Health-related physical fitness, physical activity and body composition status of adolescent learners residing within the Tlokwe Municipality: PAHL study

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Declaration

Prof. M.A. Monyeki (Promoter and co-author) hereby gives permission to the candidate, Mrs O.M. Toriola to include the article as part of a doctoral thesis. The contribution of each co-author, both as supervisor and candidate was kept within reasonable limits and included:

Mrs O.M. Toriola:	Developing the proposal, interpretation of the results, writing of the manuscript and the thesis;
Prof. M.A. Monyeki:	Principal investigator of the PAHL Study. Coordinated the study, advised on statistical analyses and interpretation thereof, structure of the manuscript, conducted reviews of the manuscript and comments on the thesis.

This thesis, therefore, serves as fulfillment 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, co-author and PAHLS Principal Investigator

Abstract

Obesity and physical inactivity (PI) are major health problems world-wide, and leading contributors to the high incidence of overweight, cardiovascular and metabolic diseases in children both globally and in South Africa in particular. Despite the importance of physical activity (PA), health-related physical fitness (HRPF) and body composition to health, very few studies have investigated the longitudinal relationship between these variables in children. Three articles based on this research were written in which a total of 283 adolescent learners (111 boys and 172 girls) with a mean age of 14.90±0.72 years from the Physical Activity and Health Longitudinal Study (PAHLS) participated. The students' physical characteristics were measured using the protocol of the International Society for the Advancement of Kinanthropometry (ISAK); the EUROFIT test protocol and International Physical Activity Questionnaire (IPAQ) were used to assess the children's HRPF and PA levels, respectively. In the first article, the results showed that girls had a slightly higher significant BMI (21.43±4.37 kg/m²) than the boys (20.01±3.71kg/m²) (p=0.002), and were substantially more overweight (32.4%) and fatter (%body fat=26.01±8.51) than the boys (17.1%)). A total of 85 (30%), 78 (27.5%) and 88 (31.1%) of the students had low, moderate and high PA involvement. It was concluded that girls were more overweight and less active than boys. The second article examined the relationships between body composition, health-related fitness and PA. Inverse relationships were found between BMI and the health-related fitness items of SBJ and BAH. Furthermore, BMI negatively associated with SAR and endurance performance, especially in girls. Percentage body fat was negatively related to SBJ, BAH, SAR and endurance performance. The aim of the third article was to evaluate the longitudinal development of HRPF, anthropometry and body composition status among the children. Regression coefficients showed that changes in BMI were inversely associated with those in health-related physical fitness. The changes in %BF were negatively associated with SBJ, BAH and aerobic capacity (VO_2max) in the boys and girls. The results also yielded a low significantly positive association between changes in WHtR and SBJ in both genders, while low inverse associations were found between WHtR and BAH in girls, and VO_2max in both genders. It is concluded that the incidence of overweight and PI was especially high in girls and excessive fatness negatively affected the girls' fitness performances. Changes in BMI, % body fat and WHtR were negatively related with the children's strength and running performances, especially among the girls in which the relative increase in overweight negatively affected their endurance running and static strength performances. In view of the health implications of the findings, it is necessary to create an enabling environment and opportunities to promote physically active lifestyles and develop life-long positive attitudes towards PA among students. Community-based strategies targeted at facilitating sustainable PA intervention programmes in schools are recommended.

Keywords: Health-related physical fitness, body composition, physical activity, longitudinal relationship, adolescents, PAHL Study.

Opsomming

Obesiteit en fisiekeonaktiwiteit (FI) is groot gesondheids-probleme wêreldwyd, en die vernaamste bydraer tot hoë insidente van oorgewig, kardiovaskulêre en metaboliese siektes in kinders wêreldwyd en in Suid Afrika veral. Ten spyte van die belangrikheid van fisiese aktiwiteit (FA), gesondheids-verwante fisiese fiksheid (HRPF) en liggaamlike komposisie tot gesondheid het baie min studies die geografiese lengte verhouding tussen die veranderlikes in kinders ondersoek. Drie artikels gebaseer op hierdie navorsing was geskryf waarin ʼn totaal van 283 adolessente leerlinge (111 seuns en 172 meisies) met die gemiddelde ouderdom van 14.90±0.72 jaar van die Fisieke Aktiwiteit en Gesondheid Longitudinale Studie (PAHLS) deelgeneem het. Die student se fisiese karaktereienskappe was gemeet deur die protokol van die Internasionale Gemeenskap vir die Bevordering van Kinanthropometrie (ISAK) te gebruik; die EUROFIT toets protokol en die Internasionale Fisieke Aktiwiteit Vraelys (IPAQ) was gebruik om die kinders se HRPF en PA vlakke te bepaal, respectively. In die eerste artikel het dit gewys meisies het ʼn effense hoër betekenisvolle BMI (21.43±4.37 kg/m^2) as seuns (20.01±3.71kg/m^2) (p=0.002) en was aansienlik meer oorgewig (32.4%) en vetter (% liggaam vet 26.1±8.51) as seuns (17.1%). ‘n Totaal van 85 (30%), 78 (27.5%) en 88 (31.1%) van die studente het ʼn lae, matige en hoë PA betrokkenheid. Dit was beslis dat meisies meer oorgewig en minder aktief was as seuns. Die tweede artikel het die verhoudings tussen liggaam komposisie, gesondheids-verwante fiksheid en PA ondersoek. Omgekeerde verhoudings was gevind tussen BMI en die gesondheids-verwante fiksheid items van SBJ en BAH. Verder het die BMI negatief geassosieer met SAR en uithouvermoëprestasie veral in meisies. Persentasie liggaam vet was negatief verwant aan SBJ, BAH, SAR en uithouvermoëprestasie. Die doel van die derde artikel was om die geografiese lengte ontwikkeling van HRPF, antropometrie en liggaamsamestellingstatus onder kinders te evalueer. Die regressie koeffisiënte het gewys dat veranderinge in BMI ʼn omgekeerde assosiasie met die in gesondheid verwante fisiekefiksheid. Die veranderings in % BF was negatief geassosieer met SBJ, BAH en aërobiese kapasiteit (VO_2max) in seuns en meisies. Die resultate het ook ʼn lae betekenisvolle positiewe assosiasie tussen veranderings in WHtR en SBJ in beide geslagte gelewer, terwyl lae omgekeerde assosiasies gevind was tussen WHtR en BAH in meisies en VO_2max in beide seuns en dogters. Dit is beslis dat die insident van oorgewig en PI hoër was veral in meisies en oormatige vetheid het die meisies se fiksheid uitvoering negatief geaffekteer. Veranderinge in BMI, % liggaam vet en WHtR was negatief geassosieer met die kinders se krag en hardloop uitvoering, veral onder die meisies waar die relatiewe vermeerdering van oorgewigheid hul uithouvermoë hardloop en statiese krag uitvoering negatief affekteer. In sig van die gesondheid implikasies van die vindinge, is dit nodig om ʼn bekwaambare omgewing en geleenthede te skep om fisiese aktiewe leefstyle te bevorder en ʼn lewenslange positiewe houding teenoor PA te ontwikkel onder die studente. Gemeenskap- gebaseerde strategiese doelwit vir die fasilitering van steunbare PA intervensie programme in skole word aanbeveel.

Sleutelwoorde: Gesondheid-verwante fisiese fiksheid, liggaamsamstelling, fisiekeaktiwiteit, longitudinaleverhouding, adolessente, PAHL Studie.

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List of abbreviations

BAH – Bent arm hang

BMI – Body mass index

CDL – Chronic disease of lifestyle

CVD – Cardiovascular disease

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

OVW – Overweight

PA – Physical activity

PAHLS - Physical Activity and Health Longitudinal Study

PE – Physical education

PI – Physical inactivity

SAR – Sit and reach

SBJ – Standing broad jump

SUP – Sit-ups

WHtR – Waist-to-hip ratio

WC – Waist circumference

WHO – World Health Organisation

SPSS - Statistical Package for the Social Sciences

List of symbols

Cm	Centimeter
% BF	Percentage of body fat
Kg	Kilogram
$kg.m^2$	Kilogram per meter squared
mm	Millimeter
VO_2max	Maximum oxygen consumption

CHAPTER 1: PROBLEM STATEMENT, PURPOSE AND HYPOTHESES OF THE STUDY

1.1 INTRODUCTION

The World Health Organization (WHO) has declared obesity a global epidemic (WHO, 2009). Over-consumption of high-calorie diets and physical inactivity are contributory causes to the high incidence of overweight and obesity (Coleman *et al.,* 2005:217). The prevalence of overweight children and adolescents has doubled between 1976 and 1994 to 13% and increased further to 15.5% in 2000 (Wiecha *et al.,* 2004:467). This is disconcerting given that the health of a nation is largely reliant on the health of its children (Forrest & Riley, 2004:155). The increasing prevalence and serious consequences of childhood overweight and obesity have prompted the need for broad public health solutions that reach beyond clinical settings (Foster *et al.*, 2008:794).

1.2. PROBLEM STATEMENT

In South Africa, a national study undertaken among adolescents reported that only 54.3% have Physical Education (PE) classes on their timetable and only 52.8% engage in vigorous physical activity in class (Reddy *et al*., 2003:1). This trend is worrisome given that PE and physical activity (PA) are two areas that can develop the physical fitness level in children.

Also alarming is the fact that PE is neglected in the South African public school system with many schools constructed without playgrounds (Reddy *et al*., 2002:1). As PA in childhood tracks into adulthood, there is the need to address the lack of PA in children and the youth in order to prevent the incidence of chronic diseases of lifestyle (CDL) risk factors which are now increasingly prevalent in children and youths (Telama *et al*., 2005:267). Research carried out in Ellisras (Mantsena *et al.,* 2003:225; Monyeki *et al.,* 2005:877) and the Tshannda (Amusa *et al.,* 2010:221) rural areas, both of which are situated in the Limpopo Province of South Africa, have consistently reported body weight disorders and incidents of health-risk behaviours in schoolchildren and adolescents. Cross-sectional studies in South Africa which investigated the relationship between physical activity and the determinants of cardiovascular disease for children and adults are available (Kruger *et al.,* 2002; Mamabolo *et al.,* 2007). Findings from these studies revealed that inactivity was significantly related to the determinants of cardiovascular disease.

The concepts that are central to CDL and health risk behaviours, as well as its prevention and management, include health-related physical fitness, body composition and physical activity. Health-related physical fitness in this context is described as a set of attributes which relates to the ability to perform physical and daily functional activities (Ruiz *et al.* 2006; Andreasi *et al.,* 2010:497). Poor health-related physical fitness can be associated with the risk of premature development of morbidity if an individual leads a sedentary lifestyle (Telama *et al*., 2005:267). Health-related physical fitness is important because healthy fitness levels could lead to the reduction in the risk of disease, and improvement in the quality of life (Andersen *et al.,* 1998:939; Andreasi *et al.,* 2010:497). Specifically, the attributes of health-related fitness are body composition, cardiovascular endurance, flexibility, muscular endurance, muscular strength (US Department of Health and Human Services, 1999), and functional metabolism (Warburton *et al.,* 2006:961).

Physical activity (PA) is defined as any bodily movement produced by skeletal muscles that results in energy expenditure, and is positively correlated with physical fitness, e.g. walking, jogging, cycling, swimming, domestic chores and gardening (Caspersen *et al.,* 1985). PA can be categorised as being of low, moderate or high intensity depending on one's caloric expenditure as a function of the time of the activity, body weight and oxygen uptake (ACSM, 2009). The ACSM (2009) guidelines also indicate that at least 30 minutes of moderate physical activity per day carried out thrice a week will yield significant health benefits, while

WHO (2009) suggests that one should take at least 10,000 walking step counts per day for health promotion.

Despite the ACSM guidelines and the World Health Organization's suggestions concerning the health benefits of PA, people are still leading inactive lifestyles. In many parts of the world there have been increases in the incidence of cardiovascular and metabolic diseases, which are found to be associated with inactivity, among other factors (Mokdad *et al.*, 2004:1238). The causes of inactivity, among others, is that these days, many people drive rather than walk to work, school or shopping malls, and to use elevators or escalators rather than climb stairs. For example, both the Center for Disease Control and Prevention (CDC) in the USA and the World Health Organization (WHO) (CDC; 2009:1; WHO, 2009) have reported an increasing prevalence of cardiovascular diseases and metabolic ailments such as hypertension, stroke, hypercholesterolemia, obesity, overweight and diabetes mellitus in adults (Rivera *et al.*, 2009:279). There is consensus among researchers that the antecedents of such chronic diseases of lifestyle (CDL) are already manifested in childhood (Strong *et al*., 2005:732; Jonker *et al.*, 2006:1238). Research findings have also indicated a rising trend of chronic diseases of lifestyle among children and youth (Jessup & Harrell, 2005:26). These trends of high health risk behaviours have been widely associated with the fact that many children spend several hours watching TV or playing computer video games, and hardly engage in wholesome PA (Andersen *et al.*, 1998:939). Another contributing factor to the incidence of CDL is unhealthy dietary habits (Andreasi *et al.*, 2010:497). In many countries, modernisation and globalisation have also led to the proliferation of fast food outlets most of which sell unhealthy foods which are lacking in nutrition. Therefore, poor dietary habits combined with physical inactivity and other unhealthy lifestyle factors undoubtedly increases cardiovascular and metabolic disease risk among children and adults (Kelishadi *et al.*, 2010:420-426).

It is clear from the reviewed literature that health-related physical fitness, PA and body composition are closely related. It is against this background information that the following research questions are posed:

a). What is the health-related fitness, PA and body composition status by gender among adolescent learners in high schools in Tlokwe Municipality, Potchefstroom?

b). What is the relationship between health-related fitness, PA and body composition status among adolescent learners in high schools in Tlokwe Municipality, Potchefstroom?

c). What is the longitudinal development of health-related fitness, PA and body composition status among adolescents in high schools in Tlokwe Municipality, Potchefstroom?

Answers to these research questions will provide practical information on body composition, health-related physical fitness and the PA status of adolescent learners in Potchefstroom. Based on the findings of the research, appropriate intervention programmes could be implemented by school authorities to improve the learners' health risk profiles. The findings will also equip both students studying in the field of Human Movement Science and biokinetics, and sports managers, coaches, and life orientation teachers with the skills needed to play specific roles in disseminating information about body composition, health-related physical fitness and PA to adolescent learners. The results of this study will also provide information upon which future research designs could be based.

1.3. OBJECTIVES

The purposes of this study are to determine:

1.3.1. the health-related fitness, PA and body composition status by gender among adolescent learners in high schools in Tlokwe Municipality, Potchefstroom.

1.3.2. the relationship between health-related fitness, PA and body composition status among learners in high schools in Tlokwe Municipality, Potchefstroom.

1.3.3. the longitudinal development of health-related fitness, PA and body composition status among adolescents in high schools in Tlokwe Municipality.

1.4. HYPOTHESES

The following hypotheses are set for the study:

1.4.1. There will be significant gender differences in health-related fitness, PA and body composition status among adolescent learners.

1.4.2. There will be a significant negative relationship between health-related fitness, PA and body composition status among adolescent learners.

1.4.4. There will be significant changes in the longitudinal development of health-related fitness, PA and body composition status among adolescents in high schools in Tlokwe Municipality.

1.5. STRUCTURE OF THE THESIS

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

Chapter 1: Introduction: This chapter includes the problem statement, purpose of the study, hypotheses and structure of the thesis. A reference list is provided at the end of the chapter in accordance with the guidelines of the North-West University.

Chapter 2: Literature review: In this chapter, literature on health-related fitness, body composition and physical activity in adolescents is reviewed.
The chapter gives an overview of the available literature and identifies the knowledge gaps in the area. The references cited are provided at the end of the chapter under discussion in accordance with the guidelines of the North-West University.

Chapter 3: ***Article 1:*** Health-related fitness, body composition and physical activity status among adolescent learners: the PAHL Study is published in the *African Journal for Physical, Health Education, Recreation and Dance*. The references are provided at the end of the chapter in accordance with the guidelines of the journal.

Chapter 4: ***Article 2:*** The relationship between health-related fitness and PA among the learners: the PAHL Study was submitted for publication in the *Iranian Journal of Paediatrics*. The references are provided at the end of the chapter in accordance with the guidelines of the journal.

Chapter 5: ***Article 3:*** The longitudinal development of health-related fitness, body composition and physical activity among adolescents in high schools within the Tlokwe municipality: PAHL-Study will be submitted for publication in the *African Journal for Physical, Health Education, Recreation and Dance*. The references are provided at the end of the chapter in accordance with the guidelines of the journal.

Chapter 6: Summary, conclusions, limitations and recommendations. The references are presented at the end of the chapter in accordance with the guidelines of the North-West University.

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CHAPTER 2: HEALTH-RELATED FITNESS, BODY COMPOSITION AND PHYSICAL ACTIVITY IN CHILDREN AND ADOLESCENTS: A LITERATURE REVIEW

2.1 Introduction

Physical inactivity is a major contributor to the high rate of excessive weight, which leads to obesity and cardiovascular disease risk (Toriola & Monyeki, 2012:795). Therefore, a low level of physical activity (PA) and health-related physical fitness is a potential predictor of morbidity and mortality associated with cardiovascular and metabolic dysfunction (Diepeveen *et al.,* 2013: 756-757). The majority of studies on children have also shown that low health-related physical fitness is linked with excessive body fatness (Johnson *et al*., 2000; Katzmarzyk *et al.*, 1998: 709; Katzmarzyk *et al.*, 2013: 1-2; Lohman *et al*., 2008:2), and higher risk factors for developing coronary heart disease (CHD), hypertension, Type 2 diabetes mellitus, cancer, other cardiovascular diseases, as well as all causes of death (Lohman *et al*., 2008:2). This becomes an issue in that it poses a big threat to the health of the youth both in the short and long terms (Mak *et al.,* 2010: 88).

Studies in the past have shown that physical fitness in youth is positively linked with high levels of PA and has a negative link with cardiovascular disease, though there are limitations in that not too many research studies have been carried out in the area of examining the relationship using longitudinal designs, and the samples of research participants have been low and not representative of the population (Esmaeiadeh & Ebadollahzadeh, 2012:105). Furthermore, many studies carried out have not been able to determine conclusively the impact of PA and body fatness on health- related physical fitness due to insufficient measures to assess PA, body composition and/or physical fitness, especially in children (Lohman *et al*., 2008:2).

Health-related physical fitness consists of different attributes, of which body composition and cardiorespiratory fitness are important. These attributes are measures of most bodily functions, which work in an integrated manner (skeletomuscular, cardiorespiratory, circulatory, endocrine-metabolic) in performing daily PA and physical exercise (Esmaeiadeh & Ebadollahzadeh, 2012:105). Being physically active is very essential and the importance of PA cannot be overemphasised as a priority for public health promotion and interventions targeted at disease prevention (Strong *et al.,* 2005: 732; Pahkala, 2009:14; Witt-Glover *et al.,* 2009: 309-334).

Childhood and adolescence are critical stages in life which are characterised by many dramatic physiological and psychological changes (Esmaeiadeh & Ebadollahzadeh, 2012:105). They are stages in which children are prone to adopting healthy or unhealthy lifestyle practices which will either have a positive or negative impact on their health status (Musa *et al.,* 2012:1369; Rossouw *et al.,* 2012:2). Among the youth PA brings about a development of healthy lifestyles by helping to prevent the incidence of chronic diseases of lifestyle (Hills *et al.*, 2012:866; Jonker *et al.,* 2006:39) and generally improves the quality of life.

This chapter presents the literature review under the following headings:

- Health-related fitness, body composition and PA.
- Factors affecting PA and health-related physical fitness in children.
- Measurement and interpretation of PA among children and adolescents.
- Health benefits of PA and health-related physical fitness.
- The relationship between physical activity, health-related physical fitness and body composition.
- The longitudinal development of health-related fitness, body composition and physical activity among adolescents.
- PA recommendations for children and adolescents.

2.2. Health-related fitness, body composition and physical activity

2.2.1. Health-related physical fitness

Health-related physical fitness can be defined as an integrated measure of the whole body functioning, be it skeletomuscular, cardiorespiratory, hematocirculatory, psychoneurological and endocrine-metabolic, that are involved in the performance of daily PA (Esmaeiade & Ebadollahzadeh, 2012:105). According to Andreasi *et al*. (2010: 497), it is a set of characteristics that has a link with the ability to perform physical and daily functional activities. It is important to know that the basic characteristics of health-related fitness are body composition, cardiorespiratory fitness, flexibility, muscular endurance and muscular strength as well as metabolic functioning (Toriola & Monyeki, 2012:797).

2.2.1.1 Cardiorespiratory fitness

Cardiorespiratory fitness (CRF) can be defined as the health-related component of physical fitness with the ability of the circulatory, respiratory, and muscular systems to supply oxygen efficiently and for a long period of time during a sustained PA (Lee *et al.*, 2010:27). Furthermore, CRF is usually expressed in metabolic equivalents (METs) or maximal oxygen uptake (VO_2max) measured by exercise tests such as a treadmill or cycle ergometer. According to the ACSM (2013), CRF might not be a quick detector and consistently reliable means of measuring habitual PA, but may be a comparatively low-cost and a necessary health indicator for both symptomatic and asymptomatic patients in clinical practice (Myers *et al.,* 2004: 912-913). Individuals with higher fitness levels are able to sustain higher intensity PA for longer periods compared to their less fit counterparts (Beam & Adams, 2011:2). Physical activity patterns, genetics, and other factors such as age, gender, medical status, and selected health-related lifestyle behaviours are the contributing factors to an individual's CRF level (Pahkala, 2009:14).

2.2.2. Body composition

Body composition has been known to be one of the major health-related components of physical fitness (PF) that is affected by body weight and interconnected with muscles, fat, bone, and other important body tissues. Sometimes though, this element of a larger whole is reduced to fat and fat-free mass, and assessed as a body fat percentage and total body weight (in kilograms) (Lindsay *et al*., 2013:2). The higher rate of obesity and underweight in the Potchefstroom area of the North-West Province among 12-18 year-old adolescents raises a concern and poses a threat to the health of the children in the area (Mamabolo *et al.,* 2007). Furthermore, Monyeki *et al*. (2012:375) have reported that approximately 9% of the children were obese while the number of underweight children was equally very high among the same population.

An individual with an excessive percentage of body fat may be at risk of diseases such as cardiac disorders, musculoskeletal injuries and degradation, and reproductive disorders, whereas body fat percentage that is lower than 6-10% to 12-15% in boys and girls respectively, could lead to negative effects which might indicate the incidence of disease, eating disorders or under-nourishment (Goon *et al.*, 2006:23), as well as irregularities in girls' menstrual cycles (Bradley, 2010:1). Body composition measurement also provides data for monitoring changes in the body that are precursors to the development of certain diseases and helps to estimate ideal body weight (Marfell-Jones *et al.,* 2006:1-5).

According to Goon *et al*. (2006:356-357), females tend to possess higher body fat percentage than their male peers. Children and adolescents who have a body fat percentage higher than 25% and 30% for boys and girls respectively, are at a higher risk of developing different types of hypokinetic diseases (Goon *et al*., 2006:23). Furthermore, the sex differences in body fat may be physiological, metabolic or social while too much body fat during childhood could have a negative influence on the quality of life. Therefore, body composition can be used to assess total body fat and regional distribution of body fat in order to evaluate one's health risk and wellbeing (Norman *et al.,* 2005: 691-692; Goon *et al.,* 2010:508-509).

2.2.3. Physical Activity

According to Caspersen *et al.* (1985: 126-127), PA is defined as any bodily movement produced by skeletal muscles that results in energy expenditure, and is positively correlated with physical fitness, e.g. walking, jogging, cycling, swimming, domestic chores and gardening. PA level can be categorised as low, moderate or high, based on the amount of calories expended by an individual during the activity period, the weight of the body and the amount of oxygen consumed (ACSM, 2013). Furthermore, it is recommended that people should engage in moderate levels of PA for at least 30 minutes per day, three times a week or take at least 10,000 step counts as a result of walking from one place to another per day for health and wellness in order to improve the quality of life (Toriola & Monyeki, 2012:797). Despite this recommendation, people's turnout regarding the involvement in PA or exercise has been very low in many parts of the world, if not the entire world (CDC, 2009).

In addition to the role it plays in the prevention of overweight and obesity and the exposure to chronic diseases of lifestyle, the importance of PA to the healthy growth and development of children and adolescents cannot be over-emphasised (Hills *et al*., 2011:866). In addition, the use of automated machines and advances in modern technology (e.g. prolonged TV viewing) has drastically reduced the level of children's involvement in PA in terms of energy expenditure (Nelson *et al.,* 2006: 1631; Rivera *et al.,* 2009: 278-279; Esmaeialzadeh & Siahkouhian, 2011: 624). This has raised much concern as low PA does not give youth the opportunity to comply with recommended PA guidelines which results in poor health-related fitness levels and creates imbalances in their body composition (Nelson *et al*., 2006: 1627-1628; Rey-Lopez *et al*., 2008: 244-247)

It has been established that the health and wellness of an individual is heavily reliant on his/her socioeconomic status (Gontarev *et al*., 2013:17). A number of research studies have pointed out that low socioeconomic status, along with factors such as poor household income, low educational qualification, and marital status, amongst others, is a contributory cause of many chronic diseases of lifestyle. Furthermore, the link between socioeconomic status and health is not only related to adults, but also to children and adolescents living in impoverished households (Drenowatz *et al.,* 2010: 214). Children living in these circumstances can easily be exposed to some chronic disease risk factors compared to their counterparts from high socioeconomic status backgrounds (Gontarev *et al.,* 2013:17).

2.3 Factors affecting health-related physical fitness, PA and body composition

2.3.1 Factors affecting health-related physical fitness

Health-related physical fitness is the ability to perform one's normal daily routine and still be able to attend to unforeseen emergencies without undue fatigue (Aboshkair *et al*., 2012:202). In children and adolescents, there could be many factors which stand as an obstacle to good health-related physical fitness. According to Active Living Research (2007), school is the best environment for the provision of daily PA as it provides the opportunity to teach the benefits of regular PA to health, which leads to building the necessary skills and attitudes that support active lifestyles in children. Furthermore, achieving the full benefit of Physical Education (PE) in a well-organised manner through effective teaching programmes should be the priority of the school system.

Regular participation in school PE has been shown to have a compensatory relationship with increasing children's PA level (Morgan *et al.,* 2007:411-412) by providing students with an adequate percentage of recommended daily PA. This is a major objective of PE, and it relies on the quality and efficiency of teachers. Several factors such as body size, maturity status, growth status, nutritional status, time spent performing PA, and family income also greatly affect children's health-related physical fitness (Boone *et al.,* 2007:1-2; Katzmarzyk *et al.,* 2013: 6-10). It has also been established that children who differ in maturity status also differ in body size, physique, and physical performance which equally have a bearing on their health-related physical fitness (Aboshkair*et al*., 2012:203).

Genetically, putting individual difference as a consideration is important because it has an effect on the PA, fitness and health paradigm (Bouchard, 1993:6). For example, it has been established that genetic differences are responsible for the most individual differences due to their responses to regular exercise programmes which are targeted at improving health-related fitness components and alleviating the different types of risk factors of chronic diseases of lifestyle, especially for cardiovascular disease and diabetes (Bouchard, 1993:6).

2.3.2 Factors affecting body composition

Body composition can be influenced by several factors ranging from disease, physical activity, gender, age, nutrition and lifestyle factors, biological maturation, genetics and race or ethnicity. It should be noted however, that the severity of the factors affecting body composition could also be mediated by genetic influences (Bouchard, 1993:6; Pahkala, 2009:14). Ideally, studies examining the factors affecting body composition should match participants for their genotype so that possible genetic influences can be determined and partitioned out. Regrettably, this is a rare occurrence in previous research. This aspect of the review covers the factors affecting body composition.

Childhood obesity has become one of the major public health issues of the new millennium (Ademola & Monday, 2013:164). The menace of excessive bodyweight is one of the most important risk factors contributing to non-communicable diseases in both developed and developing countries (Bishwalata *et al.,* 2012:184). The prevalence of underweight, overweight and obesity in youth has doubled with an increased mortality rate worldwide (Artero *et al.,* 2010:418). It is very important to understand the trends of both underweight and overweight/obesity in youth and its negative effect on overall health (Monyeki *et al.,* 2012:375).

In 2010, The World Health Organization (WHO) reported that the numbers of children below the age of five who were estimated to be overweight were 42 million worldwide (WHO, 2011a,b). Furthermore, it was revealed that the majority of youths affected were living in developing nations and consumed unprocessed food at an alarming rate once the opportunity arises (Ademola & Monday, 2013:164). The World Health Organization (WHO) asserted that the consumption of too much fast food leads to the accumulation of fats and a high body mass index (BMI), causing overweight and finally leading to obesity in no time (WHO, 2011a,b). From an epidemiological viewpoint, it was also reported that over-nutrition, which is associated with non-involvement in PA or inadequate PA, was assumed to be the outcome of several risk factors during adolescence (Wiecha *et al.,* 2004: 467-486; Coleman *et al.,* 2005: 217; Kovacs *et al.,* 2009: 337-338; Twisk *et al.,* 2002: 8-9; Monyeki *et al.,* 2012:379). Therefore, the need for strategic intervention in the healthy management of body composition in children and adolescents is imperative (Monyeki *et al.,* 2012: 379).

Wiecha (2004: 467-486) reported that the prevalence of overweight children and adolescents has increased between 1976 and 1994 to 13%; is continuously increasing, and reached about 15.5% in 2000. It was also reported that the problem is fast getting out of control and is worsened by the fact that the problem of chronic diseases usually starts during childhood and develops into adulthood (Forrest & Riley, 2004: 155-150).

Body composition is the constituent of various tissue types which include lean tissues, muscles, bones and organs that are metabolically active, as well as adipose tissues that are not (Ademola & Monday, 2013:164). The lower the body fat proportion, the healthier the body composition, and conversely the reverse applies, that the higher the body fat proportion, the unhealthier the body composition.

Since there are many factors affecting body composition, it is important that risk factors be prevented. Information on factors affecting body composition, especially in children and adolescents is scant and it is therefore necessary for researchers to provide more information on the factors affecting body composition in youths. Studies have shown that the outcome of the negative health effects of underweight and obesity are likely to be the development of diseases which emanate from a sedentary lifestyle, such as hypertension, cancer and Type II diabetes (Perry *et al.,* 1990: 407; Twisk *et al.,* 2002: 8-9; Bovet *et al.,* 2006: 9; Myers *et al.,* 2004: 912-913: Williams, 2001: 754), which then lead to a reduction in health-related physical fitness (Ding *et al.,* 1990: 341; Kruger *et al.,* 2004: 351-352; Artero *et al.,* 2010: 418).

Physical inactivity is one of the major factors affecting body composition and it has been found to be a major contributor to the incidence of imbalances in body composition, body weight disorders for example, underweight, overweight/obesity, as well as being linked to the risk factors of cardiovascular disease among children and adolescents (Toriola & Monyeki, 2012:795). According to Reddy *et al.* (2003) in a national study conducted among adolescents in South Africa, it was reported that more than 50% have Physical Education (PE) classes written on their class timetable and more than 52.8% are involved in vigorous PA during school hours. This situation is discouraging as a higher number partaking in some form of PA would be preferred, knowing full well that the involvement of children and adolescents in PE and PA is advantageous for their health-related fitness development (Toriola & Monyeki, 2012:796). The most discouraging part of it is that people do not pay an attention to PE in the South African public school system, and many of the schools have been constructed with no outdoor area provided for the youths to participate in PA (Toriola & Monyeki, 2012:796).

Lubans *et al.* (2011:1) reported that the high levels of PA are associated with improved levels of physical, social and psychological health in youths. For instance, it has been reported that PA is inversely related to overweight and obesity (Mellin *et al.*, 2002: 145-146; Tremblay & Williams, 2003: 1100-1101), and body composition that is unhealthy in childhood is linked to an increased risk of coronary heart disease (CHD) in adulthood (Baker *et al.*, 2007: 2329). Excessive fat which is measured in terms of body mass index (BMI) and per cent body fat (%BF) is found to be negatively associated with performance tasks in which the body is projected through space such as the standing broad jump, and tasks for which the body has to be lifted in space, such as bent arm hang (Beunnen, 1989; Malina & Buschang, 1985: 163-164; Monyeki *et al.*, 2005:878; Monyeki *et al.*, 2005:375).

Research has shown that physical fitness is another important issue affecting body composition, when viewed from a public health perspective among the youth (Artero *et al.*, 2010: 418). According to Prista *et al.* (2003: 952-954), Haerens *et al.* (2007: 258), Huang and Malina (2007: 707-708) and Artero *et al.* (2010: 410), who examined the possible relationship between weight status and health-related physical fitness in youths, physical fitness decreased consistently with increasing BMI, although the major influence of fat mass and fat-free mass is still not clear (Artero *et al.*, 2010:418). It should be noted also that the body composition constitutes an important element of health-related physical fitness and a powerful device that provides specific information regarding wellness (Monyeki *et al.*, 2012:378).

The outcome of both underweight and obesity are revealed to be linked to the decrease in PA/exercise and work capability, which then reduces health-related physical fitness, such as cardiorespiratory fitness, muscular fitness and speed of movement (Beunnen, 1989; Malina & Buschang, 1985: 163; Monyeki *et al.,* 2005:878; Ding *et al.,* 1990: 341; Artero *et al.,* 2010 & Shang *et al.,* 2010: 4). Furthermore, Shang *et al.* (2010:4) reported that overweight and obese youths do not perform well as their performance was poor in the standing broad jump, 50m sprint, and shuttle run, compared with youths of normal weight. This shows that the explosive strength, cardiorespiratory fitness, speed, agility and muscular capability of youths continue to be reduced due to the excess fat accumulated in the body (Shang *et al.,* 2010:4) which becomes an extra load for them to carry.

In a study conducted by Monyeki *et al.* (2012:278), normal and underweight adolescents have better physical fitness levels compared to their overweight counterparts because they significantly outperformed the overweight youths in explosive strength, although those with normal weight performed better than the underweight groups. Furthermore, underweight girls in the same study performed better in explosive strength than the normal and overweight groups. However, it was observed that normal and underweight youths were able to carry an extra load during weight-bearing tasks (Malina & Buschang, 1985; Ding *et al.,* 1990: 341; Monyeki *et al.* 2005:878). There are also sex differences in body composition as it was shown in the above studies that boys performed better than the girls. Gender-related performances in physical fitness levels is due to differences in body composition, in that boys have greater muscle mass, bone density and less body fat than girls across age groups (Monyeki *et al.,* 2007:553; Monyeki *et al.,* 2012:378). In another study, it was noted that both age and gender could affect the body composition in children and adolescents (Monyeki *et al.,* 2007).

In general, the following factors may affect the body composition of children and adolescents which may be an indicator of the risks of disease and death:

(1) Biological factors: age, sex, genetic susceptibility and ethnicity/race;

(2) Milieu factors: sociocultural, physical, and economic environments;

(3) Lifestyle factors: smoking habits including past smoking habits, dietary intake (quality and quantity), alcohol consumption and physical activity;

(4) Health-related factors: background prevalence of disease, genetic predisposition to diseases, presence of diseases, and presence of other risk factors;
(5) Biometric factors: height (including the history of stunting and wasting), fat and muscle distribution, body proportions (such as leg length and sitting height), and history of large weight fluctuation (Heymsfield *et al.*, 2005:344).

2.4 Factors affecting participation in PA among children and adolescents

Participation in PA is important to children's health as well as their growth and development, but studies in many countries have reported a gradual decline in children's participation in PA. In addition to the many reasons accounting for the rising trend of physical inactivity among children and adolescents such as habitual television viewing, prolonged participation in computer video games and reduced opportunities to participate in school PE activities, there are a number of other factors that could either disable or enable children to be physically active. The following section presents an analysis of these factors as reported in the literature:

2.4.1 Parental support and children's involvement in PA

Parental support and involvement is very important in the promotion of children's PA participation in terms of organising, funding and support (Griffith *et al*, 2007:265). There could be potential problems if either of the parents refuse to share their recreational time activities with the children (based on the understanding that social and financial assistance is varied) (Drummond *et al.*, 2010:21). Another important factor is time constraints which further impacts on the opportunity to motivate children and youths to engage in PA; for example, work commitments that limit the little leisure time available in single-parent families (Griffith *et al.,* 2007:265). Griffith *et al.* (2007:265) also opined that parental assistance and motivation could promote PA in children and also bring about an efficiency of interventions targeted at facilitating children's involvement (Wright *et al.*, 2010: 224). According to a recent longitudinal study in Australia and Denmark, parental modelling of PA was positively associated with children's PA and an association was found between children's PA and parental participation in sports (Jimenez-Pavon, 2012:310) However, some studies have reported that due to the changes in family structures parental involvement may not necessarily translate into their children's engagement in PA (Drummond *et al*., 2010:21).

2.4.2 Gender and age

Studies carried out in Australia have shown that boys (below 15 years) are more likely to participate in PA than girls in a similar age category (Drummond *et al.*, 2010:21). Similar trends have been reported in a Polish study in which older girls showed somewhat negative attitudes towards PE and sport (Czyz & Toriola, 2012: 39-55). It has also been suggested that since childhood and adolescence represent critical developmental stages, enabling environments and opportunities should be provided so that they can develop life-long positive attitudes towards PA (Toriola & Monyeki, 2012:806).

2.4.3 Culture

Culture is a system of shared understanding that shapes and, in turn, is shaped by experience. Culture provides meaning to a set of rules for behaviour that is normative, i.e. what everyone should do, and pragmatic, i.e. how to do it. Culture, unlike instinct, is learned and is distributed within a group because not everyone possesses the same knowledge, attitudes, or practices; it enables us to communicate with one another and behave in ways that are mutually interpretable, and to co-exist in a social setting (Caprio *et al*., 2008:2214). The culture in which children are raised could also influence their PA behaviour. The research conducted on the effect of culture of PA in South African children and adolescents is scant but it was established that attitudes to PA are based on cultural and sex differences (Centre for Culture, Ethnicity and Health 2006 as stated in Drummond *et al*., 2010:22), as well as parents' own participation in PA (Wilson & Dollman 2007:147). More investigation is needed in this area to elucidate the type of cultural interventions that are valuable and suitable (Drummond *et al*., 2010:22).

2.4.4 Socioeconomic status

Research findings on the possible relationship between socioeconomic status (SES) and involvement in PA are mixed. Some studies have reported that children of low SES have a higher prevalence of obesity (Drummond *et al*., 2010:22) compared to their counterparts from higher socioeconomic homes. The different criteria for evaluating SES (i.e. parental income, education, size of household and geographical location) may account for the difficulty to make meaningful comparisons across studies (Drenowatz *et al.*, 2010: 214).

2.4.5 Environmental settings

The environment in which a child lives also plays an important role in promoting or deterring his/her participation in PA. Therefore, it is equally important that interventions aimed at promoting children's involvement in PA should take environmental factors into consideration. For example, issues concerning adequate provision of equipment and facilities, safety, accessibility, infrastructure (such as sidewalks and cycle tracks), and children's attitudes towards these concerns could negatively influence their attitudes towards PA and act as barriers to their involvement (Toriola & Monyeki, 2012:805). Other salient factors are environmental constraints such as malnutrition or under nutrition, infectious diseases, conditions of poor living, and unavailability of educational facilities, all of which must be taken into consideration when discussing growth and development in children (Jacobs & De Ridder, 2012:47)

2.4.6 School settings

Special attention is being paid to schools in terms of health promotion for children and adolescents. Health promotion in school settings consists of various types ranging from smoking prevention programmes, alcohol consumption and excessive weight, to PA promotion programmes to combat sedentariness (Demetriou & Höner, 2012:187). This can only be experienced when such programmes are taught to youths by qualified personnel or teachers. Schools are in a position to influence the attitudes and behaviour of a large proportion of the young population irrespective of socioeconomic status, gender, culture or disadvantage (Drummond *et al.*, 2010:23). Additionally, schoolchildren are in their formative years during which positive attitudes towards PA could be formed. However, a study has shown that few South African children engage in vigorous PA at school (Reddy *et al.*, 2003). This situation is discouraging due to PE neglect, inadequate equipment and facilities, most especially in many South African public schools (Toriola & Monyeki, 2012:796). Furthermore, it seems that sporting equipment and facilities are distributed unevenly by the government, whereby some schools have well-developed sports equipment and facilities and qualified physical educators, and many other predominantly black schools are very poorly resourced, especially in rural areas (Amusa *et al.*, 2013:187). This trend is undesirable given that it limits children's opportunity to be physically active.

In a comprehensive review of the literature on PA among children, Drummond *et al.* (2010:26) concluded that participation in PA declines as children become older, and emphasised the need to sustain interventions and investigate the barriers to PA in adolescence.

Drummond *et al.'s* (2010:25) review of the literature can be summarised in the following key features:

- Learned behaviours in childhood could carry on throughout adolescence; therefore this an opportune time to introduce healthy habits to children and educate their parents.
- Multiple intervention strategies that integrate education, support and repetition of the messages are effective in the promotion of PA to children.
- Strategies which combine curriculum change, PE classes, family involvement and school policy are effective to promote PA among children and adolescents.
- Family involvement in PA is beneficial in motivating children to be physically active.
- The use of PE specialists in schools attracts and sustains children's interest and enjoyment in sport and PA.
- Interventions aimed at promoting participation in PA are less effective in children of low socioeconomic background due to a lack of funds.
- Boys are more active than girls but participate more in TV or computer screen-based activities than girls. Initiatives are needed to promote PA for girls and decrease screen-based activity for boys.
- Since PA levels decline at adolescence, it is necessary to investigate barriers and potential motivators for PA participation.
- It is necessary to develop an understanding of cultural impacts on PA involvement in children.
- Further research is necessary to investigate physical and social characteristics of the home environment and its impact on PA in children.
- Further research is also required to identify barriers to PA participation in low socioeconomic and disadvantaged groups.

2.5 Measurement and interpretation of PA among children and adolescents

The accurate and reliable assessments of PA are necessary for any research study where PA is either an outcome measure or an intervention. Furthermore, the fact that assessment of PA is necessary to evaluate health and wellness, makes it difficult to reliably and validly measure PA among children and adolescents (Rowlands & Eston, 2007:270), especially using questionnaires (Kuhnis *et al.*, 2013: 23-25). There are several techniques for measuring PA, e.g., self-report questionnaires (International PA questionnaire – IPAQ), observation, heart rate measurement (often referred to as heart rate telemetry), and motion sensors (e.g. pedometers and accelerometers). However, objective measurement of PA among children is problematic in a number of ways; children do not often comply with the requirements of PA motion sensors (i.e. wearing accelerometers or pedometers for long periods so that PA activity patterns can be determined); the inherent nature of children's play activities which is characterised by short-bursts of PA (Rowlands & Eston, 2007:270), and the sporadic nature of children's emotional outbursts which substantially influences their PA behaviour (Rowlands & Eston, 2007:270). In addition to the use of IPAQ and heart rate telemetry, the use of pedometers and accelerometers has been quite popular as objective measures of PA among children and youth. In order to appreciate the methodological challenges involved in measuring and interpreting PA in children, it is important to analyse the pattern of children's PA (Prista *et al.*, 2009: 384-385).

2.5.1 The pattern of children's PA

In a transition study by Bailey *et al.* (1995: 1033) on the nature of children's PA where fifteen 6-10 year-old American children were observed, the frequency, duration and different intervals between the children's activities of varying intensity (tempo) and duration were recorded. The study showed a median duration of 6s for low and medium intensity activities and 3s for high intensity activities among the children. The data of Bailey *et al.* (1995: 1033) was subsequently re-analysed by Berman *et al.* (1998: 289) using the spectral method which yielded 83 ± 11 bouts of activity per hour for the boys (mean bout duration of 21 ± 5s) and 89 ± 12 bouts for girls (mean bout duration of 20 ± 4s). Furthermore, as the use of observation techniques is labour intensive, more recent studies have used high frequency accelerometers to assess the pattern of children's PA and have obtained similar results (Rowlands & Eston, 2007:270). For example, in their study of 8-10 year-old French children, Baquet *et al.* (2007:

143-144) recorded a mean bout duration of 22.1 ± 3.5s. They concluded that 80, 93 and 96% of activity bouts of moderate, vigorous and very high intensity levels, respectively, were shorter than 10s. Baquet *et al.* (2007: 143-144) also reported that despite the fact that the time spent by the children in vigorous and very high intensity activity was low (<3%), it was more than a third of the total PA. Therefore, this underscores the importance of accurately quantifying short bouts of intense activity in measuring PA among children. However, many available methods of quantifying PA among children do not adequately address the transitory nature of children's PA pattern and consequently do not reliably reflect the relationship between PA and health (Rowlands & Eston, 2007:270).

2.5.2 Assessment methods of PA among children

2.5.2.1 PA assessment using heart rate (HR) monitors

The heart rate (HR) provides an indication of the stress PA imposes on the cardiopulmonary system (Armstrong & Welshman, 2006: 1067-1070). However, the use of HR monitoring for PA assessment is limited in a number of ways (Rowlands & Eston, 2007:271). A major limitation is the fact that PA is not the only factor that regulates HR. Heart rate can also be affected by a variety of factors such as levels of anxiety, emotional stress, fitness, and type of muscular activity, active muscle group, hydration and environment (Armstrong & Welsman, 2006:1027-1070). The fact that these factors largely influence HR at low intensity activity implies the need to use HR monitoring for assessment of only moderate to vigorous intensity activity, i.e.at heart rates above 120 BPM (Rowlands & Eston, 2007:270). In addition, the diversity in methods of analysis of HR also limits comparability between studies using HR to measure PA (Baquet *et al.,* 2007: 143-144).

HR monitors are designed to measure heart rate values every minute. However, in order to assess the rapid short bursts of children's activity, a smaller interval, say of 5 seconds would be optimal (Armstrong & Welsman, 2006: 1027-1070). Studies have also shown that since HR response lags behind changes in movement (Rowlands *et al*., 1997), and children's activity behaviour changes rapidly (Bailey *et al.,* 1995: 1033), the HR response would not provide a comprehensive picture of the transitional pattern of children's PA. However, it should be noted that HR monitoring has yielded valid and reliably objective estimates of PA, especially in prolonged periods of moderate and vigorous intensity PA.

2.5.2.2 PA assessment using pedometers

According to Gibbs-Smith (1978: 31-32), Leonardo da Vinci designed the mechanical model of a pedometer approximately 500 years ago. The pedometer is a simple motion sensor that records the acceleration and deceleration of movement in one direction and gives a measure of total activity, or movements in a specified period of assessment. However, the pedometer has the following shortcomings: Its inability to measure intensity, record counts during cycling and increases in energy expenditure due to carrying objects or walking/running uphill (Rowlands & Eston, 2007:271). In the last decade, electronic pedometers have been designed which have been shown to more accurately quantify PA in terms of assessment of total daily activity (Pfeiffer *et al.,* 2006: 152-153), and estimation of activity intensity and duration (Tudor-Locke *et al.,* 2005: 666-667). Although there are various types of pedometers, simple pedometers have been shown to yield the same relationships with fitness and fatness, as the relatively sophisticated triaxial Tritrac (Tritrac Professional Products, Reining International, Madison, WI, USA) (Rowlands & Eston, 2007:272).

Some studies have reported the possibility that wearing any activity monitoring equipment might cause a child to exhibit reactive behaviour, i.e. "a change in normal activity levels because of the participants' knowledge that their activity levels are being monitored" (Welk *et al.,* 2000:59). While some studies have attempted to blind the child to the pedometer output in an effort to prevent reactive behaviour, other studies have indicated little evidence for reactive behaviours whether or not the child is blinded (Vincent & Pangrazi, 2002: 432-433) or not (Rowlands & Eston, 2007:272).

2.5.2.3 PA assessment using accelerometers

Since 2001, there has been a dramatic increase in the number of studies using accelerometers to assess PA in children (Pfeiffer *et al.,* 2006: 152-153; Rowlands & Eston 2007:272; Trost, 2007: 299-312; Clemes & Biddle, 2013: 249). Like pedometry, accelerometry is objective and measures movement directly, which is an important factor when assessing the relationship between health and activity. Critically, accelerometers also have a time-sampling capability which allows the assessment of the temporal pattern and intensity of activity as well as total accumulated activity. However, there is a lack of standardisation regarding how accelerometers are used, which outcome measures are used, and how the output is interpreted. This limits comparability between studies and the accumulation of knowledge relating to children’s activity. At the end of 2004, experts in accelerometry made presentations at the conference on ‘Objective Monitoring of Physical Activity: Closing the Gaps in the Science of Accelerometry’ held at the University of North Carolina, USA. The collection of papers published in the Medicine and Science in Sports and Exercise journal in November 2005 provides an excellent, thorough analysis of the accelerometer literature, and the areas where there is no clear consensus and where further research is required. Some of the current issues regarding the use of accelerometry are discussed below: choice of accelerometer, frequency of data collection (time sampling interval or epoch), and translating accelerometer output into meaningful units.

Accelerometers are used to measure movement acceleration in one to three orthogonal planes (vertical, mediolateral and anteroposterior) (Rowlands & Eston, 2007:272). They include uniaxial accelerometers which are worn such that the sensitive axis is oriented in the vertical plane, and omnidirectional accelerometers, that function most sensitively to movement in the vertical plane and other directions so that the output is reflected as a composite of the signals (Pfeiffer *et al.,* 2006: 152-153; Rowlands & Eston, 2007:272). According to Rowlands and Eston (2007:272), examples of commercially available accelerometers are the uniaxial ActiGraph (ActiGraph, Fort Walton Beach, Florida, USA), the omnidirectional Actial and Actiwatch, (Mini Mitter Co., Inc., Bend, Oregon, USA), and the triaxial RT3 (Stayhealthy, Inc., Monrovia, California, USA), which superseded the Tritrac. Accelerometer counts are used to indicate the output from accelerometers and are calibrated with energy expenditure (Pfeiffer *et al.,* 2006: 152-153) so that values can be more meaningful.

A recent study by Clemes and Biddle (2013: 249) has shown that using the accelerometer, PA patterns were very similar to those from previous studies. In terms of the relationship of the recordings of the accelerometer to fitness and fatness, Rowlands and Eaton (2007:273) reported that rather than the duration of PA bouts, the intensity and the interval between PA bouts were positively related to fitness ($r > 0.4$, $p < 0.05$) and fatness ($r > 0.6$, $p < 0.01$), respectively in 24 nine year-old Hong Kong Chinese children; thus supporting the significance of assessing activity pattern in quantifying PA levels in children. It should be noted that the values are not fool proof and could underestimate the energy cost of certain physical activities (Trost, 2007: 299-312).

In spite of the errors which could arise in estimating energy expenditure from accelerometer counts, accelerometers have provided moderate to high correlations with energy expenditure in performing a variety of PA. PA is a complex behaviour to measure, especially among children (Pfeiffer *et al.,* 2006: 152-153). Since no single measure is fool proof, perhaps a combination of heart rate monitoring and accelerometry in one unit, such as the Actiheart may provide a more valid and reliable estimate of children's energy expenditure during PA than either measure alone (Rowlands & Eaton, 2007:274).

A summary of the advantages and disadvantages of the various types of measurement procedures of PA is presented in Table 1.

Table 1: Advantages and disadvantages of physical activity assessment methods

Measures	Advantages	Disadvantages
Doubly labelled water	• Precision of measure Assess energy expenditure (EE)	• High cost • Gives an assessment of total EE • No information about intensity, duration and frequency of physical activity (PA)
Direct observation	• Provides detailed quantitative and qualitative PA information • Provides information about PA behaviour (e.g. behavioural cues, environmental conditions, and the presence of significant others) • Software programmes available to enhance data collection and recording	• Labour- and time-intensive data collection • Subject reactivity • Suitable only to use with a small number of participants • Time-intensive training needed to establish between- and within-observer agreement
Heart rate monitor	• Measures physiological responses to PA • Good association with EE • Describes PA intensity, duration and frequency	• Changes in heart rate (HR) can be caused by other parameters other than PA • Susceptible to poor pick-up during free-living conditions • Useful only for aerobic activities
Pedometers	• Inexpensive • Easy to administer in large groups	• Loss of accuracy when jogging or running is being assessed. • Specifically designed to assess walking only. • No information about PA intensity, duration and frequency
Accelerometer	• Low subject burden • Can detect intermittent and sporadic PA • Describes PA intensity, duration and frequency • Allows for extended periods of recording	• Inaccurate assessment of a large range of activities (e.g. upper body movement, incline walking, water-based activities, cycling) • Data entry and reduction is complex • Lack of field-based equations to accurately estimate EE in specific populations • Accelerometer counts plateau or even begin to decline at a running speed of greater than 9-10km/hr
Self-report	• Easy to administer in large groups • Inexpensive • Low investigator and respondent burden • Describes PA duration, intensity, frequency and mode • Information available to estimate EE from daily living	• Reliability and validity problems associated with recall of PA • Hard to recall intermittent and sporadic activity • Children tend to overestimate high intensity PA behaviour and underestimate moderate PA

Source: Kolle (2009:9).

2.6 The relationship among physical activity, health-related physical fitness and body composition

2.6.1 The relationship between health-related fitness and physical activity

Fitness and health have a reciprocal relationship. While fitness influences health, one's health status also affects both PA and physical fitness. The theoretical model for describing the association between health-related fitness and PA is illustrated in the diagram proposed by Bouchard and Shephard (1994: 1-5) (Figure 1).

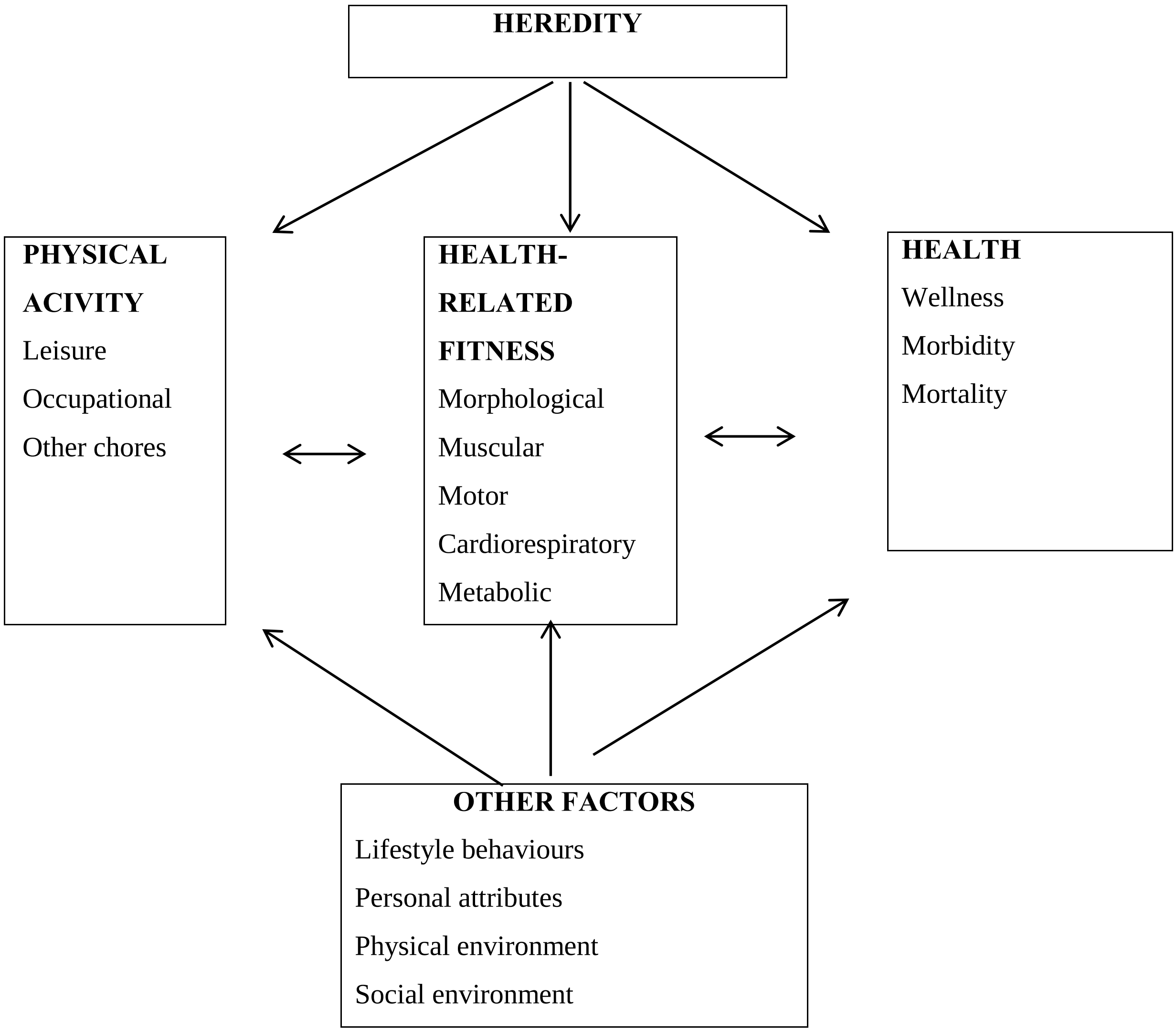

Figure 1: A model describing the relationships between physical activity, health-related fitness and health (Bouchard & Shephard, 1994:1-5; Tammelin, 2003:21)

As illustrated in Figure 1, there are other factors which affect PA, health and fitness. These include lifestyle factors other than PA, and personal attributes, as well as physical and social environments. Lifestyle factors include, but are not limited to the following: alcohol abuse, smoking, dietary habit, and sleeping patterns. A person's lifestyle behaviour can also be influenced by his/her gender, age, socioeconomic status, motivation, personality and attitude toward PA. Social environment includes socio-cultural, economic and political conditions that could influence PA, fitness and health. Environmental conditions which may influence PA, health-related fitness and health are temperature, humidity, air quality, altitude and climatic changes (Tamelin, 2003:21).

In the model proposed by Bouchard and Shephard (1994: 1-5) heredity influences all three components: PA, fitness and health. People could inherit differences in the levels of PA and health-related fitness components (Tamelin, 2003:21). As people are products of nature and nurture, genes and the environment interact to cause variability in health-related phenotypes in response to PA. Since different genotypes may be at risk for varied diseases linked to PA and a low level of health-related fitness (Bouchard, 1993: 1), PA interventions should consider individual differences in explaining responsiveness of children and adolescents to certain doses of PA.

2.7 Health benefits of physical activity for children and youths

Information is available on specific health enhancing benefits associated with PA in children. A report on PA by WHO (2005: 1-2) states that regular PA reduces the risk of heart disease, stroke, and breast and other cancers. These benefits are mediated through a number of mechanisms. In general, the report suggests that PA improves glucose metabolism, reduces body fat and lowers blood pressure. These are the main ways in which it is thought to reduce the risk of cardiovascular disease (CVD) and diabetes. It can also manage and minimise the effects on these diseases. The report further states that PA may reduce the risk of colon cancer by its effects on prostaglandins, reduced intestinal transit time, and higher antioxidant levels (WHO, 2005:1). In 1996, the Surgeon General of the United States issued a report called "Physical Activity and Health" that summarised the current consensus regarding the health benefits of PA (U.S. Department of Health and Human Services, 1996). General conclusions from the report are listed below (Welk & Blair, 2001:12). The following are the general conclusions from the Surgeon General's Report on PA and Health:

- People of all ages, both male and female, benefit from regular PA.
- Significant health benefits can be obtained by including a moderate amount of PA (e.g. 30 minutes of brisk walking or raking leaves,15 minutes of running, or 45 minutes of playing volleyball) on most, if not all, days of the week.
- Through a modest increase in daily activity, most Americans can improve their health and quality of life.
- Additional health benefits can be gained through greater amounts of PA.
- People who can maintain a regular regimen of activity that is of longer duration or of intensity that is more vigorous are likely to derive greater health benefits.
- PA reduces the risk of premature mortality in general, and of coronary heart disease, hypertension, colon cancer, and diabetes mellitus in particular.
- PA also improves mental health and is important for the health of muscles, bones and joints.
- Research on understanding and promoting PA is at an early stage, but some intervention to promote PA through schools, worksites, and health care settings have been evaluated and found to be successful.

Wildschutt (2005:31) argued that there are three main rationales for young people to take part in regular PA:

- To optimise physical fitness, current health and well-being, and growth and development;
- To develop active lifestyles that can be maintained throughout adult life;
- To reduce the risk of chronic diseases of adulthood (Mackett *et al.,* 2003:1).

It was further suggested that the normal everyday activities in which children participate, including travelling to and from school, could contribute to their daily quantum of PA, which in turn, should lead to healthier lives (Wildschutt, 2005:31).

In agreement with the current consensus regarding the health benefits of PA an editorial released from the Birth to Twenty Study (2002) states that regular PA substantially reduces the risk of dying from coronary heart disease, as well as decreases the risk of colon cancer, diabetes, and high blood pressure. It also helps to control weight; contributes to healthy bones, muscles, and joints; reduces falls among the elderly; helps to relieve the pain of arthritis; reduces symptoms of anxiety and depression; and is associated with fewer hospitalisations, doctor visits, and medications. The editorial released further suggested that 'loading' sports, such as netball, hockey, soccer, rugby, have excellent benefits for bone mineral density in later life. This, in turn, reduces the risk of developing osteoporosis in later life (that is not to say that 'non-loading' sport, such as swimming and cycling, aren't beneficial – they are great for keeping toned and fit) (Birth to 20 Study, 2002). These findings were echoed by WHO (2003) in their statement that: PA has measurable biological effects, affecting cholesterol levels, insulin sensitivity and vascular reactivity. Moreover, these effects are dose-dependent, i.e. the more the exercise the more the health benefits gained. However, considerable health benefits can also be gained with only small increases in moderate PA, e.g. regular walking (WHO, 2003:10).

2.7.1 Overweight and obesity risk reduction

Globally, obesity is affecting an increasing proportion of children. PA plays an important role in the prevention of becoming overweight and obese in childhood and adolescence, and reduces the risk of obesity in adulthood (Hills *et al*., 2012:866). It has been proved that obese children could grow up to become obese adults (Hills *et al*., 2012:866). Of the several plausible morbidity and mortality-related factors among children, physical inactivity and dietary habit have been mostly linked to the development of obesity, dyslipidaemia and hypertension. Over-consumption of food that is very rich in high-caloric diet and physical inactivity have been identified as major factors which contribute to the high incidence of overweight and obesity among the youth, most especially in children and adolescents (Wiecha *et al.*, 2004: 467; Coleman *et al.*, 2005: 217-218; Andreasi *et al.*, 2010: 497-498). Furthermore, it was revealed that the majority of youths affected by obesity and overweight live in developing nations. The World Health Organization (WHO) asserted that the consumption of too much fat is associated with an increase in BMI that subsequently causes overweight and finally rapidly leads to obesity (Ademola & Monday, 2013:164). Studies have also reported that over-nutrition, which is associated with non-involvement or inadequate participation in PA, was assumed to be the outcome of several risk factors during adolescence (Kovacs *et al.*, 2009: 337; Twisk *et al*., 2002: 58-59; Williams, 2001: 754-755); thereby reinforcing the need for strategic intervention (Monyeki *et al*., 2012: 379). PA remains one of the potent prescribed medicines in the prevention of overweight and obesity in childhood, and in conjunction with nutritional intervention reduces the health risks of chronic diseases of lifestyle. The engagement of children and adolescents in PA and sport is therefore a fundamental goal of obesity prevention (Hills *et al*., 2012:866).

2.7.2 Cardiovascular disease risk reduction

Over the past 40 years, many scientific research reports have examined the relationships between PA, physical fitness, and cardiovascular health. Specialist panels, brought together by the Centers for Disease Control and Prevention (CDC) (2009), the American College of Sports Medicine (ACSM), and the American Heart Association (AHA) with the 1996 US Surgeon General's Report on PA and Health, have ascertained that there is scientific proof connecting regular PA to different measures of cardiovascular health (Myers, 2003:1). Furthermore, reports have indicated that someone who is very active or fit tends to develop less coronary heart disease (CHD) than those leading sedentary lives. Therefore, if CHD does develop in active or fit individuals, it is more likely to occur at a later age and tends to be less severe (Myers, 2003:1). Many deaths have been attributed to lack of regular PA in many countries including the United States. In addition, PA intervention programmes which cater for large groups of people for many years reveal that PA can reduce chronic diseases, such as non-insulin-dependent diabetes, hypertension, osteoporosis, and colon cancer (Myers, 2003:1), as well as improve quality of life in terms of promoting health-related physical fitness, and normalising body composition among children and adolescents.

2.7.3 Reduction of Type II diabetes risk

Diabetes, especially Type II, is becoming increasingly common in children and youth and is popularly associated with genetic, social and lifestyle risk factors. Research has shown that a more serious lifestyle intervention with PA can delay the incidence of diabetes in any person with impaired glycaemic control (National Institute for Health and Clinical Excellence, 2011: 25-30). In a study conducted on a group of Chinese participants with impaired glucose tolerance to diabetes, for whom were assigned four intervention groups of control, to wit, diet, exercise, or diet and exercise, revealed that the exercise group experienced a 46% reduction and were less likely to develop diabetes than those in the control group ($P<0.001$) (LaMonte, Blair & Church, 2005:1208). Others were diet and exercise group with a reduction of 42%, while the diet-only group experienced a 31% reduction. From the above results, it shows that PA is beneficial in lowering the risk of Type II diabetes by improving insulin sensitivity and glucose tolerance.

2.7.4 Psychosocial benefits

Although convincing research evidence is lacking, it is assumed that PA has the potential to improve psychosocial outcomes. A major limitation of research studies in this area is to establish a cause-and-effect relationship between participation in PA and psychosocial outcomes like positive self-esteem, body image, tolerance, respect and discipline. Ideally, this would require longitudinal designs which are currently lacking. The benefits of PA are recognised, while aerobic exercises assist in reducing the state of anxiety and mood (Gaz & Smith, 2012:813). Anxiety is a state of heightened emotions that develops in reaction to fear or danger. Furthermore, exercise has been found to elevate productivity and decrease the level of absences from school or work, and improve social relationships (Gaz & Smith, 2012:813).

2.8 The longitudinal development of health-related fitness, body composition and physical activity among adolescents

Very few longitudinal studies exist which examined the development of health-related fitness and body composition from childhood to adolescence. Such longitudinal studies are potentially problematic in the following ways: First, children’s compliance with the study design and requirements is daunting in view of the unpredictability of location of their school, their parents may change jobs and consequently relocate, their choice of PA cannot be predetermined or restricted and such designs may have challenging ethical implications. Second, longitudinal studies are labour- and resource- intensive and third, it will be difficult to reliably account for physical and physiological changes in the children and adolescents as these may be confounded by their normal growth and development.

Bar-Or (1995) also cautions that, although the beneficial effects to health of enhanced PA during adult years are numerous, much less evidence is available regarding the effects of an active lifestyle during childhood and adolescence on adult health. The author postulates that the main reason for the paucity of information on the possible carryover of benefits from childhood to adulthood is the lack of longitudinal studies that have followed the same individuals over many years. One of few such large-scale longitudinal studies is the Birth to 20 Study which launched in 1990 It is the largest and longest running study of child health and development in Africa, and was started due to rising concerns about the implications of the rapid rate of urbanisation on the health and well-being of South African children. The study which comprises 3,273 families, is now in its 15th year of operation, and will run until the children reach the age of 20 years (Birth to Twenty Study, 2002).

Another longitudinal study that has been running for many years now is the Ellisras Longitudinal Study. Research carried out in Ellisras (Mantsena *et al.*, 2002: 225; Monyeki *et al.*, 2005; Monyeki *et al.*, 2007: 877) and the Tshannda (Amusa *et al.*, 2010: 221-223) rural areas, both in the Limpopo Province of South Africa have consistently reported body weight disorders, the longitudinal relationship between body composition, nutritional status and physical fitness, as well as the incidence of health-risk behaviours in school children and adolescents. Available cross-sectional studies undertaken in South Africa, which investigated the relationship between PA and determinants of cardiovascular disease among children and adults (Kruger, *et al.*, 2003; Mamabolo *et al.*, 2007: 1047) also revealed that inactivity was significantly related to risk factors of cardiovascular disease (Toriola & Monyeki, 2012:797). A longitudinal study was carried out in Finland (Tammelin, 2003:35) in which a birth cohort of 1966 (n=12,058), aged 14-31 years, was investigated to provide information about the factors associated with PA, health-related fitness and obesity during the transition from youth to adulthood. The research evaluated how PA and social status in adolescence are associated with PA in adulthood. The study also examined how a change in PA levels from adolescence to adulthood could be associated with total and abdominal obesity in adulthood. The relationship between occupational PA and physical fitness in young workers was also evaluated. In addition, population-based reference values of cardiorespiratory fitness were produced for young adults. The major findings of the study are summarised as follows:

- The following factors were associated with a high level of PA at age 31: Participation in sports twice a week or more after school hours, being a member in a sports club and a high grade in school sports at age 31. Adolescent participation in intensive endurance sports was most beneficial with respect to PA enhancement in adulthood.
- Low social class and poor school achievements positively correlated with physical inactivity at age 14.

- Poor school achievements at age 14 years were also associated with physical inactivity at 31 years of age.
- Participants who are inactive during the transition from adolescence to adulthood were more likely to be obese at 31 years of age.
- Very low levels of aerobic fitness were associated with infrequent participation in brisk exercise and increased BMI.
- High level of occupational PA was associated with a high level of physical fitness, but low level of leisure-time physical activity at age 31.

Based on the findings, Tammelin (2003:75) concluded that:

- The promotion of regular participation in PA across the lifespan is an important public health challenge.
- It is important to identify the important predictors and correlates of PA so that these could form the basis of interventions targeted at enhancing participation in PA among children and adolescents.

In the Amsterdam Growth and Health Longitudinal Study, Kemper *et al.* (2000:851) monitored daily PA and fitness in 182 males and females aged 13 to 29 years. At a mean age of 28 years, bone mineral density (BMD) was measured at three sites with dual X-ray absorptiometry (DXA), i.e. in the lumbar region (lumbar BMD), the femoral neck (hip BMD), and the distal radius (wrist BMD) of the participants. PA was estimated from an activity interview considering all daily physical activities during the last 3 months. In the study, PA was scored as:
(1) Metabolic PA score (METPA) determined by weighting the intensity (multiples of basic metabolic rate [METs]) and duration (minutes per week); and
(2) Mechanical PA score (MECHPA) obtained by weighting the peak strain (ground reaction forces as multiples of body mass) irrespective of frequency and duration of the physical activities.

Kemper *et al.* (2000:851) measured physical fitness with a neuromotor fitness test (composite of six strength, flexibility, and speed tests) and as cardiopulmonary fitness (maximal oxygen uptake). The PA and fitness scores were calculated over two age periods: at adolescence (13-

16 years) and at adulthood (21-27 years). However, the authors did not find any significant correlation between PA and wrist BMD, a bone site that is less involved in PA and fitness. The study concluded that daily PA during adolescence and young adulthood is significantly related to the BMD at the lumbar spine and femoral neck in both males and females at age 28. It was also concluded that only neuromotor fitness in contrast to aerobic fitness (at adolescence and young adulthood) is related to the BMD of 28-year old men and women.

2.9 Physical activity recommendations for children and adolescents

In the 1940s, PA was considered to be a cause of heart attack, and heart attack patients were advised to stay in bed. Then high intensity PA was advocated as the means of staying healthy. Since the 1970s, research has shown that moderate-intensity PA is beneficial for health, and the accumulation of moderate activity for 30 minutes on most, or preferably all, days of the week is recommended as an effective cardiovascular disease (CVD) prevention measure (Report of a Joint FAO/WHO Expert Consultation) (WHO, 2003a:10). The consensus statements recommended for adolescents (aged 11 to 21 years) contain two basic guidelines (Corbin & Pangrazi, 2001:43).

- Guideline 1: All adolescents should be physically active daily, or nearly every day [30 to 60 minutes], as part of play, games, sport, work, transportation, recreation, PE, or planned exercise, in the context of family, school, and community activities.
- Guideline 2: Adolescents should engage in three or more sessions per week of activities that last 20 minutes or more and require moderate to vigorous levels of exertion. In contrast to pre-adolescent children, the consensus is that adolescents should participate in some continuous and vigorous activity. The first guideline is regarded as a priority. Participation in 30 to 60 minutes of daily activity is a reasonable, even minimal, goal for sedentary youth. Beyond this, Guideline 2 is a desirable goal. The consensus statement includes activities such as brisk walking, jogging, stair climbing, basketball, racquet sports, soccer, dance, swimming laps, skating, strength (resistance training), lawn mowing, and cycling as some examples of activities that meet Guideline 2.
- Furthermore, the American Council for Physical Education for Children (COPEC) of the National Association for Sport and Physical Activity (NASPE) recently developed PA guidelines for children. These guidelines which are commonly referred to as the

NASPE Physical Activity Guidelines for children (NASPE, 2004:1), are summarised as follows:

- Elementary school aged children should accumulate at least 30 to 60 minutes of activity per day and develop mentally appropriate PA from a variety of physical activities on all, or most days of the week.
- An accumulation of more than 60 minutes, and up to several hours per day, of age and mentally developed appropriate PA is encouraged for elementary school age children.
- Some of the children's activity each day should be in periods lasting 10 to 15 minutes or more, and include moderate to vigorous activity that is typically intermittent in nature, involving alternating moderate to vigorous activity with brief periods of rest and recovery.

2.10 Chapter summary

The increasing prevalence of physical inactivity in children worldwide leads to low levels of health-related physical fitness which is known to be a potential predictor of morbidity and mortality which is associated with cardiovascular and metabolic diseases. Although higher levels of health-related fitness promotes participation in higher intensity PA for longer periods of time, PA pattern, genetics and other factors, such as age, gender, medical status, and selected health-related lifestyle behaviours are major contributing factors to an individual's fitness level.

The quantification of PA is also an important area which has been researched over the years. In other words, it raises the question of how much PA is enough for one to achieve desirable health benefits? For example, WHO has recommended that people should engage in moderate levels of PA for at least 30 minutes per day, three times a week or take at least 10,000 daily step counts as a result of walking from one place to another for health and wellness and to improve quality of life. Despite this recommendation, many people still do not actively engage in PA or exercise. Among children, prolonged TV viewing, being regularly driven to school and 'exergaming' (prolonged use of computer video games) are the major deterrents to PA participation. Other important factors which are barriers to the engagement of children and adolescents in PA are poor parental support and lack of participation, age and gender disparity, culture, socioeconomic levels, environmental settings, time allotment to PE in schools, facilities and equipment, proximity of playground to the home, and interest in PA. Studies have also shown that the provision of adequate equipment and facilities in schools should also be a priority as this could help to promote participation in PA among children.

Research findings in the area of body composition and health-related physical fitness suggest that the barriers should be considered when designing PA intervention programmes for children and adolescents. The implication of research findings in this area is that the level of physical inactivity, obesity and cardiovascular disease risk among children is on the increase and this trend has contributed to the high health costs associated with preventable non-communicable diseases.

The reviewed literature in this chapter is integrated in the three research articles (Chapters 3-5).

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CHAPTER 3: HEALTH-RELATED FITNESS, BODY COMPOSITION AND PHYSICAL ACTIVITY STATUS AMONG ADOLESCENT LEARNERS: THE PAHL STUDY

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Health-related fitness, body composition and physical activity status among adolescent learners: The PAHL study

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Abstract

Physical inactivity (PI) is found to be a major contributor to the high incidence of overweight and obesity among children and adolescents. As such, PI was significantly related to risk factors of cardiovascular disease and therefore studies especially in 14-year old adolescent learners are sparse. The purpose of this study was to determine the health-related physical fitness (HRPF), body composition and physical activity (PA) status among adolescent learners. A total of 283 adolescents learners (111 boys and 172 girls) with mean age of 14.90±0.72 from the Physical Activity and Health Longitudinal Study (PAHLS) are participants in the study. Body composition according to the standard procedures of the International Society for the Advancement of Kinanthropometry (ISAK), HRPF using the Eurofit protocol test and PA levels using the International Physical Activity Questionnaire (IPAQ) were assessed and administered. Subsequently, total PA scores were calculated. The results show that on average, the boys (165.41±9.55cm) were significantly taller than the girls (157.88±6.94cm) ($p<0.000$). Girls had a significantly higher BMI (21.43±4.37 kg/m²) than the boys (20.01±3.71kg/m²) ($p=0.002$). When the learners were categorised based on their BMI scores, the girls were more overweight (32.4%) compared to the boys (17.1%). Additionally, the girls (%body fat 26.01±8.51) were substantially ($p<0.000$) fatter than the boys (13.19±8.56). Furthermore, the results also indicated that the boys had consistently better performances in all the HRPF tests than the girls ($p<0.000$). More girls (19%) than boys (16%) watched TV for more than 3 hours daily. A total of 85 (30%), 78(27.5%) and 88(31.1%) of the adolescent students had low, moderate and high PA involvement. It can be concluded that girls were more overweight and less active than boys. In view of the health implications of the findings, the need to create enabling environment and opportunities that will promote physically active lifestyle and develop life-long positive attitudes towards PA among the learners. Community-based strategies designed to facilitate effective and sustainable PA intervention programmes in schools are recommended.

Keywords: Health-related physical fitness, body composition, physical activity, adolescents, PAHL study.

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Introduction

The World Health Organization (WHO) has declared obesity a global epidemic (WHO, 2009). The Center for Disease Control and Prevention (CDC) (2009) and WHO (2009) have also reported an increasing prevalence of cardiovascular and metabolic diseases such as hypertension, stroke, hypercholesterolemia, obesity, overweight and diabetes mellitus in children and adults (Rivera, Mendoca-Da Silva, Almeida-Silva, Viana-Deoliveria & Camargo-Carvalho, 2009). A number of studies have identified over-consumption of high-calorie diets and physical inactivity (PI) as major contributory causes of the high incidence of overweight and obesity among children (Wiecha, Whitney & Bredin, 2004; Coleman, Tiller, Sanchez, Heath, Sy, Milike & Dzewaitowski, 2005; Andreasi, Michelin, Rinaldi & Burini, 2010). For instance, Wiecha, Ayadi, Fuemmeler, Carter, Handler, Johnson, Strunk, Korzec-Ramirez & Gortmaker (2004) reported that the prevalence of overweight children and adolescents has doubled between 1976 and 1994 to 13% and has increased further to 15.5% in 2000. This trend is alarming given the fact that antecedents of chronic diseases in adulthood could be tracked from childhood (Forrest & Riley, 2004). The increasing prevalence and serious consequences of paediatric overweight and obesity have prompted calls for broad public health strategies to prevent the disease (Foster, Sherman, Borradaile, Grundy, Vander, Nachmani, Karpyn, Kumanyika & Shults, 2008).

In South Africa, a national study by Reddy, Panday, Swart, Jinabhai, Amosun & James (2003) among adolescents reported that only 54.3% have Physical Education (PE) classes on their timetable and only 52.8% engage in vigorous activity at school. This trend is disconcerting given that PE and physical activity (PA) provide opportunities for development of physical fitness in children. Also alarming is the fact that PE is neglected in the South African public school system with many schools constructed without playgrounds (Reddy, Panday, Swart, Jinabhai, Amosun & James, 2002). Since PA in childhood tracks into adulthood, it is necessary to address the lack of PA in children and youth in order to facilitate the prevention of risk factors of chronic diseases of lifestyle (CDL), which are now increasingly prevalent in children and youth (Telama, Yang, Vikari, Valimaki, Wane & Raitakari, 2005). In addition, it is believed that the largest percentage of variation in performance accounted for by chronological age, skeletal age and body size generally occur at age 14, in which height and weight are found to be interrelated (Malina, Bouchard & Bar-

Or, 2004), hence the Physical Activity and Health Longitudinal Study (PAHLS)(Monyeki, Neetens, Moss & Twisk, 2012).

Research carried out in Ellisras (Mantsena, Monyeki, Monyeki, Brits, Toriola & Kangolle, 2003; Monyeki, Koppes, Kemper, Monyeki, Toriola, Pienaar & Twisk, 2005) and the Tshannda (Amusa, Goon & Amey, 2010) rural areas both in Limpopo Province of South Africa have consistently reported body weight disorders and incidence of health-risk behaviours in school children and adolescents. Available cross-sectional studies undertaken in South Africa, which investigated the relationship between PA and determinants of cardiovascular disease among children and adults (Kruger, Venter & Vorster, 2003; Mamabolo, Kruger, Lennox, Monyeki, Pienaar, Underhay & Czlapka-Matyasik, 2007) also revealed that inactivity was significantly related to risk factors of cardiovascular disease.

The concepts that are central to CDL and health risk behaviours as well as their prevention and management include health-related physical fitness, body composition and PA. Health-related physical fitness in this context refers to a set of attributes that relates to the ability to perform daily physical and functional tasks (Ruiz, Ortega, Meusel, Harro, Oja & Sjostrom, 2006; Andreasi, Michelin, Rinaldi & Burini, 2010). While poor health-related physical fitness is often associated with the risk of premature development of morbidity, especially if an individual leads a sedentary lifestyle (Telama, Yang, Vikari, Valimaki, Wane & Raitakari, 2005), desirable health-related physical fitness prevents disease risk and improves the quality of life (Andreasi *et al*., 2010). Specifically, attributes of health-related fitness include body composition, cardiovascular endurance, flexibility, muscular endurance, muscular strength (US Department of Health and Human Services, 1999) and metabolism (Warburton, Whitney & Bredin, 2006).

In this study, PA is defined in the context of any bodily movement produced by skeletal muscles that results in energy expenditure, and is positively correlated with physical fitness, e.g. walking, jogging, cycling, swimming, domestic chores and gardening (Caspersen, Powell & Christensen, 1985). PA can be categorised as having low, moderate and high intensities depending on one's caloric expenditure as a function of time of activity, body weight and oxygen uptake (American College of Sport Medicine: ACSM, 2009). According to the ACSM (2009) participation in at least 30 minutes of moderate PA per day, carried out thrice a week will yield significant health benefits, while the WHO (2009) suggests that one should take at least 10,000 walking step counts per day for health promotion.

In spite of these recommendations people in many parts of the world are still inactive, leading to increased prevalence of cardiovascular and metabolic diseases (Mokdad, Ford, Bowman, Dietz, Vinicor, Bales & Marks, 2003). For example, people prefer to be driven to work, school or shopping malls and to use elevators or escalators rather than walk or climb the stairs. There is consensus among researchers that the antecedents of chronic diseases of lifestyle (CDL) already manifest in childhood (Strong, Malina, Blimkie, Daniels, Dishman, Gutin, Hergenroeder, Must, Nixon, Pivarnik, Rowland, Trost & Trudeau, 2005; Jonker, De Laet, Franco, Peeters, Mackenbach & Nusselder, 2006). Research findings have also indicated a rising trend of chronic diseases of lifestyle among children and youth (Jessup & Harrell, 2005). The increasing trend of health risk behaviours have been widely associated with the fact that many children spend several hours watching TV, playing computer video games and hardly engage in wholesome PA (Andersen, Crespo, Bartlett, Cheskin & Prattbl, 1998). This trend is also aggravated by globalisation which has promoted the proliferation of fast food franchises most of which sell unhealthy foods. Therefore, poor dietary habits combined with PI and other unhealthy lifestyle factors undoubtedly increase cardiovascular and metabolic disease risk among children and adults (Kelishadi, Ziaee, Ardalan, Namazi, Noormohammadpour, Ghayour-Mobarhan, Sadraei, Mirmoghtadaee & Poursafa, 2010).

Therefore, given the importance of health-related physical fitness (HRPF), PA and body composition in disease prevention, this study was primarily designed to assess these dependent measures among high school adolescents in the Tlokwe Local Municipality of the Dr Kenneth Kaunda District Municipality in the North West Province of South Africa. A secondary purpose of the study was to examine the inter-relationships among health-related fitness, PA and body composition in the adolescent learners. It was hypothesised that there will be significant gender differences in health-related fitness, PA and body composition status among the adolescent learners.

Methodology

Research design

This research was part of a larger study, i.e. The Physical Activity and Health Longitudinal Study (PAHLS), which utilised a mixed longitudinal design. The PAHLS was designed to evaluate the development of PA, determinants of health risk and factors affecting participation in sport and recreational activities among 14-year old high school students in Tlokwe Local Municipality of the Dr Kenneth Kaunda District Municipality. For the purpose of this study data from cross-sectional measurements were used.

Participants

The research involved a group of 283 boys (n=111) and girls (n=172), aged 14 years who were purposefully drawn from six out of eight secondary schools in Tlokwe Local Municipality. The schools included were those who granted permission for the study to be carried out. The participants were requested to provide demographic information in terms of their gender status, race and locality (*i.e.* town or township). For the purpose of this study, school-based locality comprised four schools from town and four schools located in township areas. Therefore, the included schools covered both low (Ikageng Township) and high socioeconomic circumstances (Potchefstroom town) of learners. The South African Department of Education categorise schools in quintiles (1-5) according to physical condition, facilities and crowding and the relative poverty of the community around the schools (Department of Education, 2003). Out of the eight schools initially selected, two urban schools declined to participate (without providing reasons). Detailed information regarding the participants has been published elsewhere (Monyeki, Neetens, Moss & Twisk, 2012)

Anthropometric measurements

The participants' height, body weight, skinfolds thickness (triceps and subscapular skinfolds), and waist and hip circumferences were measured using the standard procedures described by the International Standard of Advancement of Kinanthropometry (ISAK) (Marfell-Jones, Olds, Steward & Carter, 2006). Waist-to-hip ratio (WHR) was calculated as waist (cm)/hip (cm). Body mass index (BMI) was calculated as body mass/stature² (kg/m²). Subsequently, age-specific BMI for children was used to determine the following categories: overweight, normal weight and underweight/thinness, respectively (Cole, Bellizzi, Flegal & Dietz, 2000; Cole, Flegal, Nicholls & Jackson, 2007). Percentage body fat was calculated from skinfolds measurements using Slaughter, Lohman, Boileau, Horswill, Stillma, Van Loan & Bemben*'s* (1988) equation which is internationally accepted for the use in children and adolescents from different ethnic groups.

Health-related physical fitness measurements

Health-related physical fitness (HRPF) was determined by measuring participants' cardiorespiratory endurance, muscle strength and endurance, and flexibility using standardised tests (EUROFIT, 1988; Australian Sports Commission, 1999). Cardiovascular endurance was assessed with the 20-metre shuttle run test which is a valid test of aerobic capacity in adolescents (Davis, 2006). The following health-related fitness test items were measured according to the EUROFIT (1988) test protocol: sit-and-reach (SAR) (a test of hamstring flexibility, expressed in centimetres); sit-up (SUP) (a measure of abdominal strength and endurance, determined by correctly performed sit-ups in 30 seconds); standing broad jump (SBJ) (a test of explosive strength of leg extensors measured in centimetres) and bent arm hang (BAH) (which measures functional arm and shoulder muscular endurance to exhaustion in seconds).

Measurement of physical activity (PA)

PA was assessed using 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 (Craig, Marshall, Sjostrom, Bauman, Booth, Ainsworth, Pratt, Yngve & Sallis, 2003). IPAQ is considered suitable for use by adolescents at different settings (WHO, 2002) and 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.

Measurements procedures

Prior to data collection, permission to conduct the measurements was granted by the District Manager of the Department of Education in Potchefstroom, North-West Province. In addition, clearance was received from the Ethics Committee of North-West University, Potchefstroom Campus (Ethics no: NWU-0058-01-A1). The participating schools were briefed about the purpose of the study, and the informed consent forms were signed by the school authorities as well as the learners and their parents. To minimise loss of interest and fatigue among the participants and prevent disruption of teaching and learning activities at the schools, data were collected on days agreed by the participating schools. Only the data of learners who were 14 years old as at the time of testing were analysed.

Before the anthropometric and HRPF measurements were carried out, the IPAQ was administered to the participants who were assembled in a classroom, under the supervision of the principal investigator. In completing the IPAQ adequate instructions and clarifications, with no time limit set for completion, were given to the students who subsequently filled the questionnaires independently, without interference from fellow classmates.

The physical and physiological variables were measured in the following order: anthropometry; health-related fitness, gross and fine motor fitness. All anthropometric sites were measured twice according to standard procedures by Level 2 ISAK certified anthropometrists.

Statistical analysis

The cross-sectional data on health-related fitness, body composition and PA were analysed using descriptive statistics, such as means and standard deviations. Independent *t*-tests were computed to determine age, and gender differences in the variables among the participants. Non-parametric t-test was used to examine for significant differences between two ordinal variables and Mann-Whitney U test for assess differences between categorical variables. All data analyses were performed with Statistical Package for the Social Sciences (SPSS), version 20.0 programme (SPSS Inc., 2011).

Results

Sex differences in the anthropometric and body composition characteristics of the adolescent learners are presented in Table 1.

Table 1: Sex differences in adolescents' anthropometric and body composition characteristics

Anthropometric and body composition measurements	Males (n=111)		Females (n=172)		P-values
	Mean	SD	Mean	SD	
Age	14.90	0.72	14.88	0.82	0.88
Stature (cm)	165.41	9.55	157.88	6.94	<0.000
Body weight (kg)	55.30	13.77	53.70	12.86	0.29
BMI (kg/m^2)	20.01	3.71	21.43	4.37	0.002
Triceps skinfolds (mm)	9.98	5.08	17.52	6.82	0.00
Subscapular skinfolds (mm)	8.83	4.69	14.02	8.09	<0.000
Sum of skinfolds	18.81	9.49	31.54	14.20	<0.000
% Body fat	13.19	8.56	26.01	8.51	<0.000
Waist circumference (WC) (cm)	68.11	8.29	67.62	8.67	0.51
Hip circumference (cm)	85.29	9.41	92.54	9.81	<0.000
Waist-to-hip ratio (WHR)	0.80	0.3	0.73	0.04	<0.000

SD = standard deviation; p<0.05

On average, the boys (165.41±9.55cm) were significantly taller than the girls (157.88±6.94cm) ($p<0.000$). Although the boys (55.30±13.77kg) were heavier than the girls (53.70±12.86kg), the difference was not statistically significant ($p=0.29$). However, despite that the girls (21.43±4.37 kg/m^2) had a slightly higher BMI than the boys (20.01±3.71kg/m^2), the difference was significant ($p=0.002$). When the students were categorised based on their BMI scores the girls were more overweight (32.4%) than the boys (17.1%). However, the boys (34.2%) were generally more underweight than the boys (26.6%) (Figure 1).

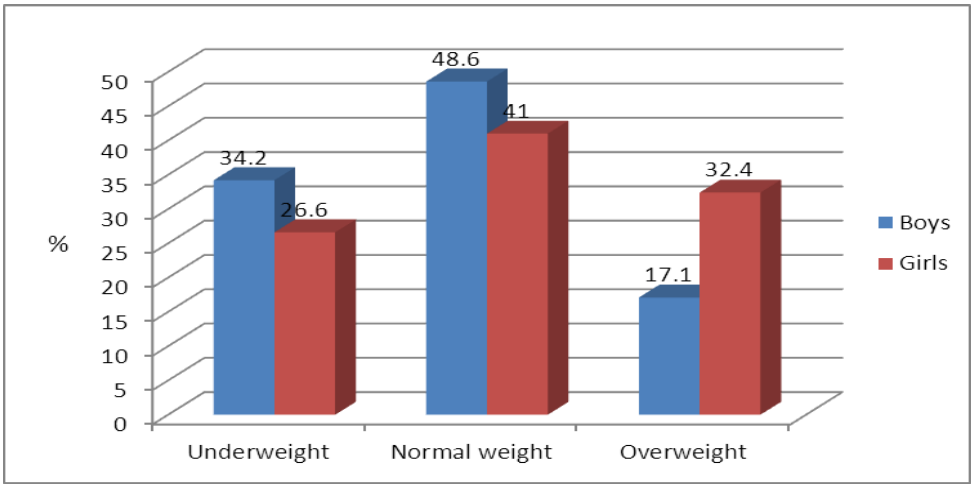

Figure 1: Percentage scores for boys' and girls' BMI categories

Data presented in Table 1 also indicate that the girls were substantially fatter than the boys (p<0.000); having consistently higher triceps (17.52±6.82mm), subscapular (14.02±8.09mm) skinfolds, sum of skinfolds (31.54±14.20mm) and % body fat (26.01±8.51%) compared to the boys whose corresponding values were 9.98±5.08mm; 8.83±4.69mm; 18.81±9.49mm and 13.19±8.56%, respectively. While the participants had comparable WCs, the adolescent girls had higher hip circumference (92.54±9.81cm) but lower WHR ratio (0.73±0.04) in contrast to the boys (85.29±9.41cm and 0.80±0.3, respectively). These differences were statistically significant (p<0.000).

Presented in Table 2 are the participants' HRPF scores in which sex differences are also highlighted. The results indicated that the boys had consistently performed better in all the health-related fitness tests than the girls, except that the girls were significantly (p<0.000) flexible than the boys.

Table 2: Sex differences in adolescents' health-related physical fitness data

Physical activity	Males		Females		P-values
	Mean	SD	Mean	SD	
SBJ (cm)	186.04	26.07	147.93	19.99	<0.000
BAH (sec.)	18.22	13.53	4.03	5.48	<0.000
SUP (no/30secs.)	35.44	6.97	23.43	10.17	<0.000
SAR (cm)	42.22	9.12	48.51	7.34	<0.000
20m multistage shuttle run	7.94	2.01	4.56	1.54	<0.000
VO_2max (ml/kg.min^{-1})	40.10	6.89	28.33	5.11	<0.000

SD = standard deviation; p<0.05

The results of the students' HRPF performances, sport participation, TV viewing habits (Tables 3 and 4) and PA involvement (Tables 5 and 6) are presented. Results of the participants' TV viewing habit indicated that overall, 51(18%), 65(23%) and 112(40%) watched TV more than 3 hours, 2-3 hours and less than an hour per day, respectively.

Table 3: Percentage scores of TV viewing for total group

Percentage score of TV viewing	N	%
TV Viewing (0-1hour)	112	40.0
TV Viewing (2-3hours)	65	23.0
TV Viewing (>3hours)	51	18.0
Do not know	55	19.0
Total	283	100

n= number of participants; % = percentage

Table 4: Percentage scores (%) of TV viewing for boys and girls

Percentage score of TV viewing	Boys		Girls	
	N	%	N	%
TV Viewing 0-1hour	42	38.0	76	44.0
TV Viewing 2-3hours	29	26.0	36	21.0
TV Viewing >3hours	18	16.0	33	19.0
Do not know	22	20.0	28	16.0
Total	111	100	172	100

n= number of participants; % = percentage

When the data were analysed according to sex categories, results indicated that more girls (19%) than boys (16%) watched TV for more than 3 hours daily. Daily TV viewing less than an hour was also more prevalent among the girls (44%) than the boys (38%). A follow-up analysis using Mann-Whitney U test showed a significant gender difference in the participants' sum of weekly TV viewing hours (Z= 32.03, p=.00).

The results on PA were also analysed for the entire group (Table 5) and separately for the adolescent boys and girls (Table 6). Analysis of IPAQ group data showed that 85 (30%), 78(27.5%) and 88(31.1%) of the adolescent learners had low, moderate and high PA involvement, respectively.

Table 5: Percentage scores of physical activity participation for the total group

Percentage score of PA	N	%
Do not know	32	11.3
Low PA	85	30.0
Moderate PA	78	27.5
High PA	88	31.1
Total	283	100

n= number of participants; % = percentage

Table 6: Percentage scores of physical activity participation for boys and girls

Percentage score of PA	Boys		Girls	
	N	%	N	%
Do not know	16	14.4	16	9.3
Low PA	18	16.2	67	39.0
Moderate PA	29	26.1	49	28.5
High PA	48	43.2	40	23.2
Total	111	100	172	100

n= number of participants; % = percentage

Analysis of the findings according to gender categories seems to be consistent with the trend observed concerning the results on the learners' TV viewing habit. Specifically, a total of 39.0% of the girls had low PA in contrast to only 23.2% who were categorised as having high PA participation. Among the boys however, only 16.2% had low PA involvement, while 43.2% could be categorised as being highly physically active. A follow-up analysis using

Mann-Whitney U test indicated a significant gender difference in this regard (Z= -4.52, p=0.00).

Discussion

In this study HRPF, PA and body composition characteristics were comparatively evaluated among a sample of adolescent male and female learners in South Africa. Results of the study showed overall that adolescent girls were substantially more overweight than the boys. Additionally, in terms of adiposity, the girls were substantially fatter than the boys; having consistently higher triceps, subscapular skinfolds, sum of skinfolds and percentage of body fat. The adolescent girls also had higher hip circumference, but lower WHR in contrast to the boys. The mean WHR values for the boys (0.80±0.30) and girls (0.73±0.04) in this study are lower than that reported for a sample of 15-year old obese Egyptian girls (0.81±0.05) living in Cairo (Hassan, Zaki, El-Masry, Mohsen & Elashmawy, 2011), who underwent a 6-month dietary and PA intervention programme. The Egyptian girls also had substantially higher BMI (32.30±3.13kg/m^2) than the learners in this study. Our sample, however, had higher BMI and WC than those reported for black South African children by Zeelie, Moss, Kruger and van Rooyen (2010). These authors reported BMI and WC values of 18.0-20.7 kg/m^2 and 64.0-66.3cm, respectively for 15-19 year-old adolescents who underwent a 10-week PA intervention programme.

The findings concerning HRPF status indicated that the boys had consistently better performances in all the HRPF tests than the girls. Compared with results of a recent South African study, the boys (35.44±6.97) and girls (23.43±10.17) in this study had superior SUP performances than a sample of 14-16 year-old (Boys: 23.0±7.3; Girls: 15.0±7.5) learners in Mankweng, a semi-urban settlement in Limpopo Province (Toriola, Moselakgomo, Shaw, Goon & Amusa, 2011a). Girls performed better than the boys in back/upper flexibility, and as such these findings are consistent with previous reports that girls are more flexible at all ages than boys with sex differences during adolescent period (Monyeki *et al*., 2005; Malina *et al*., 2004). Boys predicted VO_2max was relatively fair, whilst for girls VO_2max was poor as compared to the norms for the general population (Shvartz & Reibold, 1990)

The comparatively low HRPF scores among the girls could be attributed to their TV viewing habit which indicates that more girls (19%) than boys (16%) watched TV for longer than 3 hours daily and that they had a higher overall weekly TV watching hours. The greater prevalence of PA among the girls may also be a reflection of their IPAQ data in which 39% of them reported having low PA participation.

Participation in PA is important to children's health as well as their growth and development, but studies in many countries have reported a gradual decline in children's participation in PA. In addition to the many reasons which could account for the rising incidence of PI among children and adolescents such as habitual television viewing, prolonged participation in computer video games and reduced opportunities to participate in school-based PA, there are a number of factors that could either undermine or enable children to be physically active. One of such factors related to the present study is the fact that Physical Education is neglected in many schools, which do not have standard sport facilities that could have provided the opportunity for learners to develop physically active lifestyles (Reddy *et al*., 2003; Van Deventer, 2008).

The relatively low PA levels found among the learners in this study is consistent with widely reported tendency toward decline in PA among adolescents that is often associated with sedentary lifestyle (Telama & Yang 2000); in which many teenagers no longer meet established recommendations for daily moderate-to-vigorous PA (Strong *et al*., 2005). For instance, Biddle, Gorely and Stensel (2004) also reported a decline in PA among pre-adolescent and adolescent boys and girls.

In addition to sedentary lifestyle and indulgence in other health-risk behaviours, European children's PA level has been associated with living conditions and socioeconomic status, peer-pressure and the degree of parental PA involvement (Humbert, Brunner, Spink, Muhajarine, Anderson & Gryba, 2008). Sallis, McKenzie, Alcaraz, Faucette & Novell (1997) have also pointed out that the key determinants of PA are demographic factors (greater likelihood of activity in younger people, especially boys), social factors (encouragement from peers and parents) psychological factors (perceived competence and enjoyment) and the physical environment (availability of different facilities).

The gender difference on PA observed in the present study is not surprising as other studies have also reported the tendency for adolescent girls to be less physically active than boys. For example, studies carried out in Australia have shown that boys (below 15 years) are more likely to participate in PA than girls of similar age category (Salmon, Telford & Crawford 2004; Trost 2005). Similar trends have also been reported in South Africa (Toriola *et al*., 2011b) and Poland (Czyz & Toriola, 2012) in which adolescent girls showed somewhat negative attitudes towards Physical Education and school sport compared to their male peers.

A number of studies have reported compelling evidence supporting the view that regular PA in adolescence contributes to the development of healthy adult lifestyles by reducing chronic disease incidence (Hallal, Victoria, Azevedo & Wells, 2006), and yielding beneficial health outcomes which are carried over into adulthood (Hallal *et al*., 2006; Jonker, De Laet, Franco, Peeters, Mackenbach & Nusselder, 2006). In contrast, a low PA level is associated with a higher mortality rate, risk concerning certain types of cancer, obesity, decreased mental health, diabetes, hypertension and a poor quality of life (Andreasi *et al*., 2010).

Body composition is an important indicator of health status in children and adolescents because maintaining a healthy body composition prevents the onset of obesity which is associated with the risk of cardiovascular diseases, diabetes and stroke (Fukuyama, Inaoka, Matsumura, Yamauch, Natsuhara, Kimura & Ohtsuka, 2005). It has also been suggested that excessive development of fat in childhood or adolescence may cause adverse health problems later in life (Janz, Dawson & Mahoney, 2000). Since childhood and adolescence represent critical developmental stages, enabling environment and opportunities should be created so that they can adopt physically healthy lifestyle and develop life-long positive attitudes towards PA (Dzewaltski, Estabrooks & Johnston, 2002). This can be achieved through community-based partnerships which will facilitate development of effective and sustainable PA intervention programmes in schools.

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CHAPTER 4: The relationship between body composition, health-related fitness and physical activity among South African adolescent students: The PAHL Study

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From: Gholam-Reza Valizadeh [ijp@tums.ac.ir]
Sent: 21 November 2013 11:33 PM
To: Abel Toriola
Subject: [IJP] Submission Acknowledgement

Dear Prof Abel Toriola:

Thank you for submitting the manuscript, "The relationship between body composition, health-related fitness and physical activity among South African adolescent students: The PAHL Study" to Iranian Journal of Pediatrics. With the online journal management system that we are using, you will be able to track its progress through the editorial process by logging in to the journal web site:

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Tehran University of Medical Sciences

The relationship between body composition, health-related fitness and physical activity among South African adolescent students: The PAHL Study

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ABSTRACT

Objective: This study was designed to evaluate the relationship between body composition, health-related fitness and physical activity (PA) among 283 students (Boys: n=111; Girls: n=172) in the Tlokwe Local Municipality, South Africa, aged 14.9±0.72 and 14.88±0.82 years, respectively.

Methods: The protocol of the International Society for the Advancement of Kinanthropometry (ISAK) and EUROFIT test battery were used to assess the students' physical characteristics and health-related fitness profiles.

Results: The girls had a significantly higher mean body mass index (BMI) (21.43±4.37kg.m^{-2}) and hip circumference (HC) (92.54±9.81cm) than the boys (BMI: 20.01±3.71 kg.m^{-2}; HC: 85.29±9.41cm), who by contrast had substantially higher mean WHR (0.80±0.3) than the girls (0.73±0.04) ($p<0.001$). The distribution of subjects' data by BMI categories showed that a higher proportion of the girls (32.4%) than the boys (17.1%) were overweight. Except flexibility test in which the girls (48.51±7.34cm) did significantly better than the boys (42.22±9.12cm) ($p<0.05$), the boys' health-related fitness performances and aerobic capacity were substantially superior to those of the girls ($p<0.001$). Inverse relationships were found between BMI and the health-related fitness items of SBJ and BAH. Furthermore, BMI negatively associated with SAR and endurance performance, especially in girls. Percentage body fat was negatively related to SBJ, BAH, SAR and endurance performance. A higher prevalence of overweight was found in girls (32.4%) than the boys (17.1%), which adversely affected the adolescents' health-related physical fitness.

Conclusion: Prevalence of overweight and inactivity was especially high in girls and excessive fatness negatively affected their fitness performances. Findings warrant urgent strategic interventions, which implicate the need for school and community-based PA programmes to promote physically active lifestyles among children and adolescents.

KEY WORDS: Physical activity, health-related fitness, adolescents, obesity, non-communicable disease prevention.

INTRODUCTION

There is overwhelming research evidence that the risk factors of cardiovascular and metabolic diseases originate in childhood and adolescence[1], even in children in economically deprived settings[2]. Large-scale surveillance studies carried out by the Center for Disease Control and Prevention (CDC) and the World Health Organization (WHO) have consistently indicated the growing prevalence of risk factors of cardiovascular disease in children and adolescents such as hypertension, obesity, overweight, diabetes mellitus and high lipid profiles[3,4].

Of all the preventable factors contributing to the high incidence of cardiovascular and metabolic dysfunction among children and adolescents, physical inactivity (PI) and unhealthy eating habits, leading to faltered body composition characteristics such as obesity and excessive body weight, have become increasingly rampant in many countries. This trend has been reported in studies carried out on children and adolescents in a number of developing countries such as Brazil[5], China[6], Nigeria[7,8], Spain[9], Canada, Mexico and Kenya[10] and South Africa[11,12]. In the South African study, Amusa *et al.*[12] evaluated health-related fitness among rural primary school children in Tshannda, and reported low fitness level among the children. In another study carried out in Alexandra Township in Johannesburg, South Africa, Draper *et al.*[13] emphasised the need for school-based physical activity intervention in promoting children's fitness level.

Regular participation in PA is important in childhood and adolescence, not only in terms of its associated health benefits, but also considering the plausibility that it promotes the development of positive attitudes towards healthy lifestyles which may form the basis for inculcating good health practices. PA is associated with healthy growth and development in children and is important in preventing excessive body weight and its concomitant comorbidities[14]. However, contemporary research evidence suggests that obese and overweight children and adolescents are less physically active than their non-obese peers and spend more time in sedentary pursuits like prolonged TV viewing and habitual use of computer-assisted devices like video games, mobile phone tweeting and chatting, Internet browsing and other forms of social media[15,16].

Over the years, many nutrition studies and heath policies in developing countries[17,18] have focused on poverty and nutritional disorders in children and youth. Recent investigations have however, shown that obesity is fast becoming a major nutritionally related disease in the developing world[17,19,20]. A common explanation for this trend in many developing countries is the advent of nutrition transition facilitated by the impact of Westernization and reduced PA participation.

A national study conducted by Reddy *et al*.[21] among South African adolescents concluded that 54.3% had physical education (PE) classes on their school time table and only 52.8% engaged in school-based vigorous physical activity (PA). After independence in 1994, the South African government undertook drastic education policy changes leading to the introduction of Life Orientation (LO) as a school subject which replaced PE. In the new curriculum, PE is subsumed under LO and regarded as *physical development and movement* (PDM), alongside other LO components, i.e. *personal development, social development, and health promotion*. Consequently, the teaching of PE was stifled in terms of restricted statutory time allocation, very limited or non-existent resources, and poor teacher preparation[22]. This development created an undesirable situation in which children, especially those in public schools, are provided limited opportunity to engage in wholesome PA. It is therefore, not surprising why recent studies have reported a growing trend of overweight and obesity among South African children[11,23,24].

Effective intervention strategies targeted at preventing obesity and overweight in children require a multidimensional approach in which their body composition, PA and fitness level are evaluated. Most recent studies on South African children evaluated either their body composition and/or fitness levels[11,12,25]. Very few studies[24], if any, have investigated the relationship between the children's PA and PI status regarding their body composition and health-related fitness status. Such findings would provide reliable data for designing appropriate intervention strategies and health promotion policies.

Therefore, the primary objective of this study was to evaluate the body composition, health-related fitness and PA among adolescent learners in Dr Kenneth Kaunda District Municipality, Potchefstroom, South Africa. A secondary objective of this study was to examine the relationship between the children's PA status, their body composition and fitness parameters.

METHODS

This study is part of a larger study, i.e. Physical Activity and Health Longitudinal Study (PAHLS). Therefore, the methods used for data collection are essentially the same as those used in the larger study. These have been published previously[24] and duly acknowledged.

Design

The PAHLS is a mixed longitudinal survey designed to evaluate the development of PA, determinants of health risk and factors affecting participation in sport and recreational activities among 14-year old high school students in the Tlokwe local Municipality area of Dr Kenneth Kaunda District Municipality which is located near Potchefstroom, the capital city of North West Province, South Africa. For the purpose of this study, analyses of findings from the cross-sectional measurements are presented.

Participants

A total of 283 boys (n=111) and girls (n=172), aged 14 years who were purposefully drawn from six secondary schools in Tlokwe Local Municipality, which granted permission to carried out the research, participated in the study. The participants provided demographic information in terms gender, race and school-based locality (i.e. town or township). School-based locality comprised four schools from town and four others located in economically deprived township areas. Therefore, the schools were regarded as predominantly comprising learners with low (Ikageng township) and high socioeconomic (Potchefstroom town) backgrounds. The South African Department of Education categorises schools in quintiles (1-5) according to physical condition, facilities and crowding and the relative poverty of the community around the schools[26]. Out of the eight schools initially selected, two urban schools declined to participate in the study. Detailed information regarding the participants[23] and methods of data collection have been published elsewhere[24].

Anthropometric measurements

The participants' height, body weight, skinfold thickness (triceps and subscapular skinfolds), and waist and hip circumferences (WC and HC) were measured using the protocol of the International Society for the Advancement of Kinanthropometry (ISAK)[27]. Waist-to-hip ratio (WHR) and body mass index (BMI) were calculated as waist (cm)/hip (cm) and mass/stature^2 (kg.m^2), respectively. Subsequently, age-specific BMI for children was used to determine the following categories: overweight, normal weight and underweight/thinness[28,29]. Percentage body fat was calculated from skinfold measurements using Slaughter *et al*.'s[30] equation which is internationally acceptable for use in children and adolescents from different settings.

Health-related physical fitness measurements

The participants' health-related physical fitness status was determined by assessing their cardiorespiratory endurance, muscle strength and endurance, and flexibility using standardised techniques[31,32]. Cardiovascular endurance was assessed with the 20-metre multistage shuttle run test which is a valid measure of aerobic capacity in adolescents[33]. The following health-related fitness test items were measured according to the EUROFIT[32] test protocol: sit-and-reach (SAR) (a test of hamstring flexibility, expressed in centimetres); sit-up (SUP) (a measure of abdominal strength and endurance, determined by correctly performed sit-ups in 30 seconds); standing broad jump (SBJ) (a test of explosive strength of leg extensors measured in centimetres), and bent arm hang (BAH) (which measures functional arm and shoulder muscular endurance to exhaustion in seconds).

Measurement of physical activity

PA was assessed with the short form of the International Physical Activity Questionnaire (IPAQ)[4,34,35], which is a valid and reliable tool for estimating PA[36]. IPAQ is considered suitable for use by adolescents at different settings[35]. The short form of the IPAQ 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 or idling, which is used as an indicator of inactivity.

Measurement procedures

Before data collection, permission to conduct the measurements was granted by the District Manager of the Department of Basic Education in Potchefstroom, North-West Province. Clearance was also received from the Ethics Committee of North-West University, Potchefstroom Campus (Ethics no: NWU-0058-01-A1). The participating schools were briefed about the purpose of the study, and informed consent forms were signed by the school authorities as well as the learners and their parents. To minimise loss of interest and fatigue among the participants and prevent disruption of teaching and learning activities at the schools, data was collected on days agreed by the participating schools. Only the data of learners who were 14 years old at the time of testing were analysed.

Before the anthropometric and health-related fitness measurements were carried out, the IPAQ was administered to the participants who were assembled in a classroom, under the supervision of the principal investigator. In completing the IPAQ, adequate instructions and clarifications, with no set time limit for completion, were given to the students who subsequently filled the questionnaires independently, i.e. without interference from fellow classmates. The physical and physiological variables were measured in the following order: anthropometry, health-related fitness, gross and fine motor fitness. All anthropometric sites were measured twice by Level 2 ISAK certified Anthropometrists according to standardised procedures.

Data analyses

The cross-sectional data on the children's health-related fitness, body composition and PA were analysed using descriptive statistics, such as means and standard deviations. Independent *t*-tests were computed to determine age and sex differences in the variables among the children. A non-parametric t-test was used to examine significant differences between two ordinal variables, and the Mann-Whitney U test to evaluate possible disparity between the categorical variables. The body composition indicators were inter-correlated with the Pearson product moment method, corrected for race and locality. To further examine the relationships between the independent and dependent measures, linear regression analyses corrected for gender, race and locality were computed. If a significant interaction with gender was established, separate coefficients were reported for boys and girls separately. All data analyses were performed with the Statistical Package for the Social Sciences (SPSS), Version 20.0 programme[37]. A probability level of 0.05 or less was taken to indicate significance.

RESULTS

Table I provides the anthropometric and body composition data of the school boys and girls. On average, the boys (165.41±9.55cm) were taller than the girls (157.88±6.94cm) ($p<.001$), who in turn were substantially fatter (26.01±8.51%) than the boys (13.19±8.56%) ($p<0.001$). The results on body fat percentage are also consistent with those obtained for the skinfold measurements in which the girls generally had significantly higher values ($p<0.05$). The girls also had significantly higher mean BMI (21.43±4.37kg.m^{-2}) and HC (92.54±9.81cm) than the boys (BMI: 20.01±3.71 kg.m^{-2}; HC: 85.29±9.41cm). However, the boys had substantially higher mean WHR (0.80±0.3) than the girls (0.73±0.04) ($p<0.001$).

Presented in Figure 1 is the distribution of boys' BMI categories in which 17.1% are overweight. A higher proportion of the girls (32.4%) were overweight, while 26.4% were underweight (Figure 2) in contrast to the boys (34.2%).

Table-I: Sex differences in adolescents' anthropometric and body composition characteristics.

Variables	*Males (n=111)*		*Females (n=172)*		*p-values*
	Mean	*SD*	*Mean*	*SD*	
Age	14.90	0.72	14.88	0.82	0.88
Stature (cm)	165.41	9.55	157.88	6.94	0.00
Body weight (kg)	55.30	13.77	53.70	12.86	0.29
BMI (kg.m^{-2})	20.01	3.71	21.43	4.37	0.00
Triceps skinfolds (mm)	9.98	5.08	17.52	6.82	0.00
Subscapular skinfolds (mm)	8.83	4.69	14.02	8.09	0.00
Sum of skinfolds	18.81	9.49	31.54	14.20	0.00
% Body fat	13.19	8.56	26.01	8.51	0.00
Waist circumference (WC) (cm)	68.11	8.29	67.62	8.67	0.51
Hip circumference (cm)	85.29	9.41	92.54	9.81	0.00
Waist-to-hip ratio (WHR)	0.80	0.3	0.73	0.04	0.00

SD = standard deviation; $p<0.05$

Shown in Table II are summary data indicating sex differences in the adolescents' health-related fitness characteristics. Except flexibility measured by the SAR test in which the girls (48.51±7.34cm) performed significantly better than the boys (42.22±9.12cm) ($p<0.05$), the boys' health-related fitness performances were substantially superior to those of the girls, specifically regarding SBJ, BAH, SUP and VO_2max ($p<0.001$). For the total group normal (26%); underweight (29.1%); and overweight 26%.

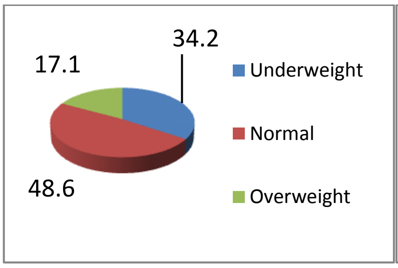

Figure 1 Distributions of boys BMI categories (%)

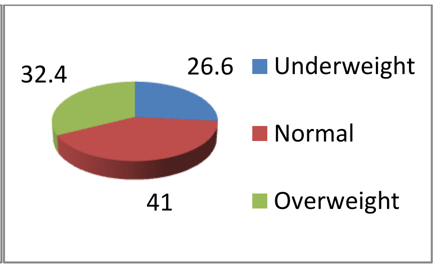

Figure 2 Distribution of girls' BMI categories (%)

Table-II: Sex differences in adolescents' health-related physical fitness data.

Physical activity	*Males*		*Females*		*p-values*
	Mean	*SD*	*Mean*	*SD*	
SBJ (cm)	186.04	26.07	147.93	19.99	0.00
BAH (sec.)	18.22	13.53	4.03	5.48	0.00
SUP (no/30secs.)	35.44	6.97	23.43	10.17	0.00
SAR (cm)	42.22	9.12	48.51	7.34	0.00
20m multistage shuttle run	7.94	2.01	4.56	1.54	0.00
VO_2max (ml/kg.min^{-1})	40.10	6.89	28.33	5.11	0.00

SD = standard deviation; $p<0.05$

Summarised in Table III is data concerning the percentage scores of the duration of daily TV viewing by the total group of students. A breakdown of similar data by sex category is presented in Table IV. In general, 51(18%) of the students watched TV for three hours or longer daily. Of these, 18(16%) boys and 33(19%) girls watched TV for longer than 3 hours daily. Also striking is the fact that 23% (65) of the adolescents watched TV 2-3 hours daily.

Table-III: Percentage scores of TV viewing for total group

Percentage score of TV viewing	*N*	*%*
TV Viewing (0-1hour)	112	40.0
TV Viewing (2-3hours)	65	23.0
TV Viewing (>3hours)	51	18.0
Do not know	55	19.0
Total	283	100

n= number of participants; % = percentage

Table-IV: Percentage scores (%) of TV viewing for boys and girls

Percentage score of TV viewing	*Boys*		*Girls*	
	N	*%*	*n*	*%*
TV Viewing 0-1hour	42	38.0	76	44.0
TV Viewing 2-3hours	29	26.0	36	21.0
TV Viewing >3hours	18	16.0	33	19.0
Do not know	22	20.0	28	16.0
Total	111	100	172	100

n= number of participants; % = percentage

In order to examine the inter-relationships among the adolescents' anthropometric and body composition variables, multiple correlation coefficients were calculated and the results provided in Table V. In the analysis the correlations were adjusted for race and locality.

Table-V: Correlation matrix of the body composition variables for boys and girls (left/bottom)*

	SSKF	*%BF*	*BMI*	*WHR*
SSKF	-	.97	.83	.09
%BF	.97	-	.78	.22
BMI	.83	.78	-	.07
WHR	.09	.22	.07	-

*All correlation coefficients are adjusted for race and locality; SSKF= Sum of 2 skinfolds; %BF= Percentage body fat; BMI= Body mass index; WHR= waist to hip ratio

As expected, strong positive associations were found between SSKF, %BF and BMI; ranging from 0.78-0.97 ($p<0.001$). In contrast, WHR poorly correlated with BMI, SSKF and %BF, yielding Pearson's coefficients of 0.07, 0.09 and 0.22, respectively.

It was also of interest to this study to examine the extent to which the participants' body composition measures could account for their health-related fitness and PA status. Consequently, a series of linear regression analyses were undertaken. The results of the regression analyses are provided in Tables VI and VII respectively. The analyses were also controlled for gender, race and locality. In the analyses the health-related fitness data was regressed on the adolescent students' BMI and %BF scores.

Regardless of whether or not the regression coefficients were adjusted for sex, race and locality, the participants' BMI negatively predicted their health-related fitness ($p<0.001$), meaning that those with higher BMI values consistently performed poorly in the health-related fitness tests.

Inverse relationships were found between BMI and the health-related fitness items of SBJ and BAH. Furthermore, BMI negatively associated with SAR and endurance performance, especially in girls. Percentage body fat was negatively related to SBJ, BAH, SAR and endurance performance.

Table-VI: Regression analyses predicting adolescents' health-related fitness from their body composition measures at 95% confidence interval (CI)

	Crude	*Adjusted for gender*	*Adjusted for race*	*Adjusted for locality*
BMI:				
SBJ (cm)	-0.04(-0.055; -0.02)p=0.00	-0.04 (-0.06; -0.02)p=0.00	-0.04(-0.5; 0.02)p=0.00	-0.04(-0.06; -0.02)p=0.00
BAH (sec.)	-0.07(-0.12; -0.03)p=0.00	-0.08(-0.13; -0.02)p=0.00	-0.09(-0.14; -0.05)p=0.00	-0.09(-0.14; -0.05)p=0.00
SUP (no/30secs.)	-0.02(-0.07; 0.03)p=0.36	0.01(-0.06; 0.07)p=0.79	-0.05(-0.11; 0.00)p=0.05	-0.05(-0.10; 0.00)p=0.06
SAR (cm)	-0. 06(-0.12; 0.00)p=0.05	-0.10(-0.16; -0.04)p=0.001	-0.02(-0.09; 0.04)p=0.45	-0.03(-0.09; 0.03)p=0.38
		B= -0.07(-0.17; -0.02)p=0.02		
		G= -0.11(-0.20; -0.01)p=0.02		
VO_2max (ml/kg.min^{-1})	-0.15(-0.21; -0.09)p=0.00	-0.24(-0.34; -0.15)p=0.00	-0.17(-0.21; -0.11)p=0.00	-0.17(-0.23; -0.10)p=0.00
		B= -0.20(-0.31; -0.09)p=0.001		
		G= -0.29(-0.44; -0.15)p=0.00		
%BF:				
SBJ (cm)	-0.21(-0.25; -0.17)p=0.00	-0.13(-0.17; -0.08)p=0.00	-0.21(-0.25; -0.18)p=0.00	-0.21(-0.25; -0.18)p=0.00
		B= -0.10(-0.16; -0.04)p=0.00		
		G= -0.15(-0.21; 0.08)p=0.00		
BAH (sec.)	-0.44(-0.54; -0.35)p=0.00	-0.23(-0.33; -0.12)p=0.00	-0.49(-0.58; -0.39)p=0.00	-0.49(-0.59; -0.40)p=0.00
		B= -0.18(-0.30; -0.07)p=0.00		
		G= -0.37(-0.61; -0.14)p=0.002		
SUP (no/30secs.)	-0.35(-0.46; -0.23)p=0.00	-0.06(-0.18; 0.06)p=0.33	-0.46(-0.59; -0.33)p=0.00	-0.46(-0.58; -0.33)p=0.00
SAR (cm)	0.13(-0.03; 0.28)p=0.12	-0.24(-0.37; -0.12)p=0.00	0.12(-0.04; 0.28)p=0.14	0.13(-0.03; 0.28)p=0.12
		B= -0.25(-0.42; -0.07)p=0.01		
		G= -0.24(-0.42; -0.06)p=0.01		
VO_2max (ml/kg.min^{-1})	-0.83(-0.96; -0.70)p=0.00	-0.68(-0.87; -0.49)p=0.00	-0.88(-1.01; -0.74)p=0.00	-0.87(-0.99; -0.73)p=0.00
		B= -0.65(-0.91; -0.40)p=0.00		
		G= -0.71(-0.99; -0.42)p=0.00		

BMI= body mass index; %BF= percentage body fat; SBJ= standing broad jump; BAH= bent arm hang; SUP= sit-ups; SAR= sit and reach; B= boys; G= girls; B=black; W= white; $p<0.05$.

Table-VII: Standardised regression coefficients (b) and p values from the regression analysis relating body composition and total physical activity for three categories of PA[#]

Variable	*B*	*p-values*
BMI:		
Low PA	0.024	0.83
Moderate PA	0.098	0.39
High PA	-0.065	0.52
%BF:		
Low PA	0.014	0.85
Moderate PA	0.011	0.48
High PA	0.010	0.90

[#]Controlled for gender, race and locality.

Results of standardised regression coefficients relating the adolescent students' body composition measures to their PA categories are presented in Table 7. In general, results yielded very low and non-significant regression coefficients, suggesting a poor association between the students' BMI and %BF data and their PA categories. In total, BMI accounted for 2.4, 9.8 and 0.6% of the variance in the students' PA status, respectively. Corresponding values for %BF were 1.4, 1.1 and 1.0%.

DISCUSSION

In this study, an attempt was made to quantify the relationship between the body composition, PA and physical fitness among South African children. Consistent with previous research on South African children[11,12,24], this study also indicated high incidence of overweight (26%) with girls mostly affected (32.4%). Additionally, overweight was negatively associated with health-related physical fitness and hence reflected a low level of physical activity.

The present results show that the body composition measures of BMI and %body fat negatively affected physical fitness performance for items in which the body is projected in space as well as flexibility and endurance running performance. These findings are congruent with those of previous studies which reported that excessive fatness is associated with poor fitness performance[17,23,38,39].

Several studies conducted in South Africa have suggested that the relatively high prevalence of obesity may be partly attributed to a decline in habitual PA, and an increase in PI and sedentary lifestyles, which are often associated with increasing urbanisation and improved socioeconomic status in households[21,40,41,42]. Other studies have also shown that children with lower levels of lean body mass and higher BMI spend more time watching television or using computers, instead of engaging in PA, sports or play[41,43]. Similar findings were also obtained in the present study in which South African children admitted spending on average more than 3 hours weekly on TV viewing. A study among rural Ellisras children[17], reported high PA levels and attributed this to the fact that regular walking is the primary mode of transportation because of the lack of resources to pay for commercial transportation.

Children today are thought to be less physically active than in previous generations. This perception is based on the increased prevalence of overweight and obesity seen from early age[44,45,46] as well as the drastic increase in the time that children devote to sedentary activities in recent decades[47]. Therefore, epidemiological studies have consistently shown a decline in PA from childhood through adolescence and into adulthood[45,48]. The fact that PE is not taught as a separate subject in South African public schools has also exacerbated the incidence of PI among children and adolescents.

Interviews with educators and schools suggested that the decision to remove specialist Physical Educators from schools and integrate PDM into the LO curriculum was a major contributory factor to the decline in PA among South African school children[49]. While it can be argued that the decision makes theoretical sense in terms of achieving stated learning outcomes; it did not factor in the lack of expertise in LO educators, resources needed for effective teaching such as equipment and learning materials, and the growing class numbers which make it difficult to control learners outside of the classroom.

Results of the present study showed that except for flexibility, the boys had superior fitness performances than the girls, who in turn were fatter and heavier on average. The findings were also supported by the results of the correlation and regression analyses in which the indices of fatness and heaviness were consistently negatively related to PA and health-related fitness. A number of studies have shown that PA contributes to normal growth and development as well as health and well-being across the lifespan[14,39]. It should be noted however, that during the first five years of life, changes in health and motor-related fitness are influenced by growth and maturation[14,39] and as such, it is difficult to isolate the effects of specific aspects of regular PA on health and fitness status from inherent adjustments in growth and development during childhood[14]. Meredith *et al*.[50] further alluded to the fact that during childhood and adolescence, nutrition and PA influence the growth and development of numerous body tissues, including body fat, skeletal muscle tissue and bone. Although nutrition could play an important role in determining the relationship between PA, health-related fitness and body composition among children, this aspect was beyond the scope of our study.

Importantly, the number of key periods and points of transition during childhood and adolescence and the crucial role of PA need to be highlighted[14]. The periods include early childhood years, the commencement of formal schooling, the transition from primary or secondary school, and higher education or workforce[14,16,51]. It should be borne in mind that there may be times in these periods when the PA patterns of some young people change considerably and when they may not be sufficiently physically active to gain health benefits (Hills *et al*. 2007). The consequences thereof are that insufficient PA at these transitional periods during growth may contribute significantly to overweight and obesity.

Limitations

The study's findings should be interpreted based on the following limitations: Firstly, given the small sample size, it was difficult to analyse the results by race even though the research project catered for the racial distributions of the study area[52]. Secondly, the present findings cannot be generalised to the entire population of adolescents in South Africa since the study was carried out in the Tlokwe Local Municipality of the North-West Province. Finally, dietary factor may have affected the results one way or the other, but unfortunately dietary influence was not investigated in the present study.

Conclusions

In conclusion, the girls in the study were more overweight and less active than the boys. Furthermore, the adolescents viewed TV more than 3hrs daily with girls mostly affected. It was also apparent that excessive fatness negatively affected health-related physical fitness of the children in the study. Based on these conclusions the study therefore recommends that school and community-based PA intervention strategies are needed that are designed to promote physically active lifestyles among children and adolescents. A sustainable way in which this can be achieved is to implement well-structured and supervised school PE programmes that will provide ample opportunity for children to participate in wholesome PA.

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Disclaimer

Any opinion, findings and conclusions or recommendations expressed in this material are those of the authors and therefore the NRF and MRC do not accept any liability in this regard.

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CHAPTER 5: LONGITUDINAL RELATIONSHIP BETWEEN HEALTH-RELATED FITNESS, PHYSICAL ACTIVITY AND BODY COMPOSITION STATUS AMONG ADOLESCENTS: THE PAHL STUDY

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Longitudinal health-related fitness, anthropometry and body composition status among adolescents: The PAHL Study

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Abstract

The aim of this study was to evaluate the longitudinal development of health-related fitness, anthropometry and body composition status among adolescents in the Tlokwe Municipality, Potchefstroom, South Africa. A total of 283 (111 boys and 172 girls) aged 15 whom are part of the on-going Physical Activity and Health Longitudinal Study (PAHLS) are the participants in the study. For the purpose of this study the data for 2011 and 2012 for the anthropometric, body composition and health-related physical fitness were used. BMI classification of boys and girls for 2011 and 2012 showed that 24.3% of them were underweight compared to 21% in 2012. In 2011, 50% of boys and girls had normal body weight compared to 52% in 2012, while 25.5% of the total group of participants were overweight (BMI classification in 2011) compared to 27% in 2012. Regression coefficients showed that changes in BMI were inversely associated with those in health-related physical fitness. The changes in %BF was negatively associated with SBJ, BAH and VO_2max in both boys and girls. A low significant positive association was found between changes in WHtR and SBJ in both genders, while inverse low associations were found between WHtR and BAH in girls and for VO_2max in both genders. The health implications of the observed findings are discussed and recommendations proffered for physical activity intervention in school PE programmes.

Keywords: Health-related physical fitness, physical activity, body composition, longitudinal relationship, adolescents.

Introduction

Childhood obesity has become a major public health concern in the new millennium (Ademola & Monday, 2013) and is one of the most important risk factors of non-communicable diseases in both developed and developing countries (Bishwalata *et al*., 2012). The prevalence of underweight, overweight and obesity in youth has resulted to an increased mortality rate worldwide (Hands, 2009; Artero *et al*., 2010). Therefore, it is very important to understand the trends in development of body weight disorders in the youth and its negative effect on overall health (Monyeki *et al*., 2012).

According to the World Health Organization (WHO), physical inactivity is one of the fastest growing risk factors of non-communicable diseases (WHO, 2009). For instance, WHO (2010) reported that the numbers of children who are overweight below the age of five were estimated to be at least 42 million worldwide (WHO, 2011). Furthermore, obesity and overweight have been found to be major contributors to the risk factors of cardiovascular disease among children and adolescents (Trembley & Williams, 2003; Toriola & Monyeki, 2012). Measured in terms of body mass index (BMI) and percentage body fat (%BF), obesity is found to be negatively associated with performance tasks in which the body is projected through space such as standing broad jump, and the tasks for which the body has to be lifted in space, such as bent arm hang and sit-ups (Monyeki *et al*., 2005).

From early childhood, a sedentary lifestyle and poor health-related fitness lead to undesirable health consequences (Pahkala *et al*., 2013), including imbalances in body composition. Therefore, the increasing prevalence of childhood overweight and obesity over the past decades raises a lot of concern (Pahkala *et al*., 2013). Among the detrimental consequences of childhood overweight on current and future health, are that children and adolescents who are overweight have very low levels of fitness compared to those who are slimmer (Kriemler *et al*., 2008; Ortega *et al*., 2008). Overweight may also lead to inactivity and not be the result of it (Metcalf *et al*., 2011).

Over-consumption of food that is very rich in high-caloric diet, and physical inactivity, worsened by prolonged TV viewing, use of social media and playing computer video games, have also been identified as major contributory factors to the high incidence of overweight and obesity among children and adolescents (Toriola & Monyeki, 2012). Wiecha *et al*.

(2004) reported that the prevalence of overweight children and adolescents has increased between 1976 and 1994 to 13%, is continuously increasing, and reached about 15.5% in 2000. Furthermore, it was revealed that majority of youths affected were living in developing nations. The rate at which children in this region consume fatty food is alarming (Ademola & Monday, 2013). For instance, WHO asserted that the consumption of too much unprocessed food leads to the accumulation of fats and a high body mass index (BMI) causing overweight and finally leading to obesity (WHO, 2011).

From an epidemiological standpoint, obesity, is associated with physical inactivity and is assumed to be the outcome of several risk factors during childhood and adolescence (Kovacs *et al*., 2009). Hence the need for strategic intervention to stem the menace of overweight and physical inactivity in children is imperative (Monyeki *et al*., 2012).

In view of the link between physical activity, physical fitness and body composition in children, it is important to gain a comprehensive understanding of the relationship using prospective design so that appropriate intervention strategies can be implemented. However, very little epidemiological research exists examining such longitudinal trends (Kristensen, 2008; Nelson *et al*., 2006).

Also, few previous studies have been conducted which focused on the longitudinal relationship between health-related physical fitness, physical activity and body composition among South African children (Kruger *et al.*, 2004; Monyeki *et al.*, 2007; Amusa *et al.*, 2011). Therefore, the purpose of this study was to evaluate the longitudinal development of health-related fitness, anthropometry and body composition status among adolescents in the Tlokwe Municipality, South Africa.

Methods

Design

This research was part of an on-going Physical Activity and Health Longitudinal Study (PAHLS, Monyeki *et al.*, 2012), which started in 2010 following a mixed longitudinal survey designed to evaluate the development of PA, determinants of health risk and factors affecting participation in sport and recreational activities among 14-year old high school students in the Tlokwe local Municipality area of Dr Kenneth Kaunda District Municipality which is located near Potchefstroom, the capital city of North-West Province, South Africa. For the purpose of this study, analyses of findings from the cross-sectional measurements of 2011 and measurements of 2012 are presented.

Participants

A total of 283 boys (n=111) and girls (n=172), aged 14 years who were purposefully drawn from six secondary schools in the Tlokwe Local Municipality, which granted permission to carry out the research, participated in the study. The participants provided demographic information in terms of gender, race and school-based locality (i.e. town or township). School-based locality comprised four schools from town and four others located in economically deprived township areas. Therefore, the schools were regarded as predominantly comprising learners with low (Ikageng township), and high socioeconomic (Potchefstroom town) backgrounds. The South African Department of Education categorises schools in quintiles (1-5) according to physical condition, facilities and crowding, and the relative poverty of the community around the schools (Department of Education, 2003). Out of the eight schools initially selected, two urban schools declined to participate in the study. Detailed information regarding the participants (Monyeki *et al.*, 2012) and methods of data collection have been published elsewhere (Toriola & Monyeki, 2012).

Anthropometric measurements

The participants' height, body weight, skinfold thickness (triceps and subscapular skinfolds), and waist and hip circumferences (WC and HC) were measured using the protocol of the International Society for the Advancement of Kinanthropometry (ISAK) (Marfell-Jones *et al.*, 2006). Waist-to-hip ratio (WHtR) and body mass index (BMI) were calculated as waist (cm)/hip (cm) and mass/stature^2 (kg.m^{-2}), respectively. Subsequently, age-specific BMI for children was used to determine the following categories: overweight, normal weight and underweight/thinness (Cole *et al.*, 2006). Percentage body fat was calculated from skinfold measurements using Slaughter *et al.'s* (1988) equation which is internationally acceptable for use in children and adolescents from different settings.

Health-related physical fitness measurements

The participants' health-related physical fitness status was determined by assessing their cardiorespiratory endurance, muscle strength and endurance, and flexibility, using standardised techniques (Australian Sports Commission, 1999; EUROFIT, 1988). Cardiovascular endurance was assessed with the 20-metre multistage shuttle run test which is a valid measure of aerobic capacity in adolescents (Davis, 2006). The following health-related fitness test items were measured according to the EUROFIT (1988) test protocol: sit-and-reach (SAR) (a test of hamstring flexibility, expressed in centimetres); sit-up (SU) (a measure of abdominal strength and endurance, determined by correctly performed sit-ups in 30 seconds); standing broad-jump (SBJ) (a test of explosive strength of leg extensors measured in centimetres), and bent-arm hang (BAH) (which measures functional arm and shoulder muscular endurance to exhaustion in seconds).

Measurement procedures

Before data collection, permission to conduct the measurements was granted by the District Manager of the Department of Basic Education in Potchefstroom, North-West Province. Clearance was also received from the Ethics Committee of North-West University, Potchefstroom Campus (Ethics no: NWU-0058-01-A1). The participating schools were briefed about the purpose of the study, and informed consent forms were signed by the school authorities as well as the learners and their parents. To minimise loss of interest and fatigue among the participants and prevent disruption of teaching and learning activities at the schools, data was collected on days agreed by the participating schools. Only the data of learners who were 14 years old as at the time of testing was analysed (Monyeki *et al.*, 2012).
Before the anthropometric and health-related fitness measurements were carried out, the demographic questionnaire, under the supervision of the principal investigator was completed. The physical and physiological variables were measured in the following order: anthropometry; health-related fitness, gross and fine motor fitness. All anthropometric sites were measured twice by Level 2 ISAK certified anthropometrists according to standardised procedures.

Data analyses

The cross-sectional data on the children's health-related fitness, body composition and PA were analysed using descriptive statistics, such as means and standard deviations. Independent t-tests were computed to determine age and sex differences in the variables among the children. A non-parametric paired t-test was used to examine significant differences between two outcome variables, and a chi-square test to evaluate significant differences. To study the development overtime for the body composition indicators and health-related physical fitness Pearson's product moment correlation coefficients were calculated for the first and second measurements for all outcome variables. To further examine the relationships between the independent and dependent measures, linear regression analyses corrected for gender, race and locality were computed. If a significant interaction with gender was established, separate coefficients were reported for boys and girls separately. All data analyses were performed with Statistical Package for the Social Sciences (SPSS), Version 20.0 programme of 2011. A probability level of 0.05 or less was taken to indicate significance.

Results

Table 1 presents the percentage distribution of the children's BMI categories by year of study, i.e. for both 2011 and 2012. Based on BMI classification of boys and girls over the two-year period, 24.3% of them were underweight with a decrease of 3.3 (21%) in 2012. For 2011, 50% of boys and girls were in the normal weight category with an increase of 2% (52%) in 2012, while 25.5% of the total group of participants was overweight in 2011, thus yielding an overall increase of 1.5% (27%) in 2012.

Table 1: Percentage distribution on BMI categories for total group of participants by year of study

Year	2011 (BOYS & GIRLS)		2012 (BOYS & GIRLS)	
BMI CLASSIFICATION	**FREQ**	**%**	**FREQ**	**%**
Underweight BMI (17&<18.5)	60	24.3	52	21
Normal BMI (18.5 &<25)	124	50.2	128	52
OVW. BMI (>22.62 & 23.34)	63	25.5	66	27
Total	247	100.0	246	100

Presented in Table 2 are data concerning the percentage distribution of BMI by gender for the students in 2011 and 2012.

Table 2: Percentage distribution on BMI of participants by gender for 2011 and 2012

BMI Classification	Year 2011				Year 2012			
	Boys		Girls		Boys		Girls	
	FREQ	%	FREQ	%	FREQ	%	FREQ	%
Underweight BMI (17 &<18.5)	20	23.0	40	25.0	17	19.5	35	21.9
Normal BMI (18.5 &<25)	49	56.3	75	46.9	42	48.3	86	53.8
OVW BMI (>22.62 & 23.34)	18	20.7	45	28.1	28	32.2	38	23.8
Total	87	100.0	160	100	87	100.0	159	99.4

In the measurements of 2011, 23% of the boys were in the underweight category, of which in the second measurements in 2012, a decrease of 3.1% was found. In 2012, underweight for boys had decreased by 3.5%. In the boys, those overweight showed an increase of 11.5%, with a decrease of 3.5% in the underweight category.

Descriptive data by gender differences in the anthropometric and body composition characteristics (male and female in 2011/2012) are provided in Table 3. In 2011, the male participants' mean height was 160.7±9.1cm (n=87) which reveals that they were not significantly taller compared in the mean height of 162.6±9.4cm (n=87) (p>0.117) noted in 2012. For the females in 2012, results showed that they were taller (163.0±9.43cm;n=159) than they were (157.8±7.09cm; n=159) in 2011, but the difference was not significant (p> 0.608). Boys were slightly heavier (57.09±14.17kg; n=87) in the first year than in the second year (57.02±13.4kg; n=87), but the difference was also not statistically significant (p>0.959). However, in the second year girls were heavier (57.33±14.0kg;n=159) than they were in the first year (54.11±13.15kg; n=159), similarly yielding a non-significant difference (p>0.992).

Table 3: Gender differences in the children's anthropometric and body composition characteristics

Variables	Males			Females		
	2011 (n=87)	2012 (n=86)		2011 (n=159)	2012 (n=158)	
	Mean ±SD	Mean ±SD	Mean differences	Mean ±SD	Mean ±SD	Mean differences
Stature (cm)	160.7±10.0	162.6±9.4	1.9	157.8±7.09	163.0±9.43	5.2
Body mass (kg)	57.1±14.17	57.0±13.4	-0.1	54.1±13.15	57.33±14.0	3.2
BMI ($kg.m^{-2}$)	20.53±3.81	21.7±4.56	1.2	21.6±4.45	21.4±4.30	-0.2
%BF	14.44±9.09	20.3±9.36	5.9	26.4±8.61	19.4±9.68	-7
WHR (mm)	0.42±0.04	0.43±0.05	0.01	0.43±0.05	0.42±0.51	-0.01
SBJ (cm)	156.4±26.2	162.5±86.7	6.1	165.7±30.8	159.8±54.7	-5.9
BAH (x/sec.)	8.0±9.38	22.8±12.4	14.8	10.8±12.1	20.4±14.2	9.6
SUP (x/sec.)	29.3±10.7	13.9±15.36	-15.4	28.0±10.46	17.0±14.3	-11
VO_2max.	31.2±7.75	34.15±7.96	2.9	34.6±8.33	34.1±8.56	-0.5
SAR (cm)	44.7±8.64	45.8±8.42	1.9	45.6±8.55	46.1±8.76	0.5

In both series of measurements for boys an increase of 1.9cm in height, 1.2 in BMI and 5.9 %BF with a decrease of 0.1kg in body mass over two years were found. In girls, an increase of 5.2cm in height and 3.2kg in body mass with a decrease of $0.2kgm^{-2}$ in BMI and 7 %BF were found. With regard to health-related physical fitness boys showed an increase of 6.1cm in SBJ, 14.8sec in BAH, 2.9 in VO_2max, 1.9cm in SAR, with a decrease of 15.4 counts in SUP. For girls, an increase of 9.6 seconds in BAH and 0.5cm in SAR with a decrease of 5.9cm in SBJ, 11 counts for SUP and 0.5 VO_2max, were observed.

Table 4: Correlation coefficients for body composition variables over two year measurements

Variables	%BF2	BodyMass2	BMI2	%BF2	∑SKF2	WHtR2
%BF1		.02	-.02	-.06	-.06	-.07
BodyMass1	.02		.86**	.44**	.55**	.70**
BMI1	-.02	.86**		.72**	.81**	.88**
%BF1	-.06	.44**	.72**		.96**	.65**
∑SKF1	-.06	.55**	.81**	.96**		.75**
WHtR1	-.07	.70**	.88**	.65**	.75**	

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

Significantly high correlation coefficients were found for BMI and %BF, sum of skinfolds and WHtR at all measurements points.

Table 5: Correlation coefficients for health-related fitness over two year measurements

Variables	SBJ2	SUP2	BAH2	SAR2	VO_2max2
SBJ1	-.02	.07	.02	.001	.02
BAH1	-.03	.11	-.01	.04	.02
SUP1	.04	.09	.10	-.002	.05
VO_2max1	-.05	.10	-.02	.002	.02
SAR1	-.01	-.06	.04	.13*	.09

**. Correlation is significant at the 0.01 level (2-tailed); *. Correlation is significant at the 0.05 level (2-tailed).

The results also show low non-significant correlation coefficients between health-related physical fitness in the first and second measurements; except for a significant correlation found between SAR at first and second measurements.

Table 6: Age and race adjusted regression coefficients (*b*) and p-values for the relationship of changes in body composition and changes in health-related fitness parameters

			SBJ (cm)		BAH (sec.)		SAR (cm)		SUP		VO_2max	
			ß	p	ß	P	ß	P	ß	p	ß	p
BMI	Boys	Crude	-0.011	0.057	-0.037	0.38	-0.09	0.138	-0.04	0.198	-0.229	0.001
		Adjusted	-0.012	0.56	-0.03	0.51	-0.10	0.155	-0.049	0.163	-0.226	0.002
	Girls	Crude	-0.012	0.05	-0.075	0.002	-0.015	0.72	-0.01	0.696	-0.19	0.000
		Adjusted	-0.12	0.068	-0.08	0.001	-0.008	0.84	-0.01	0.694	-0.197	0.000
%BF	Boys	Crude	-0.03	0.007	-0.229	0.006	0.15	0.566	-0.31	0.000	-.081	0.000
		Adjusted	-0.03	0.01	-0.227	0.01	0.13	0.34	-0.32	0.000	-0.82	0.000
	Girls	Crude	-0.056	0.000	-0.335	0.000	0.03	0.756	-0.22	0.000	-0.899	0.000
		Adjusted	-0.058	0.000	-0.334	0.000	0.03	0.71	-0.23	0.000	-0.88	0.000
WHtR	Boys	Crude	0.00	0.009	0.00	0.34	-0.070	0.589	-0.001	0.067	-0.02	0.00
		Adjusted	0.00	0.008	0.00	0.47	-0.071	0.602	-0.001	0.05	-0.003	0.001
	Girls	Crude	0.00	0.02	-0.001	0.00	-0.070	0.41	0.000	0.44	-0.002	0.00
		Adjusted	0.00	0.028	-0.001	0.00	-0.056	0.52	0.000	0.49	-0.002	0.00

BMI – body mass index, %BF = percentage body fat, WHtR = waist to height ration, SBJ = standing broad jump, BAH= bent arm hang, SUP = sit and reach

Table 6 presents the age-adjusted regression coefficients for the relationship of changes in body composition and the health-related fitness parameters. The changes in BMI were inversely associated with health-related physical fitness. The changes in %BF was negatively associated with SBJ, BAH and VO_2max in both boys and girls. Low significant positive association was found between changes in WHtR and SBJ in both genders, while low inverse associations were found between WHtR and BAH in girls and for VO_2max in both genders.

Discussion

This study was carried out to examine longitudinal development in health-related physical fitness, PA and body composition in South African school children. In general, the results showed a steady decrease in underweight on the one hand while on the other hand, a relative increase in overweight among the boys and girls was observed. In a study on health-related fitness and weight status in Hong Kong adolescents, Mak *et al.* (2010) reported higher body weight characteristics and comparatively poorer age- and gender-specific performance measures than the South African children in this study. However, our study showed an increasing tendency to be fatter and overweight, as indicated in BMI scores of the South African boys and girls over the two-year period. Since many factors affect body composition, it is important that those factors be identified so that preventative measures can be put in place to address them. The outcome of the negative health effects of underweight and obesity is likely to be the development of diseases which emanate from a sedentary lifestyle such as hypertension, cancer and Type II diabetes (Bovet *et al*., 2006; Monyeki *et al.*, 2012; Rivera, Mendoca-Da Silva, Almeida-Silva, Viana-Deoliveria & Camargo-Carvalho, 2009; Lubans *et al.,* 2011) which can considerably reduce children's health-related physical fitness (Rey-Lopez *et al*., 2008).

In this study, significantly high inter-correlations were found for BMI and %BF, sum of skinfolds and WHtR over the two testing sessions. This finding is not surprising as studies have consistently shown that since these variables are all indicators of fatness positive associations among them is to be expected (Katzmarzyk *et al.*, 2013).

It was of particular interest to this study to examine the longitudinal relationship between body composition and fitness performance measures in the South African children. The results showed that changes in BMI and %BF were inversely associated with health-related physical fitness in the boys and girls. Furthermore, significant positive relationships were found between changes in WHtR and SBJ in both genders, with correspondingly low inverse correlations noted between WHtR and BAH in girls, and VO2max in both genders. These results are probably linked to the decrease in physical activity/exercise and work capacity among the children, which consequently reduced their health-related physical fitness performances (Artero *et al*., 2010). Furthermore, Shang *et al*. (2010) reported that overweight and obese youth do not perform well, as was shown by their poor performance in SBJ, and in the 50m sprint and shuttle run, compared with youths of normal weight. This shows that the explosive strength, cardiorespiratory fitness, speed, agility and muscular capability of the youths are progressively reduced due to the excess fat accumulated in the body (Shang *et al*., 2010), which becomes an extra load for them to carry in weight-bearing tasks or whilst performing gross motor skills.

Research has shown that physical fitness is another important issue from a public health perspective (Myers *et al*., 2004; Ortega *et al*., 2008). According to Brunet *et al.* (2007), and Artero *et al*. (2010) who examined whether there is a relationship between weight status and health-related physical fitness in youth, there was a decrease in physical fitness with increasing body mass index (BMI) among children. Although the major influence of fat mass and fat-free mass is still not clear (Artero *et al*., 2010), it should be noted that body composition constitutes an important element of health-related physical fitness and a powerful device that provides specific information on wellness (Monyeki *et al*., 2012).

One factor that could account for the tendency for South African children to develop excess body fat and weight is the fact that they have limited exposure to PA in school. For instance, in the study conducted by Reddy *et al.* (2003), it was reported that among South African adolescents, more than 54.3% have Physical Education (PE) classes written into their school timetable and more than 52.8% engaged in vigorous physical activity during school hours. In spite of this shortcoming, people do not pay attention to PE in the public school system, and many schools are constructed without playgrounds (Reddy *et al*., 2003). In order to stem the rising trend of obesity and physical inactivity in South African children, it is of vital importance that the school system provides children and adolescents ample opportunity to be physically active. The need to design PA intervention programme even in the temporary absence of PE is therefore urgent and expedient.

Limitations of the study

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

1. In view of the longitudinal nature of the study, only a small sample of school children was involved. It was also not feasible to involve more children as the sample was based on the permission granted by the authorities of the schools in which the study was conducted, and caution was taken not to disrupt the children's classes as a result

of their participation in the research. The results may have been different if a larger sample size was used.

2. Since the study was undertaken in six public primary schools in Tlokwe Local Municipality area of the Dr Kenneth Kaunda District Municipality, the findings should not be generalised as reflecting the status of PA, physical fitness and body composition among school children in Tlokwe Municipality and North-West Province as a whole. Such generalisation would require much larger samples that are representative of schools in the province.

Conclusions

Based on the findings it is concluded that changes in BMI, %body fat and WHtR were negatively associated with strength and running performances in the children. The relative increase in overweight, especially in girls, negatively affected their endurance running and static strength performances.

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CHAPTER 6: SUMMARY, CONCLUSIONS & LIMITATIONS

6.1 Summary

Obesity is a leading non-communicable disease (NCD) accounting for millions of deaths globally each year. For example, the World Health Organization (WHO, 2011) indicated that chronic diseases of lifestyle (CDL) accounted for 36 million deaths globally in 2008 with 80% of these deaths occurring in developing countries, and this statistic is projected to rise by 15% in 2020.

In South Africa, it was reported that from 1997 to 2003, 20% of deaths in the 35-64 year age group were a result of chronic lifestyle diseases (Statistics South Africa, 2005). The results of a comparative risk-assessment study regarding factors contributing to deaths in South Africa, showed that high blood pressure and physical inactivity were ranked as the major leading causes of mortality in the country (Norman *et al.*, 2007:710). This is not surprising as there is overwhelming research evidence that the risk factors of cardiovascular and metabolic diseases originate in childhood and adolescence (Martínez-Vizcaíno & Sánchez-López, 2008:110); even in children in economically deprived settings (Coleman *et al.,* 2005:219). The results of large-scale surveillance studies by the Center for Disease Control and Prevention (CDC: 2009) and WHO (2009) have consistently indicated the growing prevalence of risk factors of cardiovascular disease in children and adolescents, such as hypertension, obesity, overweight, diabetes mellitus and high lipid profiles.

Of all the modifiable factors contributing to the high incidence of risk factors of chronic diseases among children and adolescents, physical inactivity and unhealthy eating habits, have become increasingly rampant in many countries. This trend has been reported among children in countries such as Brazil (Andreasi *et al.,* 2010:499), China (Qi-Qiang *et al.,* 2011:111), Nigeria (Goon *et al.,* 2009:510; Musa *et al.,* 2012:1370), Spain (Artero *et al.,* 2010:419), Canada, Mexico and Kenya (Heroux *et al*., 2013) and South Africa (Amusa *et al.,* 2010:222; Jacobs & De Ridder, 2012:43). In the South African study, Amusa *et al*. (2010:223) evaluated health-related fitness among rural primary school children in Tshannda, Limpopo Province and reported a low fitness level among the children. In another study carried out in Alexandra Township in Johannesburg, South Africa, Draper *et al.* (2010:14) emphasised the need for school-based physical activity intervention to promote children's physical fitness.

Regular participation in PA is associated with healthy growth and development in children and is important in preventing excessive body weight and cardiovascular disease (Hills *et al*., 2007:535). However, research evidence indicates that obese and overweight children are less physically active than their non-obese peers and spend more time in sedentary pursuits like prolonged TV viewing and habitual use of computer-assisted devices like video games, mobile phone tweeting and chatting, Internet browsing and other forms of social media (Gordon-Larsen *et al.,* 2002:143; Ford *et al.,* 2012:1140).

For many years, a number of nutrition studies and health policies in developing countries (Jacobs & De Ridder, 2012:44) have focused on poverty and nutritional disorders in children and the youth. Recent investigations have, however, shown that obesity is fast becoming a major nutritionally related disease in the developing world (Monyeki *et al.,* 2005:880; York, 2013:1). This trend is commonly attributed to the impact of nutrition transition facilitated in developing countries by the impact of Westernization and reduced participation in PA.

Against this background this study was carried out to assess the health-related fitness, PA and body composition status by gender among adolescent learners. The study was also aimed to determine the relationship between health-related fitness, PA and body composition status among the learners. Finally, the longitudinal relationship of health-related fitness, PA and body composition status among adolescents in high schools within the Tlokwe Municipality was investigated.

The methodology was based on that used in The Physical Activity and Health Longitudinal Study (PAHLS), which was a mixed longitudinal survey designed to evaluate the development of PA, determinants of health risk and factors affecting participation in sport and recreational activities among 14-year old high school students.

6.2 Conclusions

Based on the results of the study, the following conclusions can be drawn:

1. The results are in line with Hypothesis 1 that significant gender differences in health-related fitness, PA and body composition status among the adolescent learners will be found. As such the results show that the boys had consistently better performances in all the health-related physical fitness tests than the girls. Prevalence of overweight and inactivity was high especially in girls, and excessive fatness negatively affected their fitness performances. More girls than boys watched TV for more than 3 hours daily. A total of 85 (30%), 78(27.5%) and 88(31.1%) of the adolescent students had low, moderate and high PA involvement. The girls were also more overweight and less active than boys. Hypothesis 1, is therefore accepted.

2. Regarding Hypothesis 2, that a significant negative relationship between health-related fitness, PA and body composition status among adolescent students learners would be observed, the results showed inverse relationships between BMI and the health-related fitness items of SBJ and BAH. Furthermore, BMI negatively associated with SAR and endurance performance, especially in girls. Percentage body fat was negatively related to SBJ, BAH, SAR and endurance performance. The observed relationship was not significant between all the measures of body composition and health-related physical fitness. Hypothesis 3 is therefore partially accepted.

3. With regard to Hypothesis 3 the results show that changes in BMI, % body fat and WHtR were negatively associated with the children’s strength and running performances. The relative increase in overweight especially in girls negatively affected the endurance running and static strength performance, thus partially accepting the hypothesis.

6.3 Limitations

The following limitations should be considered in interpreting the findings of this study:

1. The research was conducted over two years, as it is part of The Physical Activity and Health Longitudinal Study (PAHLS), which was a mixed longitudinal survey designed to evaluate the development of PA, determinants of health risk and factors affecting participation in sport and recreational activities among 14-year old high school students. The findings may have been different if the research was carried out over a longer duration as sustainable changes in body composition and health-related physical fitness take a long time to manifest.

2. It is well known that nutrition plays a major role in mediating the influence of PA and physical fitness on the body composition of children. The possible impact of nutrition on the relationship between the children's body composition, PA and physical fitness could therefore, not be determined as it was beyond the scope of this research.

3. In view of the longitudinal nature of the study, only a limited sample of school children was involved. It was also not feasible to recruit more children as the study sample was based on the permission granted by the authority of each school in which the study was conducted, and caution was taken not to disrupt the children's classes as a result of their participation in the research. The results may have been different if a larger sample size was used.

4. Since the study was undertaken in six public primary schools in the Tlokwe Local Municipality area of Dr Kenneth Kaunda District Municipality, the findings should not be generalised as reflecting the status of PA, physical fitness and body composition among school children in the Tlokwe Municipality and North West Province as a whole. Such generalisation would require much larger samples that are representative of schools in the province.

6.4 Recommendations

Based on the findings of the study, the following are recommended:

1. School authorities should provide ample opportunity for children to engage in PA in view of its proven health benefits. This will help to prevent or slow down the increasing prevalence of obesity and its co-morbidities in South African school children.

2. There should be periodic monitoring of body composition, PA, physical fitness status and CDL in school children as this will facilitate early detection of those at risk so that necessary intervention programmes can be designed and implemented.

3. Parents also have an important role to play in promoting children’s participation in PA as they are seen as role models by their children. Fun run or recreation days should be organised on a monthly basis in schools in which parents are invited to participate in physical activities together with teachers and children. Parents should also demonstrate good examples to their children by being physically active.

4. Physical Education (PE) should be re-introduced as a separate subject in the curriculum. If PE is properly resourced and effectively taught, it will provide the right environment and opportunity for children to be physically active and consequently promote the development of positive attitudes towards adopting healthy lifestyles. Rather than emphasise competitive sport participation, which is limited in scope to a few potentially highly skilled children, it is more important epidemiologically to encourage as many children as possible to be physically active for health promotion.

5. In view of the limited prospective research on body composition, PA, and physical fitness in children, future studies are needed to further elucidate the inter-relationships among these variables and provide more evidence to substantiate the impact of physical activity and fitness on children’s body composition, as well as how this is mediated by nutritional status and hormonal changes associated with normal growth and development. More longitudinal studies in this area are therefore needed.

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APPENDICES

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.

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

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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.

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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:

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Manuscripts are accepted for consideration with the understanding that they have not been published elsewhere except in abstract form and are not concurrently under review elsewhere.

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Photo Quiz presents readers with a clinical challenge based on a photograph or other figure. Photo Quiz should include title, presenting the patient or clinical scenario, a question with one correct and three incorrect answers, discussion of correct answer, and short explanation of incorrect answers. Figures should be original images and presenting of references in discussion is mandatory. After acceptance and publishing of paper, this cases is used in journal website. Photo quiz articles are limited to 1,000 words including references.

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Research Article - structured abstract -250 word limit

Short Communication - structured abstract -150 word limit

Case Report - structured abstract -150 word limit

Letter - unstructured - 100 word limit

Regardless of the focus, all abstracts begin with a clearly defined purpose or objective and end with conclusions and implications for research and practice.

A structured abstract organizes information with descriptive headings that begin flush with the left margin. Incomplete sentences are acceptable in a structured abstract for the sake of brevity.

The structured abstract should be organized as Background, Method (no necessary for case reports), Findings (case presentation for case reports) and conclusion(s).

Keywords: 5-7 key words or phases should be provided which should be selected from the body of the text and not duplicate title words. Key words should be provided below the Abstract to assist with indexing of the article.

Introduction: This section should include sufficient background information to set the work in context, describe the issue addressed in the manuscript. The aims of the manuscript should be clearly stated. The introduction should not contain either findings or conclusions.

Subjects and Methods: This should be concise but provide sufficient detail to allow the work to be repeated by others. The basic design of the study and its duration should be described. The methods used should be stated and the statistical data/methods provided.

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Discussion: This should consider the results in relation to any hypotheses advanced in the Introduction and place the study in the context of other works. Only in exceptional cases should the Results and Discussion sections be combined.

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Figure Legends: Legends should be self-explanatory and typed on a separate sheet. The legend should incorporate definitions of any symbols used and all abbreviations and units of measurement should be explained so that the figure and its legend is understandable without reference to the text. (Provide a letter stating copyright authorization if figures have been reproduced from another source).

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APPENDIX B

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25 January 2010

The District Operational Director

Department of Education
North West Province
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REQUEST TO CONDUCT RESEARCH WITHIN YOUR DISTRICT

Dear Sir,

We the researcher from the School of Bio kinetics, Recreation and Sport Science are hereby making a request to conduct research in the district under your authority.

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

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

The above matter background information refers:

1. Permission is requested to conduct research in selected schools in your district as follows:
    1.1. BA Seobi Sec. School
    1.2. Tlokwe High School
    1.3. Resolofetse High School
    1.4. Botokwa High School
    1.5. Potchefstroom High School for Boys
    1.6. Potchefstroom High School for Girls
    1.7. Hoer Volkskool Potchefstroom
    1.8. Potchefstroom Gimnasium School
2. The targeted groups are boys and girls aged 14 years, in essence the grade 8 learners (NB: the proportion will be as follow: in mixed schools, 35 girls and 35 boys; in blacks schools 30 boys and 30 girls will be required).

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

4. Items to be assessed or measured are:

4.1. Demographic information of the selected participants

4.2. Anthropomtric measurements (i.e. body height; weight; skin folds thickness (triceps, sub scapular and calf skin folds), and waist and hip circumferences)

4.3. Maturation (Tanner questionnaire)

4.4. Blood pressure measurement (mercury sphygmomanometer)

4.5. Physical activity questionnaire

4.6. ActiHeart (heart rate recorder with an integrated omnidirectional accelerometer. It is clipped onto two ECG electrodes worn on the chest.)

4.7. Health-related physical fitness (i.e. 20m shuttle run, standing broad jump, sit-and-reach, bent arm hang, sit-ups)

4.8. Social and self-efficacy questionnaire

4.9. Resting metabolic rate (determined by means of a mobile gas analyser)

4.10. Blood sampling (i.e. The participants will be requested to fast overnight (10 hours). A fasting sample of 10 ml blood will be taken from each participant in order to obtain ample blood for the various analyses of the study.)

4.11. Nutritional intake questionnaire.

4.12. Leisure and recreation constraint questionnaires

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

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

Due to the fact that participants will be asked to fast 10 hours without eating breakfast in the morning, therefore sandwiches provision will be made available upon completion of the measurements. The outcomes of this project will benefit the children and the schools with the information regarding the physical activity status and the determinants of health for future.

Hoping for a positive response.

Yours sincerely,

Thank you,

Prof. M. Andries. Monyeki Dr Hanlie Moss

(Principal Investigator, NWU-Potchefstroom) Leader of Niche Area for Physical Activity, Sports and Recreation, NWU-Potchefstroom

APPENDIX C

School of Biokinetics, Recreation and Sport Science
Private Bag x6001,
Potchefstroom
2520
South Africa
Tel: +27 18 299 1790
Fax: +27 18 299 1808
E-mail: andries.monyeki@nwu.ac.za
10 March 2010
http://www.nwu.ac.za

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

Dear Parent or Guardian,

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

My name is Professor Makama Andries Monyeki (from Potchefstroom Campus of the North-West University) principal investigator in the project together with the research team would like to ask your permission to allow your child (or a child under your care) to participate in our study. To give the background of the study, research revealed that physical activity in adolescents is drastically declining. The decline in the level of physical activity of human populations has been observed, and such decline is been associated with increased mechanization, reliance on technology and urbanization, and the high rate of crime in South Africa. Physical inactivity is thought to be one of the main risk factors for the development of obesity, diabetes, cardiovascular disease, osteoporosis and psychological constraints or risks of behavioural health. Therefore, the purpose of this study is to gather information about physical activity (i.e. by questionnaire & ActiHeart rate monitor) and health determinants (i.e. through measurements of anthropometry, maturation, blood pressure measurement, health-related physical fitness, social and self-efficacy questionnaire, resting metabolic rate, oxygen consumption (by the use of a portable gas analyser apparatus), blood sampling, leisure and recreation constraint questionnaires, nutritional intake questionnaire as questionnaire on risk factors of life) over a period of five years (2010–2014).

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

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

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

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

If you have any question regarding this study, please feel free to call me at (018) 2991790 / e-mail:andries.monyeki@nwu.ac.za or the PHASrec Niche Area Leader Dr Hanlie Moss at (018) 2991821 / e-mail:hanlie.moss@nwu.ac.za. If you have any questions regarding your rights or your child's rights as participants in this study you can call Ms Hannekie Botha at (018) 299 4850 from Potchefstroom Campus of the North-West University Research Ethics Office.

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

Sincerely,

Prof. Makama Andries Monyeki

Principal Investigator – PAHLS Study

CONSENT FORM

(Parent/Guardian Copy)

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

I, ..., father/mother/guardian of ....

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

Child's Age:............................
Grade:..........................
Teacher:....................................
School Name:..

Name of Child:...
Name of Parent/Guardian:..

....	....
(Signature of Child)	(Signature of Parent/Guardian)
....	....
(Date)	(Date)

CONSENT FORM (*PAHLS*)
(Return this copy with the demographic questionnaire)

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

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

Child's Age:............................

Grade:...........................

Teacher:.....................................

School Name:..

Name of Child:...

Name of Parent/Guardian:...

....	....
(Signature of Child)	(Signature of Parent/Guardian)
....	....
(Date)	(Date)

APPENDIX D

PAHLS Project - Anthropometry Proforma

Subject number:	

Name: ……………………………………………… Sport: ………………………………

Surname first names

Date of Birth:			
	Day	Month	Year

Test Date:			
	Day	Month	Year

Box height: ....

Gender: M ☐ F ☐

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

Skinfolds	5a	Triceps : R				
(SF)	5b	Triceps : L				
(mm)	6a	Subscapular : R				
	6b	Subscapular : L				
	7a	Biceps : R				
	7b	Biceps : L				

	8a	Supraspinale : R				
	8b	Supraspinale : L				
	9	Abdominal : R				
	10a	Front thigh : R				
	10b	Front thigh : L				
	11a	Medial calf : R				
	11b	Medial calf : L				

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

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

APPENDIX E

PAHLS PHYSICAL FITNESS DATA FORM

NAME OF LEARNER: ____ SUBJECT NO. _______

<table>
<tr><th>TEST COMPONENT</th><th colspan="8">1ST TIME</th></tr>
<tr><td>POLE HEIGHT (CM)</td><td colspan="8"></td></tr>
<tr><td>VERTICAL JUMP REACHING HEIGHT (CM)</td><td colspan="8">A</td></tr>
<tr><td>FINAL VERTICAL JUMP HEIGHT A-B (CM)</td><td colspan="8"></td></tr>
<tr><th>TEST COMPONENT</th><th colspan="3">1ST READING</th><th colspan="3">2ND READING</th><th colspan="2">HIGHEST</th></tr>
<tr><td>VERTICAL JUMP HEIGHT (CM)</td><td colspan="3"></td><td colspan="3"></td><td colspan="2">B</td></tr>
<tr><td>TENDO PEAK POWER (W)</td><td colspan="3"></td><td colspan="3"></td><td colspan="2"></td></tr>
<tr><td>TENDO SPEED (M/SEC)</td><td colspan="3"></td><td colspan="3"></td><td colspan="2"></td></tr>
<tr><th>TEST COMPONENT</th><th colspan="3">1ST READING</th><th colspan="3">2ND READING</th><th colspan="2">HIGHEST</th></tr>
<tr><td>HORIZONTAL JUMP DISTANCE (CM)</td><td colspan="3"></td><td colspan="3"></td><td colspan="2"></td></tr>
<tr><th>TEST COMPONENT</th><th colspan="3">1ST READING</th><th colspan="3">2ND READING</th><th colspan="2">HIGHEST</th></tr>
<tr><td>BASKETBAL THROW DISTANCE (M)</td><td colspan="3"></td><td colspan="3"></td><td colspan="2"></td></tr>
<tr><th>TEST COMPONENT</th><th colspan="3">1ST READING</th><th colspan="3">2ND READING</th><th colspan="2">HIGHEST</th></tr>
<tr><td>L: HAND GRIP STRENGTH (KG)</td><td colspan="3"></td><td colspan="3"></td><td colspan="2"></td></tr>
<tr><td>R: HAND GRIP STRENGTH (KG)</td><td colspan="3"></td><td colspan="3"></td><td colspan="2"></td></tr>
<tr><th>TEST COMPONENT</th><th colspan="8">1ST READING</th></tr>
<tr><td>ABDOMINAL STRENGTH TEST (LEVEL)</td><td>0</td><td>1</td><td>2</td><td>3</td><td>4</td><td>5</td><td>6</td><td>7</td></tr>
<tr><th>TEST COMPONENT</th><th colspan="8">1ST TIME</th></tr>
<tr><td>BENT ARM HANG (SEC)</td><td colspan="8"></td></tr>
<tr><th>TEST COMPONENT</th><th colspan="8">1ST TIME</th></tr>
<tr><td>SIT UPS (REPS)</td><td colspan="8"></td></tr>
<tr><th>TEST COMPONENT</th><th colspan="3">1ST READING</th><th colspan="3">2ND READING</th><th colspan="2">LOWEST</th></tr>
<tr><td>5M SPEED (SEC)</td><td colspan="3"></td><td colspan="3"></td><td colspan="2"></td></tr>
<tr><td>10M SPEED (SEC)</td><td colspan="3"></td><td colspan="3"></td><td colspan="2"></td></tr>
<tr><td>40M SPEED (SEC)</td><td colspan="3"></td><td colspan="3"></td><td colspan="2"></td></tr>
<tr><th>TEST COMPONENT</th><th colspan="3">1ST READING</th><th colspan="3">2ND READING</th><th colspan="2">LOWEST</th></tr>
<tr><td>L: AGILITY 505-TEST (SEC)</td><td colspan="3"></td><td colspan="3"></td><td colspan="2"></td></tr>
<tr><td>R: AGILITY 505-TEST (SEC)</td><td colspan="3"></td><td colspan="3"></td><td colspan="2"></td></tr>
</table>

TEST COMPONENT	1ST READING
GENDER	M / F
BIRTH DATE	year / month / day

20M SHUTTLE RUN

LEVEL	SHUTTLE NUMBER AND HEART RATES															
1	1	2	3	4	5	6	7									
2	1	2	3	4	5	6	7	8								
3	1	2	3	4	5	6	7	8								
4	1	2	3	4	5	6	7	8	9							
5	1	2	3	4	5	6	7	8	9							
6	1	2	3	4	5	6	7	8	9	10						
7	1	2	3	4	5	6	7	8	9	10						
8	1	2	3	4	5	6	7	8	9	10	11					
9	1	2	3	4	5	6	7	8	9	10	11					
10	1	2	3	4	5	6	7	8	9	10	11					
11	1	2	3	4	5	6	7	8	9	10	11	12				
12	1	2	3	4	5	6	7	8	9	10	11	12				
13	1	2	3	4	5	6	7	8	9	10	11	12	13			
14	1	2	3	4	5	6	7	8	9	10	11	12	13			
15	1	2	3	4	5	6	7	8	9	10	11	12	13			
16	1	2	3	4	5	6	7	8	9	10	11	12	13	14		
17	1	2	3	4	5	6	7	8	9	10	11	12	13	14		
18	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	
19	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	
20	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16

TEST COMPONENT	1ST TIME
VO_{2MAX} (ML/KG/MIN) - INDIRECT	
VO_{2MAX} (ML/KG/MIN) - DIRECT	
VE_{MAX} (L/MIN) - DIRECT	
R_{MAX} - DIRECT	
HR_{MAX} (BEATS/MIN) - DIRECT	

APPENDIX F

BIOKINETICS, RECREATION AND SPORT SCIENCE

PHYSICAL ACTIVITY QUESTIONNAIRE (PAHLS-IPAQ)

A: GENERAL INFORMATION ABOUT YOU

School:	
Grade:	
School number:	
Name of the participant:	
Subject number:	
Address:	
Race	

Date of Survey			**Grade**	**Sex (mark with a X)**		**Date of birth**			**Age**
dd	**mm**	**Yy**		**F**	**M**	**dd**	**mm**	**yy**	

We are interested in finding out about the kinds of physical activities that people do as part of their everyday lives. The questions will ask you about the time you spent being physically active in the **last 7 days**. Please answer each question even if you do not consider yourself to be an active person. Please think about the activities you do at school, as part of your house and yard work, to get from place to place, and in your spare time for recreation, exercise or sport.

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

Think about all the **moderate** activities that you did in the **last 7 days**. **Moderate** activities refer to activities that take moderate physical effort and make you breathe somewhat harder than normal. Think only about those physical activities that you did for at least 10 minutes at a time.

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

Think about the time you spent **walking** in the **last 7 days**. This includes at work and at home, walking to travel from place to place, and any other walking that you might do solely for recreation, sport, exercise, or leisure.

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

The last question is about the time you spent **sitting** on weekdays during the **last 7 days**. Include time spent at work, at home, while doing course work and during leisure time. This may include time spent sitting at a desk, visiting friends, reading, or sitting or lying down to watch television.

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.