clin Nutr* 1999;70(Suppl):S579-85.

(5) Journal paginated by issue

Kitua AY. Field trials of malaria vaccines. *Indian J Med Res* 1997;106(Aug):95-108.

Books and other monographs

(6) Personal author(s)

Walker-Smith J. Diseases of the small intestine in child-hood. 2d ed. Kent: Pitman Medical, 1979:171-249.

(7) Editor, compiler, chairman as author

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(8) Chapter in a book

Heird WC, Cooper A. Nutrition in infants and children. *In*: Shils ME, Young VR, editors. Modern nutrition in health and disease. 7th ed. Philadelphia, PA: Lea & Febiger, 1988:944-68.

(9) Published proceedings paper

Sack DA. Bacteriological and clinical variation of acute diarrheal disease. *In*: Mazumder DNG, Chakraborty AK, De S, Kumar AK, editors. Proceedings of the 8th National Conference on Communicable Diseases. Calcutta: All-India Institute of Hygiene and Public Health, 1980:89-93.

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Philips SF, Gaginella TS. Effects of fatty acids and bile acids on intestinal water and electrolyte transport. *In*: Binder HJ, editor. Mechanisms of intestinal secretion. New York, NY: Liss, 1978:287-94. (Kroc Foundation series, v. 12).

(11) Agency publication

Hamill PW. NCHS growth curves for children birth–18 years—United States. Hyattsville, MD: National Center for Health Statistics, 1977. iv, 74 p. (DHEW publication no. (PHS) 78-1650; Vital and health statistics, series 11, no. 165).

(12) Dissertation or thesis

Rahman ASMM. Village practitioners of Bangladesh: their characteristics and role in an oral rehydration programme. London: London School of Hygiene & Tropical Medicine, 1980. 84 p. (Dissertation).

Other articles

(13) Newspaper article

Azad AS. Water pollution and health hazards. *Bangladesh Observer* 1982 Dec 11:5(col 3-5).

(14) Magazine article

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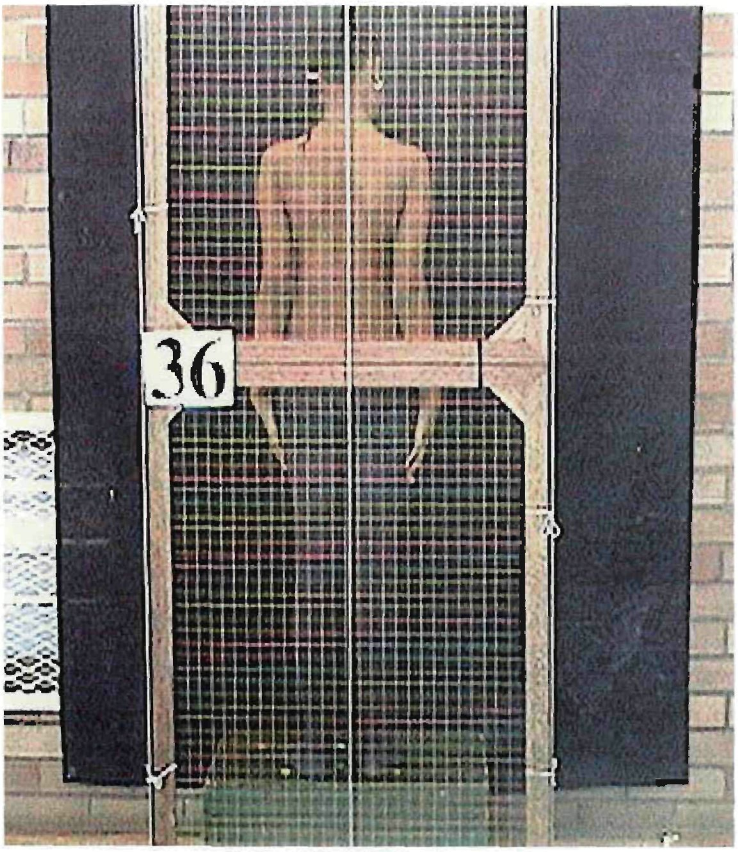
South African Journal for Research in Sport, Physical Education and Recreation



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NB. Articles can also be submitted by e-mail.

CONDITIONS

A signed declaration in respect of the originality must accompany each manuscript. On submission of the manuscript, the author shall present a written statement that the article has not been published or is not being presented for publication elsewhere. Should the article be taken from a Master's thesis or Doctoral dissertation, academic ethic requires that the student will be the first author. The author should also ensure that the LANGUAGE of the manuscript has been thoroughly edited at the time of submission (in British English). The name, address and telephone number of the person who has done the language editing must be provided. On receiving a written notification from the Managing Editor that the article has been accepted, a final hard copy of the manuscript and a diskette (virus checked) should be submitted using MS WORD as a DOC-file (see Figures). It can also be send per e-mail as an attached file.

PREPARATION OF MANUSCRIPT

Title page

The first page of each manuscript should indicate the *title* in English and Afrikaans (will be translated for foreign authors), the *names* (title, first name in full and other initials, surname) of the author(s), the *telephone* numbers (work & home), *facsimile* number, *e-mail* address (if available) and the *field of study*. The mailing address of the first named author and the institution where the work was conducted should be provided in full. A short title of not more than 45 characters, including the spaces, should be provided for use as a running head.

Abstract

Each manuscript must be accompanied by an abstract of approximately 150-200 words in *English* and should be set on a *separate page* as a SINGLE paragraph (one and a half spacing). A list of three to seven **key words** in *English* is required for indexing purposes and should be typed below the abstract.

Articles in Afrikaans must include an *additional* extended summary (500-1000 words) in English. This summary must start on a new page (following the list of sources) providing the English title of the article at the beginning.

Text

Start the text on a new page with the title of the article (centred and *without* the names of the authors). Follow the style of the most recent issue of the journal regarding the use of headings and subheadings. Use only one space after a sentence.

Tables and figures

Tables and figures should be numbered in *Arabic* numerals (1, 2, etc.). Tables require a heading at the *top* and figures a legend *below* and separate from the figure. ***Note:*** Use the decimal POINT (not the decimal comma).

References

In the *text* the Harvard method must be adopted by providing the author's surname and the date placed in parentheses. *For example:* Daly (1970); King and Loathes (1985); (Botha & Sonn, 2002); McGuines *et al.* (1986) or (Daly, 1970: 80) when Daly is not part of the sentence. More than one reference must be arranged chronologically. Note that *et al.* is used in the body of the text when there are more than two authors, but never in the list of references.

LIST OF REFERENCES

Only the references cited in the text should be listed alphabetically according to surname (last name) of authors (capitals) after the body of text under the heading, **References** (capitals) starting on a new page. In the case of articles published in *JOURNALS*, references listed should include the surnames and initials (capitals) of all authors, the date of the publication in parentheses, the full title of the article, the full title of the journal (italics), the volume number, the serial number in parentheses (omitted only if the said journal does not use issue numbers), followed by a colon and the first and last page numbers separated by a hyphen.

Example:

VAN WYK, G.J. & AMOORE, J.N. (1995). A practical solution for calculating instantaneous values of tension in the extensor muscles of the knee joint during extension and flexion. *South African Journal for Research in Sport, Physical Education and Recreation*, 18(1): 77-97.

If the reference is a *BOOK*, the surname (last name) and initials of the author or editor (Ed.) must be given, followed by the date of publication in parentheses, the title of the book (italics) as given on the title page, the number of the edition (ed.) in parentheses, the city (and abbreviation for the state in the case of the USA) where published, followed by a colon and the name of the publisher.

Example:

JEWETT, A.E.; BAIN, L.L. & ENNIS, C.E. (1995). *The curriculum process in Physical Education* (2nd ed.). Madison, WI: WCB Brown & Benchmark.

For a CHAPTER from a book, the page numbers of the chapter cited must be provided in parentheses (not italics) after the title of the book. For further details, authors should consult the most recent publication of this Journal for other examples.

Example:

DE RIDDER, J.H. (1999). Kinanthropometry in exercise and sport. In L.O. Amusa; A.L. Toriola & I.U. Onyewadume (Eds.), *Physical Education and sport in Africa* (235-263). Ibadan (Nigeria): LAP Publications.

If the reference is a THESIS or DISSERTATION, no italics is used as it is an unpublished work.

Example:

CRAVEN, D.H. (1978). The evolution of major games. Unpublished PhD dissertation. Stellenbosch: Stellenbosch University.

For *ELECTRONIC SOURCES* all references start with the same information that would be provided for a printed source (if available). The web page information follows the reference. It will usually contain the name of the author(s) (if known), year of publication or last revision, title of complete work in inverted commas, title of web page in italics, Uniform Resource Locater (URL) or access path in text brackets (do not end the path statement with a fullstop) and date of access. See *"How to cite information from the internet and the world wide web"* at http://www.apa.org/journals/webref.html for specific examples. When citing a web site in the text, merely give the author and date (in this case: Ackermann, 1996).

Example of Web Page:

ACKERMANN, E. (1996). "Writing your own Web Pages." *Creating Web Pages.* Hyperlink [http://www.mwc.edu/ernie/writeweb/writeweb.html]. Retrieved 22 October 1999.

ADMINISTRATION

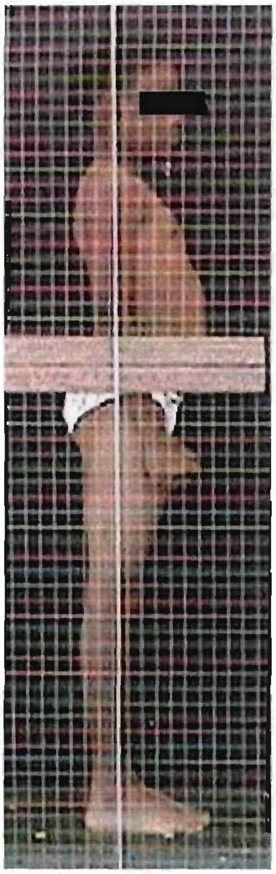
If authors honour the rules and specifications for the submission of manuscripts, unnecessary delays will be avoided. A manuscript that does not meet the requirements as set out above, will be returned to the author without being evaluated. Requesting copying rights concerning figures or photographs is the responsibility of the authors.

The corresponding author will receive a complimentary copy of the journal and five reprints of the article. The original manuscripts and illustrations will be discarded one month after publication unless a request is received to return the original to the first-named author. Page charges of **R80** per page are payable on receipt of an account issued by the editor.

Appendix E

Guidelines for Authors

International Council for Health, Physical Education, Recreation, Sport and Dance Journal of Research (ICHPER – SD Journal)



International Council for Health, Physical Education, Recreation, Sport, & Dance

Information for Authors

Did you know that the International Council of Health, Physical Education, Recreation and Dance (ICHPER··SD), headquartered in the AAHPERD building in Reston, Virginia, publishes two scholarly, blind reviewed, journals:

(1) ***Journal of ICHPER·SD*** *— a quarterly journal [Volume XLII]*
(2) ***ICHPER·SD Journal of Research*** *— a brand new biannual journal (published twice a year) [Volume I].*

And, did you know that ICHPER·SD is now actively searching for (1) quality manuscripts to be reviewed for possible publication in one of these scholarly journals and (2) experienced scholars and teachers who are willing to serve as reviewers for one or both of these journals.

Provided below is information pertaining to how to prepare and submit manuscripts for review (i.e., guidelines for writers/researchers) to both of these journals.

The Mission of the *ICHPER·SD Journal of Research*

The mission of the journal is to meet the needs of the academic community from both a national and an international perspective. Thus, academicians and professionals engaged in or studying HPER-SD, and related activities, at all levels (local, state, regional, national and international), are encouraged to contribute to the professional literature by submitting research-oriented manuscripts that will contribute and expand to knowledge base of the disciplines within our profession. *The ICHPER·SD Journal of Research is exclusively what is termed a "research journal" and invites data based manuscripts representing cutting edge research.*

The Mission of the *Journal of ICHPER·SD*

The mission of the journal is to meet the needs of the academic community from both a national and an international perspective. Thus, academicians and professionals engaged in or studying HPER-SD, and related activities, at all levels (local, state, regional, national and international), are encouraged to contribute to the professional literature by submitting scholarly, but not necessarily data-base research manuscripts, that will contribute and expand to knowledge base of the disciplines within our profession. All types of scholarly manuscripts, including position papers, research as well as non-research articles, are encouraged. *The Journal of ICHPER·SD is* ***not exclusively*** *what is termed a "research journal"— but invites scholarly manuscripts dealing with any aspect of our profession and disciplines.*

Manuscript Guidelines for Authors

Articles are invited in the areas of health, physical education, adapted physical education, recreation, dance, sport, human performance, coaching, sports medicine, and sport management. *This journal is international in scope in the sense that authors/researchers and topics can originate from any part of the world.*

All manuscripts must be submitted in English. An original hard copy of the manuscript plus a computer CD (virus free) containing the article and any tables and/or figures (as separate files, in Microsoft Word®), should be submitted to:

Editor
ICHPER·SD Journal of Research
or
Journal of ICHPER·SD
International Council for Health, Physical Education, Recreation,
Sport, & Dance (ICHPER·SD)
1900 Association Drive, Reston, Virginia 20191-1598, USA
Phone: (703) 476-3462 Fax: (703) 476-9527 Email: ichper@aahperd.org

Each manuscript must be accompanied by a one-paragraph abstract (100 words or less). The APA (latest edition) format [*Publication Manual of the American Psychological Association*] must be used consistently throughout the entire manuscript. At least one of the authors (if there is more than one) should be members of ICHPER·SD. Authors should number pages and lines throughout the manuscript, including the references. Be sure and double check references for correct spelling of authors and publication dates as well as to insure that the names in the references and in the body of the manuscript match.

For manuscripts sent from the United States, a large, self-addressed, **stamped** envelope (9" by 12") must be included for the return of the manuscripts (with editor's and reviewers' comments) for possible revision. For manuscripts sent from outside the United States, only a large self-addressed envelope (9" by 12") must be included. Manuscripts should not be submitted to another journal while under review.

The first page of each manuscript should include only the title of the article. The senior author's name, affiliation, and full address (including phone number, fax number and e-mail address) should be provided on a separate cover sheet, along with identification of co-authors, if any. The manuscripts should be typed double-spaced with a 1½ -inch margin. Generally, manuscripts should be 15-20 pages in length, plus tables, figures and references, for a total of no more than 24-25 pages. The body of the manuscript should not contain any information identifying the author(s). Manuscripts longer than this will be reviewed, and if accepted, can be published – space permitting.

All graphs, tables as well as figures and drawings should be placed on separate pages. Tables should be double-spaced. Figures and drawings must be professionally prepared and camera ready. Final manuscripts, including all corrections and revisions, must be submitted on a computer CD in Microsoft Word® as well as two hard copies.

Submitted manuscripts are reviewed by at least three members of the "review board" and by the editor. The evaluation of manuscripts is by a blind review process. Authors are notified as to the disposition of their manuscripts as soon as all reviews are completed. Once a manuscript has been tentatively accepted, the author should return two hard copies of the revised manuscript and a computer CD (Microsoft Word®) containing the manuscript and any tables or figures as separate files, for a final review, prior to being scheduled for publication.

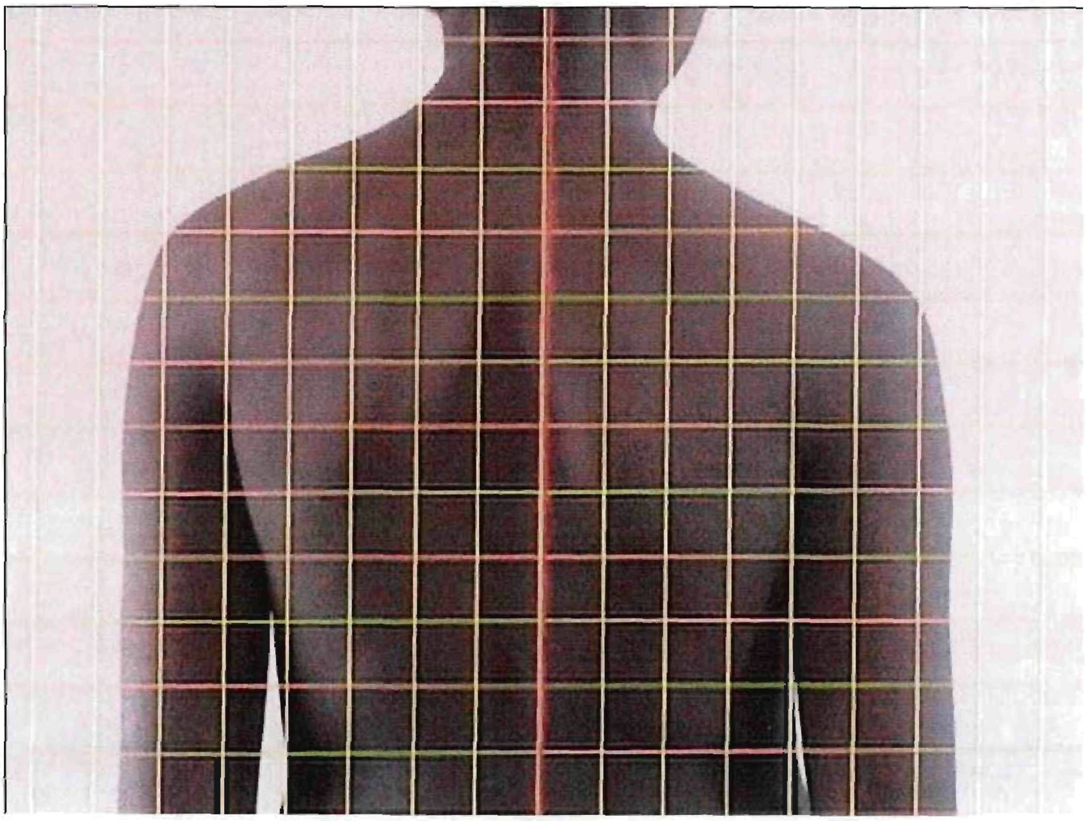
Galley proofs of accepted manuscripts are mailed to the author and are to be returned within one week following receipt from the editor. Only minor corrections are acceptable on the galley proofs. No major additions or revisions are permitted at this stage in the publication process. The senior author receives two copies of the issue in which the article appears.

There are no page charges to authors. All authors must transfer copyright to International Council for Health, Physical Education, Recreation, Sport, & Dance (ICHPER·SD) by signing a copyright release document. At least one of the authors (if there is more than one) is expected to be a member of ICHPER·SD or willing to become a member.

Form a-2-2-25-06a

Appendix F

Information for parents and informed consent letter (Afrikaans)



YUNIBESITI YA BOKONE-BOPHIRIMA
NORTH-WEST UNIVERSITY
NOORDWES-UNIVERSITEIT

Geagte Ouers/Voogde

NAVORSINGSPROJEK - POSTUURAFWYKINGS

Postuurafwykings (skewe ruggraat, ronde skouers, hol rug ens.) is 'n algemene probleem wat dikwels onder kinders voorkom. Baie van die skete en pyne wat in volwassenes onstaan, is nie as gevolg van beserings nie, maar die gevolg van 'n langtermyn swak postuur wat reeds sy oorsprong in die kinderjare gehad het. Die doel van hierdie studie is om die voorkoms van postuurafwykings by kinders tussen die ouderdomme 11 en 13 jaar by geselekteerde skole in die Noordwes-Provinsie te bepaal. Faktore wat moontlik 'n invloed op die voorkoms van postuurafwykings kan hê, naamlik gewig, lengte, LMI (liggaamsmassa-indeks) en persentasie liggaamsvet sal ook gemeet word. Identifikasie van postuurafwykings op 'n vroeë stadium maak vroeë behandeling moontlik, wat in die toekoms ernstige postuurafwykings kan voorkom. Die Potchefstroomse Christenskool het daarom toestemming gegee dat die graad 5, 6 en 7 leerlinge van die skool deel mag vorm van hierdie navorsingsprojek wat gedoen word onder die vaandel van die Skool vir Biokinetika, Rekreasie en Sportwetenskap (BRS) aan die Noordwes-Universiteit (Potchefstroom-kampus).

Vir enige navrae kontak Suzanne Stroebel by Tel: 082 575 6782 (sel) of 018 - 299 1824 (w)

Inligting rakende die studie

1. Die projek word goedgekeur deur die etiese komitee van die Noordwes-Universiteit en is 'n projek van die Skool vir BRS.
2. Die doel van die navorsingstudie sal wees om die voorkoms van postuurafwykings by kinders tussen die ouderdomme 11 en 13 jaar by geselekteerde skole in die Noordwes-Provinsie te bepaal.
3. Die deelnemers sal geweeg word en sy/haar lengte sowel as hul velvoue sal gemeet word. Elke seun en dogter se postuur sal afsonderlik geëvalueer word. Seuns sal in pt/rugby broekies gemeet word en dogter in swemklere of pt broekies met aerobic toppies. Die verskillende ouderdomsgroepe sowel as seuns en dogters sal apart gemeet word. Elke kind sal afsonderlik gemeet word en dogters sal slegs deur dames gemeet word. Privaatheid van die kind sal ten alle tye in ag geneem word. Slegs uiters professionele Biokinetici sal die metings doen en sal so te werk gaan dat geen kind in 'n verleentheid gestel word nie.
4. Alle inligting is vertroulik. Daar sal ook terugvoering aan u as ouers en aan die kinders gegee word en intervensies sal voorgestel word om moontlike ernstige postuurprobleme te voorkom. Dus sal die studie tot voordeel van u kind se gesondheid wees.
5. U samewerking in dié verband sal hoog op prys gestel word.

Vriendelike groete en byvoorbaat dankie

Suzanne Stroebel
(Biokinetikus en doktorsgraadstudent)

Professor Hans de Ridder
(Programleier Navorsing: Skool vir BRS, NWU)

Professor Dawie Malan
(Direkteur: Skool vir BRS, NWU)

POTCHEFSTROOMKAMPUS
Privaatsak X6001, Potchefstroom, 2520
Tel: (018) 299-1111 • Faks: (018) 299-2799
Internet: http://www.nwu.ac.za

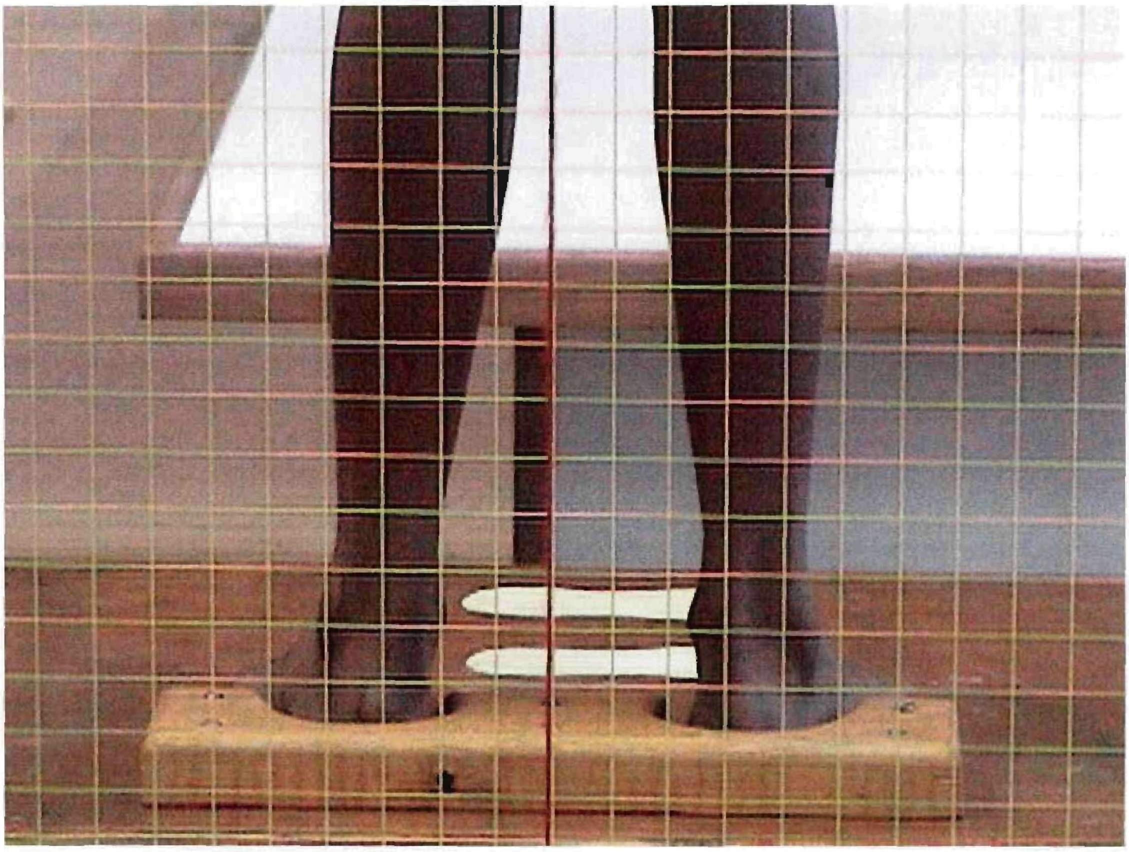
Ek______________________________________(Ouer/Voog) van __________________________(kind) in graad ____________ gee hiermee toestemming dat my kind aan die navorsingsprojek ten opsigte van postuurafwykings mag deelneem.

Handtekening______________ (Ouer/Voog)________________

Datum____________

Appendix G

Information for parents and informed consent letter (English)



YUNIBESITI YA BOKONE-BOPHIRIMA
NORTH-WEST UNIVERSITY
NOORDWES-UNIVERSITEIT

Dear Parents/Guardians

RESEARCH PROJECT – POSTURAL DEFORMITIES

Postural deformities (*skew back, round shoulders, hollow back etc.*) are a commonly encountered problem among children. Most of the aches and pains of adults are the result, not of injuries, but of the long-term effects of distortions in posture or alignment that have their origins in childhood or adolescence. The purpose of this study is to determine the prevalence of postural deformities among children aged 11 to 13 years in selected primary schools in the North West Province. The factors that may have a influence on the prevalence of postural deformities, namely weight, height, BMI (Body Mass Index), and percentage body fat will also be measured. Identification of postural deformities at an early stage makes early treatment possible, which may, in future, prevent serious postural abnormalities. Therefore, the Potchefstroom Christian primary school gave permission for children in grade 5, 6 and 7 to take part in the study that will be conducted by the School for Biokinetics, Recreation and Sport Science (BRS) from the North-West University (Potchefstroom campus).

For any enquiries contact Suzanne Stroebel at Tel: 082 575 6782 (cell) or 018 - 299 1824 (w)

Information regarding the study

6. The project will be approved by the Ethics Committee of the North-West University and is a project of the School for BRS.
7. The purpose of this study is to determine the prevalence of postural deformities among children aged 11 to 13 years in selected primary schools in the North West Province.
8. Body weight, body height and percentage body fat will be measured. Boys and girls will be evaluated separately and individually. Measurements will be taken with boys wearing rugby shorts and girls swimsuits or aerobic tops. Privacy is considered to be essential and girls will be measured by a female. Only highly professional Biokineticists will be used for the measurements and the child's best interest will always be priority as to insure that no child will be exposed to any physical or emotional embarrassment.
9. All data will be kept confidential. Feedback will be given to you as parents and children and possible interventions will be suggested as to how to prevent serious postural problems. This study would be to the advantage of the child's health.
10. Your co-operation and support in this regard would be highly appreciated

Thanking you in advance

Suzanne Stroebel
(Biokineticist and doctors degree student)

Professor Hans de Ridder
(Programme leader Research: School for BRS, NWU)

Professor Dawie Malan
(Director: School for BRS, NWU)

POTCHEFSTROOM CAMPUS
Private Bag X6001, Potchefstroom, 2520
Tel: (018) 299-1111 • Fax: (018) 299-2799
Internet: http://www.nwu.ac.za

I__________________________________(Parent/Guardian) of ____________________________(child) in grade ____________ hereby give permission that my child can participate in the postural deformities project.

Signature____________ (Parent/Guardian)________________

Date_______________

Appendix H

Measurement Form

MEASUREMENT FORM

SUBJECT NR: ______________

NAME: ____________________

SEX: M F

D.O.B:____(d)____(m)____(y)

GRADE: 5 6 7

HANDEDNESS: R L

STATURE:_________(cm)

WEIGHT:_________(kg)

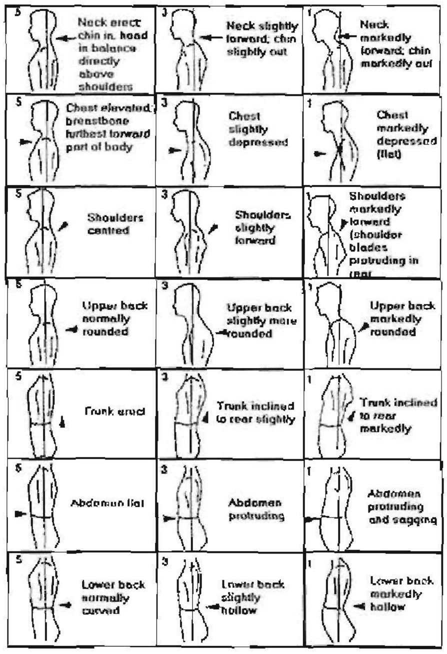
TRICEP: ________ ______(mm)

SUBSCAP:________ _______(mm)

POSTURE RATING CHART

SIDE VIEW POINTS

SCORE



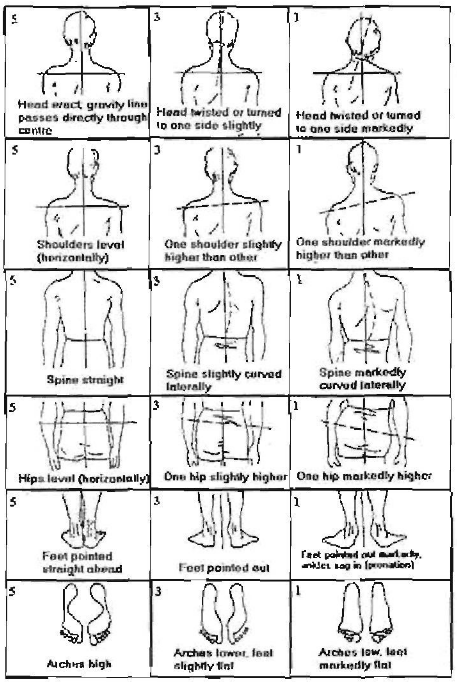
Forward Bending Test (Y/N)

L/R

POSTURE RATING CHART

BACK VIEW POINTS

SCORE



Total:

New York Posture Test