

The prevalence and changes in postural abnormalities during the course of adolescence amongst a selected group of black children: The PAHL-study

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Dedication

To my loving fiancé, mother, brother and grandmother.



Declaration

Prof. M.A. Monyeki (supervisor) and Dr E. Bruwer (Assistant co-supervisor), co-authors of an article which form part of this dissertation, hereby give permission to the candidate, Miss L. Botha to include the article as part of the Masters dissertation. The contribution of the supervisors and co-authors was limited to their professional advice and guidance as study leaders towards the completion of the study.

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Abstract

The prevalence and changes in postural abnormalities during the course of adolescence amongst a selected group of black children: The PAHL-study

Evidence exists that during growth and development in children and adolescents' various postural disorders may occur, especially in school-age children. Research regarding the changes in posture during the course of adolescents, especially in black children is, however, limited. Improper postures adopted by children and adolescents at home and at school cause body musculature imbalances that result in postural deviations that may last throughout adulthood.

Modern lifestyle and the convenience of technology can be seen as a predictor of poor posture and postural adaptations in children, but most black South African children in rural areas do not have access to computers and electronic devices. These children usually have to travel long distances carrying school back by foot and their food intake is mostly unbalanced and inadequate, which may result in poor posture over time. Boys and girls do not go through similar postural changes during adolescence and therefore gender differences that exist in the postural stability and development of children should be taken into consideration. It is important for educators, parents, and healthcare individuals to understand normal growth patterns and be aware of significant changes in a child's posture during normal growth and development in order to identify postural deviations.

The aim of this study was therefore to determine the prevalence and changes of postural deformities during the course of adolescence amongst a selected group of black boys and girls in the Potchefstroom area of the North West Province, South Africa. A total of 100 African adolescents, aged 14 years in 2010 and 18 years in 2014, who were part of Physical Activity and Health Longitudinal Study (PAHLS), were participants in this current longitudinal study. Participants underwent measurements of stature and body mass, as well as the New-York Posture Test based on 13 categories of postural deformities. Each test item was scored on a 5-3-1 basis

and the score of each item was based on the criteria and drawings located on the score sheet with: 5 = correct or normal posture; 3 = slight deviation or slightly abnormal; 1 = pronounced deviation or abnormal. The Adam's Test (forward bending test) was used to evaluate further for scoliosis. Additionally, an inkpad (The Harris Mat Impression system, Step Forward Foot Correctors®) was used to obtain a walking footprint of each participant.

The results show that in all 13 variables of postures, the prevalence of abnormal ranged from 0-35%, and slightly abnormal ranged from 16-73% for the total group across the measured points. The observed findings for the total group in the present study showed a high prevalence for forward head, forward shoulders, hip sway, lordosis and uneven shoulders in the abnormal and slightly abnormal category in 2014. Out of the 13 posture variables, boys showed more abnormal posture (forward head, $p \leq 0.001$; forward shoulders, $p \leq 0.001$ kyphosis, $p = 0.007$ and hip sway, $p = 0.048$) than the girls who were presented with three categories of significant changes in abnormal posture (forward head, $p \leq 0.001$; uneven shoulders, $p = 0.049$ and lordosis, $p = 0.004$) over a period of study.

This study showed alarming results with regard to poor posture and postural deviations during adolescence. Implementing intervention programmes in schools to address these postural deviations at an early stage should be encouraged.

Key words:

Body postural deformities, adolescence, postural changes, adaptations, South African adolescent

Opsomming

Literatuur dui aan dat die ontwikkeling van verskeie postuurafwykings baie algemeen voorkom onder adolessente. Daar is tans beperkte navorsing op die gebied van postuurafwykings en die verandering van postuur tydens adolessensie, spesifiek met verwysing na swart kinders. Wanneer kinders en adolessente verkeerde gewoontes rakende postuur tuis of by die skool aanleer, gee dit aanleiding tot muskuloskeletale wanbalanse in die liggaam wat weer postuurafwykings tot gevolg het. Hierdie postuurafwykings sal voortduur en teenwoordig wees tot in volwassenheid. Moderne lewenswyse en die tegnologie wat vandag tot ons beskikking is, kan beskou word as sterk voorspeller van swak postuur en postuurafwykings in kinders en adolessente, alhoewel die meeste swart Suid Afrikaner-kindere in arm areas grootword en nie toegang tot rekenaars en televisies het nie. Hierdie kindere moet meestal hul skooltasse dra oor lang afstande wat hul loop, terwyl hul voedselinname gewoonlik beperk en ongebalanseerd is. Laasgenoemde faktore kan aanleiding gee tot die ontwikkeling van swak en verkeerde postuur. Seuns en dogters gaan nie deur dieselfde stadiums gedurende adolessensie nie, en gevolglik bestaan daar geslagsverskille in postuurontwikkeling. Hierdie veranderinge moet in ag geneem word wanneer daar na postuurontwikkeling van seuns en dogters verwys word. Dit is uiters belangrik vir onderwysers, ouers en gesondheidswerkers om normale stadiums van groei, asook geslagsverskille in kindere en adolessente te verstaan, ten einde postuurafwykings te kan identifiseer.

Die doel van hierdie studie was dus om die voorkoms en verandering van postuurafwykings tydens adolessensie onder 'n spesifieke groep swart seuns en dogters in die Potchefstroomarea in die Noord-Wes Provinsie, Suid-Afrika, te bepaal. 'n Totaal van 100 adolessente, 14 jaar oud in 2010 en 18 jaar oud in 2014, wat deel gevorm het van die Fisieke Aktiwiteit en Gesondheid Longitudinale Studie (PAHLS), was deelnemers vir die huidige longitudinale studie. Elke deelnemer se massa en lengte is gemeet, en hul postuur is ook geëvalueer deur gebruik te maak van die New York Postuur Toets. Hierdie toets word gebaseer op 13 postuurafwykingskategorieë. Elke postuur-toetsgroep was bepunt op 'n 5-3-1 basis, waar 5 =

normale of goeie postuur, 3 = matige afwyking of matig abnormaal en 1 = swak of abnormale postuur is. Die Adam se Toets was addisioneel gebruik om skoliose te assesseer. 'n Inkkussing (The Harris Mat Impression system, Step Forward Foot Correctors®) was gebruik om 'n voetafdruk te kry.

Die resultate toon dat daar in al 13 kategorieë statisties betekenisvolle verandering in postuurafwykinge teenwoordig was. Die voorkoms van abnormale postuur varieër 0% - 35% en matig abnormaal varieër van 16% - 73% vir die totale groep (seuns en dogters) oor die tydperk. Die bevindinge in die huidige studie, vir die totale groep deelnemers, dui 'n hoër voorkoms van protraksie van die kop, protraksie van die skouers, heupswaai, lordose, koprotasie en ongelyke skouers vir abnormaal en matig abnormaal in 2014 aan. Uit die 13 kategorieë het seuns meer abnormale postuur getoon (vorentoe kop, $p \leq 0.001$; protraksie van die skouers, $p \leq 0.001$; kifose, $p = 0.007$ en heupswaai, $p = 0.048$). Die dogters het afwykinge in drie kategorieë getoon (vorentoe kop, $p \leq 0.001$; ongelyke skouers, $p = 0.049$ en lordose, $p = 0.004$) oor die toetsperiode.

Hierdie studie toon skokkende resultate met spesifieke verwysing na postuur tydens adolessensie. Die implementering van intervensies in skole word hoogs aanbeveel ten einde hierdie probleem aan te spreek in 'n fase waarin verandering en korrigering makliker gedoen kan word.

Sleuteltermes:

Postuurafwykinge, adolessensie, postuurveranderinge, Suid Afrikaner-adolessente

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List of Abbreviations

BOS:	BASE OF SUPPORT
COM:	CENTRE OF MASS
cm:	CENTIMETER
DHET:	SOUTH AFRICAN DEPARTMENT OF HIGHER EDUCATION AND TRAINING
DoE:	SOUTH AFRICAN DEPARTMENT OF EDUCATION
FHP:	FORWARD HEAD POSTURE
Kg:	KILOGRAM
SMI:	STAGE-MATCHED INTERVENTIONS
TBP:	THEORY OF PLANNED BEHAVIOUR
TTM:	TRANS THEORETICAL MODEL

Chapter 1

Introduction

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1.1 INTRODUCTION

Good posture is defined as the balanced alignment of various body segments with one another that provides minimal stress on the human body. When the alignment is out of balance, stress on the body segments will increase which causes anatomical adaptations over time (Houghlum, 2010:322; Norris, 2000:134). As such, the adapted postures lead to greater physiological and biomechanical demands, which reduce balance, stability, and strength, and limit the use of substitute motion patterns that relieve fatigued muscles (Gallagher, 2005:58). Poor posture therefore, is associated with an increase in musculoskeletal complaints and has a prominent adverse effect in performance capabilities (Gallagher, 2005:58).

1.2 PROBLEM STATEMENT

It has been reported that improper postures adopted by children at home and at school cause body musculature imbalances that result in postural abnormalities that may last throughout adulthood (Chansirinukor *et al.*, 2001:116; Pascoe *et al.*, 1997:639). Musculoskeletal disorders and pain experienced by children due to postural abnormalities can be reduced if postural changes are detected and corrected (Hong & Cheung, 2003:33). However, research indicates that educators and parents lack awareness and knowledge of postural deformities; therefore minimal attention is provided to the problem at an age when these deformities can still be corrected (Jankowicz-Szymanska *et al.*, 2010:44-45).

Lincoln and Suen (2003:312) suggested that each phase of life, from birth to death, has its classical posture picture and should be considered in the order of development and growth. Adolescence is the period in development between the onset of puberty and adulthood. It usually begins between 11 and 13 years of age with the appearance of secondary sex characteristics, terminating at 18-20 years of age with the completion of the development of the adult form. During this period, the individual undergoes extensive emotional, psychological, physical and personality changes (Mosby's Medical Dictionary, 2009). Between eight and fourteen years of age females enter puberty which lasts for about three years, while males enter puberty between nine and a half, and sixteen years of age, which lasts up to five years (Magee, 2008:974). Differences arise between boys and girls during this period, with boys tending toward broader shoulders, smaller hip width, longer leg and arm length, and greater overall skeletal size and height than girls (Magee, 2008:974). Children, especially boys, may appear ungainly and poor postural habits may occur because of this rapid growth spurt, and changes are more likely to occur during this phase (Magee, 2008:974).

Research suggests that there are intrinsic and extrinsic factors that can influence a child's posture, such as socioeconomic level, emotional factors, heredity, level of physical activity, environment or physical conditions under which the child lives, and physiological abnormalities due to human development and growth (Penha *et al.*, 2008:387; Brower & Nash, 1999:58). Studies that have focused on the impact of backpacks on adolescent posture demonstrated a significant positive linear relationship between forward head posture and backpack weight (Grimmer *et al.*, 2002:9), as well as significant associations between reports of heavy backpack weight and recent spinal pain (Devroey *et al.*, 2007:741; Grimmer & Williams, 2000:351; Steele *et al.*, 2001:94). Lower back pain in adolescence has been linked with continuing pain in adulthood as students who had lower back pain at age 14 were more likely to have back pain 25 years later than students who did not experience pain (Harreby *et al.*, 1995:2300). Some studies have shown that over 97% of adults have a postural deviation that should be corrected (Keith, 2009). The three most common types of postural deviations are anterior pelvic tilt, protracted forward shoulders, and forward head (Keith, 2009). It is essential to carry out screening examinations in schools to detect postural disorders as early as possible and correct these disorders (Jankowicz-Szymanska *et al.*, 2010:45).

Some postural abnormalities reflect normal postural development and are spontaneously corrected during growth (Penha *et al.*, 2008:387). However, abnormalities consisting of

asymmetries caused by daily demands on the human body may have a negative impact on quality of life during childhood and adulthood (Penha *et al.*, 2008:389). Determining the changes in posture during the course of adolescence is important in order to detect the prevalence of deformities remaining in late adolescence, as these adaptations and deformities will be carried into adulthood. Research on adaptations and deformities in specifically African adolescents is very limited. Studies that were found that include an African population are those of Segil (1974:393) using participants aged 6-7, 10-11 and 16-17 years, Van Biljon (2007:92) using participants aged 13-17 years, Stroebel (2008:121) who included children aged 11-13 years, and Brink *et al.* (2015:821) using participants aged 15-17 years. In the Van Biljon study, the girls had a higher prevalence of postural deformities than the boys. Lordosis, protruding abdomen, and a forward head posture were the most frequent deformities detected in both genders (Van Biljon, 2007:99). None of these studies determined the changes in postural deformities over time in either children or adolescents.

Identifying the postural deformities and deviations during adolescent years in different ethnic groups is important in order to educate and implement intervention strategies in South African high schools. Therefore the research questions to be answered by this study are:

- What is the prevalence of and changes in postural deformities during the course of adolescence among black adolescent boys in the Potchefstroom area of the North West Province?
- What is the prevalence of and changes in postural deformities during the course of adolescence among black adolescent girls in the Potchefstroom area of the North West Province?

The results of this study will empower teachers, parents, and coaches with the necessary knowledge to identify postural deformities in Africans at an early stage in order to prevent these deformities from carrying over into adulthood. Furthermore, this study will identify typical postural changes and deformities that occur specifically in black South African adolescence, a population with minimal research with regard to postural changes or deformities.

1.3 OBJECTIVES

The objectives of this study are to determine:

- The prevalence of and changes in postural deformities during the course of adolescence among black adolescent boys and girls in the Potchefstroom area of the North West Province, South Africa.

1.4 HYPOTHESES

The study is based on the following hypotheses:

1. The prevalence of postural deformities will be high among black African adolescent boys and girls in the Potchefstroom area of the North West Province.
2. The prevalence of postural deformities detected towards the end of adolescence will be significantly less than in the beginning of adolescence among black African adolescent boys and girls in the Potchefstroom area of the North West Province.

1.5 STRUCTURE OF THE DISSERTATION

This dissertation is submitted in the article format, as approved by the Senate of the North-West University, and will have the following content:

Chapter 1: Introduction.

Chapter 2: Postural development, adaptations, and deformities in the human body: a literature review. (The references in Chapters One and Two will be prepared in accordance with the guidelines proposed by the North-West University).

Chapter 3: Article 1: The prevalence of and changes in postural deformities during the course of adolescence in a cohort of African adolescents: the PAHL study.

The article will be prepared for publication in the *African Journal for Physical Activity and Health Sciences (AJPHEs)*.

Chapter 4: Summary, conclusion, limitations, and recommendations.

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Chapter 2

Postural development, adaptations, and deformities in the human body: a literature review

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2.1 INTRODUCTION

Posture of the human body has been studied in several areas such as anatomy, orthopaedics, anthropology, kinesiology, among others, due to the great significance it has in terms of human development, growth and movement (Mitova *et al.*, 2015:162; Aitken, 2008:7). Poor posture can cause general health problems like bodily dysfunction or myofascial pain (Sedrez *et al.*, 2015:81). Research confirmed that postural deformities frequently occur in growing children as a result of bad postural habits over long periods of time and although most of these postural changes occur slowly, permanent deformities can be seen after a few years (Mitova *et al.*, 2014:176).

Posture is an integral component to ensure that balance is maintained during the initiation, continuance and completion of any action, thus posture serves as a reference frame for the production of correct movement patterns (Viel *et al.*, 2010:e10259; Berthoz, 1991:102). Money and Cheung (1991:1009) indicated that there exists two main postural reference frames: firstly, the exocentric reference frame, which is mainly based on visual cues from the environment and on the gravity vector, and secondly the egocentric reference frame, which can be based on either one of the following; the segments of the body which are engaged in an ongoing action, or the individual's whole body as cited by Viel *et al.* (2010:e10259). Adolescents are particularly vulnerable to injuries as there are significant changes in the biomechanical properties of bone during this age (Da Silva *et al.*, 2003:433). Injuries during childhood affect both growing bone and soft tissues, and could result in damage of the growth mechanisms with subsequent life-lasting damage (Da Silva *et al.*, 2003:433).

Brianezi *et al.* (2011:36) found that all students (n = 201) aged between seven to ten years have a tendency to postural deviations and imbalances with regards to lateral and posterior postural assessments. All the students in their study showed prevalence of more than 21.9% of postural deviations and asymmetries (Brianezi *et al.*, 2011:36), and that these postural problems are mostly associated with pain (Szeto *et al.*, 2002:83; Griegel-Morris *et al.*, 1992:29). Griegel-Morris *et al.* (1992:29) discovered that there was a direct correlation between the incidence of pain and the severity of postural abnormalities in the subjects. Postural abnormalities may be the result of incorrect movements which cause injuries to the musculoskeletal system and limit the ability to perform normal daily activities (Sweeting & Mock, 2007:405; Szeto *et al.*, 2002:83; Griegel-Morris *et al.*, 1992:30). Posture control is seen as a prerequisite for accurate performance of voluntary movements in order to limit postural abnormalities in both children and adults, thus its development merits scrutiny and study (Szeto *et al.*, 2002:83).

In this chapter, normal postural development during growth, different postural adaptations and deformities, possible causes of these postural changes, and the importance of early detection and intervention of these postural changes will be discussed.

2.2 POSTURE DEFINED

Posture is defined as the relative arrangement of bodily parts in relation to one another (Norris, 2000:134; Bloomfield *et al.*, 1994:96). Static posture refers to the maintenance and alignment of body segments in certain positions such as sitting, standing, or lying down

(Bouisset, 2008:349; Kendall *et al.*, 2005:51; Bloomfield *et al.*, 1994:101). Dynamic posture refers to the body segments when in action or anticipation of action (Bouisset, 2008:349; Bloomfield *et al.*, 1994:101).

Good posture, both static and dynamic, is an extremely important component for aesthetic appearance, but more importantly it is essential if the body is to function with an economy of effort (Bouisset, 2008:350; Sweeting & Mock, 2007:405; Bloomfield *et al.*, 1994:95). Posture is unique to every individual; no two human beings have the same posture, although some similarities can be seen when posture pictures are compared.

2.3 NORMAL POSTURAL DEVELOPMENT OVER THE COURSE OF A LIFETIME

It is important to have a clear understanding of what ‘good’ or ‘normal’ posture refers to in order to recognize postural deformities and changes (Sweeting & Mock, 2007:399; Norris, 2000:134). Good posture is defined as the balanced alignment of various body segments with one another that provides minimal stress on the human body and protects the supporting structures of the body against progressive deformity or injury. When the alignment is out of balance, stress will increase on the body segments, which causes anatomical adaptations over time (Houghlum, 2010:322; Norris, 2000:134; Bloomfield *et al.*, 1994:97). These adapted postures lead to greater physiological and biomechanical demands, which reduce balance, stability, and strength, and thus limit the use of substitute motion patterns that relieve fatigued muscles (Gallagher, 2005:58). Sweeting and Mock (2007:405) and Gluckman (1995) argued that good posture allows the human body to complete daily activities with optimal energy efficiency.

In order for the body to be both mechanically economical and functional, all body segments must be aligned to ensure minimal anti-gravity stresses (Dul & Weerdmeester, 2008:5; Bloomfield *et al.*, 1994:97). Optimal posture refers to both minimal joint loading as well as minimal muscle work. When segmental alignment is optimised, joint surface compression is reduced and therefore the force is distributed over a larger area. This will lessen the risk of degenerative changes to a joint (Norris, 2000:134; Bloomfield *et al.*, 1994:97). To ensure that the body segments are aligned, ideal posture can be described as a straight line (plumb line) that passes through the ear lobe, the bodies of the cervical vertebrae, midway through the

shoulder (acromion process), 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 anterior to the lateral malleolus of the ankle (Kendall *et al.*, 2005:60). In this position (Figures 2.1 A and B), where all the body segments are aligned, the minimum amount of stress is applied to each joint in the body.

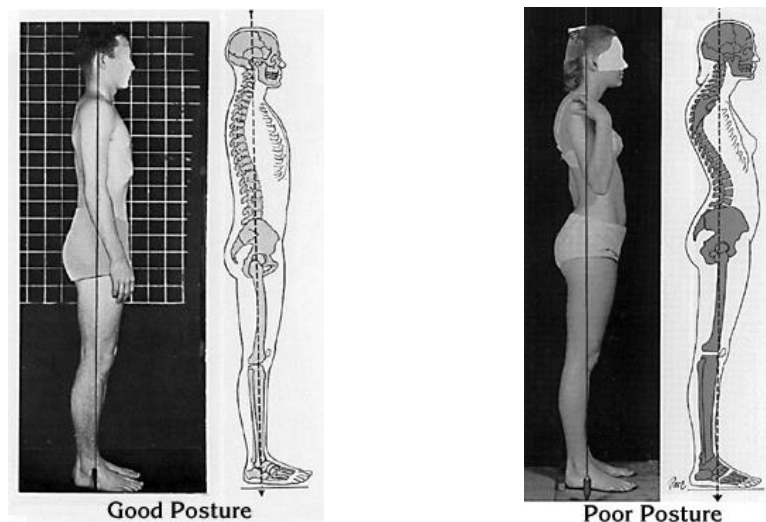


Figure 2.1: Ideal posture (A); Poor posture (B) (Kendall *et al.*, 2005:60, 66).

Illingworth (2012:92) summarised a few principles for normal postural development. Firstly, Illingworth (2012:92) stated that development is a continuous process which starts at conception and continues until maturity is reached. Secondly, the stages of development are consistent in all children, although the rate of development will vary considerably. Thirdly, development is directly linked to the maturity of the nervous system. This means for example, that a child will not be able to crawl or walk until the nervous system is ready for it. Lastly, certain automated movements need to be degraded in order for similar movement to become voluntary (Illingworth, 2012:93).

2.3.1 Curvatures of the spine

In a normal human spine there are four types of spinal curvatures which play a critical part in normal balance, flexibility in the spine, and stress absorption and distribution during daily activities (Bridwell, 2015). The cervical curvature is lordotic, thus the curvature is convex in the anterior direction. It is known as the least marked vertebral curvature and extends from the atlas to the second thoracic vertebra (C1-T2) (Willner & Johnson, 1983:876). The normal

range for the cervical lordotic curve is 20-40° (Bridwell, 2015), while McAviney *et al.* (2005:193) reported a clinically normal range for cervical lordosis to be between 31-40°.

The thoracic curve is kyphotic, in other words the curvature is concave in the anterior direction, and it extends from the second to the twelfth thoracic vertebrae (T2-T12). Mac-Thiong *et al.* (2004:1642) reported that the mean value for thoracic kyphosis is 43°, while Bridwell (2015) and The Scoliosis Research Society (Wenger & Frick, 1999:2630) defined the normal range for thoracic kyphosis to be 20-40°. Stricker (2002:135) and Fon *et al.* (1980:982) reported similar values. This angle was measured between the superior endplate of T2 and the inferior endplate of T12 (Leroux *et al.*, 2000:1689). The lumbar curve is naturally lordotic and has a greater magnitude in females. Anatomically (Figure 2.2) it extends from the twelfth thoracic vertebra to the lumbosacral angle, with an increased convexity to the last three segments (Davis, 1959). Normal range for lumbar lordosis is 25-60 degrees and is measured between the inferior endplates of T12 and the inferior endplates of L5 (Stricker, 2002:135; Leroux *et al.*, 2000:1689; Fon *et al.*, 1980:982) while Bridwell (2015) reported normal values of 40-60° and Harrison *et al.* (1996:667) 16.5-66°. In another study Mac-Thiong *et al.* (2004:1642) stated the mean value for the lumbar curve was 41.2°.

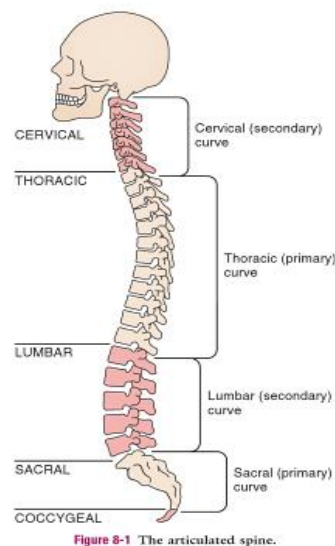


Figure 2.2: The articulated spine (Magee, 2002:874).

There should be a straight spine, or only slight kyphosis, at the junction of the thoracic and lumbar spine. Thoracic kyphosis normally has an apex at the T6-7 (thoracic vertebrae 6-7) level, while the apex of lumbar lordosis generally is at the L3-4 (lumbar vertebrae 3-4) level (Bernhardt & Bridwell, 1989:717).

2.3.2 Age-related changes in posture

Each stage during growth, from birth to death, has its classical posture picture of normal development (Figure 2.3) and, therefore should be considered when posture is evaluated (Lincoln & Suen, 2003:312). Research indicates that a child's posture may change significantly as they grow and reach different stages of development (Cil *et al.*, 2005:99; Mac-Thiong *et al.*, 2004:1646). During growth individuals develop bad habits, including abnormal sitting and standing positions, and changes occur in normal gait patterns. These changes predispose individuals to poor posture (Brianezi *et al.*, 2011:36).

Research suggests that healthcare professionals have to be very discreet when concerns are raised about a child's posture (Lincoln & Suen, 2003:312). Lincoln and Suen (2003:312) stated that a clear understanding of the normal range of spinal alignment and curvatures, as well as postural characteristics at different stages of growth and development, are necessary to diagnose postural deformities during childhood. Zagyapan *et al.* (2012:5) confirmed these findings when emphasising the importance of postural analysis in order to correct postural deformities.

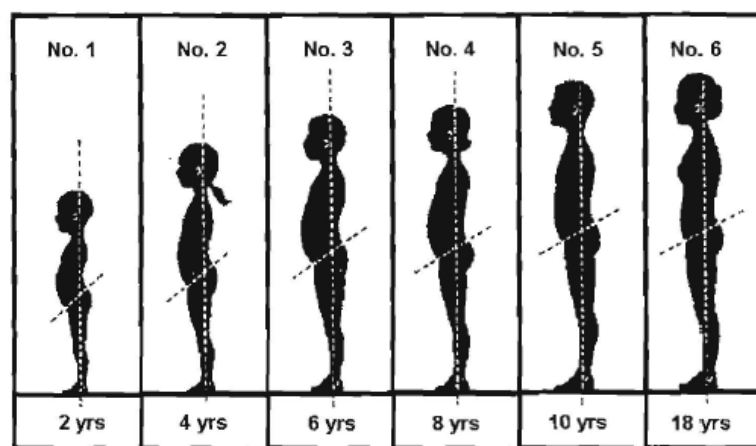


Figure 2.3: Posture at different ages (Magee, 2002:874).

Infants (0-1 year)

As a result of the intrauterine position (position of the foetus inside the uterus), rotational forces will affect the child's lower limbs. These forces mould lower limb alignment and have a direct link to the child's ligament laxity. This implies that more laxity equals less force applied on the growing epiphysis (Huelke, 1998:103; Scougall, 1977:21). The resulting

characteristics of the infant's posture includes: hips and knees flexed, hips easily over abducted, long heel cords, feet turned in and greatly relaxed, and a marked toe-grasping reflex. Due to all of these postural characteristics, this is often referred to as 'slack jointed' posture (Scougall, 1977:21). It is normal for infants to have an average hip external rotation of 70° (range, 45-90°) and internal rotation of 40° (range, 10-60°) (Lincoln & Suen, 2003:313).

Magee (2002:873) stated that the entire spine of a newborn baby is flexed (concave forward). Primary curves are found at birth, which include the curves of the thoracic spine and sacrum (Magee, 2002:873; Bloomfield *et al.*, 1994:96). The single most important function of the primary curves is to maintain the original spinal position. During maturation secondary curves develop in order to form normal extension in the spine (convex forward) (Magee, 2002:873). When the infant is mature enough to hold the head up (normally at the age of three months), the cervical part of the spine becomes convex forward, resulting in the normal cervical lordosis. From six to eight months of age, the infant will sit up and start to walk; hence these progressive changes will result in the development of the secondary curve in the lumbar spine (lumbar lordosis) (Dickson, 2004:411; Magee, 2002:873). McCoy and Dickens (1997) found that most one-year-old children do not show correct heel strike during the onset of walking, thus flat footed posture can be seen.

Toddlers (1-3 years)

As the child grows, certain changes in posture will be evident, for example, the changes in knee posture. From infancy to 18 months of age, the knees are slightly bowed (genu varum), whereas the position of the knees will change to becomes slightly knock kneed (genu valgum) until the child reaches the age of three years (Magee, 2002:873). Between 10-18 months children stand with confidence and start to walk. Most children in this age group will show normal heel strike and have outstretched arms to improve balance (McCoy & Dickens, 1997). Normal posture at this age will include lumbar lordosis, flat feet, and a wide base of support and external rotation of the legs, which increases stability (McCoy & Dickens, 1997; Scougall, 1977:22). McCoy and Dickens (1997) also stated that posture patterns remain consistent in both boys and girls in this phase of growth.

Preschool age (3-5 years)

During this phase, genu valgum (knock knees) will continue in the lower limbs (McCoy & Dickens, 1997; Bloomfield *et al.*, 1994:96). A normal preschool child has the ability to alternate legs when going up and down stairs (Watson & Lowrey, 1962:103). Sherrill

(1993:378) stated that the normal preschool child has excessive lumbar lordosis (exaggerated lumbar curve). This prominent curve in the lumbar spine is the result of a small pelvis, large abdominal contents, also known as a protruding abdomen, and weakness of the abdominal muscles at this age (Kendall *et al.*, 2005:97; Magee, 2002:874). As the child grows, most children develop a medial longitudinal arch in their feet. This is usually seen at ages four to five years as children in this growth stage are no longer flat-footed (Magee, 2002:874). Research also indicates that most African children have flat feet during this phase, but in this case it is genetically and culturally normal for them (McCoy & Dickens, 1997). According to Schafer (1987) lateral balance is maintained by means of tibial torsion during this phase.

School ages (6 years and older)

In the child, the centre of gravity is at the level of the twelfth thoracic vertebra (T12) and as the child develops and grows older, the centre of gravity drops until it reaches the level of the second sacral vertebra (S2) in adulthood. The level of the centre of gravity is usually slightly higher in males (Magee, 2002:874).

Between ages six to nine years old, most children gain nearly 10% of their total body weight and grow around 5cm a year (Brower & Nash, 1999:58). This growth rate is not consistent in all children, as it is dependent on factors such as health status, heredity, and environment (Brower & Nash, 1999:58). During this phase, fat tissue and the muscular component (muscle) are not fully developed in children. Brower and Nash (1999:58) refer to a specific postural appearance, namely 'spindly' and 'knobbed knee' for children in this phase of growth. The slimming-down process continues until the child reaches the age of ten years, when boys increase in stature and weight at a slower rate than girls.

Schafer (1987) stated that the child's posture is one of extreme mobility during the early years of school. During growth, the legs should naturally straighten by the age of six and at seven to eight years, the knock knee posture will be corrected (McCoy & Dickens, 1997).

Apparent kyphosis may cause scapular winging at age six to eight years (Magee, 2002:874). Schafer (1987) stated that a mild swayback posture during the developmental stages is normal and should not be confused with a postural deviation. Other research also indicates that scapular winging at about eight years is normal for children (Kendall *et al.*, 2005:79). The lumbar area is usually lordotic, but may lean back sharply from the lumbosacral area

(Schafer, 1987). Widhe (2001:119) also established an increase in lordosis and kyphosis during this stage.

According to Kendall *et al.* (2005:76) the dominant side will show a slightly higher hip and a slightly depressed shoulder, which leads to mild asymmetry. This is of extreme importance as these normal postural changes should not be mistaken for symptoms of scoliosis during early childhood. On the other hand, some research indicates that symmetry in the body remains normal during growth (Brower & Nash, 1999:60).

From the ages nine to twelve years a child's growth pattern is seen as stable, although weight gain still continues. Posture is erect, with narrow shoulders and hips (Brower & Nash, 1999:60; McCoy & Dickens, 1997). The continuance of growth and development will result in lessening of lordosis and flattening of the abdomen as the pelvis starts to rotate posteriorly (Brower & Nash, 1999:58). It is normal for boys to be taller than girls as they reach school age (6 years and older), but when girls reach puberty (eleven or twelve years), this trend reverses and girls grow at a faster rate than boys (Brower & Nash, 1999:58).

Normal growth spurt will occur earlier in girls in comparison to boys (Brower & Nash, 1999:58). Between eight and fourteen years of age females enter puberty, while males enter puberty between nine and a half and sixteen years of age. Puberty lasts for about three years in females and up to five years in males (Magee, 2008:974). During adolescence children mostly look (as if they are) all arms and legs, although most of the growth actually occurs in the trunk. It is among these changes that children will start to assume the body structure and somatotypes they will have for the rest of adulthood (Brower & Nash, 1999:58). Differences arise between boys and girls during this period of growth, with boys tending toward broader shoulders, smaller hip width, longer leg and arm length and greater overall skeletal size and height than girls (Magee, 2008:974). It is normal for children, especially boys, to appear ungainly and have poor postural habits, due to the rapid growth spurt and postural changes during this phase (Magee, 2008:974).

2.4 TYPES OF POSTURAL DEVIATIONS

Postural deviation refers to any deviation from the ideal posture (Grimmer *et al.*, 2002:10). These deviations and forms of poor posture occur in all categories of life, and according to statistics, the prevalence is increasing (Shultz *et al.*, 2010). There are numerous causes of postural deformities and adaptations in children, such as: scoliosis, postural round back

(kyphosis), and lumbar lordosis are the most prevalent (Keith, 2009). Loveless (1999:227) argued that a clear understanding of the individual's medical history (examination, diagnosis, potential treatment, etc.) is needed to ensure appropriate interventions given by healthcare professionals.

Postural deviations are mostly associated with the spine, but research confirms that these deviations also affect other bodily parts such as the feet, knees, shoulders, etc. (Trew & Everett, 2001). Purenovic (2007:150) found that muscles become shortened or lengthened in position if body segments are held in abnormal positions or out of alignment for extended periods of time. This will directly affect muscle efficiency, and will predispose individuals to develop musculoskeletal, pathological, and neurological conditions (Brianezi *et al.*, 2011:36; Purenovic, 2007:150). Abnormal changes in body curves might cause uneven pressure on the joints, bones, muscles and ligaments (Trew & Everett, 2001). Degenerative changes will occur if early intervention does not happen, leading to postural deviation (Hrysomallis & Goodman, 2001:389).

Previous studies confirm that postural changes and adaptations in young children are a tremendous concern. Jankowicz-Szymanska *et al.* (2010:47) found that 34.53% of primary schoolchildren had been diagnosed with faulty postures. The most common posture deformities included: flat feet 11.5%, kyphosis 5.8%, and scoliosis 25% (Jankowicz-Szymanska *et al.*, 2010:47). Penha *et al.* (2008:389) stated that the most common postural abnormalities found in children assessed were winged scapula, shoulder and head protraction, shoulder imbalance and cervical hyper lordosis.

General postural deviations that will further be discussed in this chapter and for the purposes of this study include: forward head, forward (protracted/rounded) shoulders, kyphosis, scoliosis, lordosis (anterior pelvic tilt), swayback, posture, and flat feet.

2.4.1 Forward head

Forward head posture (FHP) is a common type of postural deviation, seen in the sagittal plane, and defined as the protraction of the head to such an extent that the head is placed anterior in relation to the trunk (Silva *et al.*, 2009:44; Yip *et al.*, 2008:153). According to Silva *et al.* (2009:51) the following will result in FHP: anterior translation of the head, lower cervical flexion, and a higher degree of cervical extension. Research by Lynch *et al.* (2010:380) indicates that FHP can also be linked to shortening of the posterior cervical

extensor muscles, the sternocleidomastoid muscle, the levator scapulae muscle, and the upper trapezius. Ideal head posture can be characterised as the head not being tilted laterally (left or right), posteriorly (extended), anteriorly (forward or retracted), or rotated in any direction (Kendall *et al.*, 2005:61), thus FHP is diagnosed when the earlobe and the tip of the shoulder (mid part of the acromion) is no longer aligned (Sherrill, 1993:374).

2.4.2 Forward (protracted) shoulders

Strength imbalance of the anterior shoulder muscles which pull the shoulder forward can result in protracted shoulder posture (Rupp *et al.*, 1995). From a clinical perspective, the protracted shoulder posture is commonly known as ‘round shoulders’ and has been associated with shoulder pain in athletes, workers, and the elderly (Fernández-de-las-Penãs *et al.*, 2006:671; Kibler, 1998:336;).

Research states that the protracted shoulders posture may reduce the available impingement-free range of elevation, narrows the sub-acromial space in the shoulder, and increases strain on the anterior band of the inferior glenohumeral ligament during abduction-external rotation (Fernández-de-las-Penãs *et al.*, 2006:670; Kebaetse *et al.*, 1999:348; Kibler, 1998:336).

2.4.3 Kyphosis

Kyphosis can be defined as the excessive curvature or abnormal hyperflexion in the thoracic spine, when viewed from the lateral side (Davis *et al.*, 1995:130), thus it is an exaggeration of the normal posterior curve (Kendall *et al.*, 2005:G-3). This postural deviation can be characterised by an increased thoracic curve, hump back and protracted scapulae which result in the round shoulder appearance (Kendall *et al.*, 2005:G-3; Arnheim & Prentice, 2000:708; Boachie-Adjei & Lonner, 1996:885). Banfield (2000:56) stated that kyphosis is a common postural deviation among young children, mostly due to poor posture. The main causes of kyphosis are tight pectoral muscles and weak trapezius and rhomboids (Davis *et al.*, 1995:130). Sherrill (1993:375) found that kyphosis is very often associated with FHP.

Kyphosis can be divided into three categories (Dommissse, 1998:49), namely:

Congenital kyphosis

Congenital kyphosis can be defined as an abnormal development in the spine. A bone bar may develop between two vertebrae or the bones may not develop and form normally. As a

child grows, this will result in progressive kyphosis. Studies have found that children who are born with spina bifida usually have congenital kyphosis (Dommissie, 1998:49; Boachie-Adjei & Lonner, 1996:885).

Postural kyphosis

Postural kyphosis is a non-structural, functional deformity and is associated with a defect of the epiphyseal area of the vertebrae or of the intervertebral discs, thus it does not involve the ossification of vertebral bodies (Dommissie, 1998:49). The onset of postural kyphosis is during the late juvenile period, usually nine to twelve years (Dommissie, 1998:49). This form of kyphosis is the result of poor posture, such as slouching. The natural curve of the spine will increase as a result of stretched spinal ligaments. This postural deviation is usually seen with a flattened appearance of the anterior thoracic wall, also known as flat chest (Sherrill, 1993:384). Stricker (2002:136) and Sherrill (1993:374) reported that postural kyphosis is in most cases not progressive and can easily be corrected with intervention.

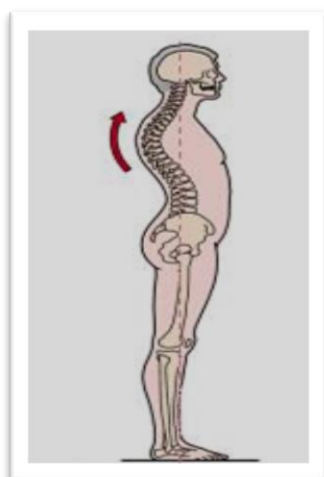


Figure 2.4: Round back form of kyphosis
(Magee, 2002:1026).

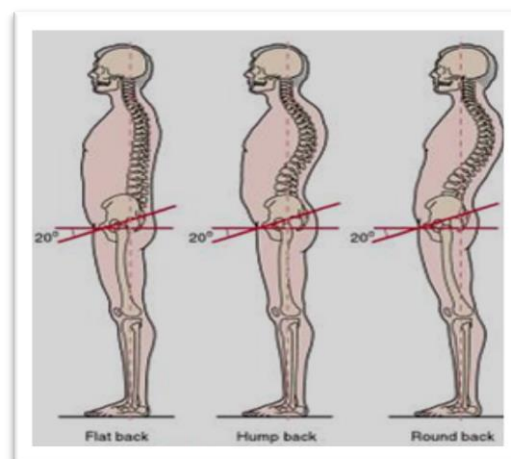


Figure 2.5: Examples of kyphosis
(Magee, 2002:1025).

Scheuermann's disease /Juvenile kyphosis

This type of kyphosis is related to the abnormal development of the vertebrae in the spine. The vertebral bodies in a subject with this disease are wedge-shaped, instead of rectangular-shaped, as seen in normal subjects (Dommissie, 1998:49). Scheuermann's disease involves the secondary ossification centres of the vertebral bodies and starts to develop with the onset of adolescence. This deformity can be seen at thoracolumbar and mid-thoracic levels

(Dommissie, 1998:49) and is commonly known to cause lumbar or thoracic kyphosis (Arnheim & Prentice, 2000:708). In the literature Scheuermann's disease is a structural deformity defined by anterior vertebral wedging greater than 5 degrees that involves three or more contiguous thoracic vertebrae in the spine (Loder, 2001:226; Wenger & Frick, 1999:2630). The area that is most affected in the spine extends from T6-T11/T12 (Dommissie, 1998:49). Most studies suggest that the main causes of Scheuermann's disease are due to genetic and mechanical factors (Stricker, 2002:135).

2.4.4 Scoliosis

Scoliosis is a general term used to describe any lateral curvature in the spine (Kendall *et al.*, 2005:107; Zabjek *et al.*, 2005:483; Stedman, 2000:1606). The curvature of the spine can either be S-shaped, which will imply that it is a structural deviation, or C-shaped, meaning that it is a functional deviation (Davis, 1995:131).

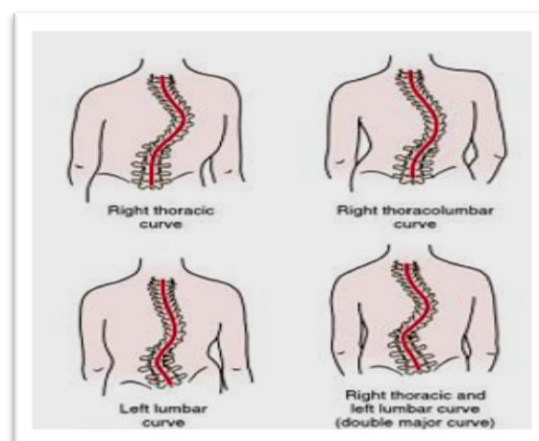


Figure 2.6: Examples of scoliosis curve pattern (Magee, 2002:516).

Causes of these scoliotic curves are classified as either structural or non-structural (Brox, 2003:649; Magee, 2002:880). In structural scoliosis, changes and intervention regarding posture cannot correct the deformity in the spine (Pope & Keller, 2014; Brox, 2003:649). Structural scoliosis can be the result of an injury, neuromuscular diseases (such as cerebral palsy, poliomyelitis, or muscular dystrophy), birth defects (such as hemi vertebra in which one side of a vertebra fails to form normally before birth), metabolic or connective tissue disorders, rheumatic diseases, certain infections, tumours or unknown factors (Anon, 1998). Spinal rotation or vertebra rotation is usually present in subjects with structural scoliosis and this deformity has the ability to progress considerably during growth (Dickson, 2004:412).

Magee (2002:880) stated that characteristics of structural scoliosis include the lack of normal flexibility, lateral bending becomes asymmetric, and the curve does not disappear on forward flexion.

Idiopathic scoliosis is the most common cause of structural scoliosis (Negrini *et al.*, 2012:4; Dickson, 2004:412) and 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 (Grivas *et al.*, 2008:35; Dickson, 2004:415; Brox, 2003:649). Filipovic and Ciliga (2010:16) stated that idiopathic adolescent scoliosis is enigmatic, seeing that this deviation is generally found in students and young individuals. The real cause of idiopathic adolescent scoliosis has not been defined yet, thus it is referred to as *idiopathic* (Filipovic & Ciliga, 2010:16). Idiopathic scoliosis can develop in various age groups namely, infantile (0-3 years), juvenile (3-10 years) and adolescent (>10 years) (Negrini *et al.*, 2012:6; Loveless, 1999:228).

Magee (2002:880) defined non-structural scoliosis as a temporary, changing curve in the spine with no structural deformity present. There is no bony deformity and, therefore, the scoliotic curve will disappear on forward flexion. Non-structural scoliosis is not progressive and is usually found in the lumbar, thoracolumbar, or cervical area of the spine (Pope & Keller, 2014; Magee, 2002:880). The causes for non-structural scoliosis include bilateral muscle imbalances, leg length discrepancies, poor postural habits, pelvic and spinal misalignments and joint subluxations (Arnheim & Prentice, 2000:709). This form of scoliosis is mostly found in the lumbar area of the spine (Dickson, 2004:411). Children and adolescents are commonly diagnosed with the pelvic tilt scoliosis caused by leg length differences.

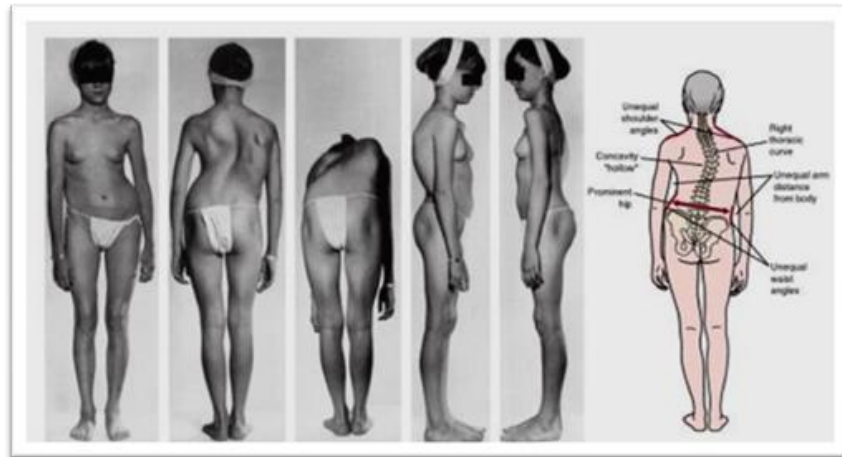


Figure 2.7: Idiopathic structural right thoracic scoliosis. Line drawing shows the prominent features of scoliosis (Tachdjian, 1972)

2.4.5 Lordosis

Lordosis can be defined as an increased anterior curve of the spine, usually found in the lumbar region. This postural deviation is usually associated with an anterior pelvic tilt (Kendall *et al.*, 2005:70). Davis *et al.* (1995:129) described lordosis as an exaggerated hyperextension of the lumbar spine. Lordosis does not only affect the five lumbar vertebrae (L1-L5), but will also cause malalignment of the pelvis (Sherrill, 1993:375). Literature states that the causes of increased lordosis include: weak muscles, lax muscles, tight muscles, postural deformity or adaptations (for example excessive weight gain), spondylolisthesis and fashion (wearing high-heeled shoes) (Magee, 2002:876-877). Characteristics of lordosis include: weak abdominal muscles, which result in an anterior pelvic tilt, weak hamstrings, and gluteus muscles, causing the inability to counteract the anterior pelvic tilt, lax abdominal muscles, tight and over developed hip flexors, and lumbar extensors forcing the pelvis into the anterior tilt (Magee, 2002:876, Sherrill, 1993:375). It is possible to find subjects where lordosis is combined with kyphosis and a forward head posture. In this case the term ‘kypho-lordosis’ will be used (Arnheim & Prentice, 2000:708). Kypho-lordosis can be described as the combined exaggeration of both spinal regions (thoracic and lumbar) and in general one will be compensating for the other (Davis *et al.*, 1995:130). Studies indicate that lordosis is usually associated with an exaggeration of the lumbar curvature in subjects (Arnheim & Prentice, 2000:708).

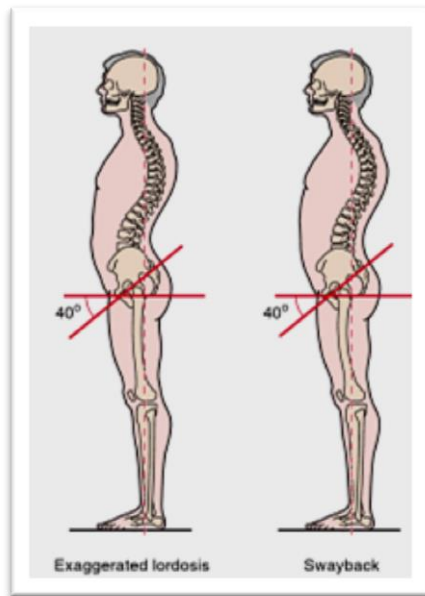


Figure 2.8: Examples of lordosis
(Magee, 2002:1023)

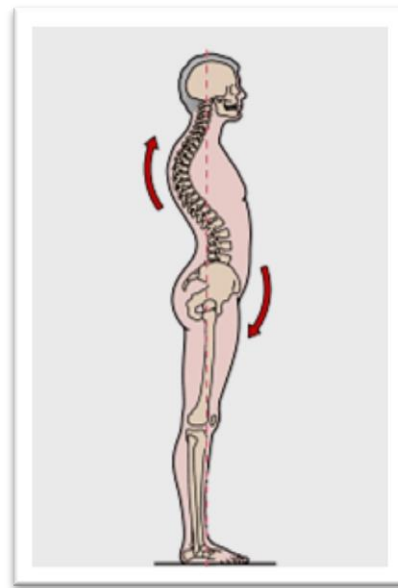


Figure 2.9: Kypho-lordotic posture (Magee, 2002:1023).

2.4.6 Swayback posture (hip sway)

With a swayback deformity, kyphosis can be seen in the thoracolumbar spine and there is an increased anterior pelvic tilt visible to approximately 40° . With this postural deformity the hips move into extension as a result of the entire pelvis shifting anteriorly. The thoracic spine will flex on the lumbar spine to maintain normal centre of gravity and this will cause an increase in the lumbar and thoracic curves. Swayback posture may be associated with tightness of the lower lumbar and hip extensors, as well as the upper abdominals, along with weakness of the lower abdominals, the hip flexors, and the lower thoracic extensors (Magee, 2002:877).

2.4.7 Flat feet (pes planus)

Flat feet can be described as flattening of the longitudinal arch of the foot when standing or walking (Akcali *et al.*, 2006:1053). In general this postural deviation is categorised as a flexible deformity, thus, with intervention, the flat arch can be corrected. In extreme cases not only flattening of the longitudinal arch is present, but also abduction of the fore foot and eversion of the heel (Jackson & Stricker, 2003:139). The main cause of flat feet is laxity in the ligaments. Due to the inability of the ligaments to support the foot, the ligaments will stretch during weight-bearing activities (Jackson & Stricker, 2003:139). Research suggests that flat feet may be postural or congenital (Sherrill, 1993:390). Congenital flat foot is not

considered as a postural deviation, when there are no alignment problems visible during a postural assessment and both muscles of the leg and foot are strong enough (Sherrill, 1993:390).

2.5 FACTORS CONTRIBUTING TO POSTURAL DEVIATIONS & ADAPTATIONS

The determinants of an individual's posture are directly linked to the position of the bony landmarks, the structure and size of bones, static and dynamic living habits, injury or diseases, and the individual's psychological state (Bloomfield *et al.*, 1994:98). Postural changes during childhood can be influenced by both intrinsic and extrinsic factors such as emotional factors, heredity, socioeconomic level, level of physical activity, the environmental and physical conditions under which the child lives, and physiological abnormalities due to human development and growth (Penha *et al.*, 2008:387).

Poor posture may cause emotional and muscular problems, which could result in postural deviations (positional or structural) if the individual remains in inappropriate positions (static or dynamic) for a long period of time (Knoplich, 2003). During the first year in school, children develop certain morphological and functional deviations, as a result of inappropriate postural adaptations (Kosinac, 2008). These changes will result in the loss of the individual's normal body posture (Ilic, 2012).

During the last decade, the environment of children has drastically changed worldwide, resulting in unhealthy dietary habits and sedentary behaviour (Ahrens *et al.*, 2006:306). There is a growing concern that the current behaviour of children may result in a higher prevalence of postural deformities and accelerate lifestyle-related diseases (Ahrens *et al.*, 2006:306). Children prefer to surf the internet, play video games, and watch television instead of engaging in more physically active leisure activities (Salmon *et al.*, 2005:8; Tremblay & Willms, 2000:1461). The concern remains that sitting for long periods of time can result in different types of body postures due to postural changes (Murphy *et al.*, 2004:116). Research indicates that musculoskeletal pain in school-aged children may be the result of improper workstations. The workstations are designed in such a way that children sit with their neck, back and trunk rotated or flexed for long periods of time, therefore, it is clear that children sit through most lessons with inadequate posture (Lis *et al.*, 2007:296; Saarni *et al.*, 2007; Murphy *et al.*, 2004:116;). Static postural changes are a result of a sedentary lifestyle while children are in school (Guedes *et al.*, 2001:198). Nural (2009:46) divided universal factors

that influence the incidence of musculoskeletal pain in schoolchildren into three groups, namely, a heavy schoolbag (weighing more than 10% of body weight), a workstation design that does not suit human body dimensions, and incorrect sitting posture, which is mainly the responsibility of the individual. Children spend approximately 30% of their time in school (mostly seated), thus the school environment, workstation and postural habits at school are important factors with regard to musculoskeletal pain (Mohd *et al.*, 2010:435; Nural *et al.*, 2009:46).

Research indicates that postural deviations can commonly be caused by placing an excessive load on the back, as occurs when carrying a backpack at school (Grimmer *et al.*, 2002:9). In addition to the weight of a heavy backpack, its placement on the student's back may also contribute to postural deviations (Devroey *et al.*, 2007:741; Fiolkowski *et al.*, 2006:891; Talbott, 2005:125). The material carried in backpacks, the weight of this material, school furniture, and body composition, among other factors, are all verifying factors for the high prevalence of postural problems in school (Al Kalaf, 2011:170). Efforts have been made over the last few years to set a norm for safe backpack load limit for students, but due to inconsistent results from various studies, universal safe backpack load limits for school-aged children remain elusive (Lindstrom-Hazel, 2009:337). Research shows that, in general, an acceptable load limit for students is between 10-15% of their body weight (Brackley & Stevenson, 2004:2187), while other studies have suggested that safe limits for backpacks should not exceed 10% of a child's body weight (Kistner *et al.*, 2012:106; Bauer & Freivalds, 2009:349; Mohan *et al.*, 2007). Despite these findings, most students carry more than 15% of their body weight (Negrini & Carabalona, 2002:193; Pascoe *et al.*, 1997:638) and therefore school-aged children are more vulnerable to injury and adaptations as they still need to grow and develop mature musculoskeletal systems. Studies related to safe backpack loads were not only related to the changes in posture, but also to direct effects of the load in the backpack on children, such as oxygen consumption, blood pressure, energy consumption (Hong *et al.*, 2000:726), heart rate (Bauer & Freivalds, 2009:346; Hong *et al.*, 2000:725; Hong & Brueggemann, 2000:258), cardiorespiratory function (Daneshmandi *et al.*, 2008:13), and gait pattern (Hong & Brueggemann, 2000:257). Researchers also found that the position of the backpack affects the spinal muscles of the child and therefore affects posture in both children and adults (Devroey *et al.*, 2007:741; Fiolkowski *et al.*, 2006:893; Grimmer *et al.*, 2002:9). It remains difficult to recommend the best location on the back on which the backpack should be placed, but the best evidence suggests that the backpack should be positioned with its

centre at waist or hip level (closer to the centre of body mass). Furthermore, research suggests that increased backpack loading can be the main cause of the changes and adaptations in thorax, pelvis, and hip angle (Devroey *et al.*, 2007:741).

Brink *et al.* (2015:824) found that increased head flexion in adolescents was associated with seated-related upper quadrant musculoskeletal pain. These changes developed within six to twelve months in adolescents who engaged in computing studies at school (Brink *et al.*, 2015:824). Andersen *et al.* (2011:9) found that there is an association between upper quadrant musculoskeletal pain and computer use, while other research indicated that computer use was linked to neck pain (Straker *et al.*, 2006). Computer use may also alter habitual sitting posture during adolescence (Straker *et al.*, 2007:642). Brink *et al.* (2015:825) stated that extreme head flexion postures, where the eye is positioned lower than the ear, should be avoided in computing adolescents. This will reduce the risk of developing upper quadrant musculoskeletal pain over a period of time (Brink *et al.*, 2015:825).

Niosh (1997:3-25) stated that there are other extrinsic risk factors which should not be overlooked, such as repetitive overhead use (>60° of shoulder elevation), sustained overhead work, and higher loads raised above shoulder height, which can be the main cause of shoulder pain. Furthermore, the use of high-heeled shoes has become an increasingly common habit among adolescents (Teixeira, 2001). The main concern regarding high-heeled shoes is that it can trigger several changes in postural alignment, particularly in the spine and lower limbs (Teixeira, 2001). These changes in posture will include the following: forward head posture, pelvic anteversion, lumbar hyper lordosis, and valgus knee. Standing in high-heeled shoes causes immediate and temporary postural changes because of the modification of the centre of gravity (Pezzan *et al.*, 2009:620). The body will go back to its original conformation as soon as the heels are removed. However, studies (Bertoncello *et al.*, 2009:111; Kerrigan *et al.*, 1998:1401) have demonstrated the permanence of these postural changes with the excessive use of this type of shoe. The increased usage of high-heeled shoes tended to increase both pelvic anteversion and hyper lordosis (Pezzan *et al.*, 2009:620). Pezzan *et al.* (2009:620) stated that postural imbalance can bring negative repercussions when it affects adolescents.

Auvinen *et al.* (2010:648) found that insufficient sleep time, six hours or less per night, predisposed individuals to neck and lower back pain. Paananen *et al.* (2010:398) reported the same, stating that individuals are predisposed to postural changes when sleeping less than

seven hours per night. Sleeping in a prone position resulted in a higher incidence of postural changes in the sagittal plane, while the supine sleeping position tends to cause scoliosis (Vasconcelos *et al.*, 2010:377). The adequate time of sleep per night, approximately eight hours, may be considered a good starting point to prevent the development of postural changes while sleeping, which is in agreement with the findings by Auvinen *et al.* (2010:645) who recommended eight to nine hours of sleep per day.

Postural adaptations can also be the result of a lack of proper orientation and education on the nutritional quality of students, as well as the quality of life and specific guidance on posture during the development and growth of the individual (Andrew & Sullivan, 2010:360; Ascher, 1976). According to Gallahue and Ozmun (2003), several factors (including nutritional deficiencies and excesses, serious illness and prolonged acute and chronic effects of exercise on levels of low and high intensity), can modify the normal development process and can influence growth patterns and have lasting effects on a child's posture. These restricted or abnormal postures can also be adopted during the performance of daily activities (Gallagher, 2005:59).

2.5.1 The effect of gender and different cultures on posture

Research confirms that the postural responses to daily demands differ according to the individual's skeletal maturity and gender (Widhe, 2001:122; Grimmer *et al.*, 1999:2265). Wang *et al.* (2004:1701) suggests that sex hormones play a major role in bone development during adolescence and bone maintenance later in life. Physical differences arise between boys and girls during this period, with boys tending toward broader shoulders, smaller hip width, longer leg and arm length and greater overall skeletal size and height than girls (Magee, 2008:974).

In girls the ovaries start to produce estrogen and progesterone which begin the bodily changes that happen during puberty. The changes during this phase, known as secondary sexual characteristics, are (Sisk & Zehr, 2005:164):

- Menstruation starts
- The ovaries start to produce eggs
- The breasts develop
- The hips and thighs widen
- Pubic and underarm hair develop

In boys the testes start to produce testosterone which begins the development of secondary sexual characteristics (Sisk & Zehr, 2005:164). These changes include:

- Sperm are produced
- The genitals develop
- The body become more muscular
- The voice breaks
- Hair grows on the face and the body

During a study on young children in Brazil (77 boys and 114 girls, aged 7-10 years) there were gender-specific differences in some of the postural abnormalities analysed (Penha, 2008:389). The boys had higher incidences of head protraction and cervical hyper lordosis, winged scapula, shoulder imbalance and protraction than the girls, while the latter had higher incidences of head tilt and greater Schöber values (Schöber's test was used to measure lumbar spine flexibility) (Penha *et al.*, 2008:389). Cho (2008:227) found that there was a gender difference regarding forward head posture. Male students showed a higher prevalence of forward head posture than female students. Forward head posture is a typical result of computing, therefore it was suspected that the male students may spend more time in front of the computer when compared to their female counterparts (Cho, 2008:227). Differences in orthostatic balance and postural response relating to gender, skeletal maturity, muscle recruitment, and spinal development level have previously been reported (Mouzat *et al.*, 2004:11; Chansirinukor *et al.*, 2001:115). Some authors have shown that women have better orthostatic equilibrium than men, seeing that the inner feet distance generally ranges from 10-20 cm, and the angle between the feet mostly ranges from 15-45° in women (Mouzat *et al.*, 2004:10). Gender differences exist in postural stability of children that vary depending on their age. Several papers have noted that girls exhibit less postural sway than boys of similar ages (Lee & Lin, 2007:177; Demura *et al.*, 2006:161; Geldhof *et al.*, 2006:785; Steindl *et al.*, 2006:481). Brianezi *et al.* (2011:36) reported in their study on 201 children (aged 7-10 years) in Sao Paolo, Brazil, that all schoolchildren (both girls and boys), have some kind of diversion or postural asymmetry. Lordosis and kyphosis in boys was higher compared to

girls, however, the presence of scoliosis was higher in girls compared to the boys (Brianezi *et al.*, 2011:36).

Dunk and Callaghan (2005:1107) reported that men and women (mean age 24.8 years) adopted different postural alignments when in a seated position at work, especially when assessing the spine and pelvis posture. Female participants sat with less lumbar flexion, very little trunk flexion, and had more rotation in the pelvis (anteriorly) in comparison to the male participants. The most significant gender differences in position were observed in an office chair with back support. Dunk and Callaghan (2005:1107) found that females perched closer to the front of the seat pan, while men tended to rather lean against the back support of the chair. Both men and women showed similar results when compared in different categories. The most lumbar flexion was observed in all participants when tasks were conducted on a computer using a “mouse”, while the least lumbar flexion was observed while typing on the computer, regardless of the chair used (Dunk & Callaghan, 2005:1107).

In some tropical countries mothers encourage infants to stand and walk at a very early age hence exercising their children's legs, in addition to which ambulation is further facilitated by not wearing any shoes or clothes (Torun & Viteri, 1994:188). The question of whether this could be a possible reason for Africans having longer legs than Europeans has been raised. According to Stroebel *et al.* (2009:127), African South African boys (aged 11-13 years) compared to Caucasian South African boys demonstrated a significantly higher prevalence rate in kyphosis, lordosis, winged scapula, and protruding abdomen.

Research on Chinese adolescents in Taiwan indicated that the competitive nature of high school studies made the physical pressure and psychological distress encountered by the adolescents high (Cho *et al.*, 2003:346). Due to the underlying pressure, high school students tend to show some faulty postures such as hyper lordosis, kyphosis, and scoliosis (Lee & Chen, 1998). High psychological distress during adolescence may be a contributing factor to the musculoskeletal pain and discomfort of adolescents (Cho *et al.*, 2003:350). According to Lee and Chen (1998:8) cumulative effects might occur if a certain posture has been maintained for a long period. These faulty postures might result in different musculoskeletal symptoms such as pain, soreness, and tingling (Lee & Chen, 1998:8).

2.6 POSTURE AND HEALTH

Keith (2009) stated that postural deviations, which are as a result of poor posture, usually begin during childhood. Poor posture can lead to pain, fatigue, poor muscle tone, low self-esteem, muscular tension, sagging of some body parts (Bloomfield *et al.*, 1994:103), and be the most important contributing factor for musculoskeletal pain such as shoulder, neck and lower back pain (Larsson *et al.*, 2007:459). This can lead to improper postures adopted by children and adolescents both at home and school, which will cause body musculature imbalances that result in postural abnormalities that may last throughout adulthood (Chansirinukor *et al.*, 2001:116; Detsch & Candotti, 2001:55). According to Keith (2009) the three most common types of postural deviations are ‘Anterior Pelvic Tilt’, ‘Protracted Shoulder Girdle’ (forward shoulders), and ‘Forward Head’.

Changes in posture due to a modern lifestyle can be the result of posture adopted in classrooms (Syazwan *et al.*, 2011:295). These adapted postures may contribute to deformities such as scoliosis, kyphosis and lordosis (Korovessis *et al.*, 2005:253; Lai & Jones, 2001:84), forward head posture (Kim *et al.*, 2008:899), and be the main cause of musculoskeletal pain at a young age (Korovessis *et al.*, 2005:254; Iyer, 2002:270, 2001:88). Neiva *et al.* (2009:235) also found that forward head posture may lead to a superior scapular positioning and the development of rounded shoulders.

2.7 PHYSICAL ACTIVITY AND POSTURE

Physical activity has an impact on the physical development process and posture of a young individual. Sport, a common form of physical activity in children, can affect the process of postural development in young children as a result of repeated unilateral exercises and high training loads (Hawrylak *et al.*, 2001:234; Wojtys *et al.*, 2000:495). It is important to mention that asymmetric sports may contribute to worsen a pre-existing asymmetry, or lead to the development of asymmetric posture in a developing child (Baranto *et al.*, 2009:1132). Several researchers have confirmed that asymmetric movements often lead to morphological asymmetry in sportsmen, thus there is a difference between the left and the right side of the body (Krzykała, 2010:82; Dorado *et al.*, 2002:596). Evaluation to identify these differences, and the importance of intervention is widely recognized to correct these changes (Krzykała, 2010:82; Dorado *et al.*, 2002:596). Grabara (2015:84) agreed and strongly recommended that postural assessments in young athletes should be considered, seeing that asymmetric spine overloads frequently occur in sports training. In the current lifestyle, parents can be

overwhelmed by the opinions of different healthcare professionals with regard to interventions for children with poor posture (Stroebe *et al.*, 2009). Research indicates that one can act on skeletal structures, realigning them more effectively while growth is incomplete. Therefore, the sooner the changes in posture and postural misalignment are identified, the higher the likelihood of being able to correct it (Hong & Cheung, 2008:33). It is of great importance to realize that although sports training might cause asymmetric postural adaptations, it is essential to emphasize the positive influence of regular physical activity on the health and development of children (Tittlbach *et al.*, 2011:290; Boreham & Riddoch, 2001:924). It is of great importance to include exercises which help maintain good posture in training sessions (Grabara, 2015:84). During a previous study, Grabara (2012:125), found that children who played football in school had a higher incidence of correct postural alignment, specifically in the frontal plane and pelvis, when compared to their untrained peers.

As a result of increased development and growth rate during the period of childhood and adolescence, the skeleton is most sensitive to mechanical loading (Janz *et al.*, 2004:1128). Haywood (1993:80) stated that long-term physical activity, short of strenuous labour, might increase the diameter of bones. Physical activity promotes bone density and therefore bone adapts favourably to the stimulation that physical activity provides (Haywood, 1993:80). This emphasises the importance of physical activity during adolescence, especially because it contributes to bone health during this period of growth. Habitual physical activity has been identified as an important component to ensure a healthy lifestyle (Janz *et al.*, 2002:563; Sallis, 2000:31; Sherman, 2000:8), due to the fact that exercise is known to increase bone development in growing teenagers (Whiting & Zernicke, 1998:99; Haywood, 1993:80).

The focus of life orientation in schools in terms of physical development and movement was to empower the learner to demonstrate an understanding of, and participate in, activities that promote physical development and movement. The second outcome was to perform rhythmic movements with awareness of posture (DoE, 2002:34). Furthermore, life orientation assists the students in exploring environmental and safety measures in a computer environment. The student should be able to understand ergonomics in terms of computer workspace and this range will include relaxation exercises, distance from computer, sitting posture, height level of computer, and enough light and air (DHET, 2014:11).

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 has recently been a focus point in research. Therefore postural education and assessment forms part of physical therapy and clinical practice. The importance of normal upright posture was proposed in the early 1900s when it was described as “a state of balance requiring minimal muscular effort to maintain” (Griegel-Morris *et al.*, 1992:31).

Postural control is the ability to control the position of the body's centre of mass (COM) over its base of support (BOS) to prevent the body from falling, and to achieve specific functional tasks (Winter, 1995:212). The process by which humans maintain the integrity of their postural control is referred to as balancing (Westcott *et al.*, 1997:642). Stability exists when the vertical line of gravity from the COM falls within the BOS and stability improves with a larger BOS, a lower COM, and/or a more central COM within the same BOS (Bell, 1998). Postural control is a complex process requiring integration of sensory information (somatosensory, visual, and vestibular feedback) and execution of appropriate postural responses (Blumle *et al.*, 2006:362). Biomechanically, a high COM of the standing human, together with a correspondingly small BOS results in unstable posture. Hence, the natural consequence is spontaneous sway requiring a dynamic postural stability control system (Winter *et al.*, 1998:1219).

Ergonomics training is one of the basic elements to empower individuals with adequate knowledge about promoting healthy ergonomic habits and rearrangement of work area (Amick *et al.*, 2003:2707; Bohr, 2000:249). Due to limited research regarding the effects of theory-based interventions on safe postural and ergonomic behaviour, conducting further research in this regard has been recommended in previous evidence (Whysall *et al.*, 2007:196; Johnson & Hall, 2005:72). Theory of planned behaviour (TPB) has been applied to many related studies of safety and occupational behaviours, such as complying with correct posture of hand (Jenner *et al.*, 2002:320), chronic back pain (Carroll & Whyte, 2003:57; Keller *et al.*, 2001:182), industrial risk perception (Rundmo, 2001:402), sitting postural habits (Mohammadi *et al.*, 2009:212), safety lifting (Johnson & Hall, 2005:72) and work-related musculoskeletal disorders (Whysall *et al.*, 2007:196).

2.8 THE WAY FORWARD FOR HEALTHY POSTURE

2.8.1 Maintenance of posture

Postural control is fundamental in order to perform numerous daily activities correctly. Horak and Macpherson (1996) stated that the main behavioural goals involved in the control of posture are postural orientation (related to the positioning of body segments relative to each other and the environment), and postural equilibrium (related to the balance of forces that act on the body). To achieve such purposes, the postural control system must obtain and integrate sensory cues that are provided by visual, vestibular, and somatosensory channels and use them as a basis for the production of motor activity involved in balance control (Polastri *et al.*, 2012:131).

Research confirmed that postural misalignment can be corrected if postural changes are identified at an early age. The physical educator in school and the educational sphere should have the knowledge to perform postural assessments in the school environment, developing a prevention programme and if possible correction of these postural changes (Brianezi *et al.*, 2011:36). Already in 1974 the American Academy of Orthopaedic Surgeons made the following statement, further emphasizing the importance of school screening programmes:

"The American Academy of Orthopaedic Surgeons hereby gives its official recommendation to any program of routine examination of schoolchildren 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).

Gonçalves and Arezes (2012:879) contributed towards the main goal to improve posture at an early stage when they found that school furniture with inclined surfaces (table and chair) resulted in a reduction in neck and trunk flexion, preserving the natural lordosis in the cervical and lumbar spine. School furniture should be designed to accommodate the natural resting position of a child, in which agonist and antagonist muscles are well balanced. Small adjustments like the inclined surfaces of the table in the direction of the child and the seat forward, are alternatives to consider improving a child's posture and minimizing tension when using furniture at school. The resulting posture may improve a child's quality of life, performance, and efficiency (Gonçalves & Arezes, 2012:879)

2.9 SUMMARY

To conclude the literature regarding posture in the human body, it is clear that poor posture has a tremendous influence on the human body, especially with postural adaptations and deformities that occur over time. These changes have been a focus point in recent studies, but without success as the posture outlook of adolescents has not improved. The main problem with poor posture being overlooked is that postural adaptations during childhood will cause body musculature imbalances that result in postural abnormalities that may last throughout adulthood (Chansirinukor *et al.*, 2001:116; Pascoe *et al.*, 1997:639).

Modern lifestyle and the convenience of technology frequently result in children with poor posture and postural adaptations (Sweeting & Mock, 2007:400), but most African children in rural areas do not have access to computers and television. These children usually have to travel long distances by foot and their food intake is mostly unbalanced and inadequate, which may result in poor posture over time. Poor posture remains a daunting problem, despite all the efforts to educate children and their parents on the effects and problems caused due to poor posture and postural habits (Hrysomallis & Goodman, 2001:389).

Ilic and Buric (2014:123) answered the frequently posed question regarding how to solve these postural problems which can cause some serious consequences as the individual ages. It is important to identify postural and body deviations as early as the pre-school age in order to conduct preventative intervention. Younger school-aged children should be guided and encouraged to improve their physical and functional abilities. These goals can be achieved, first through games, and later through more specific sport games. Ilic and Buric (2014:123) also stated that games and sport games can have a significant preventive and corrective effect if these games are chosen correctly and applied with the necessary expertise. Sport games may remove certain milder forms of postural deviations, therefore, it should be emphasized that there are sport disciplines which have a significant therapeutic and preventive-corrective effect on a child's body (Ilic & Buric, 2014:123).

Unfortunately, the focus of researchers has not included African South African children in most of their studies regarding posture, nutrition and the effect of their life style on posture. Stroebel *et al.* (2009:129) mentioned that future research regarding the prevalence of postural changes and its causes are necessary to establish if this prevalence is due to race or other factors. It was evident from the reviewed literature that limited recent research publications in posture (especially in children and adolescents) exists.

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Chapter 3

The prevalence and changes of postural deformities during the course of adolescence in a cohort of South African adolescents: the PAHL study

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3.1 ABSTRACT

Evidence exists that during growth and development in children and adolescents various postural disorders may occur, especially in school-age children. Research regarding the changes in posture during the course of adolescents, especially in black children is, however, limited. The objective of this study was therefore to determine the prevalence and changes of postural deformities during the course of adolescence among black adolescent boys and girls in the Potchefstroom area of the North West Province, South Africa. A total of 100 black South African adolescents, aged 14 years in 2010 and 18 years in 2014, were part of the Physical Activity and Health Longitudinal Study (PAHLS). Participants underwent measurements of stature and body mass, as well as the New-York Posture Test based on thirteen categories of postural deformities. Each test item was scored on a 5-3-1 basis and the score of each item was based on the criteria and drawings located on the score sheet with: 5 = correct or normal posture; 3 = slight deviation or slightly abnormal; 1 = pronounced deviation or abnormal. Uneven shoulders were rated according to the bi-acromial differences and scored as follows: 5 (0-2 degrees); 3 (2.1-4 degrees); 1 (> 4 degrees). The Adam's Test (forward bending test) was used to evaluate further for scoliosis. Additionally, an inepad (The Harris Mat Impression system, Step Forward Foot Correctors®) was used to obtain a walking footprint of each participant. The footprints were scored as follows: 5 = high arches, 3 = arches lower and feet slightly flat and 1 = arches low and feet markedly flat. The results show that in all 13 variables of postures, the prevalence of abnormal ranged from 0-35% and slightly abnormal ranged from 16-73% for the total group across the measured points. The observed findings in the present study for the total group, showed a high prevalence for forward head, forward shoulders, hip sway, lordosis and uneven shoulders in the abnormal and slightly abnormal category in 2014. Out of the 13 posture variables, boys showed more abnormal posture (forward head, $p \leq 0.001$; forward shoulders, $p \leq 0.001$ kyphosis, $p = 0.007$ and hip sway, $p = 0.048$) than the girls who were presented with three categories of significant changes in abnormal posture (forward head, $p \leq 0.001$; uneven shoulders, $p = 0.049$ and lordosis, $p = 0.004$) over a period of study. It can be concluded that the prevalence of posture abnormality was present in the study with boys being more affected than the girls. The prevalence of the postural deviations increased over the course of adolescence. Implementing intervention programmes in schools to address these postural deviations at an early stage should be encouraged.

Keywords: Body postural deformities, adolescence, postural changes, adaptations, South African adolescent

3.2 INTRODUCTION

Body posture deformities, both in children and adolescents, are a serious public health problem (McRoberts, Cloud & Black, 2013). Evidence exists that during growth and development in children and adolescents various postural disorders may occur, especially in school-age children (Trigueiro, Massada & Gargantu, 2013). Mitova (2015) stated that postural disorders and spinal deformities are among the most common diseases to be found in children and adolescents. Proper postural alignment is vital to maintaining a healthy back (Rhodes, 1996). The Posture Committee of American Academy of Orthopaedics in 1994 defines posture as the regular and balanced arrangement of skeletal components so as to preserve supportive structure of the body from injury and progressive deformity (de Souza, Faintuch, Valezi, Anna, Gama-Rodriguez, de Batista Fonseca & de Melo, 2005).

It is important to note that data on postural deformities is very diverse, and this is due to a variety of diagnostic criteria and different ages of the participants (Lizak, Czarny & Niewczas, 2014). In a study from Brazil, thoracic kyphosis, lumbar lordosis, and scoliosis were found to be present among the students who participated (Sedrez, Zaniratti da Rosa, Noll, da Silva Medeiros & Candotti, 2015). In the same study, the prevalence of postural changes was 79.7%, of which 51.5% showed frontal plane changes and 61% sagittal plane changes. Griegel-Morris, Larson, Mueller-Klaus & Oatis (1992) reported the following postural abnormalities were prevalent: forward head=66%, kyphosis=38%, right rounded shoulder=73%, left rounded shoulder=66%).

Gender differences among university students indicated that females positioned their centre of mass and hip joints anterior to the chair's pivot point, while males' centre of mass ($p = 0.0003$) and hip joints ($p = 0.0039$) were located posterior to the pivot point (Dunk & Callaghan, 2005). A study on Swedish children reported kyphosis and lordosis to be independent of gender from ages 5-6 years (female 0.96; males 1.03), and kyphosis in relation to lordosis to be more pronounced in girls (0.86) than in boys (1.08) ($p < 0.001$).

In a longitudinal study in Sweden which analysed the development of posture and spinal mobility during growth, and its relationship to low back pain and sports activities from childhood to adolescence (children from ages 5-6 years and again at 15-16 years), it was reported that thoracic kyphosis and lumbar lordosis respectively increased by 6° (Widhe, 2001). Additionally, thoracic spine flexion from the relaxed position decreased by 9°

($p < 0.001$), and extension decreased by 18° ($p < 0.001$); in lumbar spine, flexion from the relaxed position decreased 9° ($p < 0.001$) and extension increased by 5° ($p < 0.001$). This shows that the total sagittal mobility decreased during the 10-year period of study for the thoracic region by as much as 27° ($p < 0.001$) and in the lumbar region by 4° ($p < 0.001$) (Widhe, 2001). Contrary to these findings, a study by Hellsing, Reigo, McWilliam & Spangfort (1985) reported that thoracic kyphosis increased in boys but did not change in girls studied at 8, 11 and 15 years of age. Mellin and Poussa (1992) also reported that thoracic kyphosis was less prevalent in girls compared to boys, and the difference was most pronounced at age 13-14 years. According to findings by Fon, Pitt & Thies (1980), kyphosis increased with age and did not differ between males and females. However, Propst-Proctor and Bleck (1983) did not find any influence of age or gender on kyphosis, measured between T5 and T12.

Postural responses have been found to depend on the daily demands of the individual and will differ in relation to gender and skeletal maturity (Perret, Poiraudéau, Fermanian, Colau, Benhamou & Revel, 2001). During the pre-pubertal phase and puberty, children will experience the greatest amount of postural adaptations and adjustments in order for the body to be in balance with the new proportional changes in body segments (Asher, 1976). This being said, high school children, 12 to 18 years of age, will undergo rapid muscular and skeletal development (Gangnet, Pomeroy, Dumas, Skalli & Vital, 2003; Shumway-Cook & Woollacott, 2001).

In a previous study (Penha, João, Casarotto, Amino & Penteado, 2005) the results indicated that certain postural abnormalities during childhood were indicative of normal postural development. These abnormalities will most likely be corrected during normal growth and development. However, certain abnormalities can be caused by daily activities and may result in decreased quality of life during childhood and adulthood (Penha *et al.*, 2005). It has become clear that modern lifestyles have negatively affected postural development and growth, as a result of the tendency to a more sedentary life style (Minoo, Nasser & Mahmood, 2013; Brianezi, Cajazeiro & Maifrino, 2011; Bogdanovic & Markovic, 2009). Poor physical condition of school aged children can be the result of motorized transportation, watching television, playing video games, and a lack of regular physical activity. The abovementioned factors will lead to the biomechanical or anatomical changes of the vertebrae in the spine (Latalski, Bylina, Fatyga, Repko, Filipovic, Jarosz, Borowicz, Matuszewski &

Trzpis, 2013; Kratenova, Zejglicova, Maly & Filipova, 2007), and these postural adaptations will result in postural deviations (Lafond, Descarreaux, Normand & Harrison, 2007).

McGill, (2007) summarized the different postures usually adopted by children (aged 6-10 years) at home:

1. Position in front of the TV set where 70.7% adopted wrong postural habits;
2. Sitting position on a chair for study where 53.6% of children were sitting incorrectly or didn't use appropriate furniture; and
3. Lying down position (while sleeping) where 9.7% were sleeping in the prone position (sleeping on the belly is the most detrimental of all the positions), 17.07% were sleeping in the supine position (on their back), 51.2% were sleeping on their side and 21.9% were changing position multiple times.

Backpacks carried in school have been associated with back pain in young people (Korovessis, Koureas & Papazisis, 2004; Sheir-Neiss, Kruse, Rahman, Jacobson & Pelli, 2003; Negrini & Carabalona, 2002). Sheir-Neiss *et al.* (2003) reported that the prevalence for back pain increases from less than 10% up to 50% when comparing pre-teenagers to teenagers. Furthermore, Szpalski, Gunzburg, Balague, Nordin & Me´ Lot (2002) found that there is a direct link between the weight of school backpacks and lower back pain in children. Children who experience back pain may be predisposed to suffering back pain in adult life (Mackenzie, Sampath, Kruse & Sheir-Neiss, 2003; Steele, Bialocerkowski & Grimmer, 2003; Grimmer & Williams, 2000). Milardović, Pausic & Kuzmanic (2014) stated that heavy backpacks may weaken postural stability and later on, cause bigger postural deformities. It is important to take precautionary steps to reduce the weight of school bags (Grimmer, Dansie, Milanese, Pirunsan & Trott, 2002; Negrini & Carabalona, 2002).

Research on postural patterns and development in school-age children is very limited, especially when the gender differences in posture are taken into consideration (Penha *et al.*, 2005; Chansirinukor, Wilson, Grimmer & Dansie, 2001; Widhe, 2001; Grimmer, Williams & Gill, 1999), and especially in South Africa. Adolescence is the time of critical skeletal growth in the vertebral column, making children particularly vulnerable to musculoskeletal pain if neutral sitting postures are not supported in schools (Brink, Louw, Grimmer & Jordaan, 2014; Busscher, Gerver, Kingma, Wapstra, Verkerke & Veldhuizen, 2011; Grimmer & Williams, 2000; Howell, Mahood & Dickson, 1992). As such, research studies at the adolescence stage

are important so that early intervention programmes can be implemented before the problem persists into adulthood. According to Penha, Casarotto, Sacco, Marques & Joao (2008), further investigation is needed in order to explain the influence of gender differences during the process of development and to understand to what extent these changes can influence the formation of adult postural patterns. The objective of this study was therefore to determine the prevalence and changes of postural deformities during the course of adolescence among black adolescent boys and girls in the Potchefstroom area of the North West Province, South Africa.

3.3 METHODOLOGY

3.3.1 Participants

Black South African adolescents, aged 14 years in 2010 and 18 years in 2014, (N = 100) who were part of the Physical Activity and Health Longitudinal Study (PAHLS; Monyeki, Neetens, Moss & Twisk, 2012) are participants in the current study. The participants were randomly recruited from six schools selected within the Tlokwe Local Municipality in the Potchefstroom area in the North West Province. Permission for this study was granted by the District Manager of the Department of Education in Potchefstroom and ethical approval was obtained from the Ethics Committee of the North-West University (NWU-00058-10-A1). These schools were selected purposefully, as most of the learners attending these schools come from informal settlements where the lowest income per household could be expected. Many people in these communities do not have water or electricity, and have minimal resources such as clothing, furniture and much more. It is thus likely that some of these children would be chronically undernourished and develop postural adaptations. Only healthy children whose parents gave consent were allowed to participate in the study (Monyeki *et al.*, 2012).

3.3.2 Measurement procedure

The procedure was to separate the boys and girls of each school into two groups and to explain the measurement procedure to each of the participants so as to reduce any uncertainty. The first phase of the posture station included the footprints of the participants. Each participant was asked to step onto an ink pad, first with the left foot and then with the right foot. The participants then went into a private area where the “Adam’s Test” (forward bending test) was performed in their swim wear or underwear for additional evaluation of

scoliosis, the Qualysis markers were then placed on the 24 landmarks of the participant and photographs were taken. All photographs were downloaded onto a computer for interpretation and screening for any abnormalities in posture by means of the New-York Posture Test criteria.

3.3.3 Anthropometric measurements

Stature

Stature and body mass were measured using the protocol of the International Society for the Advancement of Kinanthropometry (Stewart, Benson, Olds, Marfell-Jones, MacSween & Nevill, 2011). The maximum stature of each participant was measured to the nearest 0.1cm with a stadiometer. The participant had to stand upright, with the back against the stadiometer and the head in the Frankfort plane. The weight of each participant was measured by means of an electronic scale. The scale was calibrated at the beginning of the study. The body mass was measured to the nearest 0.1kg.

Postural Evaluation

The postural assessment was performed from high quality photographs, taken in a private location with minimal clothing, from a lateral, anterior, and posterior view. The New-York Posture Test (McRoberts, 2013) which is designed to identify thirteen categories of postural deformities was used to evaluate the posture of all participants. Each test item was scored on a 5-3-1 basis and the score of each item was based on the criteria and drawings located on the score sheet with: 5 = correct or normal posture; 3 = slight deviation or slightly abnormal; 1 = pronounced deviation or abnormal. Uneven shoulders were rated according to the bi-acromial differences and scored as follows: 5 (0-2 degrees); 3 (2.1-4 degrees); 1 (> 4 degrees). The Adam's Test (forward bending test) was used to evaluate further for scoliosis.

An inepad (The Harris Mat Impression system, Step Forward Foot Correctors®) was used to obtain a walking footprint of each participant. The footprints were scored as follow: 5 = high arches, 3 = arches lower and feet slightly flat, and 1 = arches low and feet markedly flat.

3.3.4 Statistical Analysis

The Statistical Package for the Social Sciences was employed to calculate for a paired sample *t*-test to determine the differences between the first and second measurements. Frequencies

were calculated for all posture variables. Chi-square was calculated for non-parametric variables to determine the significant difference. Significant level was set at $p \leq 0.05$.

3.4 Results

Descriptive information about stature, body weight, and BMI over a four year follow-up is shown in Table 1. For the total group significant ($p \leq 0.05$) developmental changes were observed in all measurements. There were no significant difference ($p \geq 0.05$) in body mass and stature in 2010 between genders. In 2014, females (57.86 ± 13.46) were significantly ($p = 0.04$) heavier than the males (56.56 ± 1.26). Additionally, in all measurement points (2010 & 2014) females (20.96 ± 4.48 & 23.36 ± 5.58) had a significantly ($p \leq 0.05$) higher BMI than their male counterparts (19.14 ± 2.69 ; 20.02 ± 2.10).

Figure 3.1 presents the prevalence scores for posture variables for the total group. Forward head showed prevalence for abnormal to be 9% and slightly normal was 40% in 2010; in a follow-up measurement in 2014, both categories increased significantly. Chest depression showed prevalence for abnormal to be 8% and slightly abnormal to be 39% in 2010, while the 2014 measurements indicated an insignificant change over time. Forward shoulders had a prevalence of 7% in the abnormal category and 49% for slightly abnormal in 2010. A high increase (73%) was noted during the follow-up measurements in the slightly abnormal category for forward shoulders. Kyphosis (2%), hip sway (6%), protruding abdomen (5%) and lordosis (15%) showed a low prevalence for abnormal in 2010, while the follow-up measurements in 2014 resulted in a higher prevalence for abnormal in all four categories: kyphosis was noted as 7%, hip sway as 20%, protruding abdomen as 10% and lordosis as 31% for abnormal. Furthermore, twisted head and scoliosis showed a prevalence of 2% and 1% respectively for abnormal, while slightly abnormal showed a prevalence of 16% for both categories in 2010. None of these categories showed significant changes during the 2014 follow-up measurements.

Uneven shoulders showed a high prevalence for slightly abnormal (37%) in 2010 and increased even more (52%) during the 2014 measurements. The prevalence for the abnormal category did not show significant changes. Uneven hips showed a prevalence of 4% for abnormal and 39% for slightly abnormal, while flat feet showed a prevalence of 12% for abnormal and 47% for slightly abnormal in 2010. Both these postural categories showed a lower prevalence in the abnormal and slightly abnormal category during the 2014 follow-up

measurements. Lastly, pronated feet showed a prevalence of 13% for abnormal and 20% for slightly abnormal in 2010, whilst the 2014 measurements indicated a lower prevalence in the abnormal category (2%), but a higher prevalence for slightly abnormal (32%).

Table 3.1: Participants' characteristics (mean, standard deviation (SD)), p-value of the differences of anthropometric measures and BMI for the total group and by gender at the first measurements and the second measurement in 2010 and 2014 respectively.

	Total group					2010			2014		
	2010		2014		P-value of the differences	Males	Female	P-value of the differences	Males	Females	P-value of the differences
	Mean	SD	Mean	SD		Mean (SD)	Mean (SD)		Mean (SD)	Mean (SD)	
Body mass (kg)	49.00	11.18	57.45	11.79	≤0.001*	46.72(9.26)	50.08(11.89)	0.60	56.56(1.26)	57.86(13.46)	0.04*
Stature (m)	1.55	0.07	1.61	08	≤0.001*	1.56(0.08)	1.54(0.06)	0.19	1.68(0.07)	1.57(0.06)	0.99
BMI (kg/m ²)	20.37	4.07	22.29	4.99	≤0.001*	19.14(2.69)	20.96(4.48)	0.04*	20.02(2.10)	23.36(5.58)	≤0.001*

*Statistical significance $P \leq 0.05$

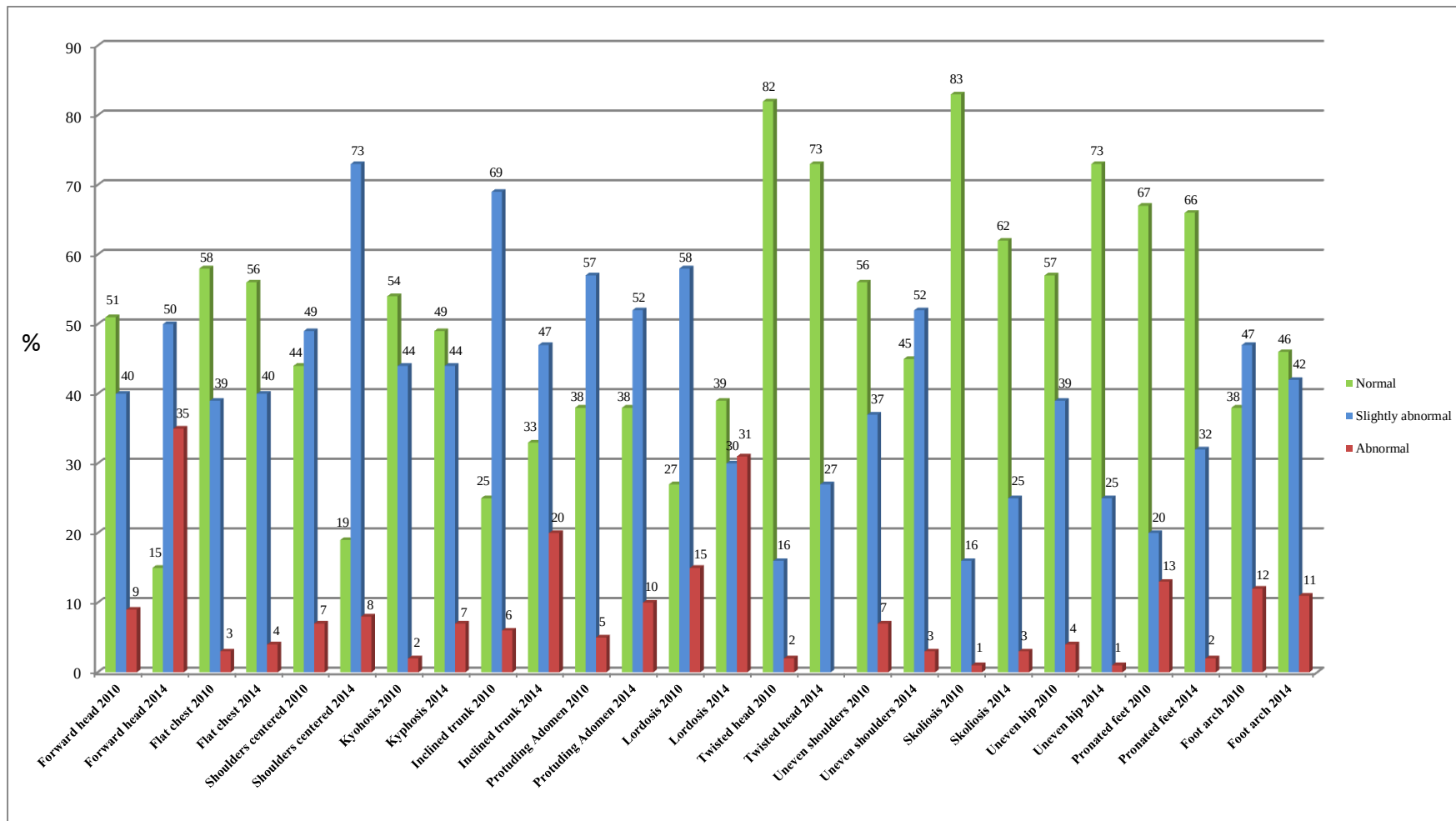


Figure 3.1: Percentage (%) scores for posture variables for the total group

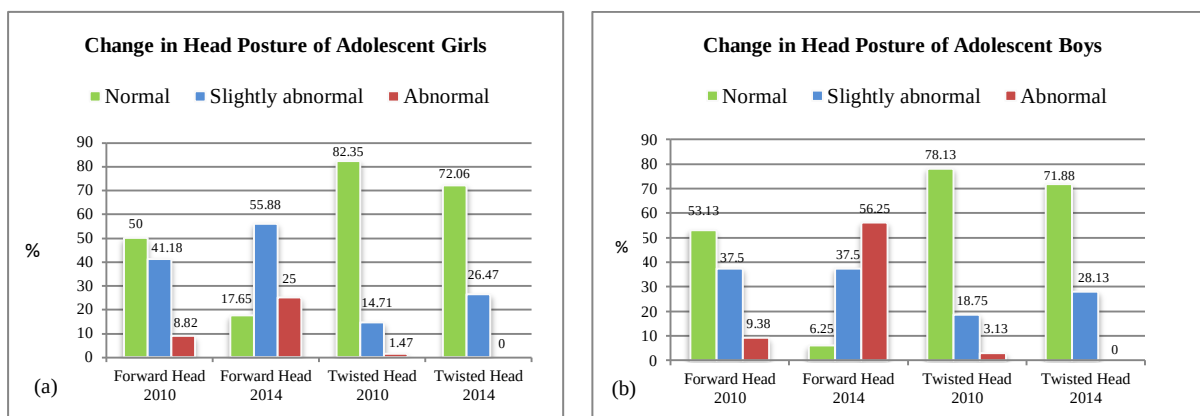


Figure 3.2 (a-b): Percentage changes in head posture for boys and girls

A significant decrease in normal forward head posture was observed over the course of adolescents in both the boys and girls – in the 2014 measurements, with a significant ($p \leq 0.001$) increase in the slightly abnormal and abnormal category were observed. No abnormal percentage was found with regards to twisted head position in 2010 and 2014 in girls and only 3% prevalence of twisted head position in 2010 among boys.

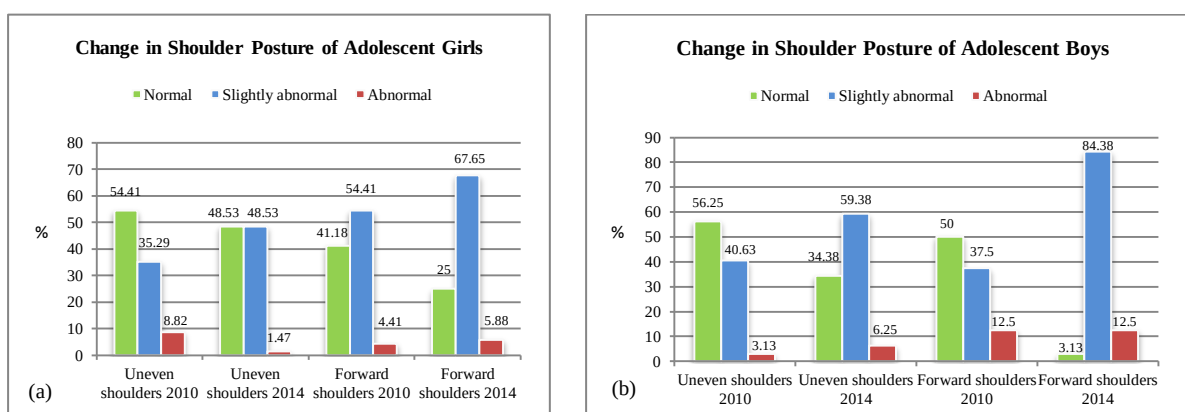


Figure 3.3 (a-b): Percentage changes in shoulder posture for boys and girls

Figure 3.3 summarises the percentage changes in shoulder posture for both boys and girls over a period of time. In the follow-up measurements of 2014 uneven shoulders showed a significant ($p = 0.049$) increase in the slightly abnormal category for girls, but were insignificant ($p \geq 0.05$) for boys. During the follow-up measurements in 2014 forward shoulders in the slightly abnormal category were insignificant for girls ($p \geq 0.05$), but increased significantly by 46.9% (2010, 37.5%; 2014, 84.38%) for boys ($p \leq 0.001$).

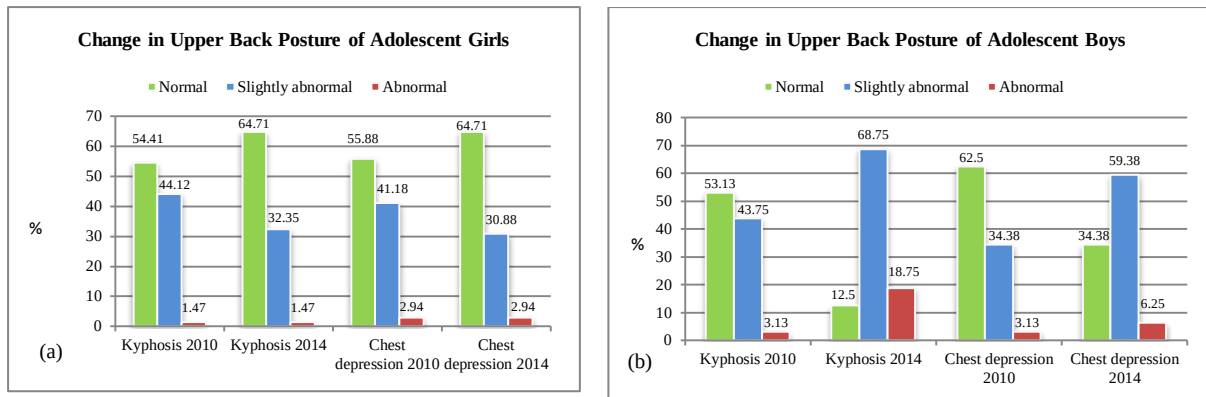


Figure 3.4 (a-b): Percentage changes in upper back posture for boys and girls

The upper back posture of the girls mostly improved over the course of adolescence. In the boys, however, kyphosis showed a significant increase ($p=0.007$) in the abnormal category. In the follow-up measurements in 2014, insignificant ($p \geq 0.05$) changes for chest depression in both the boys and girls were observed.

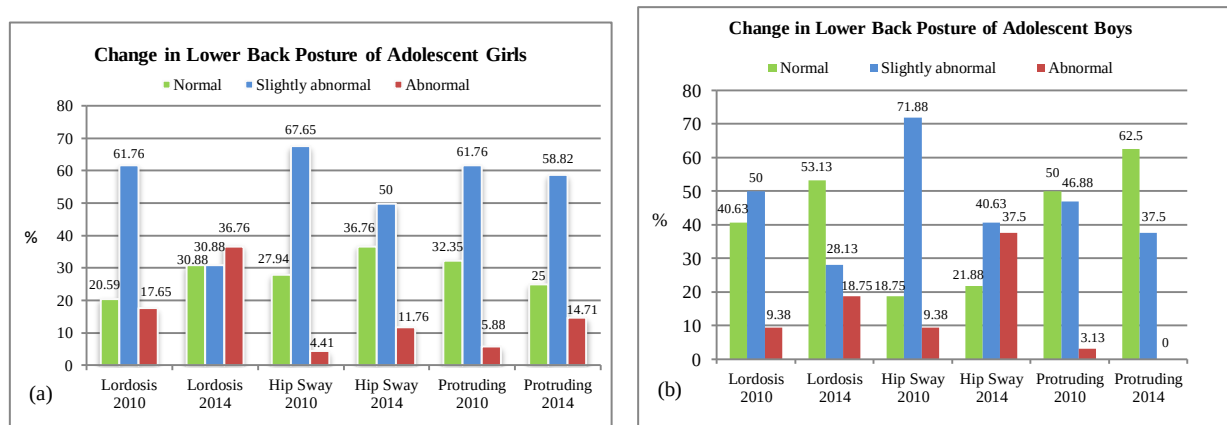


Figure 3.5 (a-b): Percentage changes in lower back posture for boys and girls

Figure 3.5 presents the percentage changes in lower back posture for boys and girls over a period of time. A significant increase ($p=0.004$) in the percentage adolescent girls with an abnormal lordotic posture was observed between 2010 to 2014 – a shift from slightly abnormal to abnormal. Hip sway for the girls showed improvement, however, insignificant. The boys showed a significant ($p=0.048$) increase in the abnormal category for hip sway. The results for protruding abdomen indicated insignificant ($p > 0.05$) improvements in the boys, whilst the girls showed a borderline significant percentage increase ($p=0.064$) in the abnormal category.

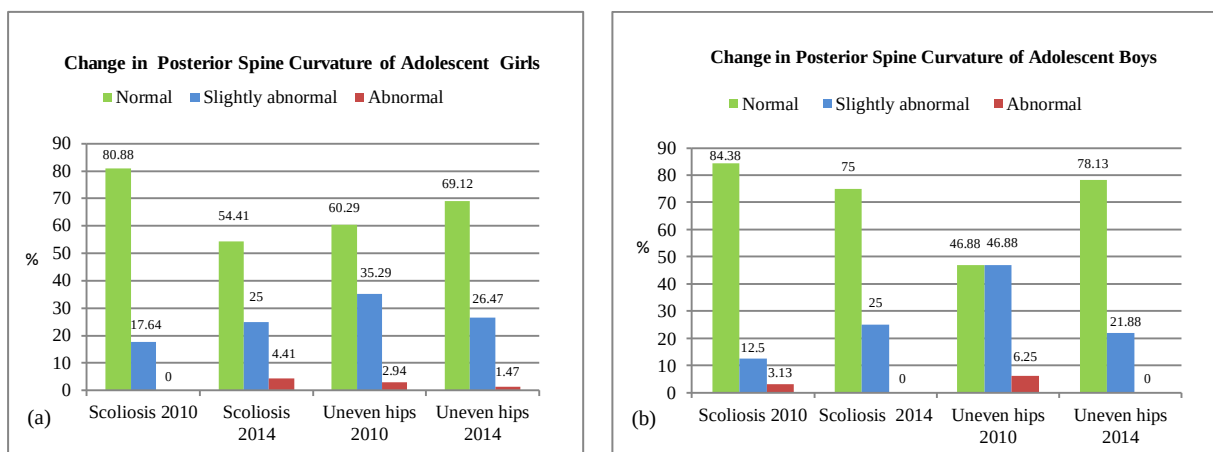


Figure 3.6 (a-b): Percentage changes in lateral spine curvature for boys and girls

Figure 3.6 presents the percentage changes in posterior spine curvature for boys and girls. In the follow-up measurements in 2014, no significant increases were found in both girls and boys – only an insignificant increase in the percentage slightly abnormal scoliosis in both groups were observed. Despite this slight increase, scoliosis and uneven hips were not present in the greatest percentage of the participants. Both girls and boys showed an increase in the normal category for uneven hips over the time period.

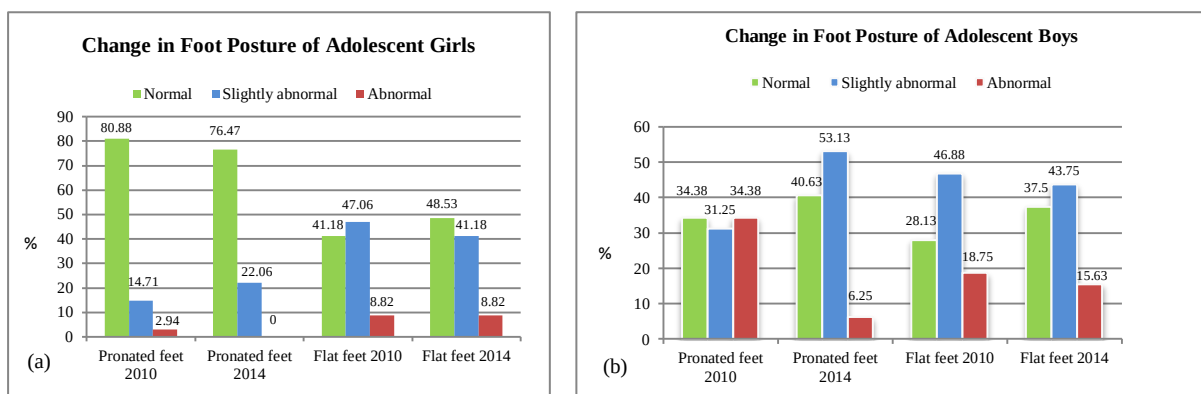


Figure 3.7 (a-b): Percentage changes in foot posture for boys and girls

Figure 3.7 presents the percentage changes in foot posture for boys and girls over a period of time. In 2010 pronated feet showed an abnormal of 2.94%, and slightly abnormal of 14.71% for girls, and an abnormal of 34.38%, and slightly abnormal of 31.25% for boys. During the follow-up measurements in 2014 pronated feet showed no percentage for girls in the abnormal category, whilst the boys indicated a higher percentage of slightly abnormal pronated feet, although all changes in pronated feet for boys still resulted in a higher normal

category. Although not significant ($p \geq 0.05$), the normal flat feet percentage increased in both the girls and boys.

3.5 DISCUSSION

The purpose of this study was to determine the prevalence and changes of postural deformities during the course of adolescence among black African adolescent boys and girls in the Potchefstroom area of the North West Province, South Africa. In all 13 variables of postures, the prevalence of abnormal ranged from 0-35% and slightly abnormal ranged from 16-73% for the total group across the measured points. The observed findings in the present study for the total group, showed a high prevalence of abnormal and slightly abnormal in forward head, forward shoulders, hip sway, lordosis and uneven shoulders in 2014. Out of the 13 posture variables, boys showed more abnormal posture (forward head, forward shoulders, kyphosis and hip sway) than the girls, who presented three categories of significant changes in abnormal posture (forward head, uneven shoulders and lordosis) over a period of study. The feet posture mostly improved over the course of adolescence in both the girls and boys.

The observed findings in boys and girls respectively were somewhat similar to the previous findings by Malepe, Goon, Anyanwu & Amusa (2015) who found that kyphosis (53.8%) was the most common postural deviation among boys in their study, while lordosis (29.5%) had the highest prevalence for postural deviations among girls. Stroebel, De Ridder, Wilders & Ellis (2009) and Loots, Loots & Steyn (2001) found the following prevalence rates: kyphosis 35.1% (Stroebel), and 100% for Loots, while for lordosis the rate was 79.8% (Stroebel) and 70% for Loots. These were the highest for the total group.

According to the results from Van Biljon and Wilders (2007), the frequency of forward head (32%), kyphosis (10%), and pronated feet (14%) was greater in boys, while lordosis (87%) was more frequent in girls. These results are similar to the findings in the present study. Ruivo, Pezarat-Correia & Carita (2014) reported that 68% of their participants showed some degree of forward head posture and 58% resulted in forward shoulders, while the present study showed 35% (abnormal), 50% (slightly abnormal) and 8% (abnormal), 73% (slightly abnormal) respectively for forward head and forward shoulders.

3.5.1 Changes on the postural studies

A study by Sedrez *et al.* (2015) reported a high prevalence of postural changes as follows: 79.7% in young individuals, with 47.5% of them showing changes in the frontal plane and 61% in the sagittal plane. Vasconcelos, Fernandes, de Oliveira, Cabral & da Silva (2010) observed a prevalence of 90.6% of postural changes in deaf children. Detsch, Luz, Candotti, de Oliveira, Lazon, Guimarães & Schimano (2007) when assessing female students aged between 14-18 years, reported a prevalence of 66% for lateral changes, and 70% for anterior posterior changes in the municipality of São Leopoldo, RS. The same authors obtained similar results when assessing children aged 6-17 years from the municipality of Novo Hamburgo, RS, finding postural changes in 70.78% of the cases (Detsch & Candotti, 2001). A high prevalence of postural changes was also found in a study that evaluated students from the first to fourth grades of elementary school in the municipality of Jaguariuna, São Paulo, which reported asymmetry or postural changes in 98% of assessed individuals (Santos, Cunha, Braga, Saad, Ribeiro, Conti & Oberg, 2009). Mitova, (2015) reported the prevalence of spinal deformities in Blagoevgrad from the examination of 2129 children aged 6-11, and found that 23.67% of the participants had spinal deformities, while 58.85% showed poor posture, with only 17.47% of the participants having correct posture. In the present study similar results were reported, 41.5% of adolescents (total group) had postural deviations in the slightly abnormal category, while 10.4% had abnormal posture. Contrary to the current study however, Stroebel *et al.* (2009) found higher percentages for kyphosis (47%) and protruding abdomen (52%) in the abnormal category for girls, while the present study showed 1.5% and 14.7% respectively. Literature suggests that a reason for the differences between genders could be attributed to the adolescent height growth spurt (Malina, Bauchard & Baror, 2011). Differences arise between boys and girls during this period, with boys tending toward broader shoulders, smaller hip width, longer leg and arm length and greater overall skeletal size and height than girls (Magee, 2008:974). Children, especially boys, may appear ungainly and poor postural habits may occur because of this rapid growth spurt and changes are more likely to occur during this phase (Magee, 2008:974). During the growth spurt bone mineralization differs between sexes and may be the reason for gender difference in posture abnormalities (Wildhe, 2001).

The findings in the present study show that girls were heavier and fatter than the boys over time (2010-2014). The current findings are in agreement with what has been reported in the literature. Rosell, Fregonesi, Camargo, Mantovani, Purga, Freitas, Ferreira & Faria (2010)

found that the girls in their study had higher BMI values, therefore indicating overweight with specific posture patterns (musculoskeletal imbalance), which would lead to an irreversible posture pattern in adulthood. Obradović, Srdić, Milošević & Dimitrić (2006) reported similar results in both genders. Pre-school children had a prevalence of 12.02% (boys) and 6.99% (girls) to be overweight, while the risk of pre-obesity was reported in 10.89% of boys and 12.11% of girls. Obesity can affect the musculoskeletal system negatively and other research shows that obese children tend to be less active than their peers (Arilla, Moro & Jimenez, 2008). Lake, Power & Cole (2000) and Song, Chung, Kim & Shin (2004) found a positive relationship between obesity and lumbar lordosis in female participants.

The present results have some limitations and as such should be interpreted with caution. A small sample size and a higher percentage of female participants may have affected the data. The loss of data during follow-up could have influenced the results in one way or another. Despite these limitations, the present study demonstrated that gender differences in posture exist, as well as some postural deviations. Further studies are needed in order to better explain the prevalence of postural deviations in African adolescents and the effect thereof during adulthood.

3.6 CONCLUSION

The prevalence of postural abnormalities was evident in the present study, with boys more affected than the girls. The prevalence of most of the postural deviations increased over the course of adolescence. Boys indicated significant percentages shifts towards abnormal posture in forward head, forward shoulders, kyphosis and hip sway, whilst girls presented three categories of significant changes in abnormal posture over the study period (forward head, uneven shoulders and lordosis). The feet posture mostly improved over the course of adolescence in both the girls and boys.

The findings of this study demonstrate clinical relevance, since they describe a specific posture pattern among school-aged children over the course of adolescence. This pattern may worsen and become irreversible in adulthood if strategic interventions are not constructed and implemented. Implementing intervention programmes in schools to address these postural deviations at an early stage should be encouraged. Additionally, empowering parents, educators, and children with the necessary knowledge to identify or prevent these postural

problems at an early stage would assist, and the importance of regular participation in physical activity is also recommended.

3.7 ACKNOWLEDGEMENTS

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Chapter 4

Summary, conclusions, limitations and recommendations

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4.1 SUMMARY

It was apparent from the literature that body posture deformities, both in children and adolescents, are a serious public health problem (McRoberts *et al.*, 2013:1). Evidence exists that during growth and development in children and adolescents various postural disorders may occur, especially in school-age children (Widhe, 2001:118; Trigueiro *et al.*, 2013:499). Mitova (2015:159) stated that postural disorders and spinal deformities are among the most common diseases in children and adolescents. Griegel-Morris *et al.* (1992:425) reported postural abnormalities which are prevalent as: forward head (66%), kyphosis (38%), right rounded shoulder (73%), and left rounded shoulder (66%). In a longitudinal study in Sweden which analysed the development of posture and spinal mobility during growth and its relationship to low back pain and sports activities from childhood to adolescence (children at ages 5-6 years and again at 15-16 years), it was reported that thoracic kyphosis and lumbar lordosis respectively increased by 6° (Widhe, 2001:120). Additionally, thoracic spine flexion from the relaxed position decreased by 9° ($p<0.001$) and extension decreased by 18° ($p<0.001$); in lumbar spine, flexion from the relaxed position decreased 9° ($p<0.001$) and extension increased by 5° ($p<0.001$). It was revealed that children should be educated about the importance of physical activity and exercise from an early age, and how to avoid bad habits during daily activities which lead to postural deformities (Mitova, 2015:162).

The aim of this study was therefore to determine:

The prevalence and changes of postural deformities during the course of adolescence among black African adolescent boys and girls in the Potchefstroom area of the North West Province, South Africa.

Chapter One provided a brief outline of the problem statement which underlined the research questions, objectives, and hypothesis set for this study as an introduction to the dissertation. The dissertation is submitted in article format and therefore includes a literature review (Chapter Two) and one research article (Chapter Three) to be presented to an accredited peer-reviewed journal.

Chapter Two presented a literature review on normal postural development, postural deviations and adaptations, the causes of these postural changes, the effect of gender and culture on posture, and the effect of physical activity on postural development and health.

From the reviewed literature it was found that posture is an integral component to ensure that balance is maintained, during the initiation, continuance and completion of any action, thus posture serves as a reference frame for the production of correct movement patterns (Viel *et al.*, 2010:e10259). During normal growth and development a child's posture may change significantly and therefore it is important to have a clear understanding of what 'good' or 'normal' posture refers to in order to recognize postural deformities and changes (Sweeting, 2007:399; Cil *et al.*, 2005:99). During growth individuals develop bad habits, including abnormal sitting and standing positions, and changes occur in normal gait patterns. These changes predispose individuals to poor posture (Brianezi *et al.*, 2011:36). Common postural deviations for this chapter include: forward head, forward (protracted/rounded) shoulders, kyphosis, scoliosis, lordosis (anterior pelvic tilt), swayback posture, and flat feet. These postural changes during childhood can be influenced by intrinsic and extrinsic factors, such as emotional factors, heredity, socio-economic level, level of physical activity, environmental and physical conditions under which the child lives and physiological abnormalities due to human development and growth (Penha *et al.*, 2008:387).

The literature confirmed that the postural responses to daily demands differ according to the individual's skeletal maturity and gender (Widhe, 2001:122). Various differences regarding posture were noted in this chapter. Physical activity has an impact on the physical

development process and posture of a young individual (Hawrylak *et al.*, 2001:234). Postural misalignment can be corrected if postural changes are identified at an early age.

This chapter ends with a summary.

Chapter Three was presented in the form of a research article. The literature review, method of research, research design, results, discussion, and conclusion were presented in the article. The title of the article is as follows:

The prevalence and changes of postural deformities during the course of adolescence in a cohort of African adolescents: the PAHL study

4.2 CONCLUSION

The conclusions drawn from this research are in accordance with the hypothesis set in Chapter One.

4.2.1 Hypothesis 1

Hypothesis 1 states that the prevalence of postural deformities will be high among black African adolescent boys and girls in the Potchefstroom area of the North West Province

According to the results, the prevalence of postural deformities in 2010 was high in a majority of the categories for slightly abnormal and/or abnormal. Forward head (slightly abnormal 40%, abnormal 9%), forward shoulders (slightly abnormal 49%, abnormal 7%), kyphosis (slightly abnormal 44%, abnormal 2%), hip sway (slightly abnormal 69%, abnormal 6%), protruding abdomen (slightly abnormal 57%, abnormal 5%), lordosis (slightly abnormal 58%, abnormal 15%), uneven shoulders (slightly abnormal 37%, abnormal 7%), and flat feet (slightly abnormal 47%, abnormal 12%) showed high prevalence rates in 2010. Hypothesis 1 is, therefore, accepted.

4.2.2 Hypothesis 2

Hypothesis 2 states that the prevalence of postural deformities detected towards the end of adolescence will be significantly less than in the beginning of adolescence among black African adolescent boys and girls in the Potchefstroom area of the North West Province.

According to the results, the prevalence of postural deformities in 2014 was higher in most of the categories. Forward head (normal decreased by 36%), flat chest (normal decreased by

2%), forward shoulders (normal decreased by 25%), kyphosis (normal decreased by 5%), twisted head (normal decreased by 9%), uneven shoulders (normal decreased by 11%), scoliosis (normal decreased by 21%) and pronated feet (normal decreased by 1%) showed a significant decrease in the normal category, thus there was an increase in postural deformities when compared to the results in 2010. Incline trunk (normal increased by 8%), lordosis (normal increased by 12%), uneven hips (normal increased by 16%) and flat feet (normal increased by 8%) are the only categories which showed a significant increase in the normal category, thus there was an overall decrease in postural abnormalities. Hypothesis 2 is, therefore, partially accepted.

Evidence exists that during growth and development in children and adolescents' various postural disorders may occur, especially in school-age children. Research regarding the changes in posture during the course of adolescents is limited, especially in black South African children. The present study therefore showed the prevalence and changes of postural deformities during the course of adolescence among black adolescent boys and girls. Boys indicated significant percentage shifts towards abnormal posture in forward head, forward shoulders, kyphosis and hip sway, whilst girls presented significant changes for abnormal posture in forward head, uneven shoulders and lordosis. The feet posture mostly improved over the course of adolescence in both the girls and boys

4.3 LIMITATIONS

The present results are not without some limitations and as such should be interpreted with caution. The limitations are as follows:

A small sample size and a higher percentage of female participants may have affected the data. During this longitudinal study (five years), it was difficult to recruit all of the participants in 2014 due to the fact that some participants had changed schools, discontinued their studies, or were sick on the day of the measurement, etc. The loss of data during follow-up did not influence the results.

4.4 RECOMMENDATIONS

From this study it appears that there is a specific need for further research on the following aspects so as to expand the knowledge of postural deviations during adolescence among African boys and girls:

- More studies with more samples, which are equally representative of boys and girls, are needed.
- To determine the effect of Life Orientation in schools with the main goal being to educate children on the topic of correct posture during daily activities.
- Interventions during adolescence to improve postural development are highly recommended.

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APPENDICES

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APPENDIX A (1)

GUIDELINES FOR AUTHORS

The African Journal for Physical Activity and Health Sciences (AJPHERD) is a peer-reviewed journal established to:

- i) Provide a forum for physical educators, health educators, specialists in human movement studies and dance, as well as other sport-related professionals in Africa, the opportunity to report their research findings based on African settings and experiences, and also to exchange ideas among themselves; Afford the professionals and other interested individuals in these disciplines the opportunity to learn more about the practice of the disciplines in different parts of the continent;
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Articles can also be submitted electronically, i.e. via e-mail attachment. However, the corresponding author should ensure that such articles are virus free. The AJPHEs reviewing process normally takes 4-6 weeks and authors will be advised about the decision on submitted manuscripts within 60 days. In order to ensure anonymity during the reviewing process authors are requested to avoid self-referencing or keep it to the barest minimum.

PREPARATION OF MANUSCRIPT

Manuscripts should be type written in fluent English (using 12-point Times New Roman font and 1½ line-spacing) on one side of white A4-sized paper justified fully with 3cm margin on all sides. *Guidelines for Authors* 317.

In preparing manuscripts, MS-Word, Office 98, or Office 2000 for Windows should be used. Length of manuscripts should not normally exceed 12 printed pages (including tables, figures, references, etc.). For articles exceeding 10 typed pages US\$ 10.0 is charged for every extra page. Longer manuscripts may be accepted for publication as supplements or special research reviews. Authors will be requested to pay a publication charge of US\$ 350.0 to defray the very high cost of publication. The pages of manuscripts must be numbered sequentially beginning with the title page. The presentation format should be consistent with the guidelines in the publication format of the American Psychological Association (APA) (4th edition).

Title page:

The title page of the manuscript should contain the following information:

Concise and informative title.

Author(s') name(s) with first and middle initials. Authors' highest qualifications and main area of research specialisation should be provided.

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A short running title of not more than 6 words.

Abstract

An abstract of 200-250 words is required with up to a maximum of 5 words provided below the abstract. The abstract must be typed on a separate page using single line spacing, with the purpose of the study, methods, major results and conclusions concisely presented. Abbreviations should either be defined or excluded.

Text

Text should carry the following designated headings: Introduction, materials and methods, results, discussion, acknowledgement, references and appendices (if appropriate).

Introduction

The introduction should start on a new page and in addition to comprehensively giving the background of the study, should clearly state the problem and purpose of the study. Authors should cite relevant references to support the basis of the study. A concise but informative and critical literature review is required.

Materials and Methods

This section should provide sufficient and relevant information regarding study participants, instrumentation, research design, validity and reliability estimates, data collection procedures, statistical methods and data analysis techniques used. Qualitative research techniques are also acceptable.

Results

Findings should be presented precisely and clearly. Tables and figures must be presented separately or at the end of the manuscript and their appropriate locations in the text indicated. The results section should not contain materials that are appropriate for presentation under the discussion section. Formulas, units, and quantities should be expressed in the *systeme* 318

Guidelines for Authors internationale (SI) units. Colour printing of figures and tables is expensive and could be done upon request authors' expense.

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References

The American Psychological Association (APA) format should be used for referencing. Only references cited in the text should be alphabetically listed in the reference section at the end of the article. References should not be numbered either in the text or in the reference list.

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For one or two authors; Kruger (2003) and Travill and Lloyd (1998). These references should be cited as follows when indicated at the end of a statement: (Kruger, 2003); (Travill & Lloyd, 1998).

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Multiple references when cited in the body of the text should be listed chronologically in ascending order, i.e. starting with the oldest reference. These should be separated with semi colons. For example, (Tom, 1982; McDaniels & Jooste, 1990; van Heerden, 2001; de Ridder *et al.*, 2003).

Reference List

In compiling the reference list at the end of the text the following examples for journal references, chapter from a book, book publication and electronic citations should be considered:

Examples of journal references:

Journal references should include the surname and initials of the author(s), year of publication, title of paper, name of the journal in which the paper has been published, volume and number of journal issue and page numbers.

For one author: McDonald, A.K. (1999). Youth sports in Africa: A review of programmes in selected countries. *International Journal of Youth Sports*, 1(4), 102-117.

For two authors: Johnson, A.G. & O’Kefee, L.M. (2003). Analysis of performance factors in provincial table tennis players. *Journal of Sport Performance*, 2(3), 12-31.

For multiple authors: Kemper, G.A., McPherson, A.B., Toledo, I. & Abdullah, I.I. (1996). Kinematic analysis of forehand smash in badminton. *Science of Racket Sports*, 24(2), 99-112.

Examples of book references: *Guidelines for Authors* 319.

Book references should specify the surname and initials of the author(s), year of publication of the book, title, edition, page numbers written in brackets, city where book was published and name of publishers. Chapter references should include the name(s) of the editor(s) and other specific information provided in the third example below:

For authored references: Amusa, L.O. & Toriola, A.L. (2003). *Foundations of Sport Science* (1st ed.) (pp. 39-45). Mokopane, South Africa: Dynasty Printers.

For edited references: Amusa, L.O. and Toriola, A.L. (Eds.) (2003). *Contemporary Issues in Physical Education and Sports* (2nd ed.) (pp. 20-24). Mokopane, South Africa: Dynasty Printers.

For chapter references in a book: Adams, L.L. & Neveling, I.A. (2004). Body fat characteristics of sumo wrestlers. In J.K. Manny and F.O. Boyd (Eds.), *Advances in Kinanthropometry* (pp. 21-29). Johannesburg, South Africa: The Publishers Company Ltd.

Example of electronic references:

Electronic sources should be easily accessible. Details of Internet website links should also be provided fully. Consider the following example:

Wilson, G.A. (1997). Does sport sponsorship have a direct effect on product sales? *The Cyber-Journal of Sport Marketing (online)*, October, 1(4), at <http://www.cad.gu.au/cjasm/wilson.html>. February 1997.

PROOFREADING

Manuscript accepted for publication may be returned to the author(s) for final correction and proofreading. Corrected proofs should be returned to the Editor-In-Chief within one week of receipt. Minor editorial corrections are handled by AJPHEs.

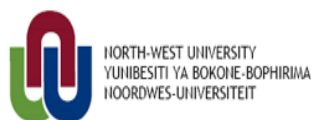
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APPENDIX B



School of Biokinetics, Recreation and
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Private Bag x6001,
Potchefstroom
2520
South Africa
Tel: +27 18 299 1790
Fax: +27 18 299 1808
E-mail: andries.monyeki@nwu.ac.za
25 January 2010

The District Operational Director
Department of Education
North West Province
Potchefstroom

REQUEST TO CONDUCT RESEARCH WITHIN YOUR DISTRICT

Dear Sir,

We, the researchers from the School of Biokinetics, Recreation and Sport Science hereby request permission to conduct research in the district under your authority.

To give the background of the study, research revealed that physical activity in adolescents is drastically declining. A decline in the level of physical activity of human populations has been observed, and such decline has been associated with increased mechanization, reliance on technology and urbanization, and the high rate of crime in South Africa and elsewhere in the world. Physical inactivity is thought to be one of the main risk factors for the development of obesity, diabetes, cardiovascular disease, osteoporosis, and psychological constraints or risks of behavioural health.

Cross-sectional studies in South Africa which investigate the relationship between physical activity and determinants of cardiovascular disease for children and adults are available.

Findings from these studies revealed inactivity was significantly related to the determinants of cardiovascular disease. Little from the abovementioned studies could investigate physical activity and determinants of cardiovascular disease on a longitudinal basis. It is therefore important to note that South Africa is a country of paradox where obesity in children co-exists with malnutrition and many other health ailments. It is, therefore, against this background that a longitudinal study investigating the development and tracking of physical activity and the determinants of cardiovascular diseases in South African adolescents is needed. Adolescence is a time when independence is established, and dietary and activity patterns may be adopted that are followed for many years. Most of the physiological, psychological, and social changes within people take place during this period of life. The period of adolescence can be looked upon as a time of more struggle and turmoil than childhood. Adolescents have long been regarded as a group of people who are searching for themselves to find some form of identity and meaning in their lives. Thus, it has great influence on adult fatness and chronic diseases of lifestyle, as well as a long-term outcome on quality of life. If youth health behaviours are tracked during adolescence, it would add support to the primary assumptions given for early interventions to prevent both cardiovascular disease as well as a delay in cognitive development. For this longitudinal study, tracking is defined as the stability of health behaviours over time, or the predictability of future values by early measurements. From the above given background, therefore, the aim of the study is to investigate over a five year period (2010-2014) a follow-up longitudinal development of physical activity and determinants of health risk factors of health behaviour in 14 year-old adolescents attending schools in the Potchefstroom area of the North West Province of South Africa.

The above matter background information refers:

1. Permission is requested to conduct research in selected schools in your district as follows:

- 1.1. BA Seobi Sec. School
- 1.2. Tlokwe High School
- 1.3. Resolofetse High School
- 1.4. Botokwa High School
- 1.5. Potchefstroom High School for Boys
- 1.6. Potchefstroom High School for Girls
- 1.7. Hoer Volkskool Potchefstroom
- 1.8. Potchefstroom Gimnasium School

2. The targeted groups are boys and girls aged 14 years, in essence the Grade 8 learners (NB: the proportion will be as follows: in mixed schools, 35 girls and 35 boys; and in black schools 30 boys and 30 girls will be required).

3. The targeted term is the first term of 2010 (to be continued during the same term in the subsequent years up until 2014).

4. Items to be assessed or measured are:

- 4.1 Demographic information of the selected participants.
- 4.2 Anthropometric measurements (i.e. body height; weight; skin folds thickness (triceps, sub scapular and calf skin folds), and waist and hip circumferences.
- 4.3 Maturation (Tanner questionnaire).
- 4.4 Blood pressure measurement (mercury sphygmomanometer).
- 4.5 Physical activity questionnaire.
- 4.6 ActiHeart (heart rate recorder with an integrated omnidirectional accelerometer. It is clipped onto two ECG electrodes worn on the chest).
- 4.7 Health-related physical fitness (i.e. 20m shuttle run, standing broad jump, sit-and-reach, bent arm hang, sit-ups).
- 4.8 Social and self-efficacy questionnaire.
- 4.9 Resting metabolic rate (determined by means of a mobile gas analyser).
- 4.10 Blood sampling (i.e. the participants will be requested to fast overnight (10 hours). A fasting sample of 10 ml blood will be taken from each participant in order to obtain ample blood for the various analyses of the study).
- 4.11 Nutritional intake questionnaire.
- 4.12 Leisure and recreation constraint questionnaires.

5. The schedule of the project will be as follows (specific dates for selected schools will be finalised per arrangement with the principals concerned):

Month and week	Duration
April 2010, week 12 – 16	3 hours per child in a selected school
April 2010, week 19 – 23	3 hours per child in a selected school

Due to the fact that participants will be asked to fast 10 hours without eating breakfast in the morning, sandwiches will be provided upon completion of the measurements. The outcomes

of this project will benefit the children and the schools with the information regarding the physical activity status and the determinants of health for future.

Hoping for a positive response.

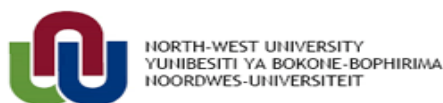
Yours sincerely,

Thank you,

Prof. M. Andries. Monyeki
(Principal Investigator, NWU-Potchefstroom)

Dr Hanlie Moss
Leader of Niche Area for Physical
Activity, Sports and Recreation, NWU-
Potchefstroom

APPENDIX C



School of Biokinetics, Recreation and Sport Science
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2520
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E-mail: andries.monyeki@nwu.ac.za
10 March 2010
<http://www.nwu.ac.za>

INFORMATION LETTER TO THE PARENTS AND CONSENT FORMS: *PAHLS STUDY*

Dear Parent or Guardian,

Your child is being invited to participate in a study entitled “Five year Longitudinal Study of Physical Activity status and the Determinants of Health in Adolescents attending high school in Potchefstroom areas of South Africa” (*PAHLS-Study, 2010–2014*).

My name is Professor Makama Andries Monyeki (from Potchefstroom Campus of the North-West University), the principal investigator in the project, who together with the research team would like to ask your permission to allow your child (or a child under your care) to participate in our study. To give the background of the study, research revealed that physical activity in adolescents is drastically declining. The decline in the level of physical activity of human populations has been observed, and such decline has been associated with increased mechanization, reliance on technology and urbanization, and the high rate of crime in South Africa. Physical inactivity is thought to be one of the main risk factors for the development of obesity, diabetes, cardiovascular disease, osteoporosis, and psychological constraints or risks of behavioural health. Therefore, the purpose of this study is to gather information about physical activity (i.e. by questionnaire & ActiHeart rate monitor), and health determinants (i.e. through measurements of anthropometry, maturation, blood pressure measurement, health-related physical fitness, social and self-efficacy questionnaire, resting metabolic rate, oxygen consumption (by the use of a portable gas analyser apparatus), blood sampling,

leisure and recreation constraint questionnaires, a nutritional intake questionnaire (as questionnaire on risk factors of life) over a period of five years (2010–2014).

Participation in this study is not part of the child's regular class work; it is an optional activity in which the learner can choose to participate. The study will assess and test the following variables: anthropometric measurements, maturation, blood pressure measurement, health-related physical fitness, social and self-efficacy questionnaire, resting metabolic rate, oxygen consumption, blood sampling, using leisure and recreation constraint questionnaires, and a nutritional intake questionnaire as questionnaire on risk factors of life. Blood samples will be collected by a registered professional nurse who will be obliged to follow good health profession practices at all times.

The data of the study will be used for research purposes only. The measurements will not be shared with your child's classmates or teacher. All information collected in this study will be kept confidential. Your child's participation is important because the information that shall be gathered on him/her will help him/her with knowledge for personal development and life skills.

Your child's participation in the project is very important, but it is entirely your choice. If your child chooses to refuse to participate in any part of the study or withdraw from the study at any time, for any reason, this will not cause anyone to be upset or angry, and this will not result in any type of penalty.

There are no costs required for your child (or a child under your care) to participate in the study. Further, no payment will be granted to your child (or a child under your care) for participating in the study.

If you have any question regarding this study, please feel free to contact me at (018) 299 1790, or e-mail:andries.monyeki@nwu.ac.za, or the PHASrec Niche Area Leader Dr Hanlie Moss at (018) 299 1821, e-mail:hanlie.moss@nwu.ac.za. If you have any questions regarding your rights or your child's rights as participants in this study you can call Ms Hannekie Botha at (018) 299 4850 from Potchefstroom Campus of the North-West University Research Ethics Office.

Thank you, in advance, for considering your child's participation in this study. Should you choose to allow your child to participate, please read, and sign the attached consent form. Keep one consent form for your records and return the other copy. All received consent forms will be kept locked during the entire period of the study. In addition, your child is requested to bring along his/her birth clinic card. The card will be given back to the child immediately after collecting information on birth date and birth weight. Any child who has returned a completed and signed consent form will participate in the study.

Sincerely,

Prof. Makama Andries Monyeki
Principal Investigator – PAHLS Study

CONSENT FORM

(Parent/Guardian Copy)

FIVE YEAR LONGITUDINAL STUDY OF PHYSICAL ACTIVITY STATUS AND THE DETERMINANTS OF HEALTH IN ADOLESCENTS ATTENDING HIGH SCHOOL IN POTCHEFSTROOM AREAS OF SOUTH AFRICA (*PAHLS-STUDY, 2010–2014*).

I, ..., father/mother/guardian of agree to permit my child to provide the information on physical activity (i.e. by questionnaire & ActiHeart rate monitor) and health determinants (i.e. through measurements of anthropometry, maturation, blood pressure measurement, health-related physical fitness, social and self-efficacy questionnaire, resting metabolic rate, oxygen consumption (by the use of a portable gas analyser apparatus), blood sampling, leisure and recreation constraint questionnaires, a nutritional intake questionnaire (as questionnaire on risk factors of life), by the researchers at my child's school. I understand that the results of this five-year longitudinal study of physical activity status and the determinants of health in adolescents attending high school in Potchefstroom areas of South Africa (*PAHLS-STUDY NWP*) will be used for research purpose and nothing else. I am aware that if I have any question or concerns about the study I can contact the researcher at (018) 299 1790 or the PHASRec Niche Area Leader at (018) 299 1821. Any questions or concerns regarding my child rights as a participant in this study can be addressed to Ms Hannekie Botha at (018) 299 4850 from Potchefstroom Campus of the North-West University Research Ethics Office. I understand that there will be no discomfort or foreseeable risks for my child to participate in the study. I understand that all information my child provides will remain strictly confidential. I have read and understood the information provided above and in the information letter. I have been provided with the opportunity to ask questions and my questions have been answered satisfactorily. I consent to have my child participate in the study described above, understanding that he/she may refuse to participate in any part of the study and can withdraw from the study at any time. I have kept one copy of this consent for my records and will return the second copy with the clinic birth card. I am aware that by giving consent my child can participate in the study. The return consent form will be kept locked during the entire period of the study.

Child's Age:.....

Grade:.....

Teacher:.....

School Name:.....

Name of Child:.....

Name of Parent/Guardian:.....

.....

(Signature of Child)

.....

(Signature of Parent/Guardian)

.....

(Date)

.....

(Date)

CONSENT FORM (*PAHLS*)

(Return this copy with the demographic questionnaire)

FIVE YEAR LONGITUDINAL STUDY OF PHYSICAL ACTIVITY STATUS AND THE DETERMINANTS OF HEALTH IN ADOLESCENTS ATTENDING HIGH SCHOOL IN POTCHEFSTROOM AREAS OF SOUTH AFRICA (*PAHLS-STUDY, 2010–2014*).

I, ..., father/mother/guardian of agree to permit my child to provide the information on physical activity (i.e. by questionnaire & ActiHeart rate monitor) and health determinants (i.e. through measurements of anthropometry, maturation, blood pressure measurement, health-related physical fitness, social and self-efficacy questionnaire, resting metabolic rate, oxygen consumption (by the use of a portable gas analyser apparatus), blood sampling, leisure and recreation constraint questionnaires, a nutritional intake questionnaire (as questionnaire on risk factors of life), by the researchers at my child's school. I understand that the results of this five-year longitudinal study of physical activity status and the determinants of health in adolescents attending high school in Potchefstroom areas of South Africa (*PAHLS-STUDY NWP*) will be used for research purposes and nothing else. I am aware that if I have any questions or concerns about the study I can contact the researcher at (018) 299 1790, e-mail:andries.monyeki@nwu.ac.za, or the PHASRec Niche Area Leader at (018) 299 1821, e-mail:hanlie.moss@nwu.ac.za. Any questions or concerns regarding my child's rights as a participant in this study can be addressed to Ms Hannekie Botha at (018) 299 4850 from Potchefstroom Campus of the North-West University Research Ethics Office. I understand that there will be no discomfort or foreseeable risks for my child to participate in the study. I understand that all information my child provides will remain strictly confidential. I have read and understood the information provided above and in the information letter. I have been provided with the opportunity to ask questions and my questions have been answered satisfactorily. I consent to

have my child participate in the study described above, understanding that he/she may refuse to participate in any part of the study and can withdraw from the study at any time. I have kept one copy of this consent for my records and will return the second copy with the clinic birth card. I am aware that by giving consent my child can participate in the study. The return consent form will be kept locked during the entire period of the study.

Child's Age:.....

Grade:.....

Teacher:.....

School Name:.....

Name of Child:.....

Name of Parent/Guardian:.....

.....

(Signature of Child)

.....

(Signature of Parent/Guardian)

.....

(Date)

.....

(Date)

APPENDIX D



PAHLS Project - Anthropometry *Pro Forma*

Subject number:	
-----------------	--

Name:

Sport:

Surname

First names

Date of Birth:			
	Day	Month	Year

Test Date:			
	Day	Month	Year

Box height:

Gender:

M

☐

F

☐

	<i>ID</i>	<i>Site</i>	<i>Trail 1</i>	<i>Trail 2</i>	<i>Trail 3</i>	<i>Mean/ Median</i>
Basic	1	Body mass				
	2	Stature				
	3	Sitting height				
	4	Armspan				

Skinfolds	5a	Triceps : R				
(SF)	5b	Triceps : L				
(mm)	6a	Subscapular : R				
	6b	Subscapular : L				
	7a	Biceps : R				
	7b	Biceps : L				
	8a	Supraspinale : R				
	8b	Supraspinale : L				
	9	Abdominal : R				
	10a	Front thigh : R				
	10b	Front thigh : L				
	11a	Medial calf : R				
	11b	Medial calf : L				

Girths	12	Head				
GR	13a	Arm (relaxed) : R				
(cm)	13b	Arm (relaxed) : L				
	14a	Arm (flexed & tensed) : R				
	14b	Arm (flexed & tensed) : L				
	15	Waist (minimum)				
	16	Gluteal (hips)				
	17a	Thigh (mid) : R				
	17b	Thigh (mid) : L				
	18a	Calf (maximum) : R				
	18b	Calf (maximum) : L				

Breadths	19	Wrist				
BR	20	Ankle				
(cm)	21	Foot length				
	22	Humerus				
	23	Femur				

APPENDIX E

POSTURE RATING CHART

SIDE VIEW POINTS

SCORE

5 	3 	1 	_____
5 	3 	1 	_____
5 	3 	1 	_____
5 	3 	1 	_____
5 	3 	1 	_____
5 	3 	1 	_____
5 	3 	1 	_____

Forward Bending Test (Y/N)

L/R

POSTURE RATING CHART

BACK VIEW POINTS

SCORE

5 	3 	1 	_____
5 	3 	1 	_____
5 	3 	1 	_____
5 	3 	1 	_____
5 	3 	1 	_____
5 	3 	1 	_____

Total:

New York Posture Test

NEW-YORK POSTURE TEST