

**Health-related physical fitness and risk factors
associated with obesity among primary school
children in the Limpopo and Mpumalanga provinces
of South Africa**

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associated with obesity among primary school
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of South Africa**

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Thesis submitted in fulfilment of the requirements for
the degree Doctor of Philosophy in Human Movement
Science at the Potchefstroom Campus of the North-
West University

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Dedications

This study is heartily dedicated to:

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Declaration

Prof. M.A. Monyeki (promoter and co-author) and Prof. A.L. Toriola (co-promoter and co-author) of the three articles which form part of this thesis, hereby give permission to the candidate, Ms V.K. Moselakgomo to include articles as part of a doctoral thesis. The contribution of each co-author, both supervisory and supportive, was kept within reasonable limits and included:

Ms V.K. Moselakgomo: Developing the proposal, data collection, data coding, interpretation of the results, writing of the manuscript and the thesis;

Prof. M.A. Monyeki: Advising on statistical analysis and interpretation thereof, structure of the manuscript, write-up of the articles and comments on the thesis.

Prof. A.L. Toriola: Contributing to the write-up of the articles.

This thesis, therefore, serves the fulfilment of the requirements for the PhD degree in Human Movement Science within Physical Activity, Sport and Recreation (PhASRec) in the Faculty of Health Sciences at the North-West University, Potchefstroom Campus.

Prof. M.A. Monyeki

Promoter and co-author

Prof. A.L. Toriola

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Abstract

It is well documented that behavioural and biological risk factors for Chronic Diseases of Lifestyle (CDL) such as overweight and high blood pressure persist from childhood into adulthood. CDL is considered to be a group of diseases that shares similar risk factors as a result of exposure over many decades to physical inactivity, unhealthy diets, smoking, lack of regular exercise, and possibly stress. This study assessed health-related physical fitness and risk factors associated with obesity among 1361 (boys: n=678; girls: n=683) primary school children aged 9-12 years in the Limpopo (LP) and Mpumalanga (MP) Provinces, South Africa. Anthropometric and physical fitness measurements were taken using the protocol of the International Society for the Advancement of Kinanthropometry (ISAK) (Marfell-Jones, *et al.*, 2006) and EUROFIT (1988) test batteries. Body composition measures included body mass index (BMI) ($\text{weight}/\text{height}^2$), percentage body fat (%BF) and waist-to-hip ratio, respectively. BMI for age and gender was used to classify the children as underweight, overweight or obese (Cole *et al.*, 2007), whilst %BF calculated from the sum of two skinfolds (triceps and subscapular) using the equation of Slaughter *et al.* (1988) indicated adiposity. The International Physical Activity Questionnaire (IPAQ) was used to categorise the children's physical activity (PA) level as follows: Low (METs scores of less than 500); Moderate (METs scores from 500 to 1499) or High (METs >1500).

In general, 75% of the children were underweight/stunted and 1.6% overweight. Frequencies of underweight, normal weight and overweight were 77%, 22.4% and 0.2% in MP and 72%, 24% and 3% in LP province. Boys were generally taller and heavier than girls. At age 10 the MP boys performed significantly ($p=0.05$) better in sit-ups (SUP: 20.5 ± 5.4) than the LP boys (18.6 ± 6.56). However, the LP boys performed significantly better than the MP boys in sit-and-reach (SAR) at ages 10 and 11. The MP boys performed significantly ($p=0.00$) better in SBJ ($121.6 \pm 9.1\text{cm}$) compared to the Limpopo ($118.4 \pm 11.00\text{cm}$) boys at age 9. Generally, LP boys were significantly ($p=0.00$) better than the MP boys across all ages. The PA results showed that 27.7% (377), 58.5% (796) and 13.8% (188) of the children participate in low, moderate and high PA, respectively. Children in the MP province had higher PA (28.6%) in comparison to the low PA participation in LP children (26.7%). Furthermore, 59.7% of MP children compared to the LP children (57.3%) participate in moderate PA. A higher PA

participation rate (15.8%) was found among the LP than MP children (11.6%). The girls had non-significantly higher BP values (systolic: 112.94 ± 11.28 mmHg; diastolic: 79.40 ± 12.80 mmHg) than boys (systolic: 110.71 ± 14.95 mmHg; diastolic: 75.53 ± 12.53 mmHg) who had higher PA levels (METs = 1286.72 ± 317.47) than girls (METs = 397.28 ± 30.14) ($p < 0.01$).

A total of 81% ($n=1089$) and 19% ($n=253$) of the combined samples had normal BP and prehypertension, respectively. When controlled for provinces, gender and age, results indicated that BMI was negatively associated with systolic BP (SBP) (-0.54) ($p < 0.01$), but positively correlated with %BF (0.133) ($p < 0.01$), whilst SBP related positively with %BF (0.125) ($p < 0.01$). The children's PA level correlated positively with BMI (0.86) ($p < 0.01$) but negatively with %BF (-0.67); weight circumference (WC) (-0.41); SUP (sit-up) (-0.22); and predicted $\dot{V}O_{2max}$ (-0.17) ($p < 0.05$).

The high percentage of underweight and pre-hypertensive children in the study warrants an urgent need to periodically evaluate PA levels among South African children and design appropriate intervention programmes to alleviate concerns over body weight disorders and low PA levels in children, thus optimising health outcomes.

Keywords: Anthropometry, body composition, health-related fitness, risk factors, physical activity, South African children.

Dit is deeglik gedokumenteer dat gedrag en biologiese risiko faktore vir Kroniese Leefstyl Siektes (KLS) soos oorgewig en hoë bloeddruk kan duur van kinderjare tot die volwassenheid. KLS word beskou as 'n groep van siektes met ooreenstemmende risiko faktore as 'n resultaat van blootstelling oor menige dekades van fisieke onaktiwiteit, ongesonde diëte, rook, gebrek aan gereelde oefening en moontlike stres. Hierdie studie ondersoek gesondheid-verwante fisieke fiksheid en risiko faktore geassosieer met obesiteit onder 1361 (seuns: n=678; meisies: n=683) primêre skool kinders tussen die ouderdom 9–12 jaar in die Limpopo (LP) en Mpumalanga (MP) Provinsies in Suid Afrika. Antropometrie en fisieke fiksheid metings is gedoen volgens die protokol van die “Internasionale Association for the Advancement of Kinanthropometry-ISAK” (Marfell-Jones *et al.*, 2006) asook EUROFIT (1988) toets batterye. Liggaamsamestelling bepalinge insluitend liggaamsmassa-indeks (LMI) ($\text{gewig}/\text{lengte}^2$), persentasie-liggaam vet (%LV) en middel-tot-heup ratio, onderskeidelik is gedoen. LMI vir ouderdom en geslag is gebruik om die kinders te klassifiseer as ondergewig, oorgewig of obees (Cole *et al.*, 2007), terwyl % LV bereken is deur die som van 2 velvoue (trisepe en subskapulê) deur gebruik te maak van die formule van Slaughter *et al.* (1988) om adipositeit aan te dui. Die Internasionale Fisieke Aktiwiteit Vraelys (IPAQ) is gebruik om die kinders se fisieke aktiwiteit-vlakke te kategoriseer in: Laag (METs laer as 500); Gemiddeld (METs van 500 tot 1499) of Hoog (METs > 1500).

In die algemeen was 75% van die kinders ondergewig/groei gestrem en 1.6% oorgewig. Frekwensie van ondergewig, normale gewig en oorgewig was 77%, 22.4% en 0.2% in MP en 72%, 24% en 3% in LP provinsie. Seuns was oor die algemeen langer en swaarder as die meisies. By die ouderdom van 10 het die MP seuns betekenisvol ($p=0.05$) beter presteer in opsitte (SUP: 20.5 ± 5.4) as die LP seuns (18.6 ± 6.56). Die LP seuns het kenmerkend beter gedoen as die MP seuns in sit-en-reik (SAR) by die ouderdomme van 10 en 11. Die MP seuns het betekenisvol ($p=0.00$) beter presteer in standverspring ($121.6 \pm 9.1\text{cm}$) in vergelyking met die Limpopo ($118.4 \pm 11.00\text{cm}$) seuns by die ouderdom van 9. In algemeen het die LP seuns betekenisvol ($p=0.00$) beter gedoen as die MP seuns in al die ouderdom groepe. Die FA resultate toon dat 27.7% (337), 58.5% (796) en 13.8% (188) van die kinders deelneem in die lae in FA van 28.6% is nie baie meer as 26.7%. Verder het 59.7% van die

MP kinders in vergelyking met die LP kinders (57.3%) in die gemiddelde FA geval. 'n Hoër FA deelname syfer is gevind tussen die LP (15.8%) en MP kinders (11.6%). Die meisies het nie-betekenisvol hoër BD waardes (sistolies: 112.94 ± 11.28 mmHg; diastolies: 79.40 ± 12.80 mmHg) as seuns (sistolies: 110.71 ± 14.95 mmHg; diastolies: 75.53 ± 12.53 mmHg) vertoon asook hoër FA vlakke (METs = 1286.72 ± 317.47) as meisies (METs = 397.28 ± 30.14) ($p < 0.01$).

'n Totaal van 81% ($n=1089$) en 19% ($n=253$) van die gekombineerde deelnemers het 'n normale BD en prehipertensie, onderskeidelik getoon. Wanneer gekontroleer word vir provinsie, geslag en ouderdom, toon die LMI negatiewe verband met sistolies BD (SBD) (-0.54) ($p < 0.01$), maar positief met %LV (0.133) ($p < 0.01$), terwyl SBD positief korreleer met %LV (0.125) ($p < 0.01$). Die kinders se FA vlakke korreleer positief met LMI (0.86) ($p < 0.01$) maar negatief met %LV (-0.67); middelomtrek (MO) (-0.41); SUP (opsitte) (-0.22); en voorspelde $\dot{V}O_{2\max}$ (-0.17) ($p < 0.05$).

Die hoë persentasie van ondergewig en prehipertensiewe kinders in die studie dui op 'n dringend behoefte om die FA vlakke onder Suid Afrikaanse kinders periodiek te evalueer en 'n geskikte intervensie programme te ontwerp om die bedreiging van liggaamgewig probleme te verlig en lae FA vlakke in kinders te optimaliseer terwille van gesondheid.

Sleutelwoorde: Antropometrie, liggamsamestelling, gesondheid-gerelateerde fisiese aktiwiteit, risiko faktore, fisiese aktiwiteit, Suid-Afrikaanse kinders.

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List of abbreviations

BMI	Body mass index
BP	Blood pressure
CDC	Centre for Disease Control and Prevention
CDL	Chronic disease of lifestyle
CRF	Cardiorespiratory fitness
CVD	Cardiovascular disease
DBP	Diastolic blood pressure
EUROFIT	European test of physical fitness
HC	Hip circumference
HRPF	Health-related physical fitness
IPAQ	International Physical Activity Questionnaire
ISAK	International Society for the Advancement of Kinanthropometry
NCDs	Non- Communicable Diseases
PA	Physical activity
PE	Physical Education
SAR	Sit-and-reach
SBJ	Standing broad jump
SBP	Systolic blood pressure
SPSS	Statistical Package for the Social Sciences
SUP	Sit-up
WC	Waist circumference
WHO	World Health Organisation
WHtR	Waist-to-hip-ratio

List of symbols

cm	Centimetre
%	Percent
%BF	Percentage of body fat
Kg	Kilogram
Kg.m ²	Kilogram per meter second
mm	Millimetre
$\dot{V}O_{2max}$	Maximum oxygen consumption

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1.1 INTRODUCTION

Several international studies consistently revealed positive relationships between overweight and adverse lipid profiles, as well as between high insulin levels and hypertension in children. (Juonala *et al.*, 2008:28; Moreno *et al.*, 2008:32; Kelishadi *et al.*, 2007:95; Ortega *et al.*, 2007:15; Ruiz *et al.*, 2007:61). In recent years it has been established that several chronic diseases of lifestyle (CDL) typical of Westernised countries, such as diabetes, cardiovascular diseases (CVD) and hypertension, can also be observed in children and are also frequently associated with body weight disorders such as underweight, overweight and obesity (Ogden *et al.*, 2008). Obesity is described as an imbalance associated with genetic trends, caloric intake and the calories expended through physical activity (PA) Katzmarzyk *et al.* (2008:33).

1.2 PROBLEM STATEMENT

It appears that many young people live a sedentary lifestyle of long hours spent in front of a television, computer or playing video games (Ortega *et al.*, 2007:1589). It is also well documented that behavioural and biological risk factors for CDL such as overweight and high blood pressure persist from childhood into adulthood (Ogden *et al.*, 2008). CDL is considered to be a group of diseases that share similar risk factors, as a result of exposure

over many decades to physical inactivity, unhealthy diets, smoking, lack of regular exercise, and possibly stress (American Heart Association, 2010). Major risk factors for the development of CDL are physical inactivity, overweight and obesity, high blood pressure, tobacco addiction and diabetes (National Centre for Disease Control, Prevention, and Health Promotion-CDC, 2010). According to the American Heart Association (2010), CDLs are strongly and closely related to overweight and obesity, and strong evidence exists that elevated cholesterol levels in childhood may play a role in the development of hypertension later in life (Ruiz *et al.*, 2007:61). In addition, poor dietary intake and physical inactivity, along with excess body fat, adversely increase cardiovascular and metabolic disease risks and these habits are often established during childhood (World Health Organisation, WHO, 2010) thus allowing overweight and obesity to reach epidemic proportions all over the world. Although physical inactivity has not on its own caused obesity, it can be observed that there is a correlation between sedentary behaviour and levels of overweight and obesity. This link between obesity and PA is of great importance due to the fact that an active lifestyle combined with dietary modifications has shown to be an effective treatment for CDL (Ortega *et al.*, 2007:15). CDC (2010), views obesity as a major factor in the incidence of metabolic syndrome (MS), a clustering of risk factors associated with CDL. However, obesity is not only a problem in developed nations, but is speedily becoming an increasing challenge in countries undergoing an epidemiological transition (Bradshaw *et al.*, 2003:93). These interrelationships between unhealthy lifestyle, risk factors and the resultant obesity, highlight the need to identify and monitor all these factors for targeted interventions in South Africa.

PA has become widely recognised as a key factor in health behaviour associated with reduced cause of morbidity and mortality as well as CDL (Ruiz *et al.*, 2007:350). It is regarded as an integral component of a healthy lifestyle (WHO, 2010). Walker and Hill (2003:15) defined PA as any bodily movement produced by skeletal muscle resulting in energy expenditure. Engaging in regular PA during childhood is hypothesised to reduce health risks associated with inactivity and benefit health both during childhood and adulthood (Strong *et al.*, 2005:732). The association health benefit of PA accrues in a dose-dependent manner, and early adaptations in the transition from sedentary living to becoming moderately active seem to have the greatest effect on risk reduction of obesity in children (Van de Venter, 2008:14). Inactivity in childhood on the other hand is related to increased levels of body fat, a major factor linked with obesity (Ortega *et al.*, 2007:1589).

South Africa is a country undergoing a rapid epidemiological transition in terms of infectious diseases and physical inactivity. Disease patterns characterised by a combination of poverty-related factors and infectious diseases such as HIV/AIDS and tuberculosis (TB) seem to be a reality. However, cardiovascular and metabolic risk factors are particularly prevalent in the country and are increasing at a rapid speed due to an increase in urbanisation, industrialisation and a Western lifestyle, resulting in a negative effect on the lives of many South Africans (Alberts *et al.*, 2005:12). The relationship between PA and obesity in South African children is prevalent probably due to range of inequality in incomes, and the apartheid legacy of a strong association between ethnicity, socioeconomic status and health income (Toriola *et al.*, 2010:16). The trend in South Africa may consequently result in potential public health crises given the increases incidence of childhood overweight, and adverse body fat and abdominal adiposity, which are likely to add to the enormous socioeconomic and public health burden in the near future (Toriola *et al.*, 2010:16).

Various surveys and research studies have expressed a general consensus that PA in a defined context such as in a school physical education (PE) and organised sports programme, is declining in many countries (Subramanian & Silverman, 2007:23). However, schools have been identified as a key setting for PA promotion among young children since attendance is claimed to be a generic part of childhood, therefore providing a conceivable and logical setting for the promotion of PA. In addition, schools represent a privileged institution for releasing and promoting a correct lifestyle starting at a younger age (National Institute of Health Medline Plus, 2009). Schools also serve as an excellent venue to provide learners with the opportunity for daily PA, so as to teach the importance of regular PA for positive health benefits, as well as build skills that support active lifestyle (Toriola *et al.*, 2010:16). Unfortunately, the trend in South Africa is that the school system has either downsized or eliminated PE altogether. This has led to a substantial reduction in time available for PE (Naylor *et al.*, 2006:9). Additionally, children are given little time to participate in regular PA while at school. Many school districts have reduced PE requirements and PA programmes. Most South African schools are being constructed without playgrounds, despite the overwhelming evidence that supports superior performance in the classroom as a result of PA. Moreover, many children are no longer walking to school because of improved means of transport due to modern technology (Toriola *et al.*, 2010:16).

A number of studies have determined the correlation of different anthropometric indices with cardiovascular and metabolic risk factors among children in developed countries. For instance, the Childhood Obesity Working Group of the International Obesity Task Force age and sex specific, BMI cut-off point developed by Cole *et al.* (2000: 320), and the Centre for Disease Control and Prevention BMI based cut-off point of 5th percentile developed by Must and Strauss (1999) were used to classify children as underweight, normal, overweight or obese. Elevated blood pressure (defined as the mean systolic and diastolic above 90th percentile for age and gender after adjusting for weight and height) identified the children which were at risk. These references proved to be good indicators for adverse health outcomes in developed countries. The trends are however, difficult to quantify or compare, as a wide variety of definitions of childhood obesity are in use and no commonly accepted standards have emerged as yet. Moreover little is known about health-related physical fitness and its association with disease risks among South African children. The fact that growth rate and fat patterning vary between different populations makes it particularly difficult to compare. Nevertheless, definitions of these interaction effects for phenotypes related to CVD are important because they will eventually allow for the identification of children at risk of early development of complications, and those likely to be resistant to dietary interventions.

Whilst body mass index (BMI) is recommended by many researchers as the best predictive index for cardiovascular and metabolic risk factors, other studies have demonstrated that waist circumference (WC), including the sum of two skinfolds, is a better measure of abdominal visceral adipose tissue than waist-to-hip ratio (WHtR) (Ruiz *et al.*, 2007; Ortega *et al.*, 2007; Ogden *et al.*, 2008). However, given the adverse health, social and economic consequences of body weight disorders in South Africa, this study has explored all these variables. It was therefore of critical importance to evaluate different anthropometric indices for the assessment of PA, body composition and health-related physical fitness status, establish norms and standards for the assessment of risk factors based on age and gender, and describe the level of disease among South African school children in relation to those in developed countries.

To be able to effectively promote changes in these complex health behaviours, reliable and valid data based on current patterns and the demographic and modifiable factors that are most strongly associated with them were collected. The study was therefore designed to answer the following research questions:

- a) What was the PA status of primary school children in the Limpopo and Mpumalanga provinces of South Africa?
- b) What was the PA, body composition and physical fitness status among primary school children in the Limpopo and Mpumalanga provinces?
- c) What was the relationship between body composition and blood pressure among primary school children in the Limpopo and Mpumalanga provinces?
- d) What was the relationship between PA and risk factors of body weight disorders among South African primary school children?

It was envisaged that the present study would play a crucial role in the identification of the relationship between PA and health-related risk factors among South African school children. Consequently, the findings envisioned development of appropriate strategies and suitable interventions to promote health and PA among South African school children. Further to this it was hoped that the study would enable researchers to make useful comparisons between the results in developed and developing nations, thereby providing baseline data for future epidemiological studies on health-related physical fitness and body composition.

1.3 OBJECTIVES

The objectives of this study included the following:

- 1.3.1 To determine the PA status of primary school children in the Limpopo and Mpumalanga provinces.
- 1.3.2 To determine the PA, body composition and health-related physical fitness status among primary school children in the Limpopo and Mpumalanga provinces.
- 1.3.3 To determine the relationship between body composition and blood pressure among primary school children in the Limpopo and Mpumalanga provinces.
- 1.3.4 To determine the relationship between PA and risk factors of body weight disorders among South African primary school children?

1.4 HYPOTHESIS

The study will be guided by the following hypotheses:

- 1.4.1 There will be significantly low PA status among primary school children in the Limpopo and Mpumalanga provinces.
- 1.4.2 There will be significant differences in PA, body composition and health-related physical fitness status among primary school children in the Limpopo and Mpumalanga provinces.
- 1.4.3 There will be significant differences in the relationship between body composition and blood pressure among primary school children in the Limpopo and Mpumalanga provinces.
- 1.4.4 There will be significant differences in the relationship between PA and risk factors of body weight disorders among South African primary school children.

1.5 STRUCTURE OF THE THESIS

The thesis will be submitted in article format as recommended by senate of the North-West University, and is structured as follows:

Chapter 1: Introduction

Chapter 2: Literature review: Health-related physical fitness and risk factors associated with obesity.

Chapter 3: *Article 1:* Physical activity, body composition and physical fitness status of primary school children in the Limpopo and Mpumalanga provinces. This article is published in the *African Journal for Physical, Health Education, Recreation and Dance (AJPHERD)* Volume 20(2:1), June 2014, pp. 343-356. The references are listed at the end of the chapter according to the *AJPHERD* format.

Chapter 4: *Article 2:* Relationship between body composition and blood pressure among primary school children in the Limpopo and Mpumalanga province, South Africa. This article is accepted for publication in the *Eastern Mediterranean Journal of Social Sciences (MJSS journal in Vol No 5 No 23 November 2014)*.

References are provided at the end of the chapter in accordance with the style of the journal.

Chapter 5: *Article 3:* The relationship between physical activity and risk factors of body weight disorders among South African primary school children. This article is submitted for publication in the *Brazilian Revista Paulista de Pediatria (BRPP)*. List of references is presented according to the journal format and provided at the end of the chapter.

Chapter 6: Summary, conclusions, limitations and recommendations. References are provided at the end of the chapter according to the North-West University guidelines.

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CHAPTER 2: LITERATURE REVIEW: HEALTH-RELATED PHYSICAL FITNESS AND RISK FACTORS ASSOCIATED WITH OBESITY

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2.1 INTRODUCTION

Physical inactivity is considered a predominant health problem for the rapid increase in global non-communicable diseases (NCDs) (World Health Organization, WHO, 2011). Lifestyle changes brought about by modern technology and the invention of industrial machines and tools has reduced the number of hours spent on habitual and occupational PA to that of sedentary living (Ford *et al.*, 2012:10). These dramatic changes amplified the scope of physical inactivity and consequently have increased the burden of health risks (Popkin *et al.*, 2012:70; Thathia *et al.*, 2013:103). Physical inactivity in adults has been implicated in the development of many health problems such as obesity and overweight, hypertension and cardiovascular, metabolic disorders (WHO, 2011), which are now observable among school-aged children and adolescents (Shang *et al.*, 2010:6 ; Monyeki *et al.*, 2012:12, Pahkala *et al.*, 2013:47; Monyeki, 2014:327). A declined PA has become a major public health challenge with both social and economic consequences (Rossouw *et al.*, 2012:108; Kimani-Murage, 2013:6). Of great concern are the trends of long-term health consequences on children and adolescents as they are also affected by this PA transition.

Paradoxically, as these trends continue, more and more is being learnt about the overall importance of PA in promoting and maintaining adequate health. Studies have proved that daily PA has a positive influence on body composition, and has many metabolically beneficial effects, including increased muscle mass, and increased resting energy expenditure, over and above decreased body fat, specifically in the intra-abdominal region (Kelishadi, 2007:29; Goon *et al.*, 2011:170; Metcalf *et al.*, 2011:96; Musa *et al.*, 2012:17). Moreover, other investigators emphasised that PA and physical fitness during childhood have a positive influence on adult health (Strong *et al.*, 2005:146), although the links of PA, physical fitness and their association with health risk factors are yet to be confirmed in children.

Data on secular trends and some cross-sectional studies have linked increased body fat among children and adolescents with impaired physical fitness. These trends have been reported in many countries including Spain (Artero *et al.*, 2010:20); Brazil (Andreasi *et al.*, 2010:86); China (Qi-Qiang *et al.*, 2011:52); Nigeria (Goon *et al.*, 2011:170; Musa *et al.*, 2012:17); Canada, Mexico and Kenya (Heroux *et al.*, 2013); and South Africa (Monyeki *et al.*, 2008:551; Amusa *et al.*, 2010:63; Jacobs & De Ridder, 2012:34). These studies have over the years, provided positive evidence which confirms that PA is associated with a lower

risk of developing serious illnesses such as cardiovascular diseases (CVD). Some studies have found low PA to be one of the connecting factors between obesity and poor physical fitness and this association is characterised by the presence of an excess amount of body fat (Mirhosseini *et al.*, 2011:10; Singh, 2013:3; Lindsay *et al.*, 2013:45). This type of association is likely to be seen in activities involving carrying excess body weight. Another explanation is that obesity by itself impairs fitness, regardless of PA (Gutin *et al.*, 2005:81; Ogden *et al.*, 2010:303).

In South Africa, studies carried out in rural areas of Limpopo Province have consistently reported body weight disorders and an incidence of health-risk behaviours in school children and adolescents (Monyeki *et al.*, 2005:59a ; Monyeki *et al.*, 2007:556b; Amusa *et al.*, 2007:86). These studies emphasised the need for urgent intervention programmes to reverse the growing trend of risk factors of CVD in children and the youth. It is alleged that physically active lifestyles among young children have a positive impact on the development of strong bones, healthy joints, an efficient heart and general wellbeing (European Heart Health Initiative, 2007:13). Engagement in regular PA during childhood has been hypothesised to be associated with a healthier, longer life with a lower risk of heart disease, high blood pressure, diabetes, obesity and some cancers (Fairclough & Stratton, 2006:36; Ford *et al.*, 2008:42; Hills *et al.*, 2010:6). However, these universal supports for the promotion of PA seem to challenge how such levels should be defined: despite much effort to encourage higher levels of PA among school children and sustain their involvement, a marked decline in participation across teenage years has been identified (Toriola *et al.*, 2011a:2; Ford *et al.*, 2012:10). Therefore, investigating PA and physical-related fitness in this study is important because risk factors often track from childhood to adulthood, thus making children and adolescents a crucial age group for better knowledge in the association between habitual PA, physical-related fitness, and CVD risk factors.

This chapter presents the literature review under the following headings:

- Definitions and interpretation of PA, exercise and physical-fitness
- Distinction between PA, exercise and physical fitness
- Factors affecting PA and physical fitness in children
- Relationship between PA and related risk factors of obesity
- Relationship between risk factors of obesity and socioeconomic status
- Measurement of PA and the socio-demography in children

- PA measurement in children
- Body composition measurement in children
- Morphological measurement (incidents of hypertension) in children
- Measurement of physical-fitness components

2.2 PHYSICAL ACTIVITY

In conceptualising the definition, PA is a highly multidimensional construct, traditionally referred to as “any bodily movement produced by the skeletal muscles that increases energy expenditure above basal level” or in simpler terms, any body movement produced by muscle action that increases energy expenditure (Caspersen *et al.*, 1985:126; Anderson *et al.*, 2009:67; Mirhosseini *et al.*, 2011:10; Metcalf *et al.*, 2011:96). PA occurs over four dimensions: frequency, intensity, time and type. PA is not equivalent to activity expenditure; rather energy expenditure is the result of PA. Total energy expenditure is comprised of several components: resting energy expenditure, the thermic effect of food, activity energy expenditure and, for children, the energy required for growth and development (Kumanyika *et al.*, 2008:118; Lindsay *et al.*, 2013:45).

PA is defined as the result in increased energy expenditure due to the cost of the activity, and is also hypothesised to increase resting metabolic rate (RMR) (Pan & Pratt, 2008:108). PA may therefore be viewed as an activity that encompasses a range of formal and informal activities. Physical exercise is one of the determinants. The latter is a subset of PA that is planned, structured, systematic and purposeful and is undertaken to improve or maintain physical fitness (Caspersen *et al.*, 1985:126; Brooks *et al.*, 2005).

2.3 PHYSICAL FITNESS

Physical fitness on the other hand is viewed as an integrated measure of most bodily functions including the skeletomuscular, cardiorespiratory, hemato-circulatory, psycho-neurological and endocrine-metabolic functions involved in the performance of daily PA and/or physical exercise, a set of attributes that is either health-related or skill-related (Hills, 2010:6). Castillo *et al.* (2005:1) defined physical fitness in more simple terms as the capacity to perform PA, and makes reference to a full range of physiological and psychological qualities. Mondal (2006:18) defined physical fitness in children as the aptitude to realise physical tasks without fatigue related to cardiorespiratory general resistance, muscular

specific resistance, and the levels of muscular force, extent of movement, speed and coordination. Physical fitness is also defined as a characteristic of an individual that relates to his/her ability to perform PA (Kim *et al.*, 2005:13). Fitness has a strong inherited component, but is modifiable within individual range through training. However, cultural changes and advances in technology that have occurred over the past few decades, have had dramatic effects on PA and physical fitness levels in various populations (Sisson & Katzmarzyk, 2008:9; Ford *et al.*, 2012:10; Toriola *et al.*, 2011b:2; Monyeki *et al.*, 2012:12; Kimane-Murage, 2013:6; Monyeki *et al.*, 2014:335). It is obvious that the environment in which we live is gradually changing to one which requires less and less PA and promotes an ever-increasing sedentary lifestyle.

2.4 DISTINCTION BETWEEN PA, EXERCISE AND PHYSICAL FITNESS

Over the years PA became widely recognised as a “key” to health behaviour associated with the reduction of all causes of morbidity and mortality as well as CDL (WHO, 2011). Distinctions between PA, exercise and physical fitness are useful in understanding health research due to the fact that the concepts used are sometimes interchangeable in the literature, which is not always appropriate (Mondal 2006:18). Several studies have shown a powerful relationship between PA and risk factors associated with obesity (Sisson & Katzmarzyk, 2008:9; Ford *et al.*, 2012:10; Toriola *et al.*, 2011b:2). Obesity as a health problem is caused by physical inactivity, amongst other things, and can be treated and prevented by increasing PA levels (Toriola *et al.*, 2011a:2). It is assumed that moderate intensity of regular PA is essential for the prevention of overweight and obesity. It is also recommended that children should engage in not less than 60 minutes of moderate to vigorous PA per day (Davis *et al.*, 2007:120; Kumanyika *et al.*, 2008:118). Insufficient PA contributes to obesity and the risk complications from chronic conditions. According to WHO (2010) in the last decades, physical fitness levels in children have been decreasing while obesity levels increase, probably because the PA levels needed from school going children were not sufficient enough to promote ideal health (Strong *et al.*, 2005:146, Watts *et al.*, 2005:35; Mendoza *et al.*, 2007:4; Freemark, 2007:30).

Relationships between physical fitness and health of the children have been documented by Draper *et al.* (2014:11) and Tremblay *et al.* (2014:11). These investigators established a clear relationship between health and physical fitness. It was reported that children who were competent in accomplishing motor skills could also improve the level of physical fitness and

consequently improve their muscular capacity, speed and agility. In addition, physical fitness has been shown to have a positive effect on musculoskeletal health (Toriola *et al.*, 2011a:2; Hallal *et al.*, 2012:380). PA, cardiorespiratory and muscular fitness are the main pillars in exercise science and have shown to reduce the risk factors associated with obesity, including CVD (European Heart Health Initiatives, 2007). PA is essential for normal growth and development in children, and plays an important role in the prevention of overweight and obesity in childhood and adolescence, as well as reducing the health risks of the condition (Hills, 2010:6). However, literature has revealed that the opportunities to expend energy through PA are discouraged by Western society, and in many settings a large proportion of children and adolescents do not meet the recommended PA guidelines. Evidence also suggests that obese youngsters are less physically active than non-obese children as they spend more time in sedentary pursuits, such as watching television and using other electronic media (Atkin *et al.*, 2013:8; Katzmarzyk *et al.*, 2013:13). A range of environmental factors, including less active transport and the changing nature of school-ground facilities, have also resulted in the reduction or removal of PA from contemporary lifestyles thereby contributing to this childhood epidemic (Sisson & Katzmarzyk, 2008:9).

A number of potential health consequences are associated with excess body fat during the growth years and as a result, the risk of ill health escalates throughout adulthood (Andersen *et al.*, 2009:67). Levels of habitual PA in many youngsters are low, contributing to both a reduction in PA as well as energy expenditure (Schoeller, 2009:67; Gilies *et al.*, 2013:10). In addition to health problems, obese children and adolescents are more likely to suffer poorer psychological and social health, low self-esteem and self-concept, a reduced quality of life, depression and social discrimination than their normal weight peers (Tsiros *et al.*, 2009:33; Shirinde *et al.*, 2012:228).

2.5 FACTORS AFFECTING PA AND PHYSICAL FITNESS IN CHILDREN

2.5.1 Age

PA of children and adolescents varies with age, type of exercise and setting (Monyeki, 2006:57). Basic movement patterns develop during pre-school ages and are the foundation for a wide range of PA at later ages (Ford *et al.*, 2008:42). With growth, maturation, and experience, basic movements are integrated and coordinated into more specialised and complex movement skills. It is at this stage that basic movements become more established and these skills improve health and fitness, and the behavioural components of PA increases

(Pahkala *et al.*, 2013:47). However, among younger people levels of PA decrease with age. A health survey published for the US population by Ogden *et al.* (2010:303) revealed that 16% of boys and 18% of girls aged two to 15 years spent less than one hour per day (5-7 hours per week) on moderate levels of activity. In another survey on National Diet and Nutrition published by Freemark, (2007:30), measurement of PA levels among seven to 18 year olds showed that most people in this age category were inactive, as indicated by time spent in moderate or vigorous intensity activity. It should therefore be noted that there are certain physiological components which gradually reduce with age and result in physical inactivity.

2.5.2 Gender difference

Previous research on children and adolescents has demonstrated small but consistent gender differences in favour of boys in physical self-concept (Gillies *et al.*, 2013:10; Atkin *et al.*, 2013:8). In general, most studies in this discipline have revealed that boys score higher on measures of general physical self-concept than girls. Specifically, studies which used subjective data collection methods to examine PA trends in boys and girls found higher levels of PA in boys compared with girls, irrespective of age (Monyeki *et al.*, 2005:54; Peltzer & Pengpid 2011; Dapi *et al.*, 2011:14; Micklesfield *et al.*, 2012:26; Toriola & Monyeki, 2012:18). Dapi *et al.* (2011:14) has shown that boys scored higher on perception of physical ability and appearance than girls. Furthermore, other studies have shown that physical self-concept declined during early adolescence (Gillies *et al.*, 2013:10; Atkin *et al.*, 2013:8) and further emphasised that this decline in self-concept is more likely in girls than in boys.

Pahkala, *et al.* (2013:47) reported that gender differences in children's development are especially evident for the growth spurt, which begins on average, two years earlier in girls than for boys. They further demonstrated that differences are evident for the development of body fat in girls, increasing from 10-11 years and leanness in boys, from 15 years. Draper *et al.* (2014:11) and Tremblay *et al.* (2014:11) revealed that young females are more sedentary at any school grade and that more active children are less likely to exhibit a large increase in body fat. But Quinns, (2006) argued that body fat is more related to total activity time than to the combined energy cost of the PA. However, Goon *et al.* (2008:14) stressed that during the important developmental years, adolescent females are considerably less active than their male counterparts. It should therefore be noted that in addition to gender, age also

demonstrates a relatively consistent pattern, with older children reporting less PA than the young ones, although once again this relationship may be more pronounced among females. According to Wolfe (2006:84), motor skills *per se*, which include gross and fine coordination, accuracy of movement, speed agility, strength, power, and aerobic capacity among others, are related in part to growth and maturation. Performance of a variety of movement tasks improves with age during childhood. Boys perform on average better than girls but Goon *et al.* (2008:14) warned that there is considerable overlap between sexes during childhood for most tasks. With the onset of adolescence, the performance of boys shows acceleration, while that of girls improves up until around 13-14 years of age and then levels off or improves only slightly. Brooks *et al.* (2005) also conducted a study on gender and PA and assumed that physical size or muscularity is an essential symbol of men power. The study assumed that sports are ultimately about PA as they offer a perfect arena for reproducing concrete, everyday examples of male physicality and muscularity. However, the study stressed that an emphasis on athletic ability might be especially difficult for those boys who do not have spectacular bodies or athletic skills. Data collected for Brooks' study, supported these assumptions in the sense that the results revealed that those boys who participated in organised sport scored significantly higher than non-participants in subscales, including physical ability, sports competence, appearance, PA, strength, endurance, flexibility, and coordination, as well as global self-esteem.

2.5.3 Adolescence

Adolescence refers to that period of rapid growth and development during which youth undergo marked changes in lean and fat mass, as cited by Wolfe (2006:84). The adolescent years constitute a unique developmental phase where rapid biological changes occur in an organism that is relatively mature cognitively and also capable of reflecting upon these changes (Gutin *et al.*, 2005:81; Hallal *et al.*, 2006:36). Adolescence is characterised by large changes in body size and composition. In simple terms it means that higher pre-pubertal BMI and other indicators of adiposity in early childhood are associated with earlier maturation. Foo *et al.* (2008:7) and Ford *et al.* (2008:43) revealed that early maturation increases the risk of subsequent obesity since numerous biological mechanisms support significant increases in body fatness in the post-pubertal period. In short, it means that during the span of adolescent growth, significant changes take place in weight, height and body composition at varying chronological ages. However, performance during adolescence is influenced in part by

individual differences in the timing of the adolescent growth spurt. Performance in a variety of tasks showed well-defined adolescent spurts in boys (Goon *et al.*, 2008:14).

2.6 RELATIONSHIP BETWEEN PA RELATED-RISK FACTORS OF OBESITY

2.6.1 Physical activity and obesity

Obesity is viewed as a major factor in the metabolic syndrome (MS), a clustering of risk factors associated with chronic disease (Ledikwe *et al.*, 2007:85). Obesity is defined as a complex phenotype in which the interaction of multiple genes and environmental conditions leads to the manifestation of the conditions (Levitt *et al.* 2005:44). MS on the other hand is defined as a constellation of risk factors, including obesity, dyslipidaemia, impaired glucose metabolism and elevated blood pressure, all major predictors for CVD (De Ferranti & Osganian, 2007:4). Obesity has become a growing threat to human health, particularly among children. The last two decades have witnessed an increase in health care costs due to obesity and related issues among children and adolescents (Hartley, 2007; Wang & Lobstein, 2006:1; Kelishadi, 2007:29; Kimane-Murage, 2013:6). It now affects every country, including South Africa, to such an extent that the situation has been declared a world epidemic (WHO, 2011). WHO, (2010) views obesity as an independent risk factor for CVD, which significantly increases the risk of morbidity and mortality. In the South African national health and nutrition examination survey published by Popkin (2012:70), a high prevalence of overweight and obesity among children and adolescents was reported, particularly in urban areas and among girls: 9% and 27% in 15-17 -year old boys and girls, and 10% and 23% in boys and girls 10-14 years, respectively. These trends were supported by other national and regional studies (Jacobs & de Ridder, 2012:34; Atkin *et al.*, 2013:8) which showed an increase in prevalence. The exponential and unabated rise in the prevalence of overweight and obesity and their associated risk factors in both developed and developing countries, has become a source of concern more now than it has ever been in the past (Hills, 2010:6). There is evidence indicating that an individual's PA behaviours are heavily influenced by the surrounding social and physical environmental contexts in which these children find themselves (Adams *et al.*, 2013:10; McMinn *et al.*, 2013:23, Atkin *et al.*, 2013:8). Among numerous factors that may contribute to childhood obesity, PA is of particular interest. Other factors associated with unhealthy lifestyle among young children include access to fast food, and the fact that many children are either driven by their parents, or transported to school in commercial vehicles (Hill, 2010:6; McMinn *et al.*, 2013:23).

Urbanisation-related intake behaviours that have been shown to promote obesity, include frequent consumption of meals at fast food outlets, oversized meal portions at home and at restaurants, high caloric foods such as high fat, a low intake of fibre, and a high intake of sweetened beverages (Pereira *et al.*, 2005:365; Ebbeling *et al.*, 2006:117). These behaviours are cultivated in an environment in which high caloric food is abundant, affordable, available, and easy to consume with minimal preparation as is the case in urban cities throughout the country. Television viewing and other sedentary activities have also been related to childhood obesity (McMinn *et al.*, 2013:23, Atkin *et al.*, 2013:8). The combination of inactivity, excessive energy intake and a possible genetic predisposition is claimed to be playing a major role in this development (Kumanyika *et al.*, 2008:118). Inactivity is a behaviour that has a primary consequence for health. Obesity is not only about overeating, but also a result of declined PA (Shields & Tremblay, 2010:5).

Numerous studies have documented that PA habits in childhood could lead to elevated cholesterol levels and an increased risk in developing CVD in early adulthood (Zheng *et al.*, 2008; Pan & Pratt, 2008:108; Costa *et al.*, 2009:93). In addition, a number of cross-sectional studies have indicated a wide variation in physical fitness and PA among children, and if these levels of fitness and activity are maintained in rank order from childhood to adolescence, those children initially observed to be unfit or inactive, relative to their peers, would predictably become unfit or inactive adolescents (Draper *et al.*, 2014:11; Tremblay *et al.*, 2014:11). This accumulating evidence suggests the importance of childhood physical fitness and PA as protective health-related phenomena.

2.7 RELATED RISK FACTORS OF OBESITY AND THE SOCIOECONOMIC STATUS

Socioeconomic trends in childhood obesity are also emerging (Miller & Silverstein, 2007). Obesity in children has become a serious health concern affecting a significant portion of most countries (Kimane-Mirage, 2013:6; Lutfiyya *et al.* 2007:15). The prevalence varies across socioeconomic strata. In developed countries, children of low socioeconomic status are said to be more likely affected than their affluent counterparts. The opposite is observed in developing countries: children of the upper socioeconomic strata are more likely than poor children to be obese (Ogden *et al.*, 2010). Recent results from the National Health and Nutritional Examination Survey (NHANES) as reported by Kimane-Mirage (2013:6) indicated that about 19% of school-age children, aged 6-14 years are obese, and an additional

16% are overweight. In another national survey, it was found that rural children were 25% more likely to be overweight or obese than their urban counterparts (Lutfiyya *et al.* 2007:15). In South Africa, an increasing prevalence of risk factors of metabolic and CVD among children from rural and low socioeconomic was also reported (Monyeki *et al.* 2005:59; Amusa *et al.*, 2007; Moselakgomo *et al.*, 2012; Mamabolo *et al.*, 2014:194). On the contrary, a study from northern India reported a childhood obesity prevalence of 5.59 % in the higher socioeconomic strata compared to 0.42 % in the lower socioeconomic strata (Marwaha *et al.*, 2006). This epidemic is especially severe in rural parts of the country, where obesity rates among rural children have been shown to be higher than children in urban areas.

It is widely believed that environmental factors are at the root of the obesity epidemic. Although research conducted in urban or suburban areas may provide clues as to the factors that affect children's PA, it cannot be assumed that these factors are the same. Many rural communities are characterised by vast distance, low socioeconomic status, transportation challenges, and low public funding levels for facilities programmes and other public amenities (Popkin 2012:70; Miller & Silverstein, 2007). These characteristics may contribute to either low or high levels of PA among school children (Popkin, 2012:70). Environmental risk factors for overweight and obesity are very strong and inter-related (Lutfiyya *et al.* 2007:15). A low level of PA is definitely promoted by an automated and automobile-oriented environment that is conducive to a sedentary lifestyle (Reilly *et al.*, 2005:330). However, it is conceivable that rural children may spend more time outdoors and have more access to fresh fruits and vegetables and playing areas with less access to fast food restaurant than their urban and suburban counterparts (Pereira *et al.*, 2005:365). In addition, parental food choices significantly modify child food preferences and the degree of parental adiposity is surrogate for children's food preferences. These factors are said to be linked to increased PA and healthy eating (Hartley, 2007). Research into the links between the environment and children's PA is scarce, especially in the South African context. However, a better understanding of the association between PA and the environmental factors associated with childhood obesity are important in assessing the benefits of intervention strategies aimed at curbing this epidemic.

2.8 MEASUREMENTS OF PA AND SOCIO-DEMOGRAPHICS IN CHILDREN

2.8.1 Demographic information

Demographic information is considered as part of the determinants or influences of being hypertensive, obese and/or overweight and in certain circumstances, underweight. The demographic information for the purpose of this study included age, gender, ethnicity and residential area. Socio-demographics were obtained from the participants, and a semi-demographic questionnaire was used to gather demographic information.

2.8.2 Sexual maturity

Sexual maturity status (I to V) according to Tanner and Whitehouse (1976), was determined based on self-report by each participant. This was relevant to the study population due to the fact that puberty and the adolescent period are acknowledged to be vulnerable times for the development of obesity due to sexual maturation, which in many individuals, results in a reduction in PA, especially among girls.

2.8.3 Socioeconomic status

Socioeconomic status (SES) has a profound effect on physical health. Several studies in developed countries have shown that NCDs and their risk factors initially occur in groups with the highest SES and those living in urban areas, before the burden shifts to all social groups (Kim *et al.*, 2004:159). Evidence also showed that those from higher SES group are usually the first to respond to NCD prevention campaigns, while those from lower SES groups continue to experience increasing rates (Mendez *et al.*, 2005). NCDs refer to behavioural risk factors (e.g., physical inactivity, poor nutrition, smoking, alcohol consumption); biological risk conditions (e.g., obesity, high blood pressure, blood lipids, and high blood glucose levels), and measures of socio-demographics and SES (e.g., age, gender, urban/rural residence, ethnicity, level of parental education and household income) (Lee *et al.*, 2008:16). The same risk factors can affect more than one NCD condition and they are also likely to cluster with each other. For example, central adiposity is clustered with high blood pressure (Moselakgomo *et al.*, 2012), high cholesterol (Goon *et al.*, 2011:170), and physical inactivity (Draper *et al.*, 2014:11).

It has been argued that the patterns observed in developed countries are likely to be replicated in developing countries (Barker *et al.*, 2007). For example, a study carried out on the

relationship between socioeconomic status and blood pressure in coastal Nigerian adolescents confirmed that high blood pressure was profound in the low socioeconomic community (Ejike *et al.*, 2008:8; Musa *et al.*, 2012). Residences in poor economic-neighbourhood were prone to high blood pressure, and environmental and economic stressors may be contributing factors (Odey *et al.*, 2008:2). In the South African population, CVD risk factors are prevalent because of increasing urbanisation (Alberts *et al.*, 2005, Toriola *et al.*, 2009). Popkin (2012:70) documented a direct association between SES and obesity among children in developing countries. The results showed that obesity was more prevalent among children of higher SES than those of lower SES. The SES determinants were obtained from the subjects using a semi-structured questionnaire.

2.9 PA MEASUREMENT IN CHILDREN

2.9.1 Physical activity questionnaire

PA is essential for the normal growth and development of children and adolescents, plays an important role in the prevention of becoming overweight and obese in childhood, and reduces the health risks of the condition (Hills *et al.*, 2010:6). Moreover, literature has demonstrated that PA affects body composition and weight favourably by promoting fat loss while maintaining or increasing lean tissue mass (Katzmarzyk *et al.*, 2013:13; Pahkala *et al.*, 2013:47). Generally, PA in children typically includes walking to school, informal outdoor games like football, running errands on foot or bicycle and fetching water for domestic use. However, PA among the youth has declined with age over the past few decades (Toriola *et al.*, 2011b:2). In this study, a self-reported habitual PA, frequency and duration of sports including indoor ball games (e.g. soccer, basketball, volleyball), and outdoor sports (including running/jogging, track-and-field sports), dancing, and free play among school children was obtained using a self-administered standardised questionnaire. The questionnaire was developed and validated for this specific population.

2.9.2 Physical activity measurement

A protocol based on the International Physical Activity Questionnaire (IPAQ) was completed in the classroom with instruction of the trained investigators. Physically active children were defined as those who participated either in sports and/or vigorous activities, very hard physical activities, or walking, seven times per week for at least 10 minutes at a time. This conforms with the current recommendations developed by WHO (2005) for the assessment of

PA in children and adolescents. Generally, PA is a multidimensional concept, and levels among children are highly varied. Involvement in PA was documented as part of children's physical health assessment.

2.10 BODY COMPOSITION MEASUREMENT IN CHILDREN

2.10.1 Anthropometry

The International Society for Advancement of Kinanthropometry (ISAK) (2006) defined anthropometry as the study of the measurement of the human body in terms of the dimension of bone muscle and adipose (fat) tissue. Anthropometry therefore provides essential and critical information which is needed to assist in describing the base quantities of the human physical variables. However, there has been debate over which of the anthropometric measures best assesses body fatness, especially in children. Body mass index (BMI) remains the most widely used measure of overweight and obesity in adults and children, as its ability to predict the percentage fat mass reliably has been widely appreciated (Bishwalata *et al.*, 2012:26; Katzmarzyk *et al.*, 2013:13). In adults, BMI of over 30.0 kg/m² has been set as the cut-off limit for the diagnosis and assessment of obesity. However, producing a general cut-off value for all ages and sexes in children remains problematic as BMI varies with age in both sexes. In order to explore other indices of assessing obesity in children, (Monyeki *et al.*, 2005:882; Rashid & Ahmed 2006:11; Foo, 2007:98; Goon *et al.*, 2008:14; Mukharjee & Prakash 2014:1) demonstrated that BMI, WHtR and %BF (from estimated skinfolds) parameters seemed better measures for abdominal visceral adipose tissue. These are the most common anthropometric measurements used to assess the amount of fat in the body, especially among children. In contrast, other researchers have degraded the use of conicity index (CI) as a valid method of identifying children with 'high' trunk fat. For example, other investigators have used methodologies such as girth circumference and skinfold measurement to assess body composition in children (Ogden *et al.*, 2006:295). Body composition refers to the human body with regard to two primary components: fat tissue and fat-free or lean tissue. In most cases body composition tests have an estimate of percentage body fat as their main objective. Once body fat is determined, other body composition variables such as fat weight, lean weight and estimated body weight can be calculated at various percentages of body fat (Ogden *et al.*, 2006:295). According to the National Health and Nutrition Survey, as reported by Tathiah *et al.* (2013:103), excess body fat and obesity play an important role in determining the risk of chronic disease, including metabolic syndrome, coronary heart

disease and diabetes mellitus. In determining body composition of the participants, height, weight, and sitting height were measured for the calculation of BMI. These physiological characteristics were measured according to ISAK (2006) protocol.

2.10.1.1 Physiological measurement

Height

Height is a basic variable that is routinely measured in Kinanthropometry (Sterwart *et al.*, 2011). The purpose of measuring height is basically to characterise or describe the participant, in order to relate body mass with height and growth. Height was measured using a Harpenden stadiometer. The participants were asked to stand erect on the floor board, barefoot with the back in line with the vertical backboard of the stadiometer, weight of the participant evenly distributed on the feet, heels of the feet placed together and touching the base of the vertical board with feet pointed slightly outward at a 60 degree angle. The buttocks, scapulae, and head positioned in contact with the vertical backboard. The participants assumed the anatomical position, with arms hanging freely by the sides of the trunk and palms facing the thighs. The participants inhaled deeply and stood fully erect without altering position of the heels. The children's heads were maintained in Frankfort horizontal plane position while examiner lowered the horizontal bar snugly to the crown of the head with enough pressure to compress the hair. The measurements were read by the examiner and recorded to the nearest 0.1 cm.

Weight

Weight was measured three times to the nearest 0.1kg using an electronic digital weighing scale. Each participant stood barefoot on the digital weighing scale with minimal clothing. The participant stood as erect as possible with head positioned in Frankfort horizontal plane on the centre of the scale, with knees extended, arms and hands hanging naturally at the sides and weight of the participants distributed evenly on their feet. Readings were taken and recorded (Sterwart *et al.*, 2011).

Sitting height

Sitting height is defined as the perpendicular distance between the transverse planes of the vertex and the inferior aspect of the buttocks when seated (Marfel-Jones, 2006). The participants were seated on a measuring box or a level platform, and with hands resting on the thighs took and held a deep breath while keeping the head in the Frankfort plane. The measurer gently applied an upwards lift through the mastoid processes. The recorder placed

the head board firmly down on the vertex, crushing the hair as much as possible. The readings were then recorded (Sterwart *et al.*, 2011).

Body mass index (BMI)

Among the number of indicators used in defining overweight and obesity in children and adolescents, BMI remains one of the most frequently used indicators in this evaluation, although there is still no globally accepted BMI cut-off point. However, the recent BMI cut-off point developed by Cole *et al.* (2007:335) allows an international comparison of the prevalence of overweight and obesity in children and adolescents. Although BMI has become a very common way of assessing overweight and obesity, it does not capture variations in fat and fat-free mass that are surely related differently to fitness. Regardless of cut-off points, assessment of BMI during childhood is a strong predictor of obesity and coronary heart disease risk factors, which points to the importance of using BMI in this study from a health perspective point of view. BMI was calculated and interpreted according to international age and gender reference data. It should be acknowledged though that there are significant changes that take place in weight, height and body composition at varying chronological ages. BMI was expressed as the measure of a person's weight in relation to their height, calculated as weight in kilograms divided by height in metres squared. Children were classified into four body mass categories (i.e., underweight, normal weight, overweight and obese according to Cole *et al.* (2007:335).

Percentage body fat (%BF)

Excess body fat constitutes a serious risk to health, and the physiological functions and physical fitness of an individual. Excess body fat could negatively influence physical performance by adversely affecting mechanical, metabolic and thermoregulatory attributes of an activity (Dores, 2005:26). However, this does not necessarily mean that individuals with high BMI and percentage body fat (%BF) will perform poorer in physical-related performances. Subcutaneous fat is stored between the skin and the muscles and between the muscles and the surrounding organs of the body (Marfell-Jones *et al.*, 2006); it represents about half of the fat in the body of an individual, whereas the other half is located internally around other body organs. However, %BF varies considerably between boys and girls, physical fitness level and age group. Generally, boys have lower %BF than girls (Quinns, 2006).

According to Quinns (2006), the minimum %BF considered to be safe and acceptable for children in good health is 5 % in boys and 12 % in girls. Therefore, precautions should be taken in the assessment of %BF in the children because a certain amount of fat is essential for bodily functions. Ruiz *et al.* (2007:61) conducted a cross-sectional study in a random sample of 9-10 and 15-16 year old Swedish boys and girls on the association between cardiorespiratory fitness and abdominal adiposity. The results indicated that those individuals with high cardiorespiratory fitness levels had significantly lower total adiposity as measured by skinfold thickness. Similar studies carried out in Spain, Nigeria and South Africa also showed that both moderate to high levels of cardiorespiratory fitness were associated with lower abdominal adiposity (Goon *et al.*, 2009:11; Moselakgomo *et al.*, 2012:30). Compartmentalisation of the body into fat may be estimated from such measures as skinfold thickness and body circumferences. Percentage body fat (%BF) and muscularity in school children were estimated from measurements of both triceps and subscapular skinfolds. %BF was estimated using the formula developed by Slaughter *et al.* (1988:60).

Skinfold measurements

Skinfold thickness measures the fat located just underneath the skin (subcutaneous fat) (WHO, 2010) which is a proxy indicator of total fat. Measurements can be performed on a number of sites, including the triceps (the back part of the upper arm), and the sub-scapular area (site just below the shoulder blade). A Rosscraft plastic slim guide calliper was used to measure skinfold thickness. The triceps and the sub-scapular skinfolds were selected for the purpose of this study. These skinfolds are chosen to assess central fat patterning. Some studies observed a correlation of central fat patterning with various disease risk factors, including elevated serum indicators of diabetic risks, blood pressure and lipids level (Smith & Rinderknecht, 2003:15; Connelly *et al.*, 2004:27 and Wang & Hoy, 2004:28). It was interesting to recognise that measures of central fat patterning can be superior indicators of health risk to that of BMI alone, and that the sum of two skinfolds may be used to indicate overall adiposity (Smith & Rinderknecht, 2003:15; Connelly *et al.*, 2004:27 and Wang & Hoy, 2004:28). Of particular concern was the level of central adiposity as demonstrated by high truncal skinfold thicknesses, which are associated with the development of metabolic problems and CVD. However, these risk profiles were probably intensified by the accompanying low physical fitness and inadequate PA levels (Draper *et al.*, 2014:11).

Triceps skinfold

The triceps skinfolds were measured to the last 0.1mm. The subject stood erect with feet together, shoulders relaxed and arms hanging freely at the sides. The tester stood behind the subject's right side. The point on the posterior surface of the right upper arm was located and the midpoint of the upper circumference marked. A fold of the skin and subcutaneous adipose tissue were grasped gently with the thumb and the index fingers approximately 2.0cm above the marked level with the skinfold parallel to the long axis of the arm. The jaws of the callipers were placed at the marked level, perpendicular to the length of the fold, and skinfold thickness was measured three times to the nearest 0.1mm while the fingers continued to hold the skinfold (Marfell-Jones *et al.*, 2006). This procedure was repeated three times with the readings recorded each time.

Subscapular skinfold

Subscapular is the site just below the shoulder blade, situated at the inferior border or on the underside of the scapular. The subscapular skinfold was measured to the nearest 0.1 mm. The subject stood erect with shoulders and arms relaxed at the side. The examiner marked the inferior angle of the scapular with a cosmetic pencil marker, then grasped the fold of the skin and subcutaneous adipose tissue directly below 0.1cm and medial to the inferior angle. The skin formed a line about 45 degrees below the horizontal extending diagonally toward the right elbow. The jaws of the callipers were then placed at the marked level, perpendicular to the length of the fold about 2.0cm to the fingers with the top jaw of the calliper on the mark over the inferior angle of the scapular. The skinfold thickness was measured to the nearest 0.1mm while the fingers continued to hold the skinfold (Marfell-Jones *et al.*, 2006). This procedure was repeated three times and the readings recorded.

Waist-hip ratio (WHtR)

A marked increase in the prevalence of body and abdominal obesity is one of the most common health problems with increasing incidence worldwide among people of all ages. The waist-to-hip ratio (WHtR) was calculated by dividing waist circumference (WC) (cm) by hip circumference (HC) (cm). However, WHtR cannot evaluate health risks associated with abdominal fat alone. The two measurements BMI and WHtR, are the most commonly used anthropometric indices to assess the pattern of fat distribution among children and adolescents. This classification system is recommended by WHO (2010) for all racial or ethnic groups. However, the use of one of these anthropometric indices may not yield the anticipated results in this study. Therefore, both BMI and WHtR were used in the evaluation

of health risks associated with abdominal fat. In addition to BMI and WHtR, upper arm relaxed and upper arm flexed, as well as tensed girth circumferences were measured, to assess the upper body extremities of the school children.

The right and left hand grip strength showed positive correlations with height, weight, BMI, WC and two skinfold measurements (Foo, 2007:98). The measurements taken of girth circumference are said to be a good indicator of fat mass, bone mineral content and lean mass, which are strongly correlated with maximum isometric grip force (Myer *et al.*, 2009). An increase in muscle mass increases physical strength and more fat is available for the energy yielded in the case of greater amounts of skinfolds (Rashid & Ahmed, 2006:11). According to Ford *et al.* (2008:42), height may positively correlate with handgrip strength. This may be due to the fact that various factors (such as greater heights) would eventually lead to longer arms, with greater lever arm for force generation, resulting in an efficient amount of force. A hand grip test determined the physical strength of the children.

Girth circumference

Excessive fatness has arguably become a primary childhood health problem in developed nations. For example, in the United Kingdom, childhood obesity rates have increased from 2.0 to 2.8-fold in ten years (Ogden *et al.*, 2006:295). Furthermore, in the United States, the heaviest children at the risk of complications have become even heavier. Obesity is virtually recognised among children and is now becoming a common feature in some developing populations. WC comprises both subcutaneous abdominal adipose tissue and visceral adipose tissue. WH girth ratios usually indicate fat percentage since fat deposits are more common around the upper abdominal area. A greater deposit of fat at this abdominal waist area than the hip area is more common in women and girls and is an indicator of high risk of CVD (Wang & Hoy, 2004:28). Thus, excess body fat is considered an intermediary in the causal pathway from health to development of CVD (Goodman *et al.*, 2005:111).

Excess visceral adipose tissue may especially be deleterious to cardiovascular health and central fatness may increase the risk of MS (Gutin *et al.*, 2005:81). Although the use of WC is a convenient means as well as a low cost method for the assessment of excess or lean body fat, it may lack precision in terms of distinguishing between the contribution of muscles and fat mass. This could consequently result in the misclassification of children with regard to adiposity status. It should therefore be appreciated that there is rapid growth and development in terms of lean and fat mass as children undergo the adolescent stage. WC

may therefore be labelled as a complementary indicator that evaluates health risks associated with excess abdominal fat. This study measured WHtR for the assessment of excessive body fat in school children.

Waist (WC)

A girth measurement is simply a circumference measure that results in a linear dimension, such as centimetres. Waist (minimal girth of the abdomen) circumference was measured three times to the nearest 0.1cm, using the Gullick anthropometric tape. The horizontal contour at the high point of the iliac crest across the mid-axillary line of the body was marked with a cosmetic pencil by the examiner, at the point midway between the lower border of the rib cage and the iliac crest at the end of normal expiration. The examiner stood on the participant's right side and placed the measuring tape around the trunk in a horizontal plane at the level marked on the right side of the trunk. The measurement was made at the minimal respiration and recorded.

Hip (HC)

Hip (maximal girth of the buttocks) circumference was measured thrice to the nearest 0.1cm using the Gullick anthropometric tape. The subject stood erect with feet together and weight evenly distributed on the feet. The widest part of the hip was located at the level of greater trochanters. The examiner squatted on the right side of the subject and placed the measuring tape around the buttocks at the maximum extension. The examiner adjusted the sides of measuring tape and checked the front and sides so that the plane of the tape was horizontal. The zero end of the tape was held at the starting point, the tape then held snugly but not too tight. The examiner took the measurement from the right side and called it for recording.

Upper arm relaxed

Upper arm relaxed refers to the circumference of the arm at the level of the mid-acromial-radial site, perpendicular to the long axis of the arm (Marfell-Jones, 2006). The subject assumed a relaxed standing position with the arms hanging by the sides and right arm abducted slightly to allow the tape to be passed through and around the arm. The measurer stood by the side of the subject with the tape, measurement was obtained to the nearest 0.1 using a flexible fibre tape.

Upper arm flexed and tensed

Upper arm flexed and tensed is the circumference of the arm perpendicular to the long axis of the arm at the level of the peak of the contracted biceps brachii, when the arm is raised anteriorly to the horizontal (Marfell-Jones, 2006). The subject assumed a relaxed standing position with left arm hanging partially by the side, elbow flexors tensed to identify the probable peak of contracted muscles. The subject's right arm rose anteriorly to the horizontal with forearm supinated and flexed at about 45-90° to the upper arm. The measurer stood at the side of the subject with the tape, and measurement was obtained to the nearest 0.1 using a flexible fibre tape. The upper arm muscles were contracted as strongly as possible and held while the measurement was made at the peak of the biceps brachii (Marfell-Jones, 2006).

2.11 MORPHOLOGICAL MEASUREMENT (INCIDENTS OF HYPERTENSION) IN CHILDREN

2.11.1 Blood pressure

Many studies view metabolic syndrome (MS) as a clustering of risk factors. A proposed definition of the MS for children is based on abdominal obesity (waist circumference > 95th percentile), and blood pressure (BP) (95th percentile for age, gender and height) (Cooper, 2000:4). It therefore means that there is a positive correlation of BP with height, body mass, BMI and body fat. BP is said to be a continuous variable that is positively correlated with cardiovascular risk across the entire BP range (Leary *et al.*, 2008:51; Tsioufis *et al.*, 2011:21). High blood pressure (HBP) or hypertension is a common condition in South Africa and a risk factor for heart attacks, stroke, left ventricular hypertrophy, renal disease and blindness. People who have hypertension are usually unaware of the condition, unless the BP has been measured (Nur *et al.*, 2008:26). It is therefore referred to as a “silent epidemic” in South Africa. In most cases, hypertension is universally underdiagnosed and/or inadequately treated, resulting in extensive target organ damage and premature death. Furthermore, hypertension frequently co-exists with other risk factors for CDL such as obesity, overweight and diabetes (Bradshaw *et al.*, 2000:93).

Health behaviours established in childhood tend to continue into adulthood, thus, BP tracks with age and elevated BP at childhood predicts essential hypertension in adulthood (Salvadori *et al.*, 2008:122; Nur *et al.*, 2008:26). Most studies support the beneficial effect of PA in lowering BP in children (Gidding *et al.*, 2006:118). This picture can also be influenced by the

impact of socio-demographic or genetic factors in different settings. For example, the prevalence of obesity among Canadian children aged 2 to 17 years doubled from 6.3% to 12.7% while rates of overweight increased from 23.3% to 34.7% (Shields & Tremblay, 2010:5). In another study carried out across European children (Germany, Austria and Switzerland), the same trends were observed (I'Allemand *et al.* 2008:16). In South Africa, many studies have shown positive correlations between obesity and hypertension in children of various populations (Collins & Alpert, 2009:155; Amusa *et al.*, 2010; Moselakgomo *et al.*, 2012:30). One major complication of obesity, that is elevated BP, was found to be severely increasing among children.

These interrelationships of hypertension with other CDL risk factors and various possible target organs that can be influenced by uncontrolled hypertension, result in a diverse picture that has an impact on different population groups within South Africa. From a health perspective, understanding the factors associated with increasing BP in South African children can help inform interventions to reduce risks and optimise health among children. Thus it is important to have a population-specific evaluation of childhood BP and its associated factors for the full range of BP levels. This study was guided by the National High Blood Pressure Education Programme's standardised guidelines for the assessment of BP among children as outlined by the National Heart, Lung, and Blood Institute. Elevated BP was defined as the mean systolic (SBP) and the diastolic BP (DBP) above 95th percentile for age and gender after adjusting for weight and height (Cooper, 2000:4). It was interesting to examine the incidence of BP and its determinants in a provincial representative sample of both Limpopo and Mpumalanga.

2.11.1.1 Blood pressure measurement

BP was measured three times at five-minute intervals of rest using an electronic blood pressure monitor (Omron HEM-705 CP devices, Tokyo, Japan). A child is required to sit with arm cuff and zero indicators on the monitor at the level of the examiner's eye. All readings are measured in duplicate on the right arm. Appropriate cuff sizes are used with cuff width approximately 40% of mid-arm circumference. The procedure is explained to the participants before taking the measurement. The cuff bladder is inflated and deflated once. Based on these guidelines, at least three systolic blood pressure (SBP) and diastolic blood pressure (DBP) readings are taken after the child had been seated for 5 min or longer. The average of the three BP measurements are included in the statistical analysis. From the BP

measurements, pulse pressure, mean BP and the rate pressure product, are calculated using the formula developed by Zheng *et al.* (2008:39). The records are used for statistical analysis.

2.12 MEASUREMENTS OF PHYSICAL-FITNESS COMPONENTS

2.12.1 Physical-fitness components

The concept of health-related fitness tests is widely used, particularly with the primary aim to prevent common diseases. A number of studies such as the American Alliance for Health, Physical Education, Recreation and Dance (AAHPERD) health-related fitness test, the Canadian Alliance for Health, Physical Education and Recreation (CAHPER) test, the Canadian Standardized Test of Fitness (CSTF), and the test battery Prudential FITNESSGRAM have evaluated physical fitness characteristics of children in America and other industrialised countries. These studies confirmed that health-related physical fitness is a key construct in exercise science and have shown beyond reasonable doubt that lower fitness levels are directly correlated to death from all causes (American College of Sports Medicine -ACSM, 2006).

Although many studies have ruled out the negative effects of physical training on growth and development, in general terms PA is considered to be necessary for adequate growth and development and evidence indicates that early excessive physical training in some sport discipline might be detrimental (Mortatti & Arruda, 2007:9; Coelho *et al.*, 2009:11). Some studies have shown an increase in maximum oxygen consumption ($\dot{V}O_{2max}$), and in running economy an increase in lower limb muscle power and running velocity, an increase in bone mineral content and back and hamstring flexibility, and a reduction in body adiposity (Vincente-Rodriguez *et al.*, 2006:33; Stabelini-Neto *et al.*, 2007:9). However, there is comparatively little information on the effects of PA and the health-related physical fitness profile of South African school children, particularly with regard to obesity. Therefore, the need for an evaluative study to establish norms and standards for the assessment of health-related physical fitness in a South African context becomes important. Additionally, comparing the results on the basis of age and gender becomes evident.

In this study, five health-related physical fitness variables of the participants were tested using the European test of physical fitness (EUROFIT) (1988:72) and the AAHPERD (1980)

protocol. The tests were selected because of their ease of administration to a large number of subjects, and their choice of reliable and valid health-related physical fitness measures. These included flexibility (sit-and-reach test), muscular endurance (sit-up test), muscular strength (hand grip and standing broad jump tests) and cardiorespiratory endurance (20-meter shuttle run).

2.12.1.1 Flexibility (sit-and-reach test)

Flexibility is typically defined as the ability of a joints to move through their full, functional range of motion permitted by muscle and connective tissues. It is the ability to maximise the range of motion at a given joint (ACSM, 2006). Lack of flexibility either in single joints or in a combination of joints can reduce sports performance, physical function, and in some cases, daily living activities. Many studies consider inflexibility a cause of certain athletics injuries (e.g., muscle strain), and a possible contributing factor to lower-back pain (Brooks *et al.*, 2005). Excessive flexibility, however, may also be a problem because it potentially promotes joint laxity or hypermobility, which can lead to pathologies.

In this study, a sit-and-reach test was performed to assess flexibility in school children. This test indicated flexibility of the lower back and the upper thigh. The test measures muscle groups (lower back and hamstring muscles) (AAHPERD, 1980), using a standard sit-and-reach box. In seated position with knees and feet placed firmly against a floor mat, subjects gradually pushed the ruler on top of the standard reach box with both hands stretched, without jerking, and bent their trunk trying to reach as far as possible with both hands straight, knees fully extended. The fingers of both hands had to reach the same distance at the same time and no bouncing movement were allowed. The test was done twice with the better result recorded as the main final score in cm. The scores were the furthest distance reached in cm.

2.12.1.2 Muscular endurance (sit-up test)

Muscular endurance is a function of the muscle producing force over multiple consecutive contractions and can be assessed in time frames ranging from seconds, to minutes, to hours (ACSM, 2009). The test is defined as the ability to control the placement of the body's centre of gravity in relation to its support base (Hallal *et al.*, 2006:36). Typical tests specifically geared to measure muscular endurance include timed push-ups and sit-up tests, completing as many repetitions as possible of a specific load or weight. Muscular endurance

is a necessary fitness component for numerous tests, including both anaerobic and aerobic tests (Mayhew *et al.*, 2008:22). In this study, sit-ups test were used to assess the children's muscular endurance. This test measured the performance of the abdomen and hip flexor muscles. In a starting position subjects were seated on a floor mat, back straight, hands clasped behind the neck, and knees flexed at an angle of 90 degrees with heels and feet flat on the floor mat; then laid down on their backs, so that shoulders touched the floor mat, and returned to the sitting position with their elbows out in front to touch their knees. The test was terminated when participants were too tired to complete a full sit-up. The total number of correctly performed movement was recorded as completed sit-up.

2.12.1.3 Muscular fitness

The role of muscular fitness in the performance of exercise and activities of daily living as well as in preventing disease has become increasingly recognised (Wolfe, 2006:84). Muscular fitness is defined as the capacity to carry out work against resistance. It is the ability of muscular unit or a combination of muscular units to apply force in minimum time (Mayhew, 2008:22). The maximum force that can be generated depends on several factors, for example, the size and number of muscles involved, the proportion of muscle fibres called into action, including the coordination of the muscle group, (Mayhew, 2008:22). This means that there is no single test for measuring muscle strength. The main health-related muscular fitness strengths are: maximal strength (isometric and dynamic), explosive strength, endurance strength and isokinetic strength. Muscular fitness scores were calculated as the mean of the hand grip and standing broad jump tests standardised scores: $\frac{1}{2}$ (hand grip strength + standing broad jump) developed by Foo (2007:98).

2.12.1.4 Hand grip test

The hand grip test is one of the most common tests for assessing muscular fitness in epidemiological studies. A strong correlation between grip strength and various anthropometric measures was reported by Ford *et al.* (2008:42). According to Foo (2007:98), a hand grip test is a determinant of bone mineral content and bone area at the forearm sites, and has a positive correlation with lean body mass and PA. The findings revealed that grip strength was higher in the dominant hand of the individuals. For the purpose of this study, the hand grip test was used to assess upper body strength using a static force precision dynamometer (TKK 5101 Grip D: Takey, Tokyo, Japan). For both genders, optimal grip

span was influenced by the hand size, which implied the need for adjustment of the grip span of the dynamometer to the hand size of the individual. For this reason, sex-specific equations were applied to determine appropriate grip span (Ford *et al.*, 2008:42). The dynamometer, adjusted for subject's hand size was held in line with the forearm at the level of the thigh and squeezed to exert maximum force.

2.12.1.5 Standing broad jump

Standing broad jump tests were undertaken to assess lower body strength and endurance in both boys and girls. Because of the broad displacement of the body mass during the jump, the standing broad jump test, provides the true measure of power. Power is defined as the variable that expresses the rate at which work is done (Mayhew, 2008:22). It is a term often used when referring to the rate of transforming metabolic energy to physical performance such as aerobic and anaerobic power. The original test was designed to measure jumping distance by determining the distance between the standing position and distance jumped. By also considering body mass of the jumper, the current test allowed calculation of the power generated during the jump. It is logical to conclude that if two jumpers have the same broad jump, but one jumper has a greater body mass; the heavier jumper needs to generate more power in order to lift the greater body mass over the same broad distance from the standing position. The power generated during the jump depends on the force component taken from the body mass, the broad displacement accomplished during the jump, and the time taken to jump (Myer *et al.*, 2009).

Power included two basic components: dynamic strength – the ability to carry the body into different directions, and speed – the ability to move the body as fast as possible (Ford *et al.*, 2008:42). Although broad jump has been called an explosive strength test, partly because the single jumping movement itself is accomplished in less than a second, it is not a true strength measure because maximal muscle force is not elicited despite the maximal jump effort. Thus, the ability to perform well on this test may be related more to power than strength. It may therefore be concluded that this test measured the ability to generate the highest dynamic rate of force, which is a very significant factor in such an explosive movement as the standing broad jump. The standing broad jump was performed on a non-slippery floor. The participant tried to jump as far as possible and land on both feet together. The standing broad jump score was calculated as the distance between the last heel-mark and the take-off line in cm.

2.12.1.6 Cardiorespiratory fitness

Childhood obesity may have an important relationship with physical fitness. Information about children's aerobic capacity from an educational perspective, in a health-related context, or in sports, has long been the goal of many researchers. There is strong evidence that PA and cardiorespiratory fitness (CRF) may protect adults from the adverse effects of obesity (Li *et al.*, 2008:4; Metcalf *et al.*, 2011:96; Amusa *et al.*, 2011:86). With regard to children, significant interaction was observed between PA and CRF, suggesting a stronger relationship between activity and metabolic risk in children with low cardiovascular fitness (CVF) (Lee *et al.*, 2010:24; Amusa *et al.*, 2011:86). Improved understanding of these basic issues in childhood CRF, especially in a South African context, would help in the facilitation of strategies to prevent the obesity epidemic.

Aerobic capacity, also called CRF or CVF is the overall capacity of the cardiovascular and respiratory systems, and the ability to carry out prolonged strenuous exercise. It is the ability of body systems to process and deliver oxygen. The maximal oxygen consumption ($\dot{V}O_{2max}$) attained during graded maximal exercise to voluntary exhaustion has long been considered by WHO as the single best indicator of CRF (Ruiz *et al.*, 2007:61). Although different ways have been used to express $\dot{V}O_{2max}$, the most common way is the volume of oxygen consumed per unit of time relative to the body mass. However, WHO (2005) warns that CRF levels differ across age groups and body mass. Nevertheless, $\dot{V}O_{2max}$ can be estimated using maximal or submaximal tests, by direct or indirect methods. The most commonly used tests are walking/running tests, followed by cycling and step tests. For the assessment of CRF, a 20-m shuttle-run test was used in this study. The test was used to examine the CRF among weight groups and its associations with BMI. This test is considered to be one of the most commonly used field test in children (AAHPERD, 1980).

2.13 CHAPTER SUMMARY

It is clear from the reviewed literature that physical inactivity is a global health problem which is associated with non-communicable diseases of life style. It was also apparent from the reviewed literature that factors such as cultural changes and advances in technology that have occurred over the past few decades, have had a dramatic impact on PA and physical fitness levels in various populations. Modern technology has reduced the number of hours

spent on activities of daily living, leaving an increased amount of leisure time and most of this time is not properly utilised and has thus resulted in sedentary living not only among adults, but also in children and youth. Sedentary lifestyle in adults has been implicated in the development of hypokinetic diseases, including (prognosis of many health problems such as) obesity, coronary heart disease (CHD), hypertension, low back pain, which have both social and economic consequences. Importantly, it is now established, particularly for CHD and hypertension, that these diseases have antecedents during childhood and adolescence. As a result of this relationship, the adolescent obesity epidemic has become a major public health challenge that has generated interest and importance internationally. Furthermore, there is an inverse relationship between obesity and physical fitness

PA of children and adolescents varies with age, type of exercise and setting. Performance during adolescence is influenced in part by individual differences in the timing of the adolescent growth spurt, of which girls were found to be mostly affected in comparison to their male counterparts. Furthermore, numerous studies indicated that daily PA has a positive influence on body composition and has many metabolically beneficial effects, including increased muscle mass and increased resting energy expenditure, over and above decreased body fat, specifically in the intra-abdominal region. This review chapter indicated various available methods used in assessing and measuring physical activity, physical fitness, body composition and metabolic risk factors. In the review it was revealed that a high prevalence of overweight and obesity among children and adolescents exists, particularly those from urban areas and among girls: 9% and 27% in 15-17 -year old boys and girls and 10% and 23% in boys and girls 10-14 years, respectively. Moreover, the reviewed literature also indicated that the level of elevated blood pressure was noticeable among children, and this was found to be a disturbing situation given the risk factors associated with elevated blood pressure later in life.

In South Africa, an increasing prevalence of risk factors of metabolic and cardiovascular diseases (CVDs) among rural school children was also reported. CVDs are considered to be the top ten leading causes of death in South Africa. Granted that high BP in children is a predictor of adult BP level, identifying children and adolescents who are at increased risk of developing essential hypertension as adults is important. Such findings will inform public policy to design and implement appropriate intervention strategies.

In the review it was also noted that a better understanding of the association between PA and the environmental factors associated with childhood obesity are important in assessing the benefits of intervention strategies aimed at curbing this epidemic.

The information in this reviewed chapter will be integrated in the subsequent chapters which are written in articles format.

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CHAPTER 3: Physical activity, body composition and physical fitness status of primary school children in Mpumalanga and Limpopo provinces of South Africa

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Physical activity, body composition and physical fitness status of primary school children in Mpumalanga and Limpopo provinces of South Africa

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3.1 ABSTRACT

This study was designed to assess the physical activity (PA), body composition and physical fitness status of 1361 (boys: n=678; girls: n= 683) primary school children aged 9-12 years in Mpumalanga (MP) and Limpopo (LP) provinces of South Africa. Anthropometric and physical fitness measurements were taken using the protocol of the International Society for the Advancement of Kinanthropometry (ISAK) (Marfell-Jones, Old, Steward & Carter, 2006) and EUROFIT (1988) test battery. Body composition was estimated by calculating body mass index (BMI) (weight/height²) and waist-to-hip ratio, respectively. BMI for age and gender was used to classify the children as underweight, overweight or obese (Cole *et al.*, 2007), whilst percentage body fat (%BF) indicated adiposity. The %BF was calculated from sum of two skinfolds (triceps and subscapular) using Slaughter *et al.*'s (1988) equation to predict body fat. The results showed that 75% of the children were underweight/stunted and 1.6% overweight. Frequencies of underweight, normal weight and overweight were 77%, 22.4% and 0.2% in MP and 72%, 24% and 3% in LP province. Boys in both provinces were taller and heavier than the girls. With regard to health-related physical fitness, at age 10 the MP boys performed significantly ($p=0.05$) better in sit-up (SUP: 20.5 ± 5.4) than the LP boys (18.6 ± 6.56). The LP boys did significantly better than the MP boys in sit-and-reach (SAR) at ages 10 and 11. The MP boys significantly ($p=0.00$) performed better in SBJ (121.6 ± 9.1 cm) as compared to the Limpopo (118.4 ± 11.00 cm) ones at age 9. Generally, LP boys did significantly ($p=0.00$) better than the MP across all ages. With regards to PA, the results showed that 27.7% (377), 58.5% (796) and 13.8% (188) of the children participate in low,

moderate and high PA, respectively. Children in MP province scored higher (28.6%) in low PA participation as compared to the lower (26.7%) found for LP children. Concerning moderate PA participation, MP children also scored higher (59.7%) compared to LP children with (57.3%). However, a higher (15.8%) rate was found for LP children than those in MP province (11.6%) with regard to high intensity PA participation. It is important to periodically evaluate PA levels in South African children in order to alleviate increasing concerns over the potential health crises associated with underweight and low levels of PA status in the children.

Keywords: Anthropometry, body composition, physical activity, health-related physical fitness, stunting, South African children.

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3.2 INTRODUCTION

Childhood and adolescence are complex stages with profound changes due to growth and maturation (Strong, Malina, Blimkie, Daniels, Dishman *et al.*, 2005). The behaviour pattern obtained throughout this stage can be crucial to a healthier future and greater quality of life (Kimani-Murage *et al.*, 2010). As such, understanding the status of under nutrition, particularly stunting, overweight in children and adolescents, physical activity (PA) and physical fitness (Monyeki, Kemper, Twisk, & Monyeki, 2003), is of critical importance for public health policy (Kruger, Puoane, Senekal & van der Merwe, 2005; Monyeki, 2006; Victora, Adair, Fall, Hallal, Martorell, *et al.*, 2008; Kimani-Murage *et al.*, 2010). Research reports have indicated that underweight, overweight and physical inactivity are associated with numerous non-communicable diseases of lifestyle (WHO, 2002; Peer, Bradshaw, Laubscher, Steyn, & Steyn, 2013).

Nutrition transition is a major driving force behind the double burden of malnutrition; a phenomenon that has become important in low and middle income countries (LMICs) where high levels of obesity have been documented despite persistence of under nutrition (Popkin, 2003; FAO, 2006). Furthermore, some epidemiological studies reported that over nutrition and physical inactivity are prevalent in countries undergoing transition (Mamabolo *et al.*, 2005; Tathiah *et al.*, 2013). It has been suggested that in epidemiologic transition, infections and under nutrition coexist with non-communicable diseases and persist over prolonged periods of time (WHO, 2002). Therefore, under nutrition, physical inactivity and obesity-related diseases may also coexist with non-communicable diseases and should be considered in evaluating health and growth status in childhood and adolescence (Kimani-Murage *et al.*, 2010).

Numerous research studies have indicated the important role of PA to health and well-being in the short and long terms (Kruger *et al.*, 2005; Victora *et al.*, 2008; Kimani-Murage *et al.*, 2010). In order to have a clear understanding of PA, several factors such as age, gender (Trost *et al.*, 2002), socio-economic status (SES) (Mota, Ribeiro & Santos, 2008), environmental and social support (Mota, Almeida, Santos & Ribeiro, 2005) should be analysed. A research study by Monyeki *et al.* (2012) on high school students in the North West province of South Africa revealed the prevalence of under nutrition, over nutrition and physical inactivity among the adolescents. Similar findings have been reported in studies by Tathiah *et al.*

(2013) in which HAZ (height-for-age z-score), WAZ (weight-for-age z-score), and BAZ (BMI-for-age z-score), scores of -0.22, -0.22 and -0.44 were reported for 953 school children in KwaZulu-Natal, South Africa.

Research has also indicated that South Africa is ranked among the 20 countries with the highest prevalence of under nutrition. For instance, it is estimated that 1 in 10 children in the country is underweight and 1 in 5, stunted especially in rural areas (National Planning Commission, 2011). When the 2002 results of the South African National Youth Risk Behaviour Survey were compared with the 2008 data, an estimated decline in the percentage of underweight learners, i.e. from 9% to 8% was found (Reddy *et al.*, 2009; Reddy *et al.*, 2010). Furthermore, results of the 2008 survey showed that 13% of learners were stunted in contrast to 8% who were wasted (Reddy *et al.*, 2010).

In spite of available research evidence, little work has been done to explore the status of under nutrition, overweight and physical inactivity in large samples, which included children from two provinces, especially Limpopo and Mpumalanga provinces of South Africa. Despite that previous studies on children's body composition, obesity and health-related fitness have been reported it is important to periodically monitor the effect of PA and nutritional status in the prognosis of non-communicable diseases in childhood. This study was therefore designed to answer the following research questions: a) What is the body composition profile of primary school children in Limpopo and Mpumalanga provinces? b) What is the health-related physical fitness status of primary school children in the provinces?

3.3 METHODOLOGY

3.3.1 Research design

The study was conducted using a descriptive, cross-sectional design in which data were collected on PA, body composition and physical fitness status among targeted samples of primary school children in Limpopo and Mpumalanga provinces of South Africa.

3.3.2 Participants

The sample comprised 1361 participants (678 boys and 683 girls) aged 9-12 years drawn from the two provinces, namely, Limpopo and Mpumalanga. They included children in

grades 3 to 6 (i.e. ages 9 to 12 years). To select the samples, the schools in each province were numbered serially based on alphabetical listing. Depending on the pupil population density, eight schools were randomly selected from each province. Class registers were used to draw a targeted group of children whose ages could be verified. Children who were reportedly ill and whose ages were above the lower and upper limits of the categories set for the study were excluded. Overall, participants were randomly selected from sixteen rural primary schools located in various parts of the provinces.

3.3.3 Demographic information

Demographic data which included age, gender, ethnicity and residence were obtained from participants as these were regarded as correlates of obesity, overweight, underweight and physical activity among children.

3.3.4 Anthropometric measurements

Height, weight, and skinfolds were measured using the protocol of the International Society for the Advancement of Kinanthropometry (ISAK) (Marfell-Jones, Old, Steward & Carter, 2006). Based on these measurements, body composition indices including body mass index (BMI) ($\text{weight}/\text{height}^2$) were derived. BMI was used to classify the children in the following weight categories: underweight, overweight or obese for age and gender (Cole *et al.*, 2007).

The sums of two skinfolds (triceps and subscapular) were calculated and Slaughter *et al.*'s (1988) equation was used to predict percentage body fat (%BF) in school children. The anthropometric and body composition status of the Limpopo and Mpumalanga children were compared with available normative data on South African children (Human Sciences Research Council, 2013).

3.3.5 Physical fitness measurements

Physical fitness measurements including muscle strength and endurance, flexibility, explosive power and cardiorespiratory endurance were assessed using EUROFIT (1988) test battery as follows: Cardiovascular endurance ($\dot{V}O_{2\max}$) was assessed with the 20-meter shuttle run test (Davis, 2006). Sit-and-reach (SAR) (measured in cm) evaluated hamstring flexibility; sit-ups (SUP) (number performed in 30 seconds) measured abdominal strength

and endurance while standing broad jump (SBJ) assessed explosive strength (in cm). The values of physical fitness measures were compared with available normative data to evaluate the status of the dependent variables in these cohorts of South African children.

3.3.6 Measurement of physical activity (PA)

The short form of the International Physical Activity Questionnaire (IPAQ) (CDC, 2002; WHO, 2002; WHO, 2009), which is a valid and reliable tool for assessing PA was used (Craig *et al.*, 2003). IPAQ is considered suitable for use by children and adolescents at different settings (WHO, 2002). Its short form consists of seven items which identify the frequency and time spent in walking and engaging in other moderate-to-vigorous intensity PA during the seven days prior to questionnaire administration. In the IPAQ only those sessions which lasted 10 minutes or more were analysed. All types of PA related to occupation, transportation, household chores and leisure time activity were included. IPAQ also elicits information about time spent sitting, which is used as an indicator of inactivity. Based on the children's IPAQ scores, their PA levels were categorised as follows: *Low* = the METs scores of less than 500; *Moderate* = METs scores of between 500 to 1499 and *High* = METs >1500.

3.3.7 Pilot test

A pilot study was also conducted before actual data collection to ascertain the logistical and technical procedures for the measurements. This was preceded by an intensive training workshop carried out to ensure that the field workers could competently undertake the anthropometric and physical fitness measurements.

3.3.8 Statistical analysis

Data were analysed using descriptive statistics, such as means, minimum, maximum values, standard deviations and frequencies. Independent t-test was used to examine significant differences between two ordinal variables to assess disparity between categorical variables. All data analyses were performed using the Statistical Package for the Social Sciences (SPSS), version 21.0 (SPSS Inc., 2013). For all statistical analysis the level of significance was set at $p \leq 0.05$.

3.4 RESULTS

The results indicated that 74.7% (1016) of the combined sample of children were underweight and 1.6% (22) overweight. Underweight was higher in MP province as compared to LP province, with 2.9% of overweight children found in LP province and 0.2 % observed in MP province (Figure 1).

When the data were analysed separately by gender, underweight was prevalent across the two provinces with 5.8% overweight noted in boys in LP province. Analysis of data on underweight and overweight by age category indicated that across the ages and provinces underweight was almost high and comparable, except for the nine-year old girls who were underweight (97.7%) and overweight (2.3%); 11-year old boys who were underweight (25.7%), and had normal weight (74.3%).

The results of the children's participation in PA showed that 27.7% (377), 58.5% (796) and 13.8% (188) of all the children participated in low, moderate and high PA, respectively. Children in MP province had higher (28.6%) compared to (26.7%) found for LP regarding low PA participation. With regards to moderate PA participation, MP children had (59.7%) higher as compared to their LP counterparts with (57.3%). Regarding high intensive PA participation level, (15.8%) was found for LP children than those in MP province (11.6%).

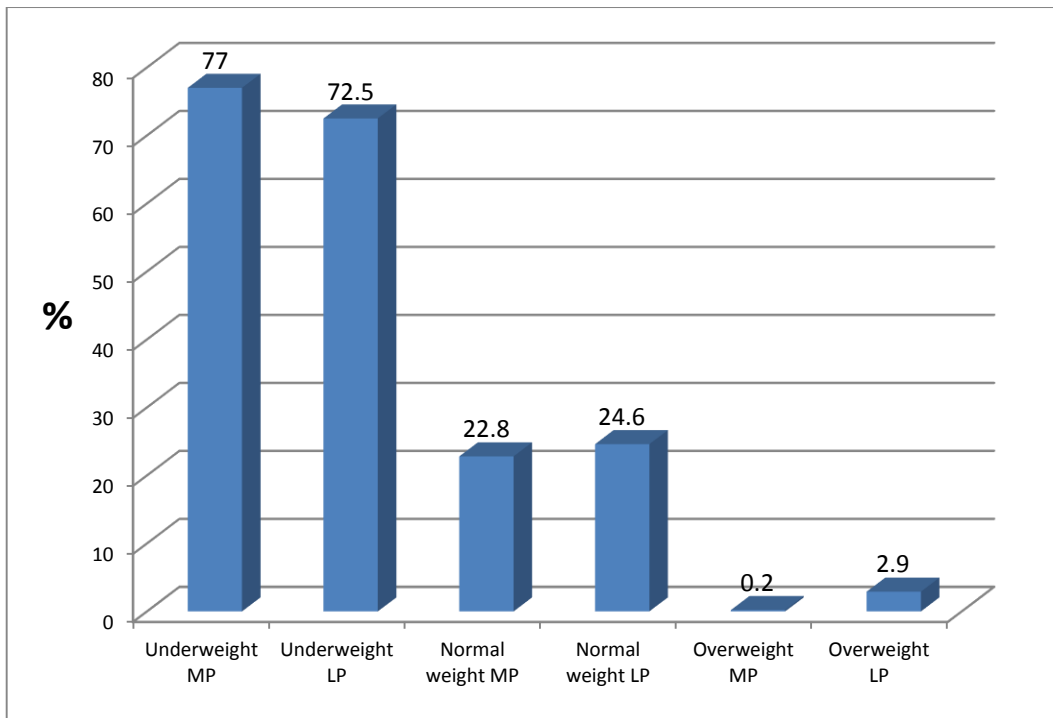


Figure 1: Weight categories for children in MP and LP provinces

Tables 1(a, b) and 2 (a, b) present descriptive data (mean, SD and p values of the differences) for PA, body composition and physical fitness for boys and girls by age, gender and provinces. In Table 2a significant ($p < 0.05$) differences in stature were found in which the 10 and 11 year-olds were taller than the 9-year old children.

No significant differences were found for stature in the other age groups. Substantial differences were found for BMI, %BF across the age groups, with significant differences observed for WHtR at ages 12 and 13 ($p < 0.05$) (Table 2b).

With regard to health-related physical fitness, at age 10 the MP boys performed significantly better ($p < 0.05$) in SUP (20.5 ± 5.430) than LP (18.6 ± 6.56) boys. The LP boys did significantly better than the MP boys in SAR at ages 10 and 11. However, the MP boys had significantly better ($p < 0.00$) performances in SBJ ($121.6 \pm 9.10\text{cm}$) compared to those in LP (118.4 ± 11.00) at age 9. Across the ages the LP boys had overall superior performances ($p < 0.01$) than the MP boys.

Table 1 (a): Descriptive statistics (mean, SD and p value of the differences) for physical activity, body composition and physical fitness by age, gender and provinces (Boys aged 9-11 years)

Variable	Age 9 boys			Age 10 boys			Age 11 boys					
	Province (MP, n=39; LP, n=56)	Mean	SD	P value of differences	Province (MP, n=65; LP, n=80)	Mean	SD	P value of differences	Province (MP, n=66; LP, n=105)	Mean	SD	P value of differences
Body mass (kg)	MP	31.1	3.84	0.005**	MP	34.5	4.70	0.23	MP	36.3	5.50	0.02*
	LP	33.1	5.31		LP	35.4	4.25		LP	38.2	4.96	
Stature (cm)	MP	135.4	8.45	0.01**	MP	140.7	9.57	0.60	MP	141.4	10.65	0.39
	LP	140.5	10.76		LP	141.5	8.37		LP	142.7	9.18	
BMI (kg/cm ²)	MP	16.9	0.04	0.00***	MP	17.3	0.06	0.00***	MP	18.1	0.15	0.00***
	LP	17.1	0.07		LP	17.6	0.11		LP	18.7	0.23	
Triceps (mm)	MP	8.0	0.65	0.02*	MP	7.6	0.65	0.56	MP	7.0	0.57	0.00***
	LP	8.3	0.45		LP	7.7	0.46		LP	6.5	0.56	
Subscapular (mm)	MP	5.0	0.65	0.00***	MP	4.5	0.53	0.01**	MP	4.2	0.45	0.00***
	LP	4.7	0.45		LP	4.3	0.46		LP	4.0	0.38	
%BF	MP	34.3	2.51	0.37	MP	25.2	1.38	0.00***	MP	16.9	0.66	0.03*
	LP	27.8	1.57		LP	20.6	1.32		LP	14.8	0.83	
WC (cm)	MP	57.1	4.59	0.66	MP	56.6	3.97	0.20	MP	56.0	4.44	0.00***
	LP	56.3	3.95		LP	55.8	3.70		LP	56.5	4.21	
SUP (#/sec)	MP	20.3	5.23	0.15	MP	20.5	5.43	0.05*	MP	17.6	7.31	0.44
	LP	20.8	5.20		LP	18.6	6.56		LP	15.9	5.90	
WHtR	MP	0.5	0.60	0.28	MP	0.4	0.04	0.17	MP	0.4	0.44	0.11
	LP	0.4	0.04		LP	0.4	0.03		LP	0.4	0.04	
SAR (cm)	MP	35.3	4.24	0.14	MP	38.0	6.47	0.02*	MP	38.8	5.90	0.001***
	LP	36.3	4.26		LP	40.5	6.35		LP	42.3	7.50	
SBJ (cm)	MP	121.6	9.10	0.00***	MP	117.1	12.39	0.28	MP	110.6	16.23	0.28
	LP	118.4	11.00		LP	114.8	12.22		LP	113.3	16.62	
TOTAL PA	MP	840.6	2.69	0.00***	MP	966.1	37.01	0.00***	MP	1152.7	36.36	0.00***
	LP	900.2	20.09		LP	1068.2	23.48		LP	1283.3	20.81	

LP= Limpopo Province; MP=Mpumalanga Province; p<0.05*; p<0.01**; p<0.001***

Table 1(b): Descriptive statistics (mean, SD and p value of the differences) for physical activity, body composition and physical fitness by age, gender and provinces (Boys aged 12-13 years)

Variable	Province (MP, n=73; LP, n=80)	Age 12 boys			P value of differences	Age 13 boys		
		Province (MP, n=76; LP, n=38)	Mean	SD		Province (MP, n=76; LP, n=38)	Mean	SD
Body mass (kg)	MP	40.2	4.28	0.001***	MP	48.5	6.56	0.00***
	LP	43.0	5.50		LP	59.3	12.26	
Stature (cm)	MP	143.7	7.79	0.44	MP	146.9	9.54	0.14
	LP	144.8	9.18		LP	142.1	24.99	
BMI (kg/cm ²)	MP	19.4	0.21	0.00***	MP	22.3	0.83	0.00***
	LP	20.4	0.40		LP	28.4	6.22	
Triceps (mm)	MP	6.1	0.36	0.00***	MP	4.9	0.35	0.00***
	LP	5.6	0.49		LP	3.8	0.39	
Subscapular (mm)	MP	3.8	0.36	0.00***	MP	2.8	0.42	0.00***
	LP	3.4	0.51		LP	2.1	0.24	
%BF	MP	12.8	0.57	0.00***	MP	10.7	0.47	0.00***
	LP	11.7	0.44		LP	10.2	0.00	
WC (cm)	MP	56.08	3.54	0.01**	MP	54.1	4.04	0.001***
	LP	54.5	4.04		LP	65.9	17.09	
SUP (#/sec)	MP	17.5	6.81	0.05*	MP	17.0	4.90	0.83
	LP	19.6	6.26		LP	16.8	5.82	
WHtR	MP	0.39	0.03	0.02*	MP	0.37	0.03	0.05*
	LP	0.4	0.04		LP	0.71	1.48	
SAR (cm)	MP	41.5	7.45	0.33	MP	44.66	8.00	0.55
	LP	40.5	5.77		LP	43.72	7.63	
SBJ (cm)	MP	117.6	17.47	0.02*	MP	120.08	14.66	0.69
	LP	123.2	12.99		LP	121.23	14.67	
TOTAL PA	MP	1397.9	44.97	0.00***	MP	1689.34	83.01	0.00***
	LP	1532.4	15.41		LP	2028.76	113.4	

MP=Mpumalanga province; LP=Limpopo province; SD=standard deviation; BMI=body mass index; %BF=percentage body fat; WC=waist circumference; SUP=sit-ups; WHtR=waist-to-height ratio; SAR=sit-and-reach; SBJ=standing broad jump; TOTAL PA= total physical activity; p<0.05*; p<0.01**; p<0.001***

Results in Table 2a showed that the MP girls were significantly ($p<0.00$) taller than their LP peers at ages 10 to 13, except that the LP children were taller at age 9. Across the ages, the LP girls had significantly higher ($p<0.00$) BMI than their MP counterparts. Significant differences were observed for %BF at ages 9 and 10, and WHtR at ages 10 and 13 in the MP children who had higher mean values (Tables 2a and b). With regards to physical fitness, marked differences were found for SUP at ages 9, 11 and 13, and the performances varied across the provinces. Regardless of age the LP girls had superior fitness performances than their MP peers.

3.5 DISCUSSION

This study showed high percentages of underweight among children from the MP and LP provinces, with a marginal proportion of overweight condition especially in Limpopo province. Similar studies carried out among Ellisras rural school children in LP province have

also reported the co-existence of stunting and wasting, as well as obesity in the children (Monyeki *et al.*, 2003).

Table 2a: Descriptive (mean, SD and p value of the differences) for physical activity, body composition and physical fitness for girls by age, gender and provinces (Girls aged 9-11 years)

Variable	Age 9 girls				Age 10 girls				Age 11 girls			
	Province (MP, n=43; LP, n=70)	Mean	SD	P value of differences	Province (MP, n=82; LP, n=88)	Mean	SD	P value of differences	Province (MP, n=66; LP, n=105)	Mean	SD	P value of differences
Body mass (kg)	MP	24.6	6.85	0.74	MP	27.7	3.59	0.42	MP	29.5	3.01	0.00***
	LP	25.4	2.91		LP	28.1	3.01		LP	29.7	3.83	
Stature (cm)	MP	132.9	8.71	0.07	MP	136.9	8.71	0.00***	MP	138.0	7.00	0.00***
	LP	133.5	7.52		LP	135.9	7.25		LP	136.7	8.80	
BMI (kg/cm ²)	MP	13.7	2.13	0.00***	MP	14.7	0.13	0.00***	MP	15.4	0.07	0.00***
	LP	14.2	0.22		LP	15.1	0.11		LP	15.8	0.13	
Triceps (mm)	MP	24.2	2.79	0.00***	MP	14.8	1.37	0.00***	MP	11.7	1.00	0.00***
	LP	18.5	1.71		LP	13.2	1.01		LP	10.7	1.16	
Subscapular (mm)	MP	19.2	4.09	0.00***	MP	9.6	1.22	0.001***	MP	7.0	1.01	0.01**
	LP	13.0	1.71		LP	7.8	0.98		LP	6.4	0.98	
%BF	MP	33.4	3.25	0.00***	MP	27.1	1.60	0.00***	MP	20.0	0.43	0.15
	LP	28.9	1.69		LP	22.3	1.27		LP	17.9	0.64	
WC (cm)	MP	71.5	6.01	0.00***	MP	63.2	5.75	0.20	MP	60.0	4.76	0.20
	LP	66.1	5.95		LP	60.6	4.59		LP	58.0	4.93	
SUP (#/sec)	MP	19.8	4.24	0.00***	MP	21.1	5.50	0.354	MP	22.1	5.61	0.002**
	LP	20.4	4.76		LP	21.9	5.86		LP	20.8	5.82	
WHtR	MP	0.54	0.05	0.49	MP	0.5	0.05	0.02*	MP	0.4	0.04	0.20
	LP	0.5	0.05		LP	0.4	0.04		LP	0.4	0.05	
SAR (cm)	MP	40.3	5.74	0.00***	MP	40.2	6.38	0.53	MP	42.4	6.30	0.002**
	LP	41.2	6.14		LP	39.6	6.36		LP	39.6	5.32	
SBJ (cm)	MP	117.3	20.13	0.41	MP	117.5	18.71	0.27	MP	114.3	16.93	0.00***
	LP	120.4	18.76		LP	114.5	14.19		LP	127.0	19.63	
TOTAL PA	MP	0.0	0.00	0.41	MP	1.7	5.03	0.00***	MP	413.9	51.86	0.00***
	LP	0.0	0.00		LP	199.4	80.15		LP	554.6	44.75	

MP=Mpumalanga province; LP=Limpopo province; SD=standard deviation; BMI=body mass index; %BF=percentage body fat; WC=waist circumference; SUP=sit-ups; WHtR=waist-to-height ratio; SAR=sit-and-reach; SBJ=standing broad jump; TOTALPA= total physical activity; p<0.05*; p<0.01**; p<0.001***

In a study on nutritional transition among learners in rural KwaZulu-Natal, South Africa, Tathiah *et al.* (2013) reported that 4.8% of the learners were underweight and 9.2% stunted, with the highest rate found among 11-12 years age group. They also found that overweight (11.1%) and obesity (22.9%) existed among children aged 9-10 years.

In contrast, our study indicated a high prevalence of underweight, normal weight and overweight in MP (77%, 22.4% and 0.2%) and LP (72%, 24% and 3%) provinces, with the younger children most markedly underweight. Probably, the worst indication of underweight was found among the 12 years old LP girls who had a mean body weight of 31.36kg.

Table 2 (b): Descriptive (mean, SD and p value of the differences) for physical activity, body composition and physical fitness for girls by age, gender and provinces (Girls aged 12-13 years)

Variable	Age 12 girls				Age 13 Girls			
	Province MP=81; LP =63	Mean	SD	P value of differences	Province (MP, n=66; LP, n=18)	Mean	SD	P value of differences
Body mass (kg)	MP	31.0	4.16	0.58	MP	32.1	4.10	0.07
	LP	31.3	3.28		LP	30.7	2.14	
Stature (cm)	MP	137.9	8.97	0.97	MP	138.6	8.90	0.03*
	LP	137.9	7.21		LP	135.2	4.72	
BMI (kg/cm ²)	MP	16.2	0.09	0.00***	MP	16.6	0.08	0.00***
	LP	16.4	0.05		LP	16.8	.016	
Triceps (mm)	MP	9.8	0.87	0.00***	MP	8.8	0.59	0.43
	LP	9.2	0.66		LP	8.7	0.48	
Subscapular (mm)	MP	5.9	0.77	0.001***	MP	5.2	0.59	0.51
	LP	5.5	0.59		LP	5.1	0.47	
%BF	MP	16.2	0.32	0.53	MP	14.5	0.12	0.00***
	LP	15.4	0.25		LP	13.6	0.00	
WC (cm)	MP	57.9	4.75	0.27	MP	57.8	4.41	0.003**
	LP	57.5	3.55		LP	54.3	4.04	
SUP (#/sec)	MP	18.1	5.13	0.55	MP	19.3	5.5	0.31
	LP	19.0	4.94		LP	20.8	3.9	
WHtR	MP	0.4	0.05	0.27	MP	0.4	0.04	0.14
	LP	0.4	0.03		LP	0.4	0.03	
SAR (cm)	MP	39.2	7.67	0.11	MP	39.8	5.66	0.001***
	LP	37.1	7.88		LP	35.1	4.44	
SBJ (cm)	MP	112.8	20.46	0.71	MP	117.6	19.74	0.79
	LP	114.0	15.83		LP	116.1	28.08	
TOTAL PA	MP	679.6	24.93	0.00***	MP	798.8	37.11	0.00***
	LP	699.8	12.41		LP	840.0	0.00	

MP=Mpumalanga province; LP=Limpopo province; SD=standard deviation; BMI=body mass index; %BF=percentage body fat; WC=waist circumference; SUP=sit-ups; WHtR=waist-to-height ratio; SAR=sit-and-reach; SBJ=standing broad jump; TOTALPA= total physical activity; p<0.05*; p<0.01**; p<0.001***

With regards to the MP girls, the most striking comparisons were found concerning those aged 9 (body weight: 24.57kg; BMI 13.74 m.kg⁻²), 11 (body weight: 29.51kg; BMI 15.46 m.kg⁻²) and 12 years (body weight: 31.00kg; BMI 16.23 m.kg⁻²).

The children's data concerning %BF depict a similar pattern with those found regarding their body mass and BMI scores since the 9 years old MP boys had the highest %BF (34.31), while the lowest body fat value was found in respect of MP girls of similar age (33.41). The same trend was observed among the 9 years old LP boys who had the highest %BF among the age categories. The 9 year old LP girls had a marginally higher %BF (28.90) compared to the lowest value (27.85) observed for their male peers.

In a study on nutritional transition among learners in rural KwaZulu-Natal, South Africa, Tathiah *et al.* (2013) reported that 4.8% of the learners were underweight and 9.2% stunted, with the highest rate found among 11-12 years age group. They also found that overweight (11.1%) and obesity (22.9%) existed among children aged 9-10 years. In contrast, our study indicated a high prevalence of underweight, normal weight and overweight in MP (77%,

22.4% and 0.2%) and LP (72%, 24% and 3%) provinces, with the younger children most markedly underweight.

In another cross-sectional growth survey undertaken in 3511 children in MP province, Kimani-Murage *et al.* (2010) used WHO/NCHS and International Obesity Task Force (IOTF) BMI cut-off points to estimate obesity in the children. They reported the higher prevalence of underweight ranging from 14-19% in boys (aged 6-14 years), than in girls. This result also contradicts our findings in which younger boys and girls had a higher tendency to be underweight. Disparity in the present findings when compared with previous results can be explained in terms of differences in cut-off points and methodologies used to estimate these anthropometric indices.

Consistent with previous research however, the present findings also confirm the co-existence of obesity, overweight and underweight in children in same socio-geographic population (Mamabolo *et al.*, 2005; Tathiah *et al.* (2013). Victora *et al.* (2008) have highlighted the health implications of under nutrition in childhood. As such, necessary intervention should be put in place to reverse the trend in children especially in economically deprived parts of the provinces.

In the present study the PA and physical fitness levels of the children were evaluated as these variables correlate with body weight and risk factors of cardiovascular and metabolic diseases in childhood (Pahkala *et al.*, 2013). In both provinces, majority of the children were found to participate in low to moderate total PA. Similar results have been published by Toriola and Monyeki (2012) in which a positive relationship was found between low level of PA and poor fitness levels among South African school children in North-West province.

In studies conducted on the physical fitness levels of South African rural school children in Limpopo Province using the Eurofit test, Amusa *et al.* (2011) reported the values for the children's SAR (26.4 ± 5.3 cm: Boys; 29.3 ± 5.1 cm: Girls); SUP (27.7 ± 9.7 : Boys; 28.7 ± 10.0 : Girls); SBJ (120.6 ± 25.6 cm: Boys; 114.7 ± 22.8 : Girls), which were higher than those found for the children of comparable age level in the present study. The findings are therefore consistent with previous studies on South African children which showed a negative relationship between the children's physical fitness and low PA participation (Monyeki *et al.*, 2005; Monyeki & Kemper, 2007; Truter, Pienaar & Du Toit, 2010).

3.6 LIMITATIONS OF THE STUDY

This study has a number of limitations which should be considered in interpreting the results. Firstly, the cross-sectional nature of the study and the fact that the study was limited to two South African provinces indicate that the findings cannot be generalised as reflecting the body composition, PA and fitness of South African children in other provinces.

Secondly, the study sample is limited as the study was carried out in rural areas of the provinces. It would have been ideal to carry out the study on larger sample sizes involving schools in both urban and rural areas. However, the strength of the study lies in the fact that it permitted the assessment of the status of PA, body composition and fitness among school children in LP and MP provinces which could provide a reliable basis for evaluating future estimates of these dependent variables in South African children.

3.7 CONCLUSION

The results showed that a high percentage of the sampled children were underweight/stunted with extremely low percentage of being overweight. Frequencies of underweight were higher in both provinces than normal and overweight with extreme low values.

With regards to PA, the children participated in low, moderate and high PA, respectively. Children in MP province had higher PA compared to the low PA participation found in LP children. A higher PA participation rate was found in the LP children than those in MP province.

The results also indicate that the children's low fitness level is associated with their low PA participation. Therefore, it is important to periodically evaluate PA levels in South African children in order to alleviate increasing concerns over the potential health crises associated with low PA participation and low physical fitness levels in the children. School and community based physical education and sport programmes should be promoted as these will provide ample opportunity for children to participate in PA.

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CHAPTER 4: Relationship between body composition and blood pressure among primary school children in Limpopo and Mpumalanga provinces of South Africa

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Relationship Between Body Composition and Blood Pressure Among South African Primary School Children

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4.1 ABSTRACT

This study evaluated the relationship between body composition (BC) and blood pressure (BP) among 1357 (681 boys and 676 girls) primary school children aged 9-13 years in Limpopo (LP) and Mpumalanga (MP) provinces of South Africa. Standard protocols were used to measure the children's BC and BP characteristics. BC was estimated by calculating body mass index (BMI) ($\text{weight}/\text{height}^2$) and waist-to-hip ratio, respectively. BMI for age and gender was used to classify the children as underweight, overweight or obese, whilst percentage body fat (%BF) indicated adiposity. The frequencies of underweight, normal weight and overweight were 77%, 22.4% and 0.2% in MP and 72%, 24% and 3% in LP province. Results showed that 81% ($n=1\ 089$) and 19% ($n=253$) of the combined sample had normal BP and prehypertension, respectively. When the data were controlled for provinces, gender and age, results indicated that BMI was negatively associated with systolic BP (SBP) (-0.54) ($p<0.01$), but positively correlated with %BF (0.133) ($p<0.01$), whilst SBP related positively with %BF (0.125) ($p<0.01$). The high percentage of underweight children and relative preponderance of prehypertension in the study warrant the implementation of appropriate intervention strategies to curb the risks and optimise health outcomes.

Keywords: Body composition, hypertension, blood pressure, primary school children.

4.2 INTRODUCTION

Population-based studies concerning correlation of anthropometric indices and risk factors of cardiovascular disease (CVD) in children and adolescents have documented that excessive abdominal or upper body fat carries an increased risk for metabolic complication later in life (American Heart Association, 2010; Centre for Disease Control and Prevention, 2010). CVD results from a disturbance or imbalance in body composition (BC) as a relative or absolute increase in the level of body fat mass and may cause high blood pressure, cardiac disorder, renal abnormalities, overweight, and abdominal fat disposition, all of which have been found to be related to chronic disease in adult life (Bishwalata *et al.*, 2012; Ademola & Monday, 2013). It has been established that several chronic diseases of lifestyle (CDL) such as CVD and hypertension in adults can also be observed in children (World Health Organization, 2011). As such, understanding the relationship between BC and blood pressure among children has received considerable attention. Interestingly, research reports indicated that CVD in children could be attributed to several risk factors such as unhealthy diet, physical inactivity and hypertension (Center for Disease Control and Prevention, 2009; World Health Organization, 2010; 2011).

A number of research studies have reported an increasing prevalence of risk factors of metabolic and CVD among rural children (Monyeki *et al.*, 2005; Amusa *et al.*, 2007; Goon, Toriola & Shaw, 2010; Musa *et al.*, 2012). In South Africa, studies carried out in rural areas of the Limpopo Province have consistently reported body weight disorders and incidence of health-risk behaviours in school children and adolescents (Mantsena *et al.*, 2003; Monyeki *et al.*, 2005; Monyeki & Kemper, 2008; Amusa *et al.*, 2007). These studies emphasised the need for urgent intervention programmes to reverse the growing trend of risk factors of CVD in children and the youth. However, many studies consider CDL to be a cluster of risk factors that contributes towards development of CVD; a transition characterised by a combination of poverty-related ailments together with emerging urbanisation, industrialisation and westernisation (Alberts *et al.*, 2005). Although poverty and infectious diseases such as HIV/AIDS and tuberculosis appear to be a reality in South Africa, the problem of CVD looks to be less pressing and little recognition is given to the magnitude of the burden of CDL in the country (Norman *et al.*, 2007). In addition, Statistics South Africa has revealed that 32% of 52 million people under the age of 15 years currently receive social grants which indicates

that a large percentage of the population are exposed to poor socioeconomic circumstances (Statistics South Africa, 2008). These risk factors are becoming a major concern in South Africa and therefore, the predisposition needs to be closely monitored.

It is well documented and understood that BC plays a vital role as a major health-related component in the overall general health of individuals with and without CVDs (Pahkala, 2009). However, factors such as biological maturation, age and gender (Fisher, 2008; Kumanyika, 2008), nutrition and lifestyle factors (Ademola & Monday, 2013) including body weight disorders, e.g., underweight, overweight and obesity (Hills, Bo Anderson & Byrne, 2011) may have negative effects on the overall wellbeing (Pahkala, 2009; Monyeki *et al.*, 2012). In order to have a clear understanding of BC and its relationship with blood pressure, several factors such as age, gender, body height, weight, and body mass index including percentage body fat need to be analysed. Some research studies reported positive relationships among these factors in countries undergoing transition (Tathiah *et al.*, 2013) and most nutrition research and policy concerning the developing world have indicated such relationships focusing on poverty and under-nutrition (Monyeki *et al.*, 2005; Mamabolo, 2007; Tathiah *et al.*, 2013). Several reports have reported the prevalence of CDL and its correlates in high income countries (Marques-Vidal *et al.*, 2008; Martinez-Vizcaino *et al.*, 2008; Vincente-Rodriguez *et al.*, 2008), but few efforts have been made to explore body weight status, age and gender as they relate to blood pressure among children and adolescents using large-scale representative samples from two provinces, for example, Mpumalanga and Limpopo provinces. In addition, little is known about how BC affects blood pressure among children and adolescents in a country undergoing nutritional transition.

Despite the fact that body weight disorders are clearly associated with other chronic diseases including hypertension (American College of Sports Medicine, 2005), it has been difficult to demonstrate convincingly the role of BC in the prediction of CVD in the South African context, particularly among children and adolescents. This difficulty can be attributed to the fact that a wide variety of definitions on childhood hypertension are in use and available standards are indecisive. Added to this complexity is the lack of consistent reference standards for evaluating body fatness in children and adolescents. Therefore, understanding weight categories becomes important because the long-term health risks for hypertension can be extensive, especially among children and adolescents. Of equal importance is the development of appropriate strategies and suitable interventions to curb these risks and

optimise health outcomes. This study therefore, assessed BC indices including BMI for age and gender which were used to classify the children as underweight, overweight or obese (Cole *et al.*, 2007), whilst WC was used to predict percentage body fat (%BF) among the children (Slaughter *et al.*, 1988). The children's BC and blood pressure results were compared with available normative data provided by the Centre for Diseases Prevention and Control-CDC (2010) and Human Sciences Research Council (2013). Additionally, the study examined the incidence of body weight disorders and their relationship with chronic disease among South African school children and compared these with data from other countries.

4.3 METHODOLOGY

4.3.1 Research design

Descriptive and cross-sectional designs were used for data collection in which BC and BP were measured among targeted samples of primary school children aged 9-13 years in the Limpopo (LP) and Mpumalanga (MP) provinces of South Africa.

4.3.2 Participants

The sample comprised 1357 participants (681 boys and 676 girls) aged 9-13 years, drawn from LP (n=651) and MP (n=706) provinces. Random sampling was used to select eight schools from each province depending on the pupil population density. Class registers were also used to draw a targeted group of children whose ages could be verified. Children who were reportedly ill and whose ages were above the lower and upper limits set for the study (i.e. 9-13 years) were excluded. Subsequently, participants were randomly selected from 16 rural primary schools located in various parts of the provinces.

4.3.3 Demographic information

Information regarding the children's socio-demographic characteristics which included age, gender, ethnicity and residence was obtained from the school register.

4.3.4 Anthropometric measurements

Anthropometric measurements which included body mass, stature, skinfolds and waist circumference were measured using the protocol of the International Society for the Advancement of Kinanthropometry (ISAK) (2006). Based on these measurements, BC indices including body mass index (BMI) ($\text{weight}/\text{height}^2$) were derived. BMI percentiles

were used to classify the children in the following weight categories: underweight, overweight or obese for age and gender (Cole *et al.*, 2007). Waist circumference (WC) measured the abdominal visceral adipose tissue to estimate %BF among the children. %BF is an internationally accepted measurement for abdominal visceral adipose tissue and is highly recommended for use among children and adolescents from various ethnic groups. The anthropometric, BC and BP data of the children from the Limpopo and Mpumalanga provinces were compared with available normative data provided by the Centre for Diseases Prevention and Control (2010) and Human Sciences Research Council (2013).

4.3.5 Blood pressure measurement

Blood pressure (BP) was measured using an electronic blood pressure monitor (Omron HEM-705 CP devices, Tokyo, Japan). The standardised guidelines of the National High Blood Pressure Education Program (of the National Heart, Lung, and Blood Institute) were applied for the assessment of BP among children (U.S Department of Health and Human Services, 2005). According to these guidelines, hypertension in children and adolescents continues to be defined as systolic BP (SBP) and/or diastolic BP (DBP) on repeated measurement, at or above the 95th percentile. BP between the 90th and 95th percentile in childhood had been designated “high normal” or “pre-hypertensive” and is an indication for lifestyle modification (Chobanian *et al.*, 2003). Based on these guidelines, the readings at the first and third BP monitors were taken as SBP and DBP, respectively. The averages of the two BP measurements were used to examine the incidents associated with elevated BP among school children in both provinces.

4.3.6 Pilot test

A pilot study, which included the training of the study’s research assistants, was also conducted before actual data collection to ascertain the logistical and technical procedures for the measurements.

4.3.7 Statistical Analyses

Data were analysed using descriptive statistics, such as means, minimum, maximum values, standard deviations and frequencies. The independent t-test was used to examine significant differences between two ordinal variables and to assess disparity between categorical variables. Analyses of variance and Scheffé *post hoc* method were used to examine significant age and gender differences in BC and BP measurements. To study the relationship

among the variables, Pearson correlation coefficients were computed. All data analyses were performed with the Statistical Package for the Social Sciences (SPSS), Version 21.0 (2011). For all statistical analysis the level of significance was set at $p \leq 0.05$.

4.4 RESULTS

The results showed that with regard to the hemodynamic variables, 81% (n=1089) of the combined sample had normal BP and 19% (n=253) had BP values indicative of prehypertension (Figure 1). Prevalence of prehypertension was considerably higher among children in the LP province (10.6%) as compared to their peers in MP province (9.0%) (data not shown).

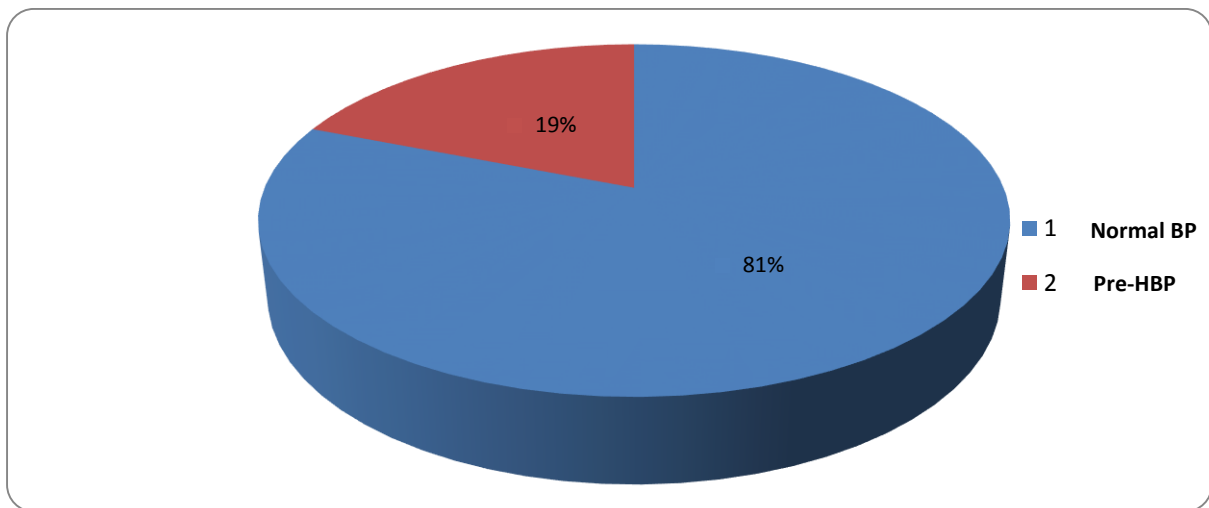


Figure 1: Percentage scores for normal and pre-hypertension for the sampled learners in LP and MP provinces

The physical characteristics of the children according to their nutritional status are presented in Figure 2. Overall, the results demonstrated that 75% (1 014) of the combined sample were underweight, 24% (322) had normal weight, and 1% overweight (data not shown). The results indicated a high prevalence of underweight among the sample. Underweight was more prevalent among girls (LP=70.5%; MP=67.4%) than boys (LP=66%; MP=58%). However, when data were analysed separately by province according to gender, prehypertension was more prevalent among LP girls (16.3%) than boys (5.0%) whereas, in the MP province, boys exhibited a higher percentage of prehypertension (14.4%) than girls' (13.5%) (data not shown).

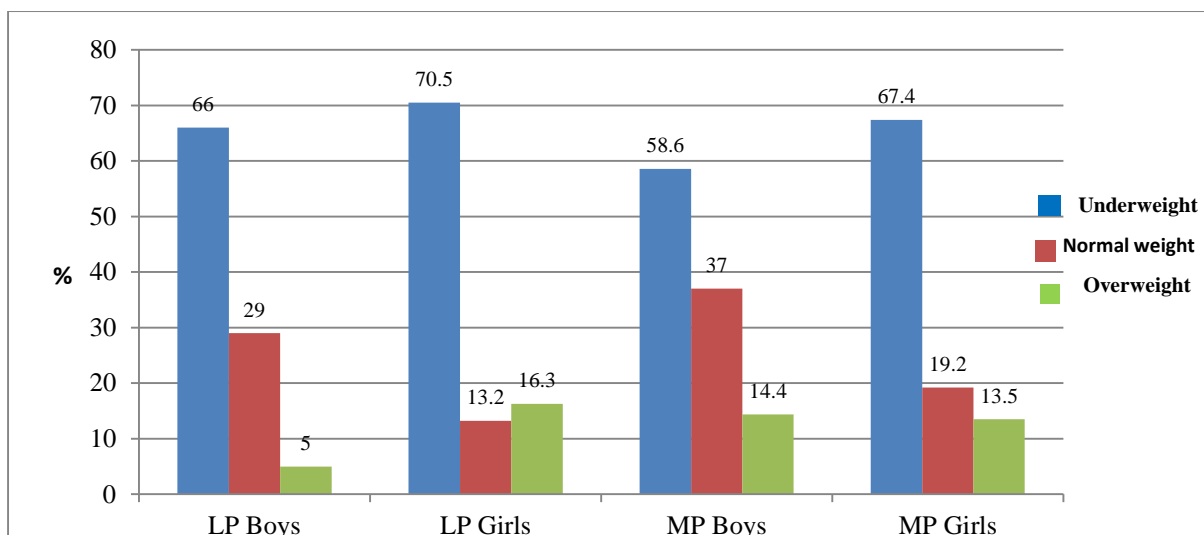


Figure 2: Percentage scores for weight status of the LP and MP children according to gender.

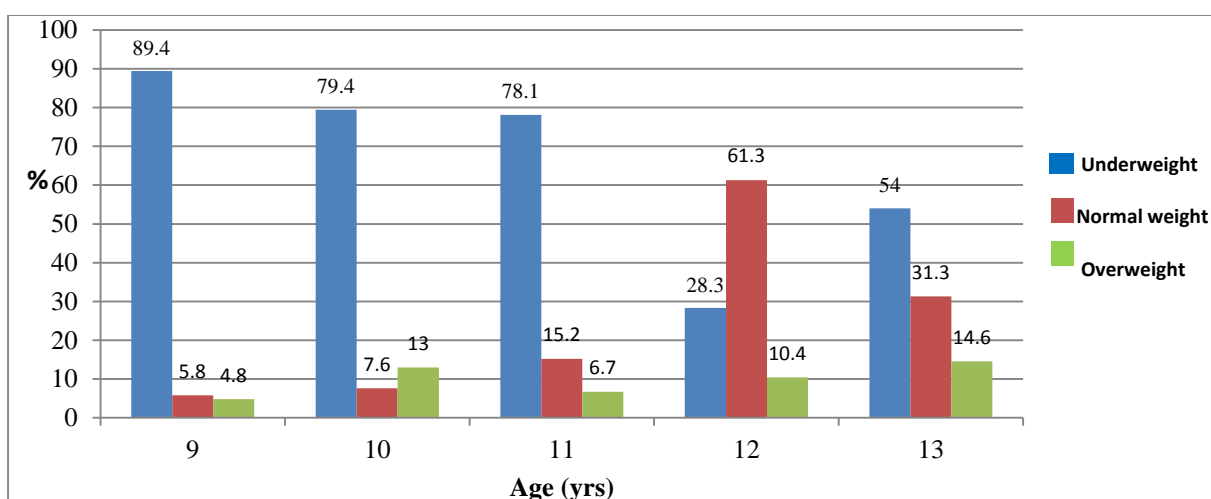


Figure 3: Percentage scores of weight status for LP and MP children according to age categories.

Figure 3 illustrates the descriptive statistics for the children in the LP and MP provinces according to age groups. The findings with regard to prehypertension according to age categories for the combined samples were as follows: Age 9=4.8%; Age 10=13.0%; Age 11=6.7%; Age 12=10.4% and Age 13=14.6%). Although the results showed non-significant differences in the children's mean age across the sample, most traits such as weight, height, BMI, %BF and WC increased significantly with age in both genders (Table 1). According to Brunet *et al.* (2007) and Artero *et al.* (2010), significant changes take place in weight, height and the general BC at varying chronological ages as children grow older. However, these

traits differ according to gender. When the data were analysed according to gender, girls were on average taller and heavier than boys. Largely, girls demonstrated higher mean values in all the anthropometric and physiological variables compared to the boys (Table 1).

Table 1: Anthropometric and physiological measurements of LP and MP school children according to age and gender

Variables	Boys (n=666)	Girls (n=673)	p-value of the difference
	Mean± SD	Mean± SD	
Age (years)	11.08 ±1.28	10.881±1.26	0.04
Stature (cm)	138.62±8.37	140.50±10.49	<0.00
Weight (kg)	33.32±8.19	35.02±8.67	<0.00
BMI (kg.m ⁻²)	17.14±2.74	17.53±2.73	0.01
SBP (mmHg)	110.67±14.93	112.94±11.29	0.002
DBP(mmHg)	75.48±12.52	79.39±12.83	<0.00
BF (%)	10.93±6.79	15.23±6.15	<0.00
WC (cm)	57.88±6.44	60.69±28.25	0.01

*p<0.05

Table 2 illustrates the descriptive data (mean±SD) with regard to the children's BC and BP. Mostly data indicated that across the provinces, MP children had higher mean values with regard to BC and BP in comparison with their LP peers. In general, the results showed a non-significant gender difference in the derived measurements, BMI and FFM. However, MP children illustrated higher mean values for height, weight, WC, %BF, SBP and DBP as compared to their counterparts in LP province. Equally, the mean values for BMI and FFM were significantly higher in MP than LP children (Table 2).

Table 2: Anthropometric and physiological data for school children in LP and MP Provinces

Variable	Combined sample (n=1361)		LP (n=708)		MP (n=653)		p-value
	Mean	SD	Mean	SD	Mean	SD	
Height (cm)	139.58	9.56	138.51	8.50	140.74	10.49	0.000*
Weight (kg)	34.42	9.22	33.51	9.61	35.41	8.68	0.000*
BMI (kg.m ⁻²)	17.46	3.35	17.24	3.55	17.69	3.10	1.000
Waist circumference (cm)	59.40	20.50	57.94	6.80	60.99	28.66	0.000*
Sum of skinfold (mm)	15.85	7.86	15.12	7.92	16.63	7.72	0.000*
Percentage body fat (%)	14.56	5.89	13.89	5.93	15.29	5.77	0.000*
Fat free mass (FFM)	28.80	6.11	28.12	6.07	29.53	6.09	1.000
Systolic BP (mmHg)	111.92	13.47	110.71	15.16	113.25	11.23	0.000*
Diastolic BP (mmHg)	77.53	13.03	75.86	13.15	79.33	12.67	0.000*

*p<0.0001

Presented in Table 3 is the summary of the anthropometric and physiological characteristics across the age groups for the combined sample of school children in the LP and MP provinces. The results regarding anthropometric characteristics of the children showed that height, weight and subsequently BMI, increased with age across the group. With regard to %BF and WC, the results showed higher values among the 9 year olds: %BF= (30.44±3.25) and WC= (65.36±38.95) compared with ages 10, 11, 12 and 13 categories. However, at ages 10, 11, 12 and 13, the mean values for %BF and WC decreased as the children grew older. The results of the physiological characteristics across the provinces demonstrated higher mean values among children at ages 10 and 11 years, respectively (SBP =113.85±12.51mmHg; DBP = 77.53±12.14mmHg) and (SBP=114.28±12.92mmHg; DBP=79.56±12.12mmHg) than other age categories. The higher mean values of the SBP and DBP are probably associated with biological changes due to growth and maturation.

Table 3: Anthropometric and physiological characteristics of LP and MP children according to age categories

Variables	Age (years) =9	Age (years) =10	Age (years) =11	Age (years) =12	Age (years) =13
	Mean± SD	Mean± SD	Mean± SD	Mean± SD	Mean± SD
Height (cm)	135.55± 9.32	138.63±8.73	139.67±9.35	141.17±8.98	142.84±10.57
Weight (kg)	28.44±5.73	31.17±5.24	33.53±5.94	36.56±6.93	43.64±12.88
BMI (kg/m ²)	15.34±1.61	16.11±1.29	17.6±1.40	18.19±1.87	21.14±5.8
BF (%)	30.44±3.25	23.69±2.91	17.15±1.96	13.99±1.92	12.37±1.90
WC (cm)	65.36±38.96	59.26±5.49	58.89±24.94	56.45±4.25	56.89±7.85
SBP (mmHg)	107.84±11.30	113.85±12.51	114.28± 12.92	110.99±13.93	109.87±14.70
DBP (mmHg)	78.39±14.06	77.53± 12.14	79.56±12.12	76.09±13.18	75.00±12.57

* The mean difference is significant at the 0.05 level.

Table 4: Correlation matrix between body composition and blood pressure, and age

Variables	Age	BMI	Systolic	Diastolic	%BF	WC
Age	-	.56**	-.001	-.08**	-.90**	-.28**
BMI	.56**	-	-.06*	-.15**	-.67**	-.26**
%BF	-.90**	.67**	-.02	.12**	-	.47**
WC	-.28**	-.26**	.02	.07**	.47**	-

** . Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

This study also examined the relationship between the children's BC, BP and age. The results are presented in Table 4. Significant positive correlations were found between age and BMI (0.56) ($p < 0.01$). Whereas, DBP (-0.08); %BF (-0.90) and WC (-.28) ($p < 0.01$) negatively correlated with age. Further results showed that BMI was negatively associated with the following variables SBP (-0.06); DBP (-0.15); %BF (-0.67) and WC (-0.26) ($p < 0.01$). Finally, %BF and WC were positively correlated (0.47) ($p < 0.01$). However, the relationships between SBP and age, %BF and WC were not significant ($p > 0.05$).

Table 5: Correlation coefficients for body composition and blood pressure controlled for provinces, gender and age

Variables	BMI	Systolic	Diastolic
BMI	-	-0.054*	0.015
%BF	0.133*	0.125*	0.043
WC	-0.002	-0.017	0.027

*.Correlation is significant at the 0.05 level (2-tailed).

Table 5 shows the correlation coefficients between the children’s BC and BP when controlled for provinces, gender and age. The results indicate that BMI was negatively associated with SBP (-0.54) ($p < 0.01$), but positively correlated with %BF (0.133) ($p < 0.01$). Also, SBP related positively with %BF (0.125) ($p < 0.01$). However, no significant correlations were found between BMI and DBP; %BF and DPB, WC and DBP ($p > 0.05$).

4.5 DISCUSSION

The present study examined the relationship between BC and BP among school children in the LP and MP provinces. The results showed a positive significant correlation between age and BMI (0.56) ($p < 0.01$) among children. However, a negative correlation ($p < 0.01$) was observed with regard to DBP (-0.08); %BF (-.90) and WC (-0.28) in association with age. The present study also indicated a positive correlation ($p < 0.01$) between BMI and age. These findings are consistent with the results of other studies (Fisher, 2008; Kumanyika, 2008; Brunet, Chaput & Tremblay, 2007; Artero *et al.*, 2010; Toriola *et al.*, 2012) in which BMI among the children was found to increase proportionately with age among children and adolescents. It is probable that the similarities are due to the apparent disparity in growth and maturation—an issue that was not investigated as it was beyond the scope of this study. Furthermore, risk factors of CVDs are often tracked from childhood to adulthood, thus making childhood and adolescence a crucial age group to investigate the association between BC and the prevalence of hypertension. The results also showed that BMI was negatively associated with the following variables SBP (-0.06); DBP (-0.15); %BF (-0.67) and WC (-0.26); $p < 0.01$, whereas a positive correlation (0.47) ($p < 0.01$) was noted concerning %BF and WC, though non-significant associations were observed between SBP and age, %BF and WC ($p > 0.05$).

Despite the high prevalence of underweight (75%) found among the cohort of LP and MP children, the prevalence of prehypertension was considerably higher among the children in LP (10.6%) and MP (9.0%) provinces, as compared to the relatively low prevalence of 3.5% reported for South African children (Moselakgomo *et al.*, 2011). The incidence of normal BP and prehypertension among this sample was 81% and 19%, respectively. The present data, which indicated a higher prevalence of normotension than prehypertension, is consistent with the findings reported for children of similar age categories (Agyemang *et al.*, 2005; Mufunda *et al.*, 2006; Toriola *et al.*, 2012; Moselakgomo *et al.*, 2011). In addition, the results of the National Health and Nutritional Examination Survey, 2012 indicated that about 19% of school children, aged 6-14 years, had a high prevalence of prehypertension and an additional 16% were at the borderline of being hypertensive. When the present data was compared with available norms from the US Department of Health and Human Services (2005) for similar age groups, it was found that the mean BP for the 11- and 10-year old LP and MP boys (110.67 ± 14.93 mmHg) and girls (112.94 ± 11.29) fell to the 90th percentile of American norms.

Compared with the few studies that have used the same diagnostic criteria, the prevalence of prehypertension is similar to that previously reported for South African children (Monyeki *et al.*, 2005; Amusa *et al.*, 2010; Moselakgomo *et al.*, 2011) in which an increasing prevalence of risk factors of cardiovascular and metabolic diseases were found among the children. Similarly, a 25% prevalence of hypertension for children living in rural areas was reported to be more likely to be lower than that found in urban children (Lutfyya *et al.*, 2007). Conflicting findings were observed in other countries in which children from the upper socioeconomic strata were more likely to be found hypertensive than children in economically deprived communities (Ogden *et al.*, 2010). Furthermore, a study from northern India (Marwaha *et al.*, 2006), reported a 5.59 % prevalence of childhood hypertension in the higher socioeconomic strata as compared to 0.42 % found in the impoverished areas. However, such comparisons should be interpreted cautiously in view of the differences in age groups, methods, definitions of blood pressure, reports on prevalence and risk estimates reported in previous studies.

4.6 LIMITATIONS OF THE STUDY

The results of this study should be interpreted cautiously in view of the following limitations. Firstly, the National Health Blood Pressure Education Program (NHBPEP) required standard guidelines necessitate that BP be measured at least several times on different occasions but

this was not feasible in the present study, as measurements were taken three times on one occasion. Therefore, a follow-up study would be required to confirm the prevalence of prehypertension among the children. Secondly, maturity status which may have influenced BC results and subsequently BP due to the significant changes during adolescent growth span was not assessed in the present study. Furthermore, research reports have indicated that hypertension in children and adolescents could be attributed to several health risk factors, such as unhealthy diet and physical inactivity, and these factors were also not evaluated in this study. In addition, the research report designated that hypertension differs according to different economic strata, for example, children from the upper socioeconomic strata are more likely to be hypertensive than children in economically deprived communities. It would have been interesting to examine the relationship between dietary intake and habitual lifestyle, socioeconomic background and environmental factors with BP among the children. However, the strength of the study lies in the fact that body weight status, age and gender as they relate to blood pressure, were assessed using large-scale representative samples from two provinces which could provide a reliable basis for evaluation of future estimates on BC and blood pressure in South African children.

4.7 CONCLUSION AND RECOMMENDATIONS

Incidence of body weight disorders and prehypertension were observed in this studied sample. Of equal importance was the positive correlation between age and BMI among children. Because of the strong correlation between age and BMI, the results seem to suggest that excessive weight gain is likely to be associated with elevated BP in the children over time. Nonetheless, BMI, %BF and WC appear to be helpful anthropometric parameters in the classification and identification of hypertensive children and adolescents. It is therefore important to incorporate these indices as part of risk factor analysis in the evaluation of hypertension and other non-communicable diseases among children and adolescents. In addition to BMI, %BF and WC, some research reports have indicated a positive relationship of blood pressure with age, gender, stature and body weight, and that these associations are prevalent in countries undergoing transition. Thus, it is also important to periodically evaluate these variables when diagnosing hypertension in children. The fact that elevated blood pressure often tracks from childhood to adulthood, makes childhood and adolescence a crucial age group to investigate BC and its association with hypertension. Furthermore, a wide variety of definitions of childhood hypertension are in use and no available standards

are decided yet, it therefore becomes important to develop appropriate strategies and suitable interventions to curb associated risks and optimise health outcomes.

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CHAPTER 5: Relationship between physical activity and risk factors of body weight disorders among primary school children in Limpopo and Mpumalanga provinces of South Africa

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Relationship between physical activity and risk factors of body weight disorders among South African primary school children

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5.1 ABSTRACT

Objective: The study determined the relationship between physical activity (PA) and risk factors of obesity among primary school children (boys: mean age 11.17 ± 1.29 , $n=678$; girls: mean age 10.88 ± 1.27 , $n=683$) in Limpopo and Mpumalanga provinces, South Africa.

Methods: The children were classified according to age and sex-specific body mass index (BMI) categories (underweight: $0 < 18$, normal weight: $18.5 < 25$, overweight: $25 < 30$ or obese: > 30) and their blood pressure (BP) measurements. Health-related fitness was assessed with standardised test protocols. Using the International PA Questionnaire (IPAQ), the children's PA levels were judged as: Low (METs scores of less than 500); Moderate (METs scores from 500 to 1499) or High (METs > 1500).

Results: The children were mostly underweight (74%) compared to other weight categories (normal weight: 23.7%; overweight: 1.0%; obese: 0.6%). Girls had non-significant elevated BP values (systolic: 112.94 ± 11.28 mmHg; diastolic: 79.40 ± 12.80 mmHg) compared to the boys (systolic: 110.71 ± 14.95 mmHg; diastolic: 75.53 ± 12.53 mmHg) who had higher PA levels (METs = 1286.72 ± 317.47) than girls (METs = 397.28 ± 30.14) ($p < 0.01$). The children's PA levels correlated positively with BMI (.86) ($p < 0.01$) but negatively with %BF (-.67); weight circumference (WC) (-.41); SUP (sit-up) (-.22); and predicted $\dot{V}O_{2max}$ (-.17) ($p < 0.05$). BMI was positively associated with SBP (standing broad jump) (.06) and SAR (sit-and-reach) (.16) ($p < 0.01$) whereas, it was negatively related to DBP (-.15); %BF (-.67); WC (-.26); SUP (-.21) and predicted $\dot{V}O_{2max}$ (-.12) ($p < 0.05$). SBP correlated negatively with total METs (-.8); SUP (-.11); SBJ (-.17) and predicted $\dot{V}O_{2max}$ (-.03) ($p < 0.1$); whereas DBP negatively correlated with total METs (-.17); BMI (-.15); and SBJ (-.09) ($p < 0.01$). %BF and WC negatively correlated with total METs (-.67); BMI (-.67); SAR (-.14) as well as with total METs (-.41) and BMI (-.26), respectively ($p < 0.05$). SAR correlated negatively with %BF (-.14); SUP (-.34); SBJ (-.32); and predicted $\dot{V}O_{2max}$ (-.07) ($p < 0.05$). SUP also related positively with %BF (.19); WC (.08); SBJ (.47) and predicted $\dot{V}O_{2max}$ (.13) ($p < 0.01$), but associated negatively with total METs (-.22); BMI (-.21), SBP (-.11) and SAR (-.34) ($p < 0.05$).

Conclusions: Deeper insights into the relationship between body composition, PA and non-communicable disease risk among children could provide a reliable basis for designing appropriate intervention programmes needed to optimise health outcomes.

Keywords: body composition; body weight; physical activity; health risk factors; children; South Africa.

5.2 INTRODUCTION

Childhood obesity, has over the past two decades, increased significantly and is now considered a serious public health issue with both short-term and long-term health consequences⁽¹⁾. Physical inactivity habits, along with excessive body fat, affect cardiovascular and metabolic disease risk and these habits are often established during childhood, thus making overweight and obesity to reach an epidemic proportion in many countries⁽¹⁾. Unconcealed symptoms of chronic diseases might not be apparent in children and adolescents, but their manifestation during childhood may track into adulthood. A number of studies have provided overwhelming evidence that low physical activity (PA) patterns or fitness is associated with an exaggerated disease risk including hypertension and body weight disorders: the CASPIAN Study⁽²⁾, AVENA Study⁽³⁾, HELENA-CSS project⁽⁴⁾, Bogalusa Heart Study⁽⁵⁾ and the European Heart Study⁽⁶⁾. It has been noted from these studies that disproportionately low PA patterns predispose children to various disease risks, of which underweight, overweight, obesity, hypertension, metabolic syndrome and sedentary lifestyle are glaring examples.

In many developed countries, studies have shown that increased PA patterns and/ or high cardiorespiratory fitness confer protection against chronic illness in individuals with underlying risk factors, including obesity⁽⁷⁾. Such studies have documented increasing PA as the key strategy for the treatment of paediatric body weight faltering, and have demonstrated a strong negative relationship between PA and obesity⁽⁸⁾. Conversely, increased daily PA and high cardiorespiratory fitness reduce the risk for a large number of chronic diseases, including hypertension⁽⁹⁾ and body weight disease risk⁽⁸⁾. In addition, physical fitness is important from a health perspective not only in adults but, children and adolescents as well⁽¹⁰⁾. Thus, children with low fitness could derive health benefits by improving their PA level as this is associated with numerous physiological and psychological health benefits⁽¹¹⁻¹³⁾.

South Africa is a country undergoing modern transition since the time of industrial revolution. Modern technology has brought about notable changes in lifestyle which promote sedentary living. The number of hours spent on activities for survival and daily living have been reduced due to urbanisation and modern technology, leaving ample free time at people's disposal. According to Huang and Malina⁽⁹⁾, a sedentary lifestyle in adults has been associated with the development of many health problems such as obesity, coronary heart disease (CHD), hypertension, lower back pain, all of which have both social and economic consequences⁽¹⁴⁻¹⁶⁾. Notably, it is now established that these diseases have precursors during childhood and adolescence⁽¹⁷⁻²⁰⁾.

Despite the fact that the major cause of the growing prevalence of obesity and its associated diseases is a reduction in daily PA among children^(16, 21-23), studies examining the relationship between PA and related health risk factors in children and adolescents are scarce in South Africa. Studies carried out in rural areas of the Limpopo Province have consistently reported body weight disorders and incidence of health-risk behaviours in South African school children and adolescents⁽²⁴⁻²⁷⁾. These studies emphasised the need for urgent intervention programmes to reverse the growing trend of risk factors of obesity in children and youth. Despite the fact that physical fitness plays a vital role in the overall health of individuals with and without CVDs, PA participation has decreased tremendously, especially among the youth. Results from South Africa's 2014 report card on PA for children and adolescents have indicated the co-existence of obesity and underweight as well as a low level of PA among the children⁽²⁸⁾.

It is of interest therefore, to examine the role of PA in the aetiology and prognosis of body weight disorders and associated health risks among children in the South African context. As risk factors of disease are of major public health concern, children's predisposition needs to be closely monitored. The trends are difficult to quantify or compare as a wide variety of definitions of body weight disorders in childhood are in use and available standards are debatable. Even in the presence of consensus of opinion regarding health risks associated with PA participation in children and adolescents, it is important to continuously monitor observable trends as such outcomes will inform the development and implementation of appropriate health policies. Therefore, this study was designed to assess the relationship between PA and risk factors of disordered body weight among South African primary school children. In addition to facilitating meaningful comparisons with results obtained in other countries, the present study could provide baseline data for interpreting future

epidemiological surveys on body composition, PA and fitness in children. Specifically, the study evaluated anthropometric indices, PA and the physical fitness profiles of South African children and their relationship with the risk factors of cardiovascular and metabolic diseases.

5.3 METHODOLOGY

5.3.1 *Research design*

A cross-sectional design was used to collect data on anthropometric, hemodynamic, PA and physical fitness variables as determinants of health risks in targeted samples of primary school children in the Limpopo and Mpumalanga provinces of South Africa. The descriptive characteristics of the children's anthropometric, physiological and health-related fitness variables are presented.

5.3.2 Participants

A total of 678 boys and 683 girls aged 9-13 years were randomly selected from eight schools in each of the Limpopo (LP) (n=708) and Mpumalanga (MP) (n= 653) provinces that participated in the study. Class registers were used to draw targeted samples of children depending on the pupil density at each school. Information regarding the children's socio-demographic characteristics (correlates of disordered body weight, PA, fitness and cardio-metabolic disease risk) which included; age, gender, ethnicity and residence was obtained from the school register. However, children who were reportedly ill and whose ages were above the lower and upper limits of the categories set for the study were excluded.

5.3.3 Anthropometric measurements

The participants' anthropometric measurements, which included body weight, body height, skinfolds and waist circumference, were measured using the protocol of the International Society for the Advancement of Kinanthropometry⁽²⁹⁾. Based on these variables, body mass index (BMI) ($\text{weight}/\text{height}^2$) was derived and used to classify the children according to weight categories as follows: underweight ($0 < 18$), normal ($18.5 < 25$), overweight ($25 < 30$) or obese (> 30) for age and gender. Waist circumference (WC) measured the abdominal visceral adipose tissue to estimate percentage body fat (%BF) among the children. In addition, the sums of two skinfolds (triceps and subscapular) were calculated and Slaughter *et als'* equation⁽³⁰⁾ was used to predict %BF.

5.3.4 Blood pressure measurement

Blood pressure (BP) was measured using an electronic blood pressure monitor with cuff designed for children (Omron HEM-705 CP devices, Tokyo, Japan). The standardised guidelines of the National High Blood Pressure Education Program⁽³¹⁾ (National Heart, Lung, and Blood Institute) were applied for the BP measurements to determine potential health risk factors and the relationship between PA and BP among children. BP values between 90th and 95th percentiles in childhood are designated as “high normal” or “pre-hypertensive,” and are an indication for lifestyle modification⁽³²⁾. Based on these guidelines, at least three systolic blood pressure (SBP) and diastolic blood pressure (DBP) readings were taken after the child had been seated for 5 min or longer. The averages of the three BP measurements were included in the statistical analysis. From the BP measurements, pulse pressure, mean BP and the rate pressure product, were calculated using the formula developed by Zheng *et al.* (2008:39). The records were used for statistical analysis.

5.3.5 Health-related physical fitness measurements

For the purpose of this study, five health-related physical fitness variables were tested using the standard protocols of the European Test of Physical Fitness (EUROFIT) and the American Alliance for Health, Physical Education, Recreation and Dance (AAHPERD): flexibility (sit-and-reach test), muscular endurance (sit-up test), muscular strength and upper body extremities (hand grip and standing broad jump tests), and cardiorespiratory endurance (20-meter multistage shuttle run). The tests were selected because of their ease of administration to a large number of subjects.

5.3.6 Physical activity measurement

A short version of the International Physical Activity Questionnaire (IPAQ) was used to evaluate PA level among the children. The self-report questionnaire included items on habitual PA, the frequency and duration of sports participation, including indoor ball games such as soccer, basketball, volleyball, and other outdoor activities like running/jogging, track-and-field sports, dancing and free play among the school children. The school children completed the IPAQ in the classroom under the supervision and guidance of trained investigators. The children were defined as physically active (those who participate in sports and/or vigorous activities), moderately active (those who participate in hard physical and moderate activities) and low physically active (those who participate in activities like walking

and sitting) at least seven times per week for a minimum of 10 minutes at a time. In the IPAQ only those sessions which lasted 10 minutes or more were analysed. All types of PA related to occupation, transportation, household chores and leisure time PA were included. IPAQ also covered information about time spent sitting, which is used as an indicator of inactivity. Based on the children's IPAQ scores, their PA levels were categorised as follows: Low = the METs scores of less than 500; Moderate = METs scores of between 500 to 1499 and High = METs >1500.

5.3.7 Measurement procedure

Eight trained research assistants who are post-graduate students at the Department of Nursing and School of Education, University of the Limpopo, South Africa participated in the data collection. A specialised training workshop was conducted for the research assistants to enable them to competently carry out the measurements. At the workshop each assistant was trained to perform a specific task and measurement procedure at a designated work station, e.g. performance measurement. Each work station had a team leader who coordinated prescribed data collection procedures. Before data collection commenced, the participants filled the demographic section of the data form. In addition, the participants reported their habitual PA under the supervision of the principal investigators.

5.3.8 Ethical considerations

The Ethics Sub-Committee of the Faculty of Health Sciences, North-West University, South Africa (Ethics no: NWU-00088-12-S1) and other relevant provincial regulatory organisations granted ethics approval for the research to be carried out. Before data collection, permission to conduct the study was granted by Provincial Heads of Education Departments and District Managers of the Department of Basic Education in the Limpopo and Mpumalanga Provinces. An information leaflet and informed consent form were administered to the head teachers, pupils and their parents or guardians who gave permission for the study to be conducted.

5.3.9 Data analysis

Data were analysed using descriptive statistics, such as means, standard deviations and frequencies. Independent *t*-test was used to examine significant differences between two ordinal variables to assess disparity between the categorical variables. Pearson's correlation coefficients were calculated to determine the relationship between physical activity, health-related fitness and risk factors of body weight disorders among the school children. All data

analyses were performed using the Statistical Package for the Social Sciences (SPSS), Version 21.0⁽³³⁾. For all statistical analysis the level of significance was set at $p \leq 0.05$.

5.4 RESULTS

The results revealed that with regard to the BMI frequencies among the children, prevalence of underweight (74%; $n=1\ 016$) was higher than other weight categories: normal (23.7%; $n=323$); overweight (1.0%; $n=14$) and obese (0.6%; $n=8$). Furthermore, the results indicated that with regard to the hemodynamic variables, 81% ($n=1089$) of the combined sample had normal BP, and 19% ($n=253$) had BP values indicative of prehypertension. Prevalence of prehypertension was considerably higher among children in the LP province (10.6%) as compared to their peers in MP province (9.0%).

Table 1 - BMI classifications of combined sample of school children in MP and LP provinces by gender*

Weight classification (BMI categories)	Boys (n=678)	Girls (n=683)
Underweight (0-18.5)	334 (49.3%)	682 (99.9%)
Normal weight (18.5-25.0)	323 (47.6%)	-
Overweight (25-30)	14 (2.1%)	-
Obese (>30.0)	7 (1.0%)	1 (0.1%)

Table 1 presents BMI classifications of the combined sample of school children in the MP and LP provinces according to gender. When the BMI classification was analysed, the results showed that girls had a higher prevalence of underweight (99.9%) and lower incidence of obesity (0.1%) than boys (underweight: 49.3%; normal weight: 47.6%; overweight: 2.1%; and obesity: 1.0%). Further analysis of the data according to provinces indicated that prevalence of underweight was higher among MP children (77.0%) than those in LP (72.5%). However, the results of the BMI classification also revealed that LP children had a higher incidence of normal weight (24.6%), overweight (2.0%) and obesity (1.0%) than their MP counterparts, who by contrast, had lower corresponding percentages: normal weight (22.8%), overweight (0%) and obesity (0.2) (Table 2).

Table 2 - BMI classifications of combined sample of school children by provinces*

Weight classification (BMI categories)	MP	LP
Underweight (0-18.5)	503 (77.0%)	513 (72.50%)
Normal weight (18.5-25.0)	149 (22.8%)	174 (24.60%)
Overweight (25-30)	-	14 (2.0%)
Obese (>30.0)	1 (0.2%)	7 (1.0%)

*Results are presented as frequencies (percentages).

It was also of interest to this study to examine gender-related distribution of body weight categories according to province. The results are presented in Table 3. When the data was analysed separately by gender across provinces, distribution of the children's BMI categories were as follows: MP boys (underweight: 53.3%; normal weight: 46.7%), and LP boys (underweight: 45.7%; normal weight: 48.5%). None of the male children measured in MP were overweight and obese in contrast to those in LP: overweight (3.9%) and obese (1.9%). The results for MP girls indicated that none had either normal or overweight, but one was obese (0.3%), whereas an overwhelming majority were underweight (99.7%). However, all LP girls were underweight.

Table 3 - BMI classifications of school children in MP and LP provinces by gender*

Weight classification (BMI categories)	Boys		Girls	
	MP (n=319)	LP (n=359)	MP (n=334)	LP (n=349)
Underweight (0-18.5)	170 (53.3%)	164 (45.7%)	333 (99.7%)	349 (100%)
Normal weight (18.5-25.0)	149 (46.7%)	174 (48.5%)	-	-
Overweight (25-30)	-	14 (3.9%)	-	-
Obese (>30.0)	-	7 (1.9%)	1 (0.35%)	-

*Results are presented as frequencies (percentages).

The descriptive data on body composition, fitness and PA measurements of LP and MP school children are provided in Table 4. The results showed that the combined sample of boys (mean age: 11.17±1.29) was significantly older than the girls (mean age: 10.88±1.27). Similarly, significant differences were observed regarding anthropometric variables with boys having greater values for body mass, stature, sitting height and consequently, BMI than girls ($p < 0.05$). However, regarding adiposity, as indicated by %BF and WC, girls exhibited

higher values than boys ($p < 0.05$). Data on the hemodynamic variables showed that girls had higher mean SBP (112.94 ± 11.28) and DBP (79.40 ± 12.80) than boys (SBP: 110.71 ± 14.95 ; DBP: 75.53 ± 12.53). Results on physical fitness parameters revealed that mean scores for SUP and $\dot{V}O_{2max}$ were significantly different ($p < 0.05$), with the girls having greater values compared to boys. However, boys were significantly more flexible than girls ($p < 0.05$). Concerning PA, the boys had significantly higher ($p < 0.05$) total METs (1286.72 ± 317.47) than girls (397.28 ± 30.14), suggesting that they were more active on average.

Table 5 presents the correlation matrix between the children's PA, fitness and risk factors of obesity when controlled for gender and province. Overall, the total METs of the sampled groups correlated positively with BMI (.86); SAR (.10) and SBJ (.01; $p < 0.01$), but negatively related to SBP (-.08); DBP (-.17); %BF (-.67); WC (-.41); SUP (-.22); and predicted $\dot{V}O_{2max}$ (-.17; $p < 0.05$).

Table 4 - Descriptive data on body composition, fitness and physical activity measurements of LP and MP school children

Variables	Boys (n=678)	Girls (n=683)	p-value of the difference variables
	Mean± SD	Mean± SD	
Age (yrs)	11.17±1.29	10.88±1.27	0.006**
Body mass (kg)	39.69±8.79	29.04±4.39	0.000**
Stature (cm)	142.44±11.01	136.58±8.25	0.000**
Sitting height (cm)	71.93±5.23	68.88±4.73	0.000**
BMI (m.kg ⁻²)	19.38±3.12	15.49±1.04	0.000**
SBP	110.71±14.95	112.94±11.28	0.002**
DBP	75.53±12.53	79.40±12.80	0.000**
%BF	17.81±6.96	21.00±5.92	0.000**
WC	56.28±5.77	60.67±6.36	0.000**
SAR	40.47±7.09	39.77±6.49	0.059
SUP	18.28±6.23	20.38±5.46	0.000**
SBJ	117.32±14.71	117.76±19.11	0.627
$\dot{V}O_{2max}$	22.29±6.09	25.43±6.75	0.000**
Total METs	1286.72±317.47	397.28±30.14	0.000**

SD=standard deviation; BMI=body mass index; %BF= percent body fat; WC=waist circumference; SUP=sit-ups; SAR=sit-and-reach; SBJ=standing broad jump; $\dot{V}O_{2max}$ = maximum oxygen consumption; Total METs= total metabolic equivalents; p<0.01*; p<0.001**

The body composition results revealed that BMI associated positively with SBP (.06); SAR (.16) and SBJ (.03; p<01) whereas was negatively linked with DBP (-.15); %BF (-.67); WC (-.26); SUP (-.21) and predicted $\dot{V}O_{2max}$ (-.12; p<0.05).

Table 5 - Correlation matrix between physical activity, fitness and risk factors of obesity

Variables	Total MET	BMI	SBP	DBP	%BF	WC	SAR	SUP	SBJ	Predicted $\dot{V}O_{2max}$
Total MET	-	.86**	-.08**	-.17**	-.67**	-.41**	.10**	-.22**	.01	-.17**
BMI	.86**	-	.06*	-.15**	-.67**	-.26**	.16**	-.21**	.03	-.12**
SBP	-.08**	-.06*	-	.42**	-.02	.02	.06*	-.11**	-.17**	-.03
DBP	-.17**	-.15**	.42**	-	.12**	.07**	.02	-.02	-.09**	.09**
%BF	-.67**	-.67**	-.02	.12**	-	.47**	-.14**	.19**	.02	.04
WC	-.41**	-.26**	.02	.07**	.47**	-	.04	.08	.02	.03
SAR	.10**	.16**	.06*	.02	-.14**	.04	-	-.34**	-.32**	-.07*
Sit-up	-.22**	-.21**	-.11**	-.02	.19**	.08**	-.34**	-	.47**	.13**
SBJ	.01	.03	-.17**	-.09**	.02	.02	-.32**	.47**	-	.06*
Predicted $\dot{V}O_{2max}$	-.17**	-.12**	-.03	.09**	.04	.03	-.07*	.13**	.06*	-

Total METs= total metabolic equivalents; BMI=body mass index; SBP= systolic blood pressure; DBP= diastolic blood pressure; %BF=

percentage body fat; WC=waist circumference; SAR=sit-and-reach; SUP=sit-ups SBJ=standing broad jump; Predicted $\dot{V}O_{2max}$ = predicted maximum oxygen consumption; Total METs= total metabolic equivalents
 **. Correlation is significant at the 0.01 level (2-tailed).
 *. Correlation is significant at the 0.05 level (2-tailed).

With regard to the hemodynamic variables, SBP correlated positively only with DBP (.42); WC (0.02) and SAR (.06) but was negatively related with total METs (-.8); BMI (-.06); %BF (-.02); SUP (-.11); SBJ (-.17) and predicted $\dot{V}O_{2max}$ (-.03; $p < 0.1$); ($p < 0.05$). Whereas DBP positively correlated with SBP (.42); %BF (.12); WC (.07); SAR (.02) and predicted $\dot{V}O_{2max}$ (.09), it negatively associated with total METs (-.17); BMI (-.15); SUP (-.02) and SBJ (-.09; $p < 0.01$) ($p < 0.05$). %BF positively associated with DBP (.12); WC (.47); SUP (.19); SBJ (.02) and predicted $\dot{V}O_{2max}$ (.04; $p < 0.01$), but had a negative correlation with total METs (-.67); BMI (-.67); and SAR (-.14; $p < 0.05$). Except for total METs (-.41) and BMI (-.26; $p < 0.05$), WC associated positively with all other variables, including SBP (.02); DBP(.07); %BF (.47); SAR (.04); SUP (.08); SBJ (.02) and predicted $\dot{V}O_{2max}$ (.03). Only %BF yielded substantial correlation ($p < 0.01$).

Concerning the physical fitness parameters, SAR correlated positively with total METs (.10); BMI (.16; $p < 0.05$); SBP (.06); DBP and WC (.02; $p > 0.05$), but negatively with %BF (-.14); SUP (-.34); SBJ (-.32) and predicted $\dot{V}O_{2max}$ (-.07; $p < 0.05$). SUP interrelated positively with %BF (.19); WC (.08); SBJ (.47) and predicted $\dot{V}O_{2max}$ (.13; $p < 0.01$), but associated negatively with total METs (-.22); BMI (-.21); SBP (-.11); DBP (-.02; $p > 0.05$); and SAR (-.34; $p < 0.05$). SBJ positively correlated with total METs (.01); BMI (.03); %BF (.02); WC

(.02); SUP (.47; $p < 0.01$) and predicted $\dot{V}O_{2max}$ (.06; $p < 0.05$), though negative correlation was observed with regard to SBP (-.17); DBP (-.09) and SAR (-.32; $p < 0.05$). Predicted aerobic capacity positively correlated with DBP (.09; $p < 0.05$); %BF (.04); WC (.03) and SUP (.13; $p < 0.01$), however, it negatively associated with total METs (-.17); BMI (-.12); SAR (-.07; $p < 0.5$) and SBP (-.03).

5.5 DISCUSSION

The gender-related differences in body weight found in this study have been widely reported on South African^(24-25, 34-35) and Portuguese⁽³⁶⁾ children. In a study conducted among school children in Mankweng and Toronto-Limpopo province, South Africa⁽²⁶⁾ it was reported that 11.0% of the girls were overweight compared with 9.1% of the boys. In contrast, the findings of this study indicated that only 2.1% of the combined sample of MP and LP boys, and none of the girls, were overweight. Similar to the study conducted by Amusa⁽²⁶⁾, body fatness assessed by excessively high measures of %BF and WC rather than BMI, was more prevalent in girls than boys in the present study. Surprisingly, the results do not mimic the data on the children's BMI classification which indicated that more boys than girls in the combined samples were obese. This seeming contradiction supports the need to consider appropriate definitions and cut-off points for evaluation of obesity and body weight disorders in various population groups⁽³⁷⁾. The findings of the present study also demonstrated a high prevalence of underweight among the children. Recent studies on South African children have reported the co-existence of underweight and obesity in rural population groups undergoing nutrition transition^(28,37,38).

The present results which demonstrated that girls had a higher %BF and WC compared with boys suggest that girls are more at risk of being overweight and obese. This finding could be partly explained in the light of the fact that girls experience profound body composition changes at adolescence, due to the stimulation of their sex hormones and development of their reproductive organs that are often associated with biological maturation⁽⁸⁾. Although nutritional intake was not assessed in this study, it should not be ignored as a possible explanation for the gender-related disparities in body composition and PA found among the children.

The present study also examined the relationship between PA and risk factors of body weight disorders among South African children. Using the IPAQ data, the findings herein showed

that the boys (1286.72 ± 317.47 METs) had higher levels of PA than girls (397.28 ± 30.14 METs). While these results are not surprising, they contradict the data obtained for SUP, SBJ and aerobic capacity in which the girls had superior performances. When analysed in the context of rural environment, culture and traditions, it is expected that girls are limited indoors in order to do household chores, in contrast to the boys who are often assigned physically demanding tasks like farming, cattle rearing and in some instances, hunting. In addition, the gendered role being performed by boys and girls could influence their nutritional intake and PA levels. This cultural analysis regarding role prescription in a rural African community is probably applicable to the cohort of children in this study.

The results of the present study are consistent with those of other studies⁽³⁹⁻⁴²⁾ in which blood pressure was found to be positively correlated with stature, body mass, BMI, %BF and WC. Therefore, the present results showed a tendency for children with relatively high body composition measures to develop a propensity for elevated BP in future. These findings highlight the need for routine measurement of BP as part of physical examination in school children. In view of the fact that the relationship between PA and risk factors of body weight disorders in children is mediated by a multiplicity of factors such as growth and development, genetics, socio-cultural and environmental influences and dietary habits, it was not feasible to control the effects of these factors in this study.

The findings on physical performance variables indicated that the boys (40.47 ± 7.09 cm) were more flexible than the girls (39.77 ± 6.49 cm). The results contradict those reported in other studies^(27,33,43) in which girls were found to perform better in the SAR test. However, this finding is consistent with those of studies involving Nigerian⁽⁴³⁾ and South African⁽²⁶⁾ children. The gender differences in the children's trunk and hamstring flexibility may be attributed to the girls' relatively high WC which could limit their performances in the flexibility test. Furthermore, ages nine to 13 could be termed as a pre-pubertal stage of life when many children, especially girls, typically have difficulty performing the SAR test⁽⁴⁴⁾.

5.6 LIMITATIONS

The results of this study should be interpreted cautiously based on a number of limitations. Firstly, since the study sample was drawn from children and adolescents in two provinces it is not representative of all school children in South Africa and therefore, cannot be generalised in this context. Secondly, certain sociocultural beliefs, values and practices do apply in some rural South African communities whereby female children are discouraged from being

physically active: a feature considered to be unfeminine in preference to performing household chores. However, the socio-cultural factors were not assessed as they were beyond the scope of this study. Thirdly, it is possible that the boys overestimated their PA involvement in completing the IPAQ, which may explain the discrepant findings concerning the girls' superior performances in certain strength-related fitness tests. The above shortcomings notwithstanding, the strength of this study lies in the fact that it was conducted using a fairly large sample of rural school children from two provinces, which could provide valuable baseline information that could form the basis for future studies on the relationship between body composition PA and health risk in children.

5.7 CONCLUSIONS AND RECOMMENDATIONS

This study assessed the relationship between PA and risk factors of weight disorders among primary school children in the Limpopo and Mpumalanga provinces of South Africa. Since too much or little percentage body fat is detrimental to health, a low percentage of body fat can adversely affect metabolism and may indicate the presence of disease such as underweight physical inactivity. The study demonstrates that underweight is prevalent among the sampled children, thus confirming the notion of the co-existence of obesity with underweight in the country. In addition, the positive correlation of body composition with %BF and WC found in the study indicates possible future development of elevated BP. Also, gender difference regarding PA would seem to suggest the prevalence of physical inactivity among the children, more especially girls, which may consequently lead to sedentariness: a habit known to be associated with health risks. Granted that South Africa has an escalating level of obesity which may impact negatively on public health promotion in the country, greater attention should be given to aspects of body composition, PA and physical fitness components among children, so that findings can inform the development of public health policy and practice.

More research should be conducted to evaluate the fitness and cardiovascular disease risk factors among children and adolescents since they are indicators of future adult disease patterns. In this regard, intervention measures should be devised to address the rising trend of overweight and obesity in children and adolescents, as that could stem the prevalence of associated body weight disorders and health risks. Although a physically active lifestyle along with healthy eating habits in children and adolescents are feasible healthy options, the relationship between PA and risk factors of weight disorders among school children could

also be confounded by growth and development factors. More research is therefore needed to evaluate the fitness and health risk factors among South African children and adolescents with a view to elucidating the influences of nutritional and biological factors.

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CHAPTER 6: SUMMARY, CONCLUSIONS, LIMITATIONS AND RECOMMENDATIONS

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6.1 SUMMARY

Despite the abundance of scientific information which points to the health benefits of physical activity (PA), many young people still adopt sedentary lifestyles which are characterised by prolonged TV viewing, playing computer video games and participation in social media (Ortega *et al.*, 2007:1589). Such sedentary activities, which promote physical inactivity among children and adolescents, when combined with faulty nutritional habits lead to the development of risk factors of chronic diseases of lifestyle (CDL) like overweight and obesity, high blood pressure, drug abuse and diabetes (National Centre for Disease Control, Prevention, and Health Promotion, 2010).

Overweight and obesity are widely known to be strong predictors of CDLs, and are precursors of cardiovascular disorders and metabolic syndromes later in life (Ruiz *et al.*, 2007:61). According to the World Health Organisation (WHO) (2010) overweight and obesity among children and adolescents have reached epidemic proportions in many developed and developing countries. While studies have indicated that overweight and obesity are caused by a multiplicity of factors, there is consensus among researchers that an active lifestyle combined with dietary modifications, has shown to be an effective treatment for CDL (Ortega *et al.*, 2007:15). Whilst obesity is not only a problem in developed nations, it is fast becoming an increasing health challenge in countries undergoing an epidemiological transition (Bradshaw *et al.*, 2003:93). Therefore, the interrelationships between unhealthy lifestyle, disease risk factors and the resultant obesity, highlights the necessity to identify and

periodically monitor these factors, especially among South African children and adolescents, so that appropriate interventions can be implemented to reverse the trend.

WHO (2010) has long recognised PA as an integral component of a healthy lifestyle as it is a key factor in health behaviour associated with reduced cause of morbidity and mortality as well as CDL (Ruiz *et al.*, 2007:350), in children and youth. Therefore, it is hypothesised that regular participation in PA during childhood will reduce health risks associated with inactivity at childhood and adulthood (Strong *et al.*, 2005:732). While participation in moderate to vigorous PA reduces the risk of obesity and body weight disorders in children (Van Deventer, 2008:14), physical inactivity is associated with increased body fatness (Ortega *et al.*, 2007:1589).

South Africa is undergoing a rapid epidemiological transition as well as nutrition transition (Draper *et al.*, 2014) characterised by a combination of under nutrition and obesity, poverty-related factors, physical inactivity and infectious diseases such as HIV/AIDS and tuberculosis (TB). According to Alberts *et al.* (2005:12), cardiovascular and metabolic risk factors are increasing rapidly in the country due to increasing urbanisation, industrialisation and adoption of Western lifestyles which negatively affect the lives of the people and are likely to worsen the enormous socioeconomic and public health burden in the near future (Toriola *et al.*, 2010:16).

International surveys, such as those undertaken by Hardman and Marshall (2001) as well as Subramanian and Silverman (2007:23), have consistently reported that PA defined in the context of school physical education (PE) and organised sports programmes, has declined in many countries. Schools do not only provide a logical setting for daily PA promotion; they are also strategically well positioned to promote healthy lifestyles in children and youth (National Institute of Health Medline Plus, 2009; Toriola *et al.*, 2010:16). However, after independence in 1994, PE was replaced by Life Orientation in the curriculum and this led to a substantial reduction in statutory time allocation for teaching the subject, poor resourcing and a low prioritisation of children's PE and PA involvement (Naylor *et al.*, 2006:9). The marginalisation of PE in the curriculum has led to appalling situations in which many schools are constructed without playgrounds, teachers are poorly trained and resourced to teach PE and have limited opportunity to participate in wholesome PA at school (Toriola *et al.*, 2010:16).

In spite of the widely reported positive associations between PA and health-related physical fitness (ACSM, 2009), few studies have examined the association of these fitness parameters with the risk of disease among South African children. The fact that growth rates and fat patterning among children vary between populations makes it particularly difficult to examine such relationships and make meaningful comparisons across populations. Nevertheless, definitions of these interaction effects for phenotypes related to cardiovascular morbidity are important because they will allow for the identification of children at risk, early development of complications and those likely to be resistant to targeted interventions designed to optimise health outcomes.

Whilst some studies have recommended BMI as the best predictive index for cardiovascular and metabolic risk factors, WC has been implicated in other studies. Also, the sum of two skinfolds has been regarded as a better measure of abdominal visceral adipose tissue than WHtR. Despite the plausibility of these measures to identify risk factors of CDL among children, a wide variety of cut-off points exist in the literature and the need to develop population-specific norms has been suggested (Goon *et al.*, 2009). Therefore, given the potentially adverse health, social, and economic consequences of body weight disorders in South African children, it was considered critically important to evaluate current trends in the anthropometric indices of body composition, PA and health-related physical fitness status, as well as evaluate age-and sex-specific standards for the assessment of risk factors based in children, and determine the relationships among these variables.

The study was consequently designed to answer the following questions:

- a) What is the physical activity status of primary school children in the Limpopo and Mpumalanga provinces of South Africa?
- b) What is the physical activity, body composition and physical fitness status among primary school children in the Limpopo and Mpumalanga provinces?
- c) What is the relationship between body composition and blood pressure among primary school children in the Limpopo and Mpumalanga provinces?
- d) What is the relationship between physical activity and risk factors of body weight disorders among South African primary school children?

Therefore, it is envisaged that in addition to providing baseline data for future epidemiological studies on health-related physical fitness and body composition as well as the identification of children at risk, the results of the study will facilitate the development of interventions to reverse the trend and optimise health outcomes. The findings will also clarify the relationship between physical activity and health-related risk factors among South African school children.

6.2 CONCLUSIONS

1. The results support Hypothesis 1 that there will be significantly low PA status among primary school children in Limpopo and Mpumalanga provinces. In addition to both boys and girls in provinces having low PA based on their overall IPAQ scores, gender differences were found in which girls had lower PA compared with the boys. Children in MP province had high PA (28.6%) compared to the low PA participation found in LP children (26.7%). Furthermore, 59.7% of MP children as compared to the LP children (57.3%) participated in moderate PA. A higher PA participation rate of 15.8% was found in the LP children than those in MP province (11.6%). Therefore, hypothesis is accepted.
2. Regarding Hypothesis 2 that there will be significance differences in PA status and body composition among primary school children in the Limpopo and Mpumalanga provinces, the results showed substantial difference in which the frequencies of underweight, normal weight and overweight were 77%, 22.4% and 0.2% in MP whilst 72%, 24% and 3% were found for LP province, respectively. The hypothesis is rejected in this regard.
3. Concerning Hypothesis 3, which states that there will be significance difference in relationship between body composition and blood pressure among primary school children in the Limpopo and Mpumalanga provinces, results showed that 81% (n=1 089) and 19% (n=253) of the combined sample of children had normal BP and prehypertension, respectively. When the data were controlled for provinces, gender and age, findings indicated that BMI was significantly negatively associated with systolic BP (SBP) (-0.54), but positively correlated with %BF (0.133), whilst SBP related positively with %BF (0.125). The hypothesis is accepted.
4. With regard to Hypothesis 4 that there will be significant gender differences in the relationship between PA, health-related physical fitness and risk factors of body weight disorders among South African primary school children, results also yielded significant

disparities between the boys and girls in MP and LP provinces. Specifically, findings indicated that at age 10 the MP boys performed significantly better in sit-up (SUP: 20.5 ± 5.430) than the LP boys (18.6 ± 6.56). The LP boys did significantly better than the MP boys in sit-and-reach (SAR) at ages 10 and 11. The MP boys substantially performed better in SBJ ($121.6 \pm 910\text{cm}$) as compared to the LP ($118.4 \pm 11.00\text{cm}$) ones at age 9. Generally, LP boys did significantly better than the MP across all ages. The hypothesis is accepted.

6.3 LIMITATIONS

The findings of this study should be interpreted in light of the following limitations:

Whilst an attempt was made to randomly select the schools and learners in the MP and LP provinces that participated in the study, this was not feasible as the research was carried out only in the schools which gave the necessary permission. Therefore, the data collected are not representative of all primary school learners in the provinces. However, the fact that data were obtained from fairly large sample sizes in both provinces has provided baseline information which could form the basis for future research investigating the health-related physical fitness and risk factors of obesity among South African primary school children.

Ideally, studies on children's body composition, health-related fitness, cardiovascular and metabolic disease risk should assess the children's nutritional status and control for the effects of growth and development which could clarify the findings obtained. However, this approach was not feasible in the present research. Classifying the children based on nutritional status and excluding the effects of physical growth and maturation may have yielded findings that are more interesting.

The lack of standard sports facilities at the schools from where data were collected was also a constraining factor. This was a challenge in the implementation of the health-related fitness tests.

Involvement of the children in regular PA prior to the study, for example, representing their schools or provinces in sport competitions, may have affected the findings of the study as such learners would be more physically active and fitter than those who were not participating in regular sport competition. Since only a few such learners were identified, it

was decided that their data should not be excluded as these would not exert any significant effect on the findings.

6.4 RECOMMENDATIONS

1. In view of the children's low PA status it is crucial that school authorities provide ample opportunity for learners to engage in PA and school sport. Efforts in this regard can only be sustainable if teachers, school authorities, parents, community and all stakeholders are involved in creating the right social and emotional environment which will motivate learners to be physically active.
2. As Physical Education (PE) provides the ideal opportunity for learners to participate in PA, the teaching of PE as a separate curriculum offering is advocated. It is recommended therefore, that PE is divorced from Life Orientation, and taught as a standalone subject and placed on school timetables. Resources for effecting teaching of PE and adequate teacher preparation should also be provided.
3. Although a number of studies have been conducted on body composition, PA, health-related physical fitness and disease risk factors in children in various provinces of South Africa, it is important that periodic monitoring of these dependent variables be carried out so that the trend in the development of body weight disorders and associated cardiovascular and metabolic disease risk can be determined. Early identification of children at risk would therefore be helpful to try and reverse any undesirable trends and maximise health outcomes.
4. Future research should design and implement intervention programmes based on the findings of this study as these will help to forestall deleterious health outcomes and prevent risk factors of CDL among children and adolescents. School and community-based PA intervention programmes could potentially yield positive health outcomes.

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APPENDIX A: GUIDELINES FOR AUTHORS

The African Journal for Physical, Health Education, Recreation and Dance (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,
- ii) 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,
- iii) Create an awareness in the rest of the world about the professional practice in the disciplines in Africa.

GENERAL POLICY

AJPHERD publishes research papers that contribute to knowledge and practice, and also develops theory either as new information, reviews, confirmation of previous findings, application of new teaching/coaching techniques and research notes. Letters to the editor relating to the materials previously published in AJPHERD could be submitted within 3 months after publication of the article in question. Such letter will be referred to the corresponding author and both the letter and response will be published concurrently in a subsequent issue of the journal.

Manuscripts are considered for publication in AJPHERD based on the understanding that they have not been published or submitted for publication in any other journal. In submitting papers for publication, corresponding authors should make such declarations. Where part of a paper has been published or presented at congresses, seminars or symposia, reference to that publication should be made in the acknowledgement section of the manuscript.

AJPHRD is published quarterly, i.e. in March, June, September and December. Supplements/Special editions are also published periodically.

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Three copies of original manuscript and all correspondence should be addressed to the Editor-In-Chief:

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Science and Technology, P. Bag X5050, Thohoyandou 0950 Republic of South Africa	

Articles can also be submitted electronically, i.e. via e-mail attachment. However, the corresponding author should ensure that such articles are virus free. AJPHRD 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 per 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.

Author(s)' institutional addresses, including telephone and fax numbers.

Corresponding author's contact details, including e-mail address.

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. 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.

Discussion

The discussion section should reflect only important aspects of the study and its major conclusions. Information presented in the results section should not be repeated under the discussion. Relevant references should be cited in order to justify the findings of the study. Overall, the discussion should be critical and tactfully written.

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.

Authors are advised to consider the following examples in referencing:

Examples of citations in body of the text:-

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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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.

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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/cjism/wilson.html>. February 1997.

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1.1 Research Methods

1.1.1 Analysis Result

Tables and figures should be included within the text of the paper and must be numbered, please use for the tables Garamond or Times New Roman 10 pts.

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Reference to a journal publication:

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Mettam, G. R., & Adams, L. B. (1994). How to prepare an electronic version of your article. In B. S. Jones, & R. Z. Smith (Eds.), *Introduction to the electronic age* (pp. 281-304). New York: E-Publishing Inc.

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INSTRUCTIONS TO AUTHORS

- Target and policy
- Instructions for original articles
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Target and policy

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Original articles: epidemiological, clinical or experimental studies.

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The article should be typed in format A4 (210X297mm), 25mm margins in all sides, double space in all sections. Use Times New Roman font, size 11, pages numbered on the upper right corner (start with face page) and text processor Microsoft Word®. The manuscripts must have, at most:

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For the abstract, it is important to obey English grammatical rules. It must be done by someone who is fluent at English.

KEY-WORDS

Provide, below the summary in Portuguese and English, 3 to 6 descriptors, which will help the adequate inclusion of the paper in the bibliographic data banks. Use exclusively descriptors from the list Descriptors in Sciences of Health, elaborated by BIREME and available at <http://decs.bvs.br/>. This list shows correspondent terms in Portuguese and English.

TEXT:

- Original article: divided in introduction (succinct, with 4 to 6 paragraphs, only to justify the work and showing, at the end, the objectives); method (specify the outline of the study, describe the population studied and selection methods, define the used procedures, detail statistic method. It is compulsory to declare the

approval of procedures by the Committee for Ethics in Research of the institution); results (clear and objective the author should not repeat information from tables and charts in the text); discussion (interpret results and compare with literature data, emphasizing important aspects of the study and their implications, as well as their limitations end this section with conclusions related to the objectives of the study).

- Review articles: They don't obey a rigid scheme of sections, but it is suggested that they have an introduction to emphasize the importance of the subject, the reviewing itself, followed by comments and, when necessary, by recommendations.
- Case reports: divided into introduction (succinct, with 3 to 5 paragraphs, to stand out what is known of the disease or of the procedure); case description itself (do not use data that can identify the patient) and discussion (in which is made the comparison to other cases of literature and the innovative or relevant perspective of the case in question).

ACKNOWLEDGEMENT:

Thank succinctly people or institutions that have contributed for the study, but are not authors.

DECLARATION OF INTEREST CONFLICT

Describing any connections of the authors to companies that may have any interest in publishing the manuscript submitted to the publication. If there is no interest conflict, write: no interest conflict.

REFERENCES

In the text: They must be numbered and ordered according to the order of appearance in the text and must be identified by superscripted Arabic numbers without parentheses, and after the punctuation.

At the end of the text (list of references): They must follow the recommended style from International Committee of Medical Journal Editors Uniform Requirements and available at http://www.nlm.nih.gov/bsd/uniform_requirements.html, according to the following examples:

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Up to 6 authors: list all the authors:

Jih WK, Lett SM, des Vignes FN, Garrison KM, Sipe PL, Marchant CD. The increasing incidence of pertussis in Massachusetts adolescents and adults, 1989-1998. *Infect Dis* 2000;182:1409-16.

More than 6 authors:

Rose ME, Huerbin MB, Melick J, Marion DW, Palmer AM, Schiding JK *et al.* Regulation of interstitial excitatory amino acid concentrations after cortical contusion injury. *Brain Res* 2002;935:40-6.

Research groups:

a. Without a defined author:

Diabetes Prevention Program Research Group. Hypertension, insulin, and proinsulin in participants with impaired glucose tolerance. *Hypertension* 2002;40:679-86.

b. *With defined author:*

Vallancien G, Emberton M, Harving N, van Moorselaar RJ; Alf-One Study Group. Sexual dysfunction in 1,274 European men suffering from lower urinary tract symptoms. *J Urol* 2003;169:2257-61.

No authors:

Non-referred authorship. 21st century heart solution may have a sting in the tail. *BMJ* 2002;325:184.

Volume with supplement:

Geraud G, Spierings EL, Keywood C. Tolerability and safety of frovatriptan with short- and long-term use for treatment of migraine and in comparison with sumatriptan. *Headache* 2002;42 (Suppl 2):S93-9.

Article published electronically, before the printed version:

Yu WM, Hawley TS, Hawley RG, Qu CK. Immortalization of yolk sac-derived precursor cells. *Blood*; Epub 2002 Jul 5.

Articles accepted for publishing still in press:

Tian D, Araki H, Stahl E, Bergelson J, Kreitman M. Signature of balancing selection in *Arabidopsis*. *Proc Natl Acad Sci USA*. In press 2002.

Articles in portuguese:

follow the style above, in the Portuguese Language.

2. Books, thesis and annals

Books:

Gilstrap LC 3rd, Cunningham FG, VanDorsten JP. Operative obstetrics. 2nd ed. New York: McGraw-Hill; 2002.

(If it is the 1st edition, it is not necessary to mention the edition).

Chapters of books:

Meltzer PS, Kallioniemi A, Trent JM. Chromosome alterations in human solid tumors. In: Vogelstein B, Kinzler KW, editors. *The genetic basis of human cancer*. 2nd ed. New York: McGraw-Hill; 2002. p. 93-113.

(If it is the first edition, it is not necessary to mention the edition).

Conference published in annals:

Christensen S, Oppacher F. An analysis of Koza's computational effort statistic for genetic programming. *Proceedings of the 5th European Conference on Genetic Programming*; 2002 Apr 3-5; Kinsdale, Ireland. p. 182-91.

Abstracts published in annals:

Blank D, Grassi PR, Schlindwein RS, Melo JL, Eckhert GE. The growing threat of injury and violence against youths in southern Brazil: a ten year analysis. *Abstracts of the Second World Conference on Injury Control*; 1993 May 20-23; Atlanta, USA . p. 137-8.

Mastership or doctorate thesis:

Afiune JY. Avaliação ecocardiográfica evolutiva de recém-nascidos pré-termo, do nascimento até o termo [tese de mestrado]. São Paulo (SP): USP; 2000.

3. Other published material

Articles in Newspapers, bulletins and other lay press:

Tynan T. Medical improvements lower homicide rate: study sees drop in assault rate. *The Washington Post* 2002 Aug 12. p. 1.

Laws, regulations and recommendations:

Brasil - Ministério da Saúde. Recursos humanos e material mínimo para assistência ao RN na sala de parto. Portaria SAS/MS 96; 1994.

Brasil - Ministério da Saúde. Secretaria de políticas de saúde - área técnica de saúde da mulher. Parto, aborto e puerpério: assistência humanizada à mulher. Brasília: Ministério da Saúde, 2001.

Brasil - Presidência da República. Decreto nº 6.871, de 4 de junho de 2009, do Ministério da Agricultura, Pecuária e Abastecimento.

Regulamenta a Lei nº 8.918, de 14 de julho de 1994, que dispõe sobre a padronização, a classificação, o registro, a inspeção, a produção e a fiscalização de bebidas. Brasília: Diário Oficial da União; 2009. Available from: http://www.planalto.gov.br/ccivil_03/_Ato2007-2010/2009/Decreto/D6871.htm

(If material is available in the internet, put Available from <http://www...>)

4. Electronic material

Article from electronic periodical:

Aboud S. Quality improvement initiative in nursing homes: the ANA acts in an advisory role. Am J Nurs [serial on the Internet]. 2002;102(6) [cited 2002 Aug 12]. Available from:

<http://www.nursingworld.org/AJN/2002/june/Wawatch.htm>

Monograph in the internet or electronic book:

Foley KM, Gelband H, editors. Improving palliative care for cancer [monograph on the Internet]. Washington: National Academy Press; 2001 [cited 2002 Jul 9]. Available from:

<http://www.nap.edu/books/0309074029/html/>.

Homepage/web site:

Cancer-Pain.org [homepage on the Internet]. New York: Association of Cancer Online Resources [cited 2002 Jul 9]. Available from:

<http://www.cancer-pain.org/>.

Part of a homepage or a web site:

American Medical Association [homepage on the Internet]. AMA Office of Group Practice Liaison [cited 2002 Aug 12]. Available from:

<http://www.ama-assn.org/ama/pub/category/1736.html>

Brasil - Ministério da Saúde - DATASUS [homepage on the Internet].

Informações de Saúde- Estatísticas Vitais- Mortalidade e Nascidos Vivos: nascidos vivos desde 1994 [cited 2007 Feb 10]. Available from:

<http://tabnet.datasus.gov.br/cgi/deftohtm.exe?sinasc/cnv/nvuf.def>

Observation: *Personal communication must not be mentioned as references.*

TABLES:

Each table must be at a separate page with a title and numbered in the order of appearance in the text. Explanations must be on the footer of the table, not in the title. Do not use any space beside the symbol \pm . Type the tables in the text processor Word, using lines and columns do not separate columns as tabulation marks. Do not import tables from Excel or Powerpoint.

CHARTS :

Number the graphics according to the order of appearance in the text and put the title under it. The graphics must always be two-dimensional, in black/white (do not use colors) and made in PowerPoint. Send the file apart from the text: do not import charts to the text. **Revista Paulista de Pediatria** does not accept scanned charts.

FIGURES:

The figures must be numbered in order of appearance in the text. Explanations must be in the subtitles (send subtitles with the text file of the manuscript, at a separate page). Figures from other sources must indicate this condition at the subtitle, and there must be a written permission from the source for their reproduction. Obtaining permission to reproduce the images is under the author's responsibility. For pictures of patients, these must not allow the identification of the person in case it is possible to identify the person, it is compulsory to have a consent letter signed by the photographed person or his/her responsible, allowing the publication of the material. Images generated in the computer must be attached with the formats .jpg, .gif or .tif, with minimum resolution of 300 dpi, in a separate file (do not import to the text). It is also possible to send the figure in paper and, in that case, the journal will not be responsible for misplacements, so the author should keep in his/her files the original. The journal does not accept scanned figures.

Online Submission

ONLY ARTICLE SUBMISSIONS MADE THROUGH THE ONLINE SYSTEM WILL BE ACCEPTED.

To submit your article, click the link below and follow the steps through the process:

<http://mc04.manuscriptcentral.com/rpp-scielo>

Below you will find instructions that will assist you with navigating your Author Center. These instructions cover the various stages of submission. Be advised that any journal specific guidelines for authors can be found in the "**Instructions & Forms**" section at the top right hand corner of the site.

New Submissions

To **start the submission** of a new manuscript, click on the submit a new manuscript link in the "Author Resources" area below.

To **continue** with the submission of a new manuscript already in progress, click on the "Unsubmitted Manuscripts" queue in the "My Manuscripts" area below. Find the submission you wish to continue with and then click on the "Continue Submission" button.

Revised Submissions

To **start the submission** of a revised manuscript, click on the revision link in the "Author Resources" area below or click the "Manuscripts with Decisions" queue in the "My Manuscripts" area below to display a list of decided manuscripts. Find the submission you wish to start the revision process for and click on the "Create Revision" link for that manuscript.

To **continue** with a revised manuscript that has yet to be submitted, either click on the revision link as outlined above or click on the "Revised Manuscripts in Draft" queue in the "My Manuscripts" area below. Find the submission you wish to continue with and then click on the "Continue Submission" button.

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APPENDIX B: LETTER TO THE DISTRICT OPERATIONAL DIRECTOR



**Tshwane University
of Technology**
We empower people



NORTH-WEST UNIVERSITY
YUNIBESITHI YA BOKOHE BOPHIRIMA
NOORDWES-UNIVERSITEIT

Faculty of Sciences

Department of Sport, Rehabilitation and Dental Sciences

14 May 2012

ATTENTION: Mr Morebudi Jackson Thamaga

HOD For Education – Limpopo Province
Corner 113 Biccard & 24 Excelsior Street
Private Bag X 9489
POLOKWANE
0700

Dear Sir/Madam,

REQUEST TO CONDUCT RESEARCH WITHIN YOUR REGION/DISTRICT

We the researchers from the Department of Sport, Rehabilitation and Dental Sciences, Tshwane University of Technology, Pretoria and School of Biokinetics, Recreation and Sport Science, North-West University (Potchefstroom Campus) are hereby making a request to conduct research in the circuits under your authority.

To give the background of the study, Obesity has become a global epidemic with an estimated 1.3 billion people overweight or obese (World Health Organisation, 2005). The prevalence of obesity in developed countries such as the United State is as high as 26.6% in men and 32.2 % in women above the age of 20 years. In recent years it has been established that several CDL typical of westernised countries such as diabetes, cardiovascular diseases (CVD) and hypertension can also be observed in children in frequent association with obesity. Too many young people have fallen into a sedentary lifestyle of long hours spent in front of television, computer and playing video games. It is well documented that behavioural and biological risk factors of such disease persist from childhood into adulthood and that several risk factors including overweight and high blood pressure are tracked from childhood to adult life and are linked to adult disease.

The link between obesity and physical activity is important due to the fact that active lifestyle combined with dietary modification has been shown to be an effective treatment for obesity. National Centre for Disease Control, Prevention, and Health Promotion, 2010) view obesity as major factor in the metabolic syndrome (MS), a clustering of risk factors associated with CDL. However, obesity is not only problem in developed nations, but is

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APPENDIX C: INFORMED CONSENT FORM



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NRF RSA-POLAND RESEARCH PROJECT

INFORMATION LEAFLET AND INFORMED CONSENT FORM FOR SCHOOL PRINCIPALS AND PARENTS OF MINORS

PROJECT TITLE: HEALTH-RELATED PHYSICAL FITNESS AND RISK FACTORS OF OBESITY AMONG PRIMARY SCHOOL CHILDREN OF LIMPOPO AND MPUMALANGA PROVINCES OF SOUTH AFRICA

Primary Investigator: V.K. Moselakgomo, BA (Hons) (Kinesiology); MTech: Clinical Technology

Project Leader: Prof A.L Toriola, PhD, Department of Sport, Rehabilitation and Dental Sciences, Tshwane University of Technology, Pretoria, South Africa

Co-Project Leader: Prof M.A. Monyeki, School of Biokinetics, Recreation and Sport Science, North-West University, Potchefstroom campus, Potchefstroom, South Africa

Dear School Principal/Parent/Guardian,

Your learner/child is invited to participate in a research study that forms part of the NRF South Africa-Poland Research Project. This information leaflet will help you to decide if you would like your learner/child to participate. Before you give your consent, you should fully understand what is involved. You should not agree that your learner/child to take part unless you are completely satisfied with all aspects of the study.

WHAT IS THE STUDY ALL ABOUT?

National reports document youths' inactive and unhealthy lifestyles leading to prevalence of obesity and risk factors of cardiovascular and metabolic diseases, and reaffirm the need for increased physical activity among children and adolescents. In South Africa, a national study undertaken among the youth suggests that only 54.3% have physical education classes on their timetable and of these only 52.8% engage in vigorous activity during class. This is worrisome given that regular physical activity develops the physical fitness level and health of children. Unfortunately, participation in physical activity seems alarmingly low in the public school system. Physical activities and physical education having been eliminated, some secondary schools are even being constructed without playgrounds. However, physical activity habits in childhood tracks into adulthood, thereby emphasizing the need to address the lack of physical activity in children and youth.

Schools often play a formal role in delivering health and physical education, thus potentially influencing knowledge and attitudes towards health habits as well as making a unique contribution to total daily physical activity. However, schools are complex, busy places where the core business is learning. Not surprisingly, common barriers to implementing

school-based physical activity models include insufficient time, competing priorities, lack of resources and non-supportive environments. This may likely be true with some South African schools, especially public schools. Additionally, it is observed that while some private South African schools offers and teach physical education, it is completely absent in most public schools. One wonders what impact this scenario would have on the physical fitness of the learners. However, little is known concerning the impact of the fitness levels of adolescents' children in schools with physical education and those without physical education in South Africa. Understanding the influence of physical education on physical fitness of adolescents' children is important.

Firstly, it will create an awareness regarding the benefits of physical activity among children. Secondly, such information will inform public policy. More so now that escalating levels of obesity and chronic disease worldwide have ignited public health interest in physical activity and inactivity, thus measurement of young people's physical activity is key component of understanding disease prevention and there is a need to examine physical activity in children for public health purposes. Increased levels of sedentary behaviours among youth indicate a critical need for physical education programmes to adopt curriculum that is inclusive of all students and that increases their interest and motivation levels for physical activity participation. It thus seems worthwhile encouraging physical activity among the youth and to sustain these efforts throughout life. Prevention must begin at a young age.

Despite the importance of physical activity to children's health, there is evidence of reduced levels of fitness and increased body fat levels among children from many countries around the world. The link between low levels of physical activity and an associated increase in the risk of developing obesity and chronic diseases of lifestyle (CDL) emphasizes the need for these problems to be addressed in childhood. How do school children in Limpopo and Mpumalanga Provinces stand in the wake of the expressed concerns regarding the decline in children's physical activity levels and the lip service accorded to and/or lop-sidedness in the teaching of physical education in schools? What are the repercussions of these on the children health and fitness? Even in schools where physical education is taught the underlying quality issues concerning its effective delivery are also of critical importance. Also important are the opportunities that regular physical education presents to children in developing social skills as these would complement the formation of life-long interests and positive attitudes towards participation in physical education and physical activity activities.

WHAT YOUR LEARNER/CHILD WILL BE REQUIRED TO DO IN THE STUDY?

If you decide that your learner/child should take part in the study, you will be required to sign this informed consent form and understand the following:

- Your learner/child will have his/her blood pressure measured thrice at five minutes interval using an electronic blood pressure monitor (Omron HEM-705 CP device, Tokyo, Japan).
- Your learner/child will complete a questionnaire on physical activity status in which he/she will be asked to respond to questions pertaining to his/her physical activity involvement.
- To have his/her body composition assessed using two skinfold measurements. Skinfold measurements will be taken at two anatomical landmarks (e.g. triceps muscle, subscapular muscle,) using a skinfold caliper. The technique employed to measure these skinfold sites requires that the researcher 'pinch' the subcutaneous fat

at the aforementioned anatomical landmarks. His/her weight and height will also be measured.

- To have his/her waist and hip circumferences measured with a tape measure.
- On two occasions, learners will be required to dress in light clothes only to facilitate the measurements.
- To perform series of physical fitness tests: flexibility test (sit-and-reach), muscular endurance (sit - up) in 60 seconds; muscular strength (push - up) in 60 seconds; grip strength and cardiorespiratory endurance (20m multistage shuttle run test).

ARE THERE ANY CONDITIONS THAT MAY EXCLUDE YOUR LEARNER/CHILD FROM THE STUDY?

He/she will not be eligible to participate in this study if he/she is currently suffering from any of the following conditions: Asthma, depression, muscle injuries or cardiovascular defects. Also, if he/she is older than 13 years or younger than 9 years and lives outside Limpopo and Mpumalanga Provinces, he/she will be excluded from the study.

WHAT ARE THE RISKS INVOLVED IN THIS STUDY? OR CAN ANY OF THE STUDY PROCEDURES RESULT IN PERSONAL DISCOMFORT OR INCONVENIENCE?

The study and procedures involve no foreseeable physical discomfort or inconvenience to your child or your family. The measurements are not painful as they are non - invasive and will not cause any discomfort. Also, blood **WILL NOT** be drawn from your learner/child and he/she **WILL NOT BE INJECTED** at all.

WHAT ARE THE POTENTIAL BENEFITS THAT MAY COME FROM THE STUDY?

The benefits of participating in this study are:

- It will make a contribution towards broadening of academic knowledge and understanding of CDL risk factors in children and the role of physical education and physical activity in modifying the risk factors in South African school children.
- He/she will receive personal information on his/her health: CDL risk factors, physical fitness, body composition and blood pressure level.
- It can identify children and adolescents who are at risks of overweight and obesity as a result of inactivity.
- It can direct efforts and reform in the teaching and promoting of physical education/physical activity in the public school system.

WILL YOUR LEARNER/CHILD RECEIVE ANY FINANCIAL COMPENSATION OR INCENTIVE FOR PARTICIPATING IN THE STUDY?

Please note that neither your learner/child nor your school be paid to participate in the study.

WHAT ARE YOUR LEARNER/CHILD'S RIGHTS AS A PARTICIPANT IN THIS STUDY?

Your learner/child's participation in this study is entirely voluntary. He/she has the right to

withdraw at any stage without any penalty or future disadvantage whatsoever. He/she doesn't have to provide the reason/s for his/her decision. He/she may also be asked to withdraw from the study if either he/she does not adhere to the study protocol and cannot cope with the demands of the tests.

HOW WILL CONFIDENTIALITY AND ANONYMITY BE ENSURED IN THE STUDY?

Confidentiality of data will be maintained - in other words your learner/child identity will only be known to the project leaders. All information regarding your child's identity will be removed or masked in the data on transcriptions, analyses and final report documents (e.g. dissertation and journal articles). Thus, his/her identity will not be revealed during or after the study, even when the study is published or used in any format.

IS THE PRIMARY RESEARCHER AND RESEARCH ASSISTANTS QUALIFIED TO CARRY OUT THE STUDY?

The primary researcher (Ms VK Moselakgomo) is a qualified sport scientist (Kinanthropometrist) who has previously completed similar research studies. Also, she has received special training in exercise and physical activity studies from the University of Limpopo and Tshwane University of Technology, South Africa. The research assistants include students at the departments of nursing and kinesiology (human movement studies), University of Limpopo, Limpopo, South Africa. They have been specifically trained to collect the research data.

HAS THE STUDY RECEIVED ETHICAL APPROVAL?

Yes. The study has been approved by the National Research Foundation (NRF). All parts of the study will be conducted according to internationally accepted ethical principles.

WHO CAN YOU CONTACT FOR ADDITIONAL INFORMATION REGARDING THE STUDY?

The primary investigator, Ms V.K. Moselakgomo, can be contacted using the following no: 0828183601. The project leaders can also be contacted during office hours at Tel (012) 382 5806 (Prof A.L. Toriola) and Tel (018) 299 1790 (Prof M.A. Monyeki).

DECLARATION: CONFLICT OF INTEREST

The researchers do not have any conflict of interest that may influence the study procedures, your learner/child, data collection, data analysis and publication of results.

A FINAL WORD

Your learner/child's co-operation and participation in the study will be greatly appreciated. Please sign the underneath informed consent if you agree to allow your learner/child to partake in the study. In such a case, you will receive a copy of the signed informed consent from the researcher.

INFORMED CONSENT

I hereby confirm that I have been adequately informed by the researcher about the nature, conduct, benefits and risks of the study. I have also received, read and understood the above written information. I am aware that the results of the study, including personal details regarding my learner/child age and health status will be anonymously processed into a research report. I understand that his/her participation is voluntary and that he/her may, at any stage, without prejudice, withdraw his/her consent and participation in the study. He/she had sufficient opportunity to ask questions and of my own free will declare that my learner/child can participate in the above mentioned study.

Research participant's name: _____ (Please print)

Research participant's School Principal or Rep./parent/guardian's name: _____
_____(Please print)

Research participant's School Principal or Rep. /parent/guardian's signature: _____
_____Date: _____

Researcher's name: _____ (Please print)

Researcher's signature: _____Date: _____

VERBAL INFORMED CONSENT

(Applicable when signatories cannot read or write)

I hereby declare that I have read and explained the contents of the information sheet to the School Principal/parent/guardian. The nature and purpose of the study were explained, as well as the possible risks and benefits of the study. The Principal/parent/guardian has clearly indicated that his/her learner/child is free to withdraw from the study at any time for any reason and without jeopardizing his/her relationship with the research team.

I hereby certify that the Principal or rep. /parent/guardian has verbally agreed to allow his/her learner/child to participate in this study.

Research participant's name: _____ (Please print)

Research participant's Principal/parent/guardian's name: _____
_____(Please print)

Researcher's name: _____ (Please print)

Researcher's signature: _____Date: _____

CHILD ASSENT FORM

I, (print full name), understand that my Principal/parent(s)/guardian(s) has given permission (said it is okay) for me to take part in the above titled NRF project.

I am taking part because I want to, and I have been told that I can stop at any time I want to and I won't get in trouble (nothing bad will happen to me if I want to stop).

Name/Signature/Thumb Print

APPENDIX D: ANTHROPOMETRIC AND PHYSIOLOGICAL DATA FORM

ANTHROPOMETRIC AND PHYSIOLOGICAL DATA FORM

Participant No:

Name:.....(Optional)

Test Date:.....

DOB:.....
 dd mm yy

Gender: M F

School Address:

Race: Black
 White

	ID	Site	Trial 1	Trial 2	Trial 3	Median
Station 1: Basic	1	Body mass (kg)				
	2	Stature (cm)				
	3	Leg length (cm)				
	4	BMI (kg/m ²)				

Station 2: Blood pressure (mmHg)	5	Systolic				
	6	Diastolic				
	7	Mean BP				
	8	Rate pressure product				

Station 3: Skinfolds (mm)	9	Triceps				
	10	Subscapular				
	11	% Body fat				

Station 4: Girths (cm)	12	Waist (minimum)				
	13	Gluteal (hip)				
	14	Waist-Hip Ratio				

Station 5: Flexibility (cm)	15	Sit-and-reach				
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Station 6: Muscular	16	Sit-up (no/min)				
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Strength/endurance						
	17	Hand Grip strength (Kg)				
Station 7: Explosive power	18	Sanding Broad Jump (cm)				
Station 8: Aerobic Capacity	19	20m Multistage shuttle run				
	20	Predicted VO ₂ max				

APPENDIX E: INTERNATIONAL PHYSICAL ACTIVITY QUESTIONNAIRE (IPAQ)

INTERNATIONAL PHYSICAL ACTIVITY QUESTIONNAIRE (IPAQ)

Think about all the **vigorous/ very hard** activities that you did in the **last 7 days**. **Vigorous/ Very hard** physical activities refer to activities that take hard physical effort and make you breathe much harder than normal. Think *only* about those physical activities that you did for at least 10 minutes at a time.

1. During the **last 7 days**, on how many days did you do **very hard** physical activities like heavy lifting, digging, aerobics, or fast bicycling?

_____ **days per week**

No very hard physical activities →

Skip to question 3

2. How much time did you usually spend doing **very hard** physical activities on one of those days?

_____ **hours per day**

_____ **minutes per day**

Don't know/Not sure

3. During the **last 7 days**, on how many days did you do **moderate** physical activities like carrying light loads, bicycling at a regular pace, or doubles tennis? Do not include walking.

_____ **days per week**

No moderate physical activities →

Skip to question 5

4. How much time did you usually spend doing **moderate** physical activities on one of those days?

_____ **hours per day**

_____ **minutes per day**

Don't know/Not sure

5. During the **last 7 days**, on how many days did you **walk** for at least 10 minutes at a time?

_____ **days per week**

No walking → **Skip to question 7**

6. How much time did you usually spend **walking** on one of those days?

_____ **hours per day**

_____ **minutes per day**

Don't know/Not sure

7. During the **last 7 days**, how much time did you spend **sitting** on a **week day**?
(watching TV, Videogames/Internet, Listening to music, reading)

_____ **hours per day**

_____ **minutes per day**

Don't know/Not sure

This is the end of the questionnaire, thank you for participating.