PHYSICAL FITNESS PROFILE OF PRIMARY SCHOOLCHILDREN FROM LOWER SOCIO-ECONOMIC COMMUNITIES IN PORT ELIZABETH

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Submitted in fulfilment of the requirements for the degree
MASTER OF ARTS (Human Movement Science)
to be awarded at the Nelson Mandela University

April 2018

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In accordance with Rule G5.6.3, I hereby declare that the above-mentioned thesis is my own work and that it has not previously been submitted for assessment to another University or for another qualification.

SIGNATURE

March 2018

DATE

ACKNOWLEDGEMENTS

I would like to acknowledge the contributions of and offer a special thank you to the following individuals and organisations for their support and commitment to this study:

- Firstly, to my creator, in whom my all strength and courage comes from;
- To my family and friends, your prayers and reassurances have enabled me to persevere on this road less travelled;
- To my supervisors, Professor Rosa Du Randt, Professor Cheryl Walter and statistician, Doctor Danie Venter thank you for your guidance, support and advice;
- The staff and learners of the participating DASH schools, thank you for your commitment to the project and to the DASH volunteers, thank you for making the testing period enjoyable with your diligent assistance.
- To the Human Movement Science Department (Nelson Mandela University, South Africa) and the Department of Sport, Exercise and Health (University of Basel, Switzerland), especially to Mrs Shona Ellis, Ms Deirdre Bowers, Professor Uwe Pühse, and Mr Ivan Müller for your unwavering support and guidance on the project.
- To my fellow master's students Thomas Hagar, Stefanie Gall, Dominique Bänninger and other master students on the DASH Study, thank you for your friendships and support;
- To the DASH team, thank you for this opportunity for which I am forever grateful, this research process with all its intricacies has been a life-changing experience;
- To CATHSSETA, Swiss South African Joint Research Programme, DHET, Dormehl Cunningham and Nelson Mandela University for the research funds granted throughout the research process.

TABLE OF CONTENTS

CHAPTER 3

RESEARCH METHODOLOGY

CHAPTER 4

RESULTS

CHAPTER 5

DISCUSSION, CONCLUSION AND RECOMMENDATIONS

LIST OF TABLES

LIST OF FIGURES

LIST OF ACRONYMS

BAZ	BMI-for-age z-score
BF%	Body fat percentage
BMI	Body mass index
CRF	Cardiorespiratory fitness
DASH	Disease Activity and Schoolchildren's Health
GS	Grip strength
HAZ	Height-for-age z-score
HRPF	Health-related physical fitness
MVPA	Moderate-to-vigorous physical fitness
NCD	Non-communicable disease
PA	Physical activity
PE	Physical education
PF	Physical fitness
SAR	Sit-and-reach
SBJ	Standing broad jump
SES	Socio-economic status
SRT	Shuttle run test
WAZ	Weight-for-age z-score
WHO	World Health Organisation

ABSTRACT

The aim of this study was to measure the physical fitness status of primary schoolchildren from lower socio-economic areas in Port Elizabeth, South Africa. A total of 915 schoolchildren (n=462 boys and n=453 girls), aged 8-to-11-years from eight government schools participated in this study. These included four schools from the Northern Areas (previously reserved for Coloured individuals) and four schools from the Township Areas (previously reserved for Black African individuals). Measurements included weight, height, skinfolds, sit-and-reach, grip strength, standing broad jump and the 20 m shuttle run test. Results showed that girls had higher body fat percentage values than boys ($p<.0005$). Children of Black African ethnicity were taller and heavier ($p<.0005$), with higher body fat percentages and body mass index results ($p<.0005$) than Coloured children (excluding the 8-year-old age group). Children attending Northern Areas schools presented with higher frequencies of underweight, stunting and thinness ($p<.0005$), than children from Township Area schools who presented with a higher prevalence of overweight and obesity ($p<.0005$). In relation to physical fitness, boys presented with higher values ($p<.0005$) for all components, except for flexibility; in which girls performed better ($p<.0005$). The composite fitness score revealed that boys, Black African children and children from Township Area schools performed better ($p<.0005$) than Coloured children and children attending Northern Area schools, respectively. Furthermore, children categorised as overweight and obese presented with lower VO_2max values than their thin and normal weight peers. Overall, findings revealed that the physical fitness status of children from these disadvantaged areas were not satisfactory. In addition, distinct geographical and ethnic differences were identified.

Keywords: physical fitness, health-related physical fitness, physical activity, malnutrition.

CHAPTER 1

PROBLEM IDENTIFICATION

1.1 INTRODUCTION

This study investigated the status of physical fitness (PF) and associated anthropometric indicators and nutritional status of Grade 4 learners from marginalised areas in Port Elizabeth, South Africa. This chapter serves as an introduction and contextualises the study by providing the rationale and relevance of the study in the field of schoolchildren's health and fitness. The research aim and objectives are presented, followed by the scope of the study, terminology, significance of the study and an outline of the chapters to follow.

1.2 CONTEXTUALIZATION OF THE STUDY

According to the World Health Organisation (WHO), unhealthy diets and physical inactivity are among the leading causes of major non-communicable diseases (NCD's) such as cardiovascular disease and diabetes (WHO, 2004:2). During childhood, the effects of inactivity and poor PF may not manifest as imminent disease concerns and may go unnoticed. Boreham & Riddoch (2001:919) hypothesised that "adult" chronic diseases can be influenced by poor health behaviours during childhood (especially individuals who are genetically inclined to this). With time, unhealthy behaviours such as physical inactivity and poor nutrition may trigger NCD symptoms. The increased prevalence of symptoms for NCD's and metabolic diseases (obesity, hypertension, hyperinsulinemia, glucose intolerance, and hypertriglyceridemia) during childhood and adolescence indicates the importance of physical activity (PA) and PF (Boreham & Riddoch, 2001:919; Malina & Katzmarzyk, 2006:S295). Regular PA and PF assessments are key health markers in childhood, to ameliorate risk factors associated with NCD's and metabolic diseases (Malina & Katzmarzyk, 2006:S305; Ortega, Ruiz, Castillo & Sjöström, 2008:1; Naidoo & Coopoo, 2012:76). PF testing in children is, therefore, a meaningful indicator of current health status and a predictor of adult health (Plowman, 2005:151).

PA and PF are also recognized as contributing factors for children's growth and development: resulting in beneficial changes to cardiovascular health, musculoskeletal development, neuromuscular awareness and psychosocial health (Strong, Malina, Blimkie, Daniels, Dishman, Gutin, Hergenroeder, Must, Nixon & Pivarnik, 2005:736; Ortega *et al.*, 2008:1; Uys, Bassett, Draper, Micklesfield, Monyeki, de Villiers, Lambert & Group, 2016:S265). PF assessments give an indication of general health and identify whether the child is developing appropriately for their age and in relation to their peers. The importance of researching the status of children's PF is, therefore, justified. The Health of the Nation Study conducted by Armstrong, Lambert & Lambert (2011:1015) reported that the PF characteristics of South African children are still affected by the political history of the country. The disparity between ethnic groups and social classes is still palpable as a result of apartheid (Edginton, Chin, Amusa & Toriola, 2012:435; Walter, 2014:358). Armstrong *et al.* (2011:1015) reported that fitness scores for children of White ethnicity were higher than children of Black African ethnicity (Armstrong *et al.*, 2011:1015). Furthermore, research by McVeigh & Meiring (2014:373) found that White children were more physically active than Black African children.

The status of children's PF may also be influenced by socio-economic circumstances which can contribute to inactivity. Children living in socio-economically deprived communities are often exposed to crime and poor recreational facilities which can hinder opportunities to play freely. Research by McVeigh, Norris & Wet (2004:987) reported that South African children of higher socio-economic status (SES) were mainly of White ethnicity. Research findings showed that White children weighed more and had greater lean tissue than children of lower SES who were mainly of Black African ethnicity (McVeigh *et al.*, 2004:982). Only 30% of Black African children participated in physical education (PE) classes whereas over 90% of White children engaged in PE at school (McVeigh *et al.*, 2004:986). Schools situated in disadvantaged communities were previously marginalised and negatively affected by the impact of the apartheid policies (Rajput & van Deventer, 2010:147-148). At present, disadvantaged schools face various challenges in relation to the implementation of PE. This is due to the absence of qualified teachers, poor facilities and the absence of equipment (Walter, 2014:358). The provision for extra-curricular and community sports opportunities is also lacking in these communities (Rajput & van Deventer, 2010:157; Edginton *et al.*, 2012:436; Walter, 2014:358). The recent 2016 Healthy Active Kids South Africa (HAKSA) Report Card, highlighted inadequate levels of PA generally: children scored a C-grade for PA participation, D-grade for PE and an F-grade for sedentary behaviour (Uys *et al.*, 2016:S265).

The information above emphasises the importance of measuring and monitoring the PF of children. The paucity of research on the PF status of children from socio-economically deprived communities further justifies the need for further studies.

1.3 RESEARCH AIM AND OBJECTIVES

1.3.1 Research aim

The primary aim of this study was to investigate the PF status of primary schoolchildren, aged 8-to-11-years, from eight selected schools situated in lower socio-economic communities in Port Elizabeth.

1.3.2 Research objectives

To successfully achieve the primary aim of this study, the following objectives were addressed:

- To explore, describe and compare the following anthropometric indicators per selected demographics (age, gender, ethnicity, and geographical area): height, body weight, body mass index (BMI), body fat percentage (BF%), weight-for-age (WAZ), height-for-age (HAZ) and BMI-for-age (BAZ) z-scores.
- To explore, describe and compare the following PF components per selected demographics (age, gender, ethnicity, and geographical area): flexibility, muscular strength, and cardiorespiratory fitness (CRF).
- To compare the anthropometric indicators and PF components for the whole group across the eight schools.
- To determine the relationship between CRF and selected anthropometric variables (WAZ, HAZ, BAZ).

1.4 SCOPE OF THE STUDY

The current study formed part of a two-year longitudinal cluster randomised controlled trial which measured ‘the impact of disease burden and setting specific interventions on schoolchildren’s CRF and psycho-social health in Port Elizabeth, South Africa’. It was known as the DASH Study, an acronym for Disease Activity and Schoolchildren's Health. Ethics clearance for the larger study was obtained from the Ethics Commission Northwest and Central Switzerland and the Nelson Mandela University Research Ethics Committee in South Africa. The DASH Study was funded by the Swiss South African Joint Research Programme and consisted of three cross-sectional surveys (baseline (T1), mid (T2) and final (T3) surveys). At each survey time point the disease status, anthropometry, level of PF, cognitive performance, and psycho-social health were measured. The baseline data for anthropometry and PF forms part of the present study. Figure 1.1 below illustrates the timeline for the broader study. The present study was exploratory and descriptive in nature and implemented quantitative research methods. A modified Eurofit test battery was used to assess the health-related PF (HRPF) of children. The aim of the current study was to investigate the PF of primary schoolchildren, aged 8-to-11-years, from eight selected schools situated in lower socio-economic communities within Port Elizabeth. The population relevant to this study included eight selected quintile 3 government (public) primary schools situated in historically disadvantaged areas of Port Elizabeth, South Africa. The sample consisted of 915 (462 boys and 453 girls) Grade 4 schoolchildren that met clear study criteria. The researcher formed part of the DASH team, who collected and analysed the data and was responsible for reporting on the findings obtained during the first survey point for the PF variables and nutritional indicators.

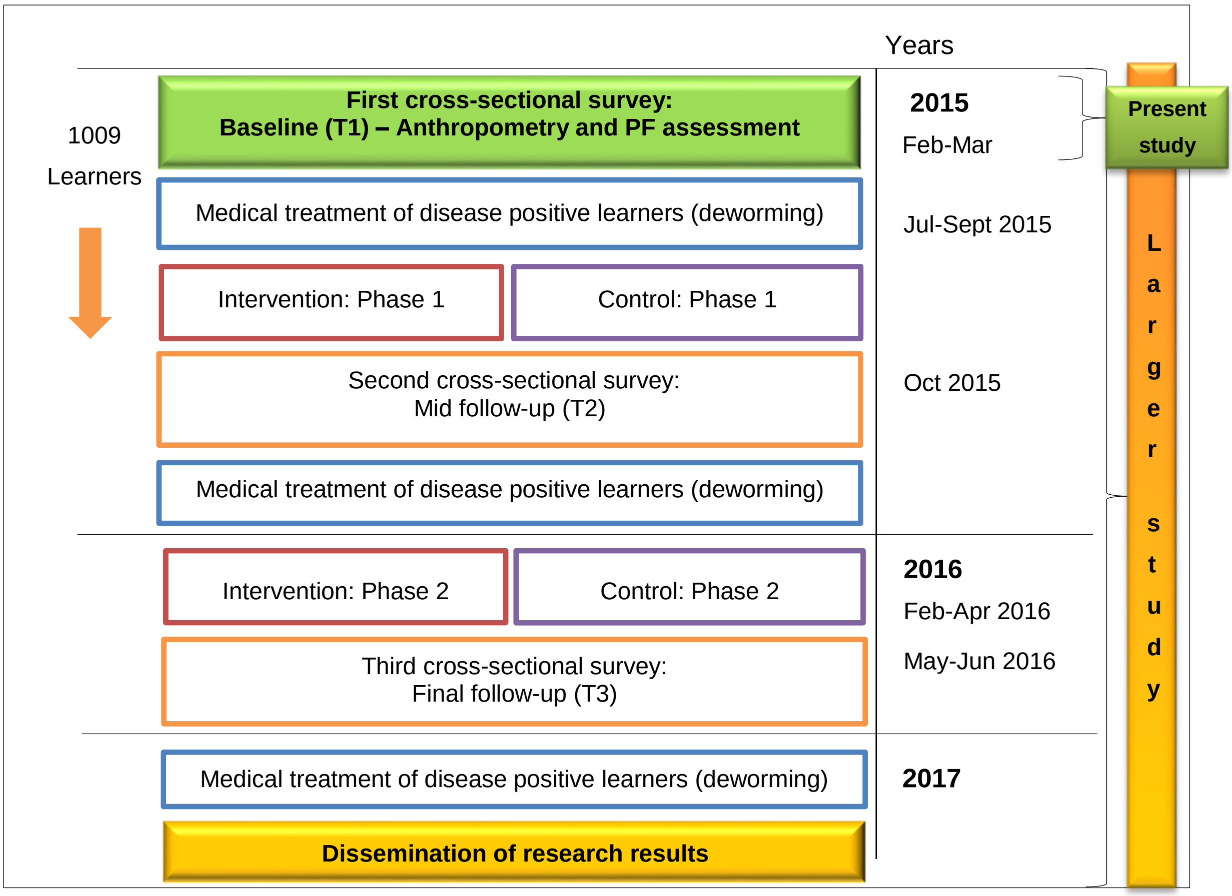

Figure 1.1: Conceptual framework of the DASH Study with respective timeline

1.5 TERMINOLOGY

The following key concepts are clarified in order to facilitate the understanding of this study.

- **Quintile system:** In South Africa, the quintile system is used to allocate funds to the schools based on their needs. Schools are categorised into 5 groups or quintiles with quintile 1 being the poorest and quintile 5, the least poor (Department of Education, 2004:7; Kanjee, 2009:7). Schools in quintiles 1 to 3 are no-fee paying schools (Department of Basic Education, 2016:5). The quintile score is based on national consensus data which is defined by the school's income, the unemployment rate and the level of literacy in the surrounding area of the school (Department of Education, 2004:7). The current study focused on quintile 3 government schools.

- **Physical activity:** Any bodily movement produced by skeletal muscles that result in energy expenditure (Caspersen, Powell & Christenson, 1985:126). Therefore, PA relates to the movements that individuals perform in daily life and can be categorized as work-related, leisure, household tasks or other activities (Caspersen *et al.*, 1985:126, 128).

- **Physical fitness:** A set of attributes that allows an individual to perform certain standards or intensities of PA without undue fatigue (Freedson, Cureton & Heath, 2000:S77). These attributes are usually categorised into two groups: health-related components and skill-related components (Caspersen *et al.*, 1985:128). The latter pertains to athletic ability rather than health outcomes. This study focuses on HRPF: references to PF in this dissertation, therefore, refers to HRPF.

  - **Health-related physical fitness:** Encompasses components that place emphasis on health and includes: CRF, muscular strength, muscular endurance, flexibility and body composition (Morrow Jr, Jackson, Disch & Mood, 2011:190).

    - **Cardiorespiratory fitness:** The ability of the body's circulatory and respiratory systems to supply fuel and oxygen during sustained PA (Hoeger & Hoeger, 2016:175). CRF is also referred to as cardiovascular fitness (or aerobic fitness) which is the ability of the heart, blood, blood vessels and the respiratory system to supply nutrients and oxygen to allow sustained PA (Corbin, Welk, Corbin & Welk, 2011:6). The term CRF was used for the present study.

    - **Muscular strength:** The amount of force that is produced with a single maximal effort of the muscle group (Corbin *et al.*, 2011:160). The current study focused on isometric and dynamic strength:
      - **Isometric strength:** Refers to an increase in muscle tension without changing the length of the muscle (Corbin *et al.*, 2011:165).

        - **Dynamic strength:** Muscle's ability to exert a force that results in body movement (Corbin *et al.*, 2011:165).

    - **Flexibility:** The range of motion available at a joint (Morrow Jr *et al.*, 2011:373). Flexibility is a property of internal body tissues that determines the ability to move various joints through a full range of motion (Holt, Holt & Pelham, 1995:172).

    - **Body composition:** The relative amounts of muscular, skeletal and adipose tissue as well as other vital parts of the body (Caspersen *et al.*, 1985:129). The physical make-up of the body is derived using various methods: the following methods are used in this study.
        - **Body fat percentage** (BF%) is the proportion of total fat (as it accounts for essential fat and storage fat) in the body based on the individual's total weight (Hoeger & Hoeger, 2016:112). BF% can be determined directly or indirectly. For the present study, BF% is determined indirectly and estimated using skinfold measurements.
        - **Body mass index** (BMI) is used to assess weight relative to height by using a simple formula, calculated by dividing body weight in kilograms (kg) by height in metres squared (m^2) (ACSM, 2014:63).

- **Malnutrition:** Refers to deviations above or below optimal nutritional status, which may derive from nutrient deficiencies or inappropriate portions of food (Shetty, 2006:524). The term malnutrition is also used to encompass three broad conditions: undernutrition, micronutrient-related malnutrition as well as overnutrition (WHO, 2017). For the current study undernutrition and overnutrition are clarified below:

    - **Undernutrition:** The three most common anthropometric indicators used to assess the growth status in children are z-scores: weight-for-age (WAZ), height-for-age (HAZ) and weight-for-height or BMI-for-age (BAZ) (WHO, 2017:46).

- **Low weight-for-age:** Also known as underweight (WHO, 2017). This reflects weight relative to chronological age (de Onis & Blössner, 1997:47).
- **Low height-for-age**: An indication of stunting (WHO, 2017). This reflects a continued process of "failing" to grow as a consequence of poor health or inadequate food intake during the first two years of life (de Onis & Blössner, 1997:47)
- **Low weight-for-height**: An indication of thinness or wasting (depending on age) (de Onis, 2015:11). This indicates recent or severe weight loss as a result of insufficient food and/or infectious disease (de Onis & Blössner, 1997:46)

- **Overnutrition:** Defined as an excessive accumulation of adipose tissue which may eventually impair health and quality of life (WHO, 2017).
  - **High weight-for-age:** The preferred term is overweight or obesity (de Onis & Blössner, 1997:46), a consequence of an energy imbalance between energy consumed and energy expenditure (WHO, 2017).

1.6 SIGNIFICANCE OF THE STUDY

This study provides valuable data on the PF status in terms of growth and development of a low socio-economic population for selected geographical areas, gender, and ethnicity. There is a paucity of research on the PF status of primary schoolchildren attending quintile 3 schools and the present study contributes to this body of knowledge. This study formed the baseline PF data of the larger DASH Study, which incorporated an intervention on the sample assessed. The data provided also has a general reference to PF and malnutrition associated with low socio-economic communities.

1.7 OUTLINE OF THE CHAPTERS

This master's dissertation encompasses five chapters. These are:

Chapter 1: Problem identification, to give the reader perspective on childhood PF and provides the reader with the scope of the study.

Chapter 2: Literature review, comprises insights from relevant studies regarding PF during childhood.

Chapter 3: Research methodology, to outline methodological and ethical decisions made during the process of this study in order to ensure valid and reliable outcome methods.

Chapter 4: Results, to give a descriptive and statistical analysis of the findings.

Chapter 5: Discussion, conclusion, and recommendations, to provide perspective of the study with regards to the aim and objectives. The main findings are discussed along with the limitations. Recommendations are provided based on significant findings of the study.

In summary, the aim and objectives of the study are posed in light of the concerns mentioned in this chapter. The current nutritional health and PF status of children in South Africa will naturally have an influence on the health and well-being of adults in the future. Chapter 2 to follow provides a review of related literature.

CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION

Physical inactivity and low PF status are independent risk factors for lifestyle-related diseases and premature adult mortality (Malina & Katzmarzyk, 2006:S295). Thus, growing recognition of the importance of PA serves as a means of primary prevention of NCD's in children for later in life (Uys *et al.*, 2016:S265). The health benefits of PF and PA are well established; however, PA is only one of several other factors that influence PF. Therefore, independent of PA, PF is considered to be an important marker of health in both childhood and adulthood (Malina & Katzmarzyk, 2006:S295; De Miguel-Etayo, Gracia-Marco, Ortega, Intemann, Foraita, Lissner, Oja, Barba, Michels & Tornaritis, 2014:S57). Therefore, it is important that children's PF statuses are regularly quantified in order to effectively coach and educate children from a young age on the benefits of PA and how their PF can be maintained or improved upon.

This chapter gives a broad overview of the literature that supports the aim of this study, which was to investigate the PF status of primary schoolchildren, aged between 8 and 11 years, from lower socio-economic communities in Port Elizabeth. In the sections that follow, PF and PA concepts, guidelines and recommendations are discussed. The history of PF and the development of fitness test batteries are also elaborated upon. A review of PF in South Africa details the history of and political impact on PE, followed by a discussion on the prevalence of malnutrition and the decline of PA among schoolchildren. This chapter concludes with a literature review of empirical studies related to the objectives of the present study and provides insight into the PF status of primary schoolchildren.

2.2 DEFINING PHYSICAL ACTIVITY AND PHYSICAL FITNESS

Researchers often debate whether PF or PA are more important for health benefits. However, a distinction should be made between the two as each serves a different purpose in people's lives (Blair, Cheng & Holder, 2001:S379; Plowman, 2005:151). By definition, these two elements have different functions and contribute to health differently. Therefore, it is not possible to casually conclude which of the two is more important to health.

PA is defined as any bodily movement produced by the skeletal muscles which results in energy expenditure (Caspersen *et al.*, 1985:126). In most cases, PA is an umbrella term used to describe activities that involve physical exertion which lead to health benefits (Caspersen *et al.*, 1985:126-127). Regular participation in PA also improves quality of life and acts as a protective barrier by lowering the risk of lifestyle-related chronic diseases (as discussed earlier) (Blair *et al.*, 2001:S396; Pate, Oria & Pillsbury, 2012:67; CDC, 2015). Everyone can engage in PA, regardless of an individuals' age or health state, and they should, as it is an integral part of our lives. These activities can range from leisure activities, like gardening or hiking, to more strenuous exercise activities and competitive sport. When applied to children, this includes structured PA or extra-mural activities and unstructured free play, amongst others.

The term PF is defined as "a state or an ability that enables an individual to perform daily activities without undue fatigue" (Freedson *et al.*, 2000:S77; Malina & Katzmarzyk, 2006:S295). PF is a combination of attributes an individual has (due to genetics) or achieves (due to regular PA), and is relative to an individuals' ability to perform PA without excessive fatigue (ACSM, 2014:2). Neither the hereditary contribution or environmental influence, may have as great an effect as what regular PA does on PF (Blair *et al.*, 2001:S379). It is also well known that PF includes various components, which emphasise different facets of health and skill-related performance.

Historically, PF involved three basic components, namely, muscular strength and endurance, cardiorespiratory endurance and motor ability (Malina & Katzmarzyk, 2006:S295). However, the traditional concept of PF has since evolved (Malina, Bouchard & Bar-Or, 2004:216). PF is a multifaceted ability as it can range from every day health-related physical demands to highly specific skill-related capabilities. HRPF creates a link between PF, PA and health as several HRPF components are important determinants of various health outcomes (Blair *et al.*, 2001:S379; Boreham & Riddoch, 2001:924; Corbin *et al.*, 2011:7). Skill-related PF refers to agility, balance, coordination, speed, power and reaction time (Caspersen *et al.*, 1985:128). Undoubtedly, both are important components of PF.

> "Once a skill is learnt it is retained with minimal effort, however, without regular PA the benefits of HRPF is reduced, hence the saying *a skill is learned and fitness is earned"*
>
> *(Safrit, 1990:11-12)*

HRPF is divided into five components, each of which contributes to a positive health state. The five components are body composition, flexibility, muscular strength, muscular endurance and cardiovascular fitness (Corbin *et al.*, 2011:6). These components affect an individuals' state of functional health as they reduce the risk factors and vulnerability to chronic disease (Gallahue & Ozmun, 1995:264; Mood, Jackson & Morrow, 2007:219). Each of these are independent of each other but may also be integrated as all body functions and systems are involved in the optimal performance of PA (Ruiz, Ortega, Gutierrez, Meusel, Sjöström & Castillo, 2006:270; Corbin *et al.*, 2011:7,9). Table 2.1 depicts the five HRPF components and their corresponding benefits when normal reference performance is maintained.

Table 2.1: Health-related physical fitness components and health benefits

PF component	Health benefit
Body composition	• Reduction in risk of CVD and metabolic syndrome
Cardiovascular fitness	• Reduction in CVD and all-cause mortality
Muscular fitness includes muscular strength, muscular endurance and flexibility	• Increased fat-free mass and resting metabolic rate • Improved posture and functional capacity • Increase or maintenance of bone mass • Reduced risk of lower back pain and injury • Ability to conduct daily activities

(Morrow Jr *et al.*, 2011:190)

While distinctions have been made between PA and PF, Malina & Katzmarzyk (2006:S303) suggest that habitually active individuals could also be physically fit. For children and adolescents, the relationship between PA and PF is low to moderate, as PA accounts for a small percentage of variance in PF components (Malina & Katzmarzyk, 2006:S303). Thus, it cannot be assumed that physically active children are fit and healthy or that physically active children are in excellent physical condition according to their level of maturity and development. The latter is unknown without objectively measuring PF status (Caspersen *et al.*, 1985:130).

To summarise, PA is considered to be a process and PF the end result thereof (Plowman, 2005:143). Engaging in regular PA results in improved levels of PF and improved PF increases the ability to perform PA (Blair *et al.*, 2001:S397). The following section will discuss PA guidelines and recommendations for children, as the factors influencing PA participation differ between adults and children.

2.3 PHYSICAL ACTIVITY GUIDELINES AND RECOMMENDATIONS FOR CHILDREN

The fact that children are naturally drawn to active play should count in their favour (especially in the absence of sedentary alternatives). There are, however, specific guidelines and principles to follow when participating in PA (namely the type, intensity, frequency and duration thereof) (Haywood & Getchell, 2009:69).

PA is a fundamental facet of the growing child as it aids optimal physical growth, development and psychological well-being (Haskell, Montoye & Orenstein, 1985:206). For children, PA includes a wide range of activities that involve movement which can be free-play, games, sports, PE or even household work. Their play comes naturally, therefore PA needs to be fun and exciting yet at the same time developmentally appropriate to achieve the maximum benefits and behavioural health outcomes (Boreham & Riddoch, 2001:915; Strong *et al.*, 2005:737; CDC, 2015). The developmental changes during childhood when considering body size, muscular strength or cardiovascular endurance also affects childrens' physiological and metabolic response to PA (Simons-Morton, Parcel, O'Hara, Blair & Pate, 1988:410). PA in terms of growth and development in early childhood differs in comparison to late childhood. The PA requirements in early childhood are basic as emphasis is placed on the development of fundamental movement skills (FMS). These FMS form the foundation for more complex and integrated movement patterns (Strong *et al.*, 2005:736). FMS can be divided into three categories: locomotor skills (walking, running, jumping), object control skills (catching, throwing, kicking) and stability skills (static balance and dynamic balance) (Lubans, Morgan, Cliff, Barnett & Okely, 2010:1020). Eventually, in late childhood, these FMS become established and the emphasis shifts to one of a health and fitness approach, which contributes to a physically active lifestyle (Strong *et al.*, 2005:734, 736; Tinazci & Emiroglu, 2009:88). A panel of experts reviewed over 850 articles and found evidence-based data that highlighted the beneficial effects of PA on musculoskeletal health, adiposity and CRF (Strong *et al.*, 2005:736; Janssen & LeBlanc, 2010:2). There are numerous health benefits with regards to PA for children. The evidence is clear that active children display healthier cardiovascular profiles, have lower body composition and higher peak bone mass than their sedentary peers (Boreham & Riddoch, 2001:915).

According to the WHO, PA for health is recommended for specific age groups. Recommendations, therefore, address three age groups, namely 5-to-17-year-olds, 18-to-64-year-olds and people older than 65-years of age (WHO, 2010). These PA guidelines are based on the feasibility of the individual and what is beneficial for their health (Boreham & Riddoch, 2001:917). Children have a unique physiological response to exercise because their anatomy and functional ability changes dramatically with age (Simons-Morton *et al.*, 1988:410). Hence, it is necessary to consider PA guidelines relative to the developmental or biological age of the child. It is recommended that children between the ages of 5 and 17 years should participate in at least 60 minutes of moderate to vigorous PA (MVPA) per day (Strong *et al.*, 2005:737; Janssen & LeBlanc, 2010:1; WHO, 2017). Regular participation in MVPA works to stimulate a functional adaptation of all tissues and organs in the body, and in so doing, it reduces the child's vulnerability to NCD's (Ruiz *et al.*, 2006:269). Recommendations from the Centre for Disease Control and Prevention (CDC) include increased time for MVPA, promoting the development and maintenance of CRF and increased participation in activities which enhance and maintain muscular strength, muscular endurance and flexibility (CDC, 2015). PA, executed at least three days per week, should be largely aerobic, in other words activities which stress the cardiovascular and respiratory systems, resulting in the greatest health benefit (Janssen & LeBlanc, 2010:1, 13; WHO, 2010:7). This can be achieved during PE, during school breaks, during extra-mural activities or at home.

Because children spend a large portion of their day at school, schools should function as an appropriate setting to promote PA and reduce sedentary behaviour (Zahner, Puder, Roth, Schmid, Guldimann, Pühse, Knöpfli, Braun-Fahrländer, Marti & Kriemler, 2006:10). PE is, therefore vital for healthy and active children (Rajput & van Deventer, 2010:158; Amusa, Goon, Amey & Toriola, 2011:4678) and, should be prioritised from a young age. It is recommended that children participate in at least two hours of PE per week to achieve a holistic educational outcome. By encouraging children to be active and to live healthy lifestyles, one can improve their quality of life (van Deventer, 2008:4,6; Monyeki, 2014:11).

In summary, children's PA and PF experiences should encourage positive attitudes towards exercise. Thereby developing a sound knowledge base of healthy behaviour that will naturally carry over into adulthood. The regular assessment of PF during childhood may also initiate and facilitate the process of lifelong PA participation. The following section will review the importance of PF for children.

2.4 IMPORTANCE OF PHYSICAL FITNESS FOR CHILDREN

PA is often the focus of health-related research in children, however, evidence that PF is directly related to health without mediation through PA, is also plausible (Boreham & Riddoch, 2001:924). Indicators of PF track from childhood to adolescence (at a moderate level) as well as to adulthood (Malina & Katzmarzyk, 2006:S302). Therefore, a child's PF status is an important marker for their future health as an adult and maybe a precursor for adult morbidity and mortality (Twisk, Kemper & van Mechelen, 2000:1455). Further elaboration on the importance of PF in relation to health and PA therefore seems justified.

Measuring PF or PA as markers of health can be a complex task. Measurements of PA include: self-reports, direct monitoring using either electrical or mechanical devices or a physiological measure. Thus, measurements of PA are possible however measurement error is likely (Boreham & Riddoch, 2001:924) for example with regards to the accuracy and honesty of self-reports as well as incomplete recall. This is particularly true when it comes to children who may not understand or have difficulty with the recall of an activity. Therefore, the assessment of the product of PA, that is PF, may be a more accurate and reliable measure. Assessing PF is a valuable tool for two reasons. Firstly, PF, especially CRF (Ruiz *et al.*, 2006:272) is used as a predictor of health and is an indicator of potential risks for chronic diseases (Freedson *et al.*, 2000:S77). Evidence from research shows that the functional conditioning of the cardiovascular system may lead to a reduced risk for coronary heart disease (Boreham & Riddoch, 2001:923). However, the latter must be interpreted with caution as certain individuals are genetically fitter than others by virtue of their bloodline.

Improved fitness is associated with a good health status and may reduce potential disease risk (however these improvements do not guarantee a resistance to chronic disease) (Haskell *et al.*, 1985:203). Secondly, ones PF status reflects an individuals' ability to perform PA as improved levels of PF reflect participation in regular PA (Ruiz *et al.*, 2006:271). Each HRPF component contributes to good health and most of these components improve with training. Nonetheless these improvements are also not permanent as training benefits are lost without frequent participation in PA (Gallahue & Ozmun, 1995:264; Siedentop & Van der Mars, 2004:153). Therefore, an increased PF status does not nullify the importance of regular participation in PA, as both elements are part of a healthy and active lifestyle (Blair *et al.*, 2001:S396; Plowman, 2005:155).

In summary, research on the relationship between PA, PF and health does exist for adulthood whereas data for childhood is rather sparse. For the purpose of this study, HRPF is used to provide an indication of the current childhood health status. In order to justify the battery of assessments selected for the purpose of the present study, an overview of the history of PF test batteries is provided below.

2.5 HISTORY OF PHYSICAL FITNESS TEST BATTERIES

Historically, greater emphasis was placed on the measurement of PF in youth in the 1950s, as large-scale surveys of PA in children and adolescents date back to the 1980s (Malina & Katzmarzyk, 2006:S305). The following section will review the history of PF test batteries to gain an understanding of the reasoning for the use of HRPF test batteries for childrens' health-related fitness.

Attention to the development of fitness test batteries began in the United States of America (USA) after the 2nd World War as well as during the Cold War (1950s). Thereafter, numerous test batteries emerged worldwide (Morrow Jr *et al.*, 2011:246). Combinations of test batteries have been used internationally in countries like Belgium, Poland, Colombia, Argentina, China, Japan, and Taiwan, in numerous PF surveys (Malina & Katzmarzyk, 2006:S298). The USA were certainly at the forefront of fitness test batteries, however, countries such as Canada, Australia and countries in Europe soon began to develop their own test batteries (COUNCIL, 1983:5; Harris & Cale, 2006:210). A report by Kraus and Hirshland (1954) revealed inadequate comparisons on the fitness of American to European children. Nearly 60% of American youth failed the Kraus-Weber Minimal Fitness Test versus their European counterparts, of which only 9% failed (Freedson *et al.*, 2000:S78; Morrow Jr *et al.*, 2011:246). This suggested that American children and the youth were unfit, which put their personal health, and their country at risk (Mood *et al.*, 2007:218). The American youth were unable to meet the minimal requirements for muscular strength and flexibility. This caused great concern in the USA and provided an incentive to introduce standardised testing within the school environment (Kemper & Van Mechelen, 1996:204; Morrow Jr *et al.*, 2011:246). In 1957, an organisation for physical educators was established known as The American Alliance for Health and Physical Education (AAHPER, 1976, after which a new acronym incorporated 'Dance' and it changed to AAHPERD as it is known today) (Pate *et al.*, 2012:26). By 1964 and again in 1974 the test battery was modified, however, the test battery remained largely skill-orientated (Freedson *et al.*, 2000:S78). In 1976, a later revision of the test emphasised health-related components (AAHPERD Health-Related Physical Fitness Test) and a modified skill-related test (Youth Fitness Test) was developed (Pate *et al.*, 2012:26).

Assessing the PF of children has changed over the years and has shifted from an emphasis on skill performance to a health-related fitness approach (Morrow Jr *et al.*, 2011:249). Due to the fact that childhood health status can predict adult morbidity and mortality, it was considered beneficial to monitor HRPF from childhood into adulthood (Pate *et al.*, 2012:15). Henceforth, numerous organisations got involved in the development and implementation of PF test batteries. The following are a few examples of test batteries currently used as a measure of HRPF testing: AAHPERD HRPF test, Young Men's Christian Association (YMCA), Fitnessgram, Canadian Association for Health, Physical Education, and Recreation (CAHPER) Fitness Performance Test and Eurofit (Shephard, 2007:93; Pate *et al.*, 2012:28-31; Oğuzhan, Kemal & Gökhan, 2014:585).

Most schools in Europe implement the Eurofit battery while schools in America largely use the Fitnessgram test (Cvejić, Pejović & Ostojić, 2013:136). The Cooper Institute developed the Fitnessgram in the USA in 1982. This was the first recognised test battery that implemented health-related, criterion-referenced standards for the evaluation of youth (Morrow Jr *et al.*, 2011:250). At the same time European countries began publishing their own test batteries and in 1978, a coordinated effort resulted in the formation of The Council of Europe. In 1983, a provisional Eurofit manual was developed and in 1988 the final handbook was released (COUNCIL, 1983:9; Kemper & Van Mechelen, 1996:204). The Eurofit test battery combines health-related, performance-related and motor-related abilities (Mood *et al.*, 2007:288; Morrow Jr *et al.*, 2011:255). Table 2.2 lists the Fitnessgram and Eurofit test batteries in relation to various tests used to measure each component. Both the Fitnessgram and Eurofit test batteries include four HRPF components. However, only the Eurofit includes performance-related components as it was specifically designed to assess the effectiveness of PE (Tomkinson, Olds & Borms, 2007:105).

Table 2.2: Comparison of the Fitnessgram and Eurofit test batteries

PF component	Fitnessgram	Eurofit
Aerobic capacity	20 m shuttle run 1 mile Walk/run test	20 m shuttle run Bike ergometer test
Body composition	Skinfolds Body mass index	Skinfolds
Abdominal strength and endurance	Curl-ups	Sit-ups
Upper body strength and endurance	Push ups Modified pull-ups Pull-ups Flexed arm hang	Grip strength Bent arm hang Arm pull
Trunk extensor strength and endurance	Trunk lift	
Flexibility	Back saver sit-and-reach Shoulder stretch	Sit-and-reach
Running speed and agility		10 x 5 m shuttle run
Speed of limb movement		Plate tapping
Dynamic strength (explosive power)		Standing broad jump
Balance		Flamingo balance

(Morrow Jr *et al.*, 2011:254)

In summary, it is clear that ultimately there are large similarities between the various PF test batteries that evolved over the years. For the purposes of the present study, an adapted version of the Eurofit test battery was selected in order to assess HRPF with the view to gain insight into the PF of South African schoolchildren and to assess the effectiveness of PE in the applicable schools. The following section will review the factors affecting the levels of PF of South African children.

2.6 FACTORS IMPACTING PHYSICAL FITNESS OF SOUTH AFRICAN CHILDREN

This section discusses salient factors which hinder and affect the PF of children in South Africa. Many of these factors stem from the legacy of apartheid, particularly where children from lower socio-economic backgrounds are concerned. The systemic segregation affected the PE, PF, PA and nutritional status of South African children (McVeigh *et al.*, 2004:982; Reddy, James, Sewpaul, Koopman, Funani, Sifunda, Josie, Masuka, Kambaran & Omardien, 2008:44; Armstrong, 2009:153). Details pertaining to the relevant effects are further elaborated in the following subsections.

2.6.1 Physical education and political change

PE is the foundation of a healthy and active lifestyle and, without it, PF levels may be reduced. The objective of PE is to improve the quality of life for young individuals in order that they may function effectively and live healthy lives (Rajput & van Deventer, 2010:151). South Africa's history of apartheid, affected the quality of PE and therefore how the subject was offered in schools (Edginton *et al.*, 2012:436). Policies from the previous government enforced a racial divide among ethnic groups, which empowered those from historically White communities and discriminated against the historically Black African communities (Rajput & van Deventer, 2010:155; Walter, 2014:358). PE was compulsory and implemented for one hour per week in the advantaged White schools. However, as a result of the political uprising this was not the case in most disadvantaged schools, therefore PE was subsequently dropped from the curriculum (Rajput & van Deventer, 2010:155).

The 1994 elections saw the formation of a new democratically elected government that aimed to eradicate inequalities of the past. Democracy in South Africa brought about transformation including the reconstruction of the education system. Amidst these changes, PE became a marginalised subject and was officially dropped from the curriculum (1994) as it was considered non-examinable and incorrectly perceived as a 'low status' subject when compared to other examinable subjects (Du Toit, Van der Merwe & Rossouw, 2007:244). The Outcomes Based Education (OBE) system introduced Life Orientation (LO) as a new learning area in an attempt to cover PE (Rajput & van Deventer, 2010:149). However, the content of LO has been compromised and it was very difficult for teachers to specialise in one particular area when many learning spheres are condensed into one learning area (Rajput & van Deventer, 2010:157). Furthermore, the quality of the subject was diluted as it was typically taught by teachers who were unqualified to teach all the learning outcomes. The OBE system was intended to ensure a swift transformation process which allowed learners to reach their maximum potential in a system that encouraged equality for all learners (van Deventer, 2012:154-155). Unfortunately, this system failed and by 1997 Curriculum 2005 (C2005), a revision of the OBE system, was implemented. By 2002, C2005 was revised to the National Curriculum Statement (NCS) (Du Toit *et al.*, 2007:244; Rajput & van Deventer, 2010:149, 156).

After two decades, the apartheid legacy is still visible across ethnic and socio-economic disparities (Armstrong *et al.*, 2011:1014). The South African schooling system presently reflects two social backgrounds which stem from the apartheid era: the advantaged schools (formerly accessible to White South Africans only) and the previously disadvantaged schools (formerly accessible to Black Africans, Coloured and Indian South Africans only) (Du Toit *et al.*, 2007:244-245). The current government seeks to eradicate past inequalities by allocating funds to public schools on a differentiated basis, by covering costs such as infrastructure and salaries. Government schools in South Africa are classified into five groups referred to as quintiles. The quintile system is used to classify schools into categories that allow the Education Department to allocate funds to the schools based on their needs (Department of Education, 2004:7; Kanjee, 2009:7). The quintile score is based on national consensus data which is defined by the school's income, the unemployment rate and the level of literacy in the surrounding area of the school (Department of Education, 2004:7). Quintile 1 serves the poorest communities and quintile 5 the least poor (Department of Basic Education, 2016:5). As per the South African Schools Act, section 39 (7) of 1 January 2016, schools situated in the poorest communities are exempt from paying school fees. Therefore, quintile 1 to 3 schools (previously disadvantaged) have been declared no-fee schools, whereas quintile 4 and 5 schools (mostly advantaged schools), are fee-paying schools (Department of Basic Education, 2016:5).

The status of PE in schools reveals great inequalities: a visible contrast remains between quintiles 1 to 3 and quintile 4 and 5 schools (Rajput & van Deventer, 2010:157). Although the Government has made efforts to reinstate PE in the national school curriculum, it is found that PE is often not offered in many schools (van Deventer, 2008:14; Rajput & van Deventer, 2010:157; Du Toit, Pienaar & Truter, 2011:24; Walter, 2014:359). As such, the lack of PE may have a negative effect on the lifestyles of many children in lower quintile schools (van Deventer, 2008:15). A study by McVeigh *et al.* (2004:987) examined the relationship between SES and PA patterns in South African children. The study reported that no White children attended schools in the quintile 1 to 3 categories. Furthermore, White children were more active than Black African children were. McVeigh *et al.* (2004:982) deduced that the lack of PE in the school system may have a direct bearing on the reduced activity levels of the children. South African researchers have called for the reintroduction of PE as a stand-alone subject in the school curriculum (Amusa *et al.*, 2011:4678; Armstrong *et al.*, 2011:999; Monyeki, 2014:335). It is the responsibility of the South African Department of Basic Education to ensure that PE is part of the teaching curriculum and is actively taught (Edginton *et al.*, 2012:436). Additionally, school leadership and staff are also responsible for the implementation thereof.

While children from lower SES communities are most at risk, they also have fewer opportunities for PA in comparison to children living in more affluent communities (Walter, 2011:782). Quintile 4 and 5 schools have done well to uphold the status of PE in the curriculum. These schools have prioritised the maintenance of facilities and improved the relevant infrastructure, resulting in a balanced variety of sport available to the learners (Edginton *et al.*, 2012:436). In poverty-stricken areas, communities rely on the school and the local government to provide the necessary resources required for PE and sport (Walter, 2011:787). These schools often have a shortage of PE facilities, equipment and qualified teachers (Walter, 2014:359). Children may be discouraged from participating in PE as the school environment lacks the basic infrastructure and resources necessary for the activities. Consequently, these children are susceptible to sedentary lifestyles. A study by Amusa *et al.* (2011:4666) hypothesised that, as a consequence of democracy in 1994, South African children have become less active, resulting in a decline of PF levels.

In summary, PE should serve as a vehicle to promote active lifestyles for children. However, PE is often neglected and seen as inferior to other subjects in the school curriculum. Findings from this study sought to provide baseline data for PE interventions to improve children's health and wellbeing. Baseline data was derived from the PF levels of socio-economically deprived South African children who have limited opportunities for PE and extra-mural activities. Apart from PE, the general wellbeing and optimal development of children is also affected by their nutrition. The following section will review the implication of malnutrition.

2.6.2 Malnutrition

Malnutrition is an imbalance between the supply of protein and energy and the body's demand from each source, ultimately affecting optimal growth and functioning (de Onis & Blössner, 1997:3). Malnutrition can be a result of several factors often related to the poor quality of food, nutrient deficiencies, infectious diseases and diets based on inappropriate food choices and portions (de Onis & Blössner, 1997:3; Shetty, 2006:524). Malnutrition generally implies undernutrition, however, the term rather refers to both deviations above or below the adequate nutritional status (Shetty, 2006:524).

The South African National Youth Risk Behaviour Survey cross-sectional data from 2002 and 2008 indicated a substantial increase in the rates of weight gain and obesity. This suggests that South Africa is experiencing a nutritional transition, which is a key driving force behind malnutrition (Kimani-Murage, Kahn, Pettifor, Tollman, Dunger, Gómez-Olivé & Norris, 2010:159; Reddy, Resnicow, James, Funani, Kambaran, Omardien, Masuka, Sewpaul, Vaughan & Mbewu, 2012:264). Developing countries tend to go through socio-economic and nutritional transitions which can cause an increase in overnutrition and a decrease in undernutrition (Puoane, Steyn, Bradshaw, Laubscher, Fourie, Lambert & Mbananga, 2002:1046; McVeigh *et al.*, 2004:982; Reddy *et al.*, 2012:262). The nutritional transition typically begins in urban populations but is also known to affect lower socio-economic areas and is often accompanied by changes in diet (Popkin, 2003:518). As a result, rapid urbanisation in South Africa has caused a shift from traditional low fat, high-fibre diets to an increase in the consumption of energy-dense foods which are high in sugar, fats and carbohydrates (Kimani-Murage *et al.*, 2010:159).

Concerns for malnutrition are not limited to adults alone as children are also largely at risk (WHO, 2017). Childhood growth largely revolves around the availability of nutritious food (the abundance or lack thereof) which is dependent on the economic status of the family (Travill, Cameron & Kemper, 2008:37). Children who are undernourished are often underdeveloped and may display reduced resistance to disease, while children who are over nourished are at a risk of NCD's (Rossouw, Grant & Viljoen, 2012:5). Therefore, childhood malnutrition is a serious health concern. The implications of childhood undernutrition may only manifest later in life as poor nutrition during childhood may lead to adaptations which result in obesity later in life (Kimani-Murage *et al.*, 2010:159, 168). Thus, the nutritional status of children is fundamental to their growth and development. Overnutrition and undernutrition are both considered as high risk in terms of the global burden of disease (Reddy *et al.*, 2008:37). It becomes complex when undernutrition and overweight or obesity are found in the same household, or even affect the same child (Rossouw *et al.*, 2012:6). In South Africa, the prevalence of overweight and obesity is higher amongst girls, while the prevalence of stunting and wasting is higher amongst boys (Monyeki, Awotidebe, Strydom, De Ridder, Mamabolo & Kemper, 2015:1167).

The following subsection describes the prevalence of overnutrition among South African children as well as factors which contribute to the incidence of childhood overweight and obesity.

2.6.2.1 Prevalence of overnutrition amongst South African children

Obesity occurs as a result of an energy imbalance in which energy intake exceeds energy expenditure (Parsons, Power, Logan & Summerbelt, 1999:S19). If this imbalance is sustained over long periods of time, the excess energy is stored in fat cells and accumulates as body fat. Obesity stems from a plethora of contributing factors which affect all backgrounds, social classes and ethnic origins.

In South Africa, an increased prevalence of overnutrition is often found among Black African women (Mvo, 1999:27; Puoane *et al.*, 2002:1046). In Black African culture, food plays a pivitol role as it is positively associated with wealth and happiness and a lack thereof is associated with poverty (Puoane, Matwa, Hughes & Bradley, 2006:91 - 92). According to research conducted by Mvo (1999:27), weight loss and thinness is often associated with problems and periods of anxiety within the Black African culture. It has been established that knowledge concerning nutrition is influenced by learned cultural norms and beliefs (Shisana, Labadarios, Rehle, Simbayi, Zuma, Reddy, Parker, Hoosain, Naidoo & Team, 2014:179). Therefore, a basic understanding of nutrition and knowledge about food intake and PA plays an important role in the prevention of obesity and related NCD's (Shisana *et al.*, 2014:177).

According to the South African National Health and Nutrition Examination (SANHNE) Survey, the prevalence of overweight and obesity for children aged between 2 and 14 years was higher amongst girls than boys (16.5% and 7.1% in comparison to 11% and 4.7% for girls and boys, respectively) (Shisana *et al.*, 2014:204). Furthermore, higher rates of obesity were found among children from urban populations when compared to children living in rural areas (Shisana *et al.*, 2014:204). A combined overweight and obesity prevalence of 13.5% was reported amongst schoolchildren, aged 6 to 14 years, which was higher than the global average trend of 10% (Shisana *et al.*, 2014:211). Childhood obesity may also be a learned behaviour of bad eating habits that may be adopted from a young age (Cooke, 2009:72). Thus, the parenting practices of overweight and obese children are crucial, as parents may influence the nutritional and activity-related choices of their children. Overnutrition has adverse effects on children's health both in short-term as well as the long-term. Children who are overweight and obese are likely to experience cardiovascular complications (increased risk factors for NCD's) and psychosocial consequences (self-development, emotional development and social development) which may affect the child's overall development (Reilly, Methven, McDowell, Hacking, Alexander, Stewart & Kelnar, 2003:748 - 749).

Along with the prevalence of childhood obesity, researchers have found a significant association between stunting and overweight children. This association is especially true in countries that experience nutrient transition as well as large changes in their diet (Popkin, Richards & Montiero, 1996:3009). The phenomenon is said to be the cause of inadequate nutritional adaptations during the foetal and early childhood stages which can result in obesity later in life (Kimani-Murage *et al.*, 2010:168).

2.6.2.2 Prevalence of undernutrition amongst South African children

Undernutrition, as a result of insufficient food (or in some cases an infectious disease) may lead to wasting, thinness, underweight and stunted growth (de Onis, 2015:11). Furthermore, children who experience undernutrition may also be predisposed to infection and impaired physiological function which may reduce their work capacity (Shetty, 2006:524).

Results from the SANHNE revealed that boys were more stunted, underweight and thinner in comparison to girls (Shisana *et al.*, 2014:211). For children from 0-to-14-years of age, the prevalence of stunting was 15.4%, 2.9% of children were wasted (thin) and 5.8% of children were categorised as underweight (Shisana *et al.*, 2014:207). When considering geographical areas, the incidence of undernutrition was mostly prevalent in the rural areas (Shisana *et al.*, 2014:211). The incidence of undernutrition was highest among Coloured children, followed by Black African children, the prevalence was 18.6% and 16.7% for stunting, 4.5% and 3.8% for wasting and 11.5% and 6.8% for underweight, respectively (Shisana *et al.*, 2014:208). Overall, the prevalence of undernutrition in rural informal areas was 20.6%, 6.8% and 12.1% for stunting, wasting and underweight, respectively (Shisana *et al.*, 2014:207).

This disparity in the undernutrition prevalence suggests that the imprint of the apartheid history is still apparent as groups suffering poverty are largely susceptible to developing nutritional disorders (Armstrong, Lambert & Lambert, 2011:835). Undernutrition is not merely a lack of food intake (quantity) but also an inadequate intake of nutritious food (quality). Thus, children from poverty-stricken areas who are not sufficiently nourished may lack concentration for school work and the energy to play and be physically active (Graham, Hochfeld, Stuart & Van Gent, 2015:12). The following section will review concerns regarding physical inactivity among South African children.

2.6.3 Decline of physical activity

Literature confirms as was reported by Simons-Morton *et al*., in 1988, that PA is essential to the functioning capacity of every individual (Simons-Morton *et al.*, 1988:405). PA is especially important for children as it regulates their adipose tissue and the structural integrity of their growing bones (Malina & Katzmarzyk, 2006:S303).

Most children engage in unstructured free play. However, many assume that because children play, they exercise and automatically meet their daily PA requirements, however, this is not necessarily the case (Haywood & Getchell, 2009:204).

Findings from the South African National Youth Risk Survey, reported that only 43.2% of learners participate in sufficient vigorous PA (Reddy *et al.*, 2008:44). In South Africa, various barriers to PA participation are reported, including environmental and social factors. These may include, but are not limited to poverty, crime, lack of basic infrastructure and equipment, as well as the absence of PE at schools (Monyeki, 2014:8). This is echoed in the aforementioned survey which reported that 13.3% of respondents did not participate in PA due to the lack of facilities and equipment, 10% felt unsafe, 28.8% lacked the desire and motivation to participate, while the remaining 30.1% did not have a reason for their inactivity (Reddy *et al.*, 2008:45, 120). In light of these findings, addressing the barriers to PA in vulnerable groups such as children, especially those living in disadvantaged communities, should be a priority and the impact of malnutrition should be considered. Despite the countless benefits of regular PA, it remains an under-utilised health resource (Rajput & van Deventer, 2010:151).

This chapter thus far has reviewed the barriers which influence the PF of South African schoolchildren. From a young age, these children are faced with challenges that may discourage interest in their PF, including their future health. The impact of the apartheid era has left ethnic disparities and socio-economic inequalities that affect the PF status of the country, from children through to adults. With already reduced levels of PA among children, lifelong participation in PA may be discouraged without the foundation of PE in the curriculum of lower socio-economic schools. Strategies should also be put in place to address both extremes of malnutrition amongst South African children. Children who are malnourished may differ in their performance of PF tests when compared to well-nourished children. However, nutritional status is unknown in the target population if the growth status of the children is not assessed.

The following section is a review of the HRPF from various international and national studies.

2.7 INTERNATIONAL AND NATIONAL REVIEW OF RESEARCH ON CHILDREN'S HEALTH-RELATED PHYSICAL FITNESS

Tables 2.3 and 2.4 present the findings of the HRPF of children from seven international studies published between 2006 and 2014 and seven South African studies from 2005 to 2017, respectively. Results were extracted based on the relevant battery of assessments selected for the purpose of the present study. Of the seven international studies, four were cross-sectional studies and the last three were a meta-analysis, a systematic literature review and a cohort study. The overall age of participants in these studies ranged from 6 to 19-years-old.

Table 2.3: Health-related physical fitness of children from various international studies (2006 – 2014)

Reference	Study design and test battery	Participant demographics	Main findings
Olds, Tomkinson, Léger & Cazorla (2006)	• Meta-analysis • 20 m shuttle run test (SRT)	• 37 countries • 418 026 participants • 6-to-19-year-olds	• The best performing children were all from Northern European countries (0.6 - 0.9 standard deviations above the global mean). The worst performing children were from Brazil, Singapore, USA, Italy, Portugal and Greece (0.4 - 0.9 standard deviations below the global mean); • The difference between the most fit and least fit group of children was 10 - 12 ml/kg/min; • Boys were significantly faster than girls at every age (km/h) (speed was converted to VO_2max using the equation by Léger, Mercier, Gadoury & Lambert (1988:95)): – Boys: 8-years: 9.88±1.00 (49 ml/kg/min); 9-years: 10.12±1.08 (47.9 ml/kg/min); 10-years: 10.45±1.14 (48.6 ml/kg/min) and 11-years: 10.71±1.20 (47 ml/kg/min); – Girls: 8-years: 9.46±0.81 (47.47 ml/kg/min); 9-years: 9.67±0.88 (45.68 ml/kg/min); 10-years: 9.96±0.93 (46.28 ml/kg/min) and 11-years: 10.13±1.01 (44.57 ml/kg/min).

Reference	Study design and test battery	Participant demographics	Main findings
Ara, Moreno, Leiva, Gutin & Casajús (2007)	• Cross-sectional design • Eurofit	• Spanish • 1 068 participants • 7-to-12-year-olds	• Fitness scores were provided for active and non-active children thus tendencies were deduced based on the results. • Physically active boys showed significantly higher values than non-active boys for: body mass (kg) (35.8±0.6; 33.5±0.7), height (cm) (137.5±0.6; 135.4±0.9) and BMI (kg/m^2) (18.5±0.2; 18.0±0.2) respectively; • Active girls (71.6±1.4) had significantly lower subcutaneous fat (sum of 6 skinfolds in mm) than sedentary girls (76.6±1.9); • No difference was found for overweight (rural – boys: 32%; girls: 26% and urban – boys: 34%; girls: 30%) and obese children (rural – boys:4%; girls: 6% and urban – boys:8%; girls: 7%) living in rural and urban areas. • Physically active learners performed better than non-active learners except in the sit-and-reach (SAR) test. PF results for active and non-active learners were reported as follows: – SAR (cm): boys (active: 16.58±5.28 and non-active: 16.69±5.42) and girls (active: 19.82±5.38 and non-active: 18.90±5.67) – methodology: in a seated position, with feet flat against a box, slide ruler was placed between feet while reaching forward and keeping the knees straight (therefore, the zero points differed); – Grip strength (GS) (kg): boys (active: 17.00±5.36 and non-active: 15.82±4.80) and girls (active: 15.13±5.04 and non-active: 14.68±4.68); – Standing broad jump (SBJ) (cm): boys (active: 132.39±25.91 and non-active: 127.17±24.28) and girls (active: 120.14±26.12 and non-active: 115.50±25.06); – 20 m SRT (ml/kg/min): boys (active: 48.31±4.36 ml/kg/min and non-active: 46.59±3.98 ml/kg/min) and girls (active: 46.02±3.76 ml/kg/min and non-active: 44.67±3.86 ml/kg/min).

Reference	Study design and test battery	Participant demographics	Main findings
Tremblay, Shields, Laviolette, Craig, Janssen & Gorber (2010)	• Cross-sectional survey • 2007 - 2009 Canadian Health Measures Survey (CHMS) compared with the 1981 Canada Fitness Survey (CFS)	• Canadian • 2 087 participants • 6-to-19-year-olds	• Fitness scores were provided according to age ranges therefore tendencies were inferred based on the results. • HRPF measures from the 2007-2009 Canadian Health Measures Survey were reported as follows: • BMI increased with age. The mean BMI was similar for boys and girls in all age groups. – 6-to-10-years: boys: 17.7 kg/m^2 and girls: 17.1 kg/m^2 – 11-to-14-years: boys: 20.6 kg/m^2 and girls: 20.4 kg/m^2 • SAR scores were stable both genders for the specified age range. As expected girls were more flexible than boys. – 6-to-10-years: boys 24 cm and girls 29 cm; – 11-to-14-years: boys 21 cm and girls 28 cm; • GS increased with age for all age groups. As expected boys scored higher than girls. – 6-to-10-years: boys 25 kg and girls 23 kg; – age 11-to-14-years: boys 51 kg and girls 42 kg; • At all ages boys had higher VO_2max (ml/kg/min) values than girls; – Age 6-to-10-years: boys (56.3 ml/kg/min) and girls (50.7 ml/kg/min); – Age 11-to-14-years: boys (54.9 ml/kg/min) and girls (48.9 ml/kg/min).
Sacchetti, Ceciliani, Garulli, Masotti, Poletti, Beltrami & Leoni (2012)	• Cross-sectional design • Eurofit	• Italian • 497 participants • 8-to-9-year-olds	• Mean BMI was reported for boys (17.80±2.90 kg/m^2) and girls (17.90±3.10 kg/m^2); • In accordance with the reference values presented by Cole, Bellizzi, Flegal & Dietz (2000:1243) for 8.5 yrs, 64% of children were reported to be of normal weight, 24.3% overweight, 9.7% obese and 1.6% underweight. • As expected boys (129.30±19.20 cm) achieved better scores than girls (114.20±18.30 cm) in the SBJ test.

Reference	Study design and test battery	Participant demographics	Main findings
Catley & Tomkinson (2013)	• Systematic review of 15 studies	• Australian • 85 347 participants • 9-to-17-year-olds	• PF peaked at the age of 15 yrs. Boys typically scored higher than girls: the magnitude was moderate for SAR, GS and SBJ tests and higher for the 20 m SRT. • Normative values were created for the percentile value of 50 ($P_{50\,=}$ average) for the age range 9-to-17-year-olds: – P_{50}, SAR ranged from 20.9 cm to 25.7 cm for boys and 24.6 cm to 29.1 cm for girls. – P_{50}, GS ranged from 16.4 kg to 36.5 kg for boys and 14.4 kg to 26.9 kg for girls. – P_{50}, SBJ ranged from 138 cm to 189 cm for boys and 126 cm to 156 cm for girls. – P_{50}, 20 m SRT (completed stages) ranged from 3 to 4 (9.5 -10 km/h) for boys and 2 to 4 (9 – 10 km/h) for girls.
Gulías-González, Sánchez-López, Olivas-Bravo, Solera-Martínez & Martínez-Vizcaíno (2014)	• Cross-sectional • Eurofit	• Spanish • 1 725 participants • 6-to-12-year-olds	• Mean flexibility scores decreased with age for boys (8-years: 15.20±5.30 cm; 9-years: 15.30±6.50 cm; 10-years: 12.8±6.50 cm and 11-years: 13.3±6.10 cm) but remained stable for girls (8-years: 18.00±5.90 cm; 9-years: 16.7±6.70 cm; 10-years: 17.8±7.00 cm and 11-years: 17.3±6.80 cm). • Age related increases were reported for both genders in the SBJ and GS test: – SBJ: boys (8-years: 122.40±17.90 cm; 9-years: 125.10±20.50 cm; 10-years: 131.00±18.30 cm and 11-years: 141.40±23.50 cm) and girls (8-years: 111.70±16.60 cm; 9-years: 113.20±17.90 cm; 10-years: 118.80±19.50 cm and 11-years: 129.00±21.20 cm). – GS: boys (8-years: 13.90±2.50 kg; 9-years: 15.70±3.60 kg; 10-years: 17.10±3.90 kg and 11-years: 18.80±4.00 kg) and girls (8-years: 12.50±2.80 kg; 9-years: 14.10±2.90 kg; 10-years: 16.00±3.60 kg and 11-years: 19.00±4.20 kg). • Mean levels of VO_2max declined with age for both genders (8-years: 47.40±4.30 ml/kg/min; 9-years: 46.80±4.60 ml/kg/min; 10-years: 45.90±4.50 ml/kg/min and 11-years: 45.90±5.30 ml/kg/min) and girls (8-years: 46.00±2.80 ml/kg/min; 9-years: 44.20±3.00 ml/kg/min; 10-years: 43.30±3.40 ml/kg/min and 11=years: 42.30±3.80 ml/kg/min).

Reference	Study design and test battery	Participant demographics	Main findings
De Miguel-Etayo, Gracia-Marco, Ortega, Intemann, Foraita, Lissner, Oja, Barba, Michels & Tornaritis (2014)	• Cohort study • Eurofit • Fitnessgram	• European • 18 745 participants • 6-to-9-year-olds	• Results provide gender and age-specific PF reference standards for European children aged 6-to-10.9 years. • Normative values are provided for the percentile value of 50 (P_{50} = average) for the age range 6-to-9-year-olds: – Back-saver SAR (cm) at P_{50}: boys (10.5 to 34.4 cm) and girls (7.5 to 30.6 cm). – GS at P_{50}: boys (5.0 kg to 18.6 kg) and girls: (5.4 kg to 20.8 kg). – SBJ at P_{50}: boys (46.7 to 160.8 cm) and girls (52.0 to 170.1 cm). – 20 m SRT (VO_2max: ml/kg/min) at P_{50}: boys (42.9 to 53.9 ml/kg/min) and girls (42.8 to 56.6 ml/kg/min). • Boys performed better than girls in speed, lower- and upper-limb strength and CRF. • Older children performed better than younger children, except for CRF in boys and flexibility in girls.

**SAR = sit-and-reach; GS = grip strength; SBJ = standing broad jump; SRT = shuttle run test.

Of the seven South African studies reviewed, three were national studies and four were regional studies. Six studies used a cross-sectional study design and the seventh study was a longitudinal cross-sectional study. Three of these studies were conducted in rural settings, one in an urban setting and three of the studies involved participants from a range of socio-economic levels. The age of the participants included in these studies ranged from 6-to-17-years of age.

Table 2.4: Health-related physical fitness of children from various South African studies (2005 – 2017)

Reference	Study design and test battery	Participant demographics	Main findings
Monyeki, Koppes, Kemper, Monyeki, Toriola, Pienaar & Twisk (2005)	• Cross-sectional design • Eurofit	• North West • 855 rural participants • 7-to-14-year-olds	• BMI was found to have a significantly positive relationship with the SAR (cm) and SBJ (cm) tests. • Normal nourished children (16.64±5.47) were more flexible in the SAR test than undernourished children (15.37±5.01). • Normal nourished children (130.67±17.64) were able to jump further in the SBJ test than undernourished children (128.53±19.47). • There was no significant difference in the SRT (s) between normal nourished children (22.47±2.15) and undernourished children (22.42±1.90).

Reference	Study design and test battery	Participant demographics	Main findings
Travill (2007)	• Cross-sectional • Adapted Eurofit • Balke treadmill test	• Western Cape • 720 urban socially disadvantaged participants • 8-to-17-year-olds	• BMI between genders showed significant differences after 9-years of age. – BMI: boys (8-years: 15.8±1.04 kg/m²; 9-years: 16.9±2.04 kg/m²; 10-years: 16.3±1.26 kg/m² and 11-years: 17.3±1.65 kg/m²) and girls (8-years: 15.9±2.04 kg/m²; 9-years: 16.7±2.49 kg/m²; 10-years: 17.3±2.36 kg/m² and 11-years: 18.0±1.66 kg/m²). • Girls had significantly higher BF% than boys for all age groups: boys: 8-years: 6.9%; 9-years: 8%; 10-years: 7.8% and 11-years: 8% and girls: 8-years: 19.2%; 9-years: 20.5%, 10-years: 20.7% and 11-years: 22.8%. • In the SAR test girls reached their peak before boys. Girls (8-years: 35.3 cm, 9-years: 40.9 cm, 10-years: 38.8 cm and 11-years: 39.8 cm) peaked at 9-years-old while boys (8-years: 34.3 cm, 9-years: 36 cm, 10-years: 41 cm and 11-years: 38.1 cm) peaked at 10-years-old.
Truter, Pienaar & Du Toit (2010)	• Cross-sectional • Fitnessgram • Bruininks-Oseretsky Test of Motor Proficiency Ⅱ	• North West • 280 participants (distribution of socio-economic strata) • 9-to-12-year-olds	• The mean BMI of the normal weight group was 17.20±1.70 kg/m² compared to the overweight group (22.30±1.50 kg/m²) and obese groups (29.50±3.70 kg/m²). • BF% were reported as follows: normal weight: 17.70%±5.20, overweight: 28.20±6.00% and obese: 38.20%±7.70. • The mean values of PF parameters decreased as BMI increased from normal weight to obese. This difference was significant in the SBJ values. – Total group: SBJ-normal weight: 120.10±22.90 cm, SBJ-overweight: 110.40±17.70 cm and SBJ-obese: 94.60±14.70 cm. – Boys: SBJ-normal weight: 127.10±21.40 cm, SBJ-overweight: 115.90±16.30 cm and SBJ-obese: 94.30±20.90 cm

Reference	Study design and test battery	Participant demographics	Main findings
			• Girls: SBJ-normal weight: 114.10±22.50 cm, SBJ-overweight: 105.70±17.90 cm and SBJ-obese: 94.70±10.30 cm
Amusa, Goon, Amey & Toriola (2011)	• Longitudinal cross-sectional study • Eurofit • AAHPERD	• Limpopo • 409 rural participants • 6-to-13-year-olds	• BF% was higher in girls than in boys for all grades. • The boys generally performed more superiorly than the girls in PF tests requiring body movement and power (SBJ: boys:120.00±16.00 cm; girls: 115.60±18.70 cm). • Girls were superior to boys in the tests of flexibility (SAR: boys: 25.5±6.70 cm; girls: 28.10±6.50 cm).
Armstrong, Lambert & Lambert (2011)	• Cross-sectional • Eurofit	• Western Cape, Gauteng, Eastern Cape, Free State and KwaZulu Natal • 10 295 participants (different socio-economic strata) • 6-to-13-year-olds	• Height and weight results revealed that White children (34.6 kg) weighed more than Black African children (33.1 kg). • There were no differences in SAR scores between ethnic groups: Black African children (21.30 cm), Coloured (22.80 cm) and White children (21.00 cm). As expected, girls showed superior results for all ages when compared against boys. • SBJ test revealed that Coloured (163.10 cm) and White children jumped (163.70 cm), 13 cm further than Black African children (150.40 cm). • 20 m SRT revealed that Black African children were slower than White and Coloured children in all age groups. • SD was not provided for the adjusted mean scores for the total group.

Reference	Study design and test battery	Participant demographics	Main findings
Moselakgomo, Monyeki & Toriola (2014)	• Cross-sectional • Eurofit	• Mpumalanga province (MP) and Limpopo province (LP) • 1 361 rural participants • 9-to-12-year-olds	• 74.7% of the children were underweight and 1.6% were overweight. • The boys in both provinces were taller and heavier than the girls. – BMI - boys: 9-years: LP: 17.10±0.07 kg/m² and MP: 16.90±0.04 kg/m²; 10-years: LP: 17.60±0.11 kg/m² and MP: 17.30±0.06 kg/m²; 11-years: LP: 18.70±0.23 kg/m² and MP 18.10±0.15 kg/m². – BMI - girls: 9-years: LP: 14.20±0.22 kg/m² and MP: 13.70±2.13 kg/m²; 10-years: LP: 15.10±0.11 kg/m² and MP: 14.70±0.13 kg/m²; 11-years: LP: 15.80±0.13 kg/m² and MP: 15.40±0.07 kg/m². • Generally, boys from LP did significantly better than boys from MP for SAR and SBJ: – 9-years: LP (SAR: 36.30±4.26 cm; SBJ: 118.40±11.00 cm) and MP (SAR: 35.30±4.24 cm; SBJ: 121.60±9.10 cm). – 10-years: LP (SAR: 40.50±6.35 cm; SBJ: 114.80±12.22 cm) and MP (SAR: 38.00±6.47 cm; SBJ: 117.10±12.39 cm). • 11-years: LP (SAR: 42.30±7.50 cm; SBJ: 113.30±16.62 cm) and MP (SAR: 38.80±5.90 cm; SBJ: 110.60±16.23 cm). • Regardless of age, girls from LP had superior performances for SAR and SBJ PF tests than girls from MP: – 9-years: LP (SAR: 41.20±6.14 cm; SBJ: 120.40±18.76 cm) and MP (SAR: 40.30±5.74 cm; SBJ: 117.30±20.13 cm). – 10-years: LP (SAR: 39.60±6.36 cm; SBJ: 114.50±14.19 cm) and MP (SAR: 40.20±6.38 cm; SBJ: 117.50±18.71 cm).

Reference	Study design and test battery	Participant demographics	Main findings
			• 11-years: LP (SAR: 39.60±5.32 cm; SBJ: 127.00±19.63 cm) and MP (SAR: 42.40±6.30 cm; SBJ: 114.30±16.93 cm).
Armstrong, Lambert & Lambert (2017)	• Cross-sectional • Eurofit	• Western Cape, Eastern Cape, Gauteng, KwaZula-Natal and Free State • 10 285 participants (different socio-economic strata) • 6-to-13-year-olds	• Mean results showed that flexibility was not affected by overnutrition for SAR (overweight/obese group: 22.10±7.90 cm). No difference was found between the flexibility of the nourished (22.80±7.90 cm) and undernourished children (stunted: 22.20±7.80 cm, wasted: 21.80±8.00 cm, underweight: 22.30±7.10 cm). • For the SBJ test, underweight (126.70±22.70 cm) children performed the worst followed by stunted children (141.40±22.90 cm), overweight/obese children (150.30±23.00 cm) and wasted children. (158.50±23.20 cm). The best score was achieved by normal weight children (160.00±23.00 cm).

**SAR = sit-and-reach; GS = grip strength; SBJ = standing broad jump; SRT = shuttle run test.

In Tables 2.3 and 2.4, varying sample sizes and methodologies were used to assess PF and anthropometric variables. Despite different assessment methods, a global trend of overweight and obesity was evident. Further details pertaining to body composition, nutritional health and PF are discussed in the following subsections.

2.7.1 Body composition and nutritional status

The BMI values for international studies reported in Table 2.3 ranged from 17.01 kg/m² to 20.06 kg/m². According to the reference values of Cole *et al.* (2000:1243), this is within normal range. Tremblay *et al.* (2010:14) compared a typical 12-year-old Canadian from 1981 (CFS) to 2007 - 2009 (CHMS) and found the body composition of Canadian children in the latter study to be less healthy. From 2007 to 2009, on average, a 12-year-old boy and girl had an increased BMI of 1.1 kg/m², boys and girls were taller and weighed about 6.4 kg and 4.9 kg more, respectively. However, in Table 2.4, South African studies reported BMI values that range over a broader spectrum from 13.7 kg/m² to 29.5 kg/m², this large range highlights the paradox of undernutrition and overnutrition that exists in the country.

A growing child affected by any degree of malnutrition, may bear the repercussions thereof well into their adult years. This may be because malnutrition can cause structural, metabolic and functional deficiencies during their growth and development (Travill, 2007:279; Armstrong *et al.*, 2017:5). South African studies have reported on the prevalence of malnutrition for different socio-economic and sociographical populations. Rural children are mostly affected by different forms of undernutrition, with a marginal degree of overweight and obesity, if none at all, reported. Monyeki *et al.* (2005:879) found that 77% of the sample were undernourished. Similar values were reported by Moselakgomo *et al.* (2014:343), as 75% of children were underweight and stunted, however, 1.6% of the sample was classified as overweight. High BF% values were reported by Amusa *et al.* (2011:4678), but these were unexpected cases. This confirms the coexistence of underweight and overweight among South African children. Children living in urban parts of South Africa are largely affected by overnutrition. High values of both undernutrition and overnutrition were reported from two studies of urban children living in the Western Cape (Armstrong, Lambert, Sharwood & Lambert, 2006:439; Travill, 2007:284). However, socio-economic differences distinguished the two studies from one another. The study sample by

Travill (2007:284) conducted in Khayelitsha, a socially disadvantaged area, reported a higher prevalence of undernourished children (8-to-17-year-old) (40.2%) whereas Armstrong *et al.* (2006:439) reported a higher rate of overnutrition (overweight: 5.5% and obesity: 6.5%) from a distribution of different socio-economic groups around South Africa, including the Western Cape province. Within Southern Africa, higher rates of undernutrition are often reported (especially in lower-income areas) but the prevalence of overnutrition is on the rise. Armstrong *et al.* (2017:209) presented the following findings for a nationally representative study on children aged 6-to-12-years-old: 15.4% overweight or obese, 8.1% stunted and 0.7% wasted. These values highlight the nutritional transition South Africa is experiencing as the country adopts a westernised diet. One of the fundamental causes of obesity is the energy imbalance between increased calories consumed and reduced energy expenditure, which may lead to reduced fitness levels.

The interactions between PF and nutritional status were discussed in the study by Armstrong *et al.* (2017:212) who concluded that malnourished children performed poorly in weight-bearing and aerobic fitness tests. Therefore, a small body frame, reduced muscle mass or excess body fat will compromise the PF performance of children.

2.7.2 Physical fitness status in relation to age and gender interactions

The main aim of this study was to assess the PF status of schoolchildren. In this section, age and gender interactions will be discussed relative to the studies presented in Tables 2.3 and 2.4.

Cardiovascular fitness (also referred to as CRF) is an important component of HRPF as it reflects the overall capacity of the cardiovascular system (Ruiz *et al.*, 2006:272). A meta-analysis of 109 reports from 37 countries, described a worldwide variation in the results of the 20 m SRT between 1981 and 2003. Findings showed that performance was negatively related to being overweight (Olds *et al.*, 2006:1025) the climate, the geographic location as well as the culture. Research indicates that performance was negatively related to a country’s average temperature, as children living in extreme climates (hot and humid or very cold) may avoid physical exertion due to the weather (Olds *et al.*, 2006:1034). Olds *et al.* (2006:1030) reported that boys were significantly faster than girls were for every age group. Due to consistent countrywide findings, these gender differences were said to be biological, despite different social, political and economic factors involved (Olds *et al.*, 2006:1034). According to Olds *et al.* (2006:1034), if studies failed to find pre-pubertal gender differences, it is likely the result of a small study sample size. The performance of participants improved until post-pubertal years (±12 years in girls and ±16 years in boys) (Olds *et al.*, 2006:1030). On the other hand, in a sample of Spanish children, Gulías-González *et al.* (2014:627) reported a decline in VO_2max which may have been caused by an increase in adiposity, relative to the increase in age. Age-related changes are generally larger for boys than girls, especially during their teenage years. Therefore, fitness levels are also affected by maturation.

Inherent gender differences in PF performance exists for certain fitness components due to physiological and anatomical differences (Plowman & Meredith, 2013:4 - 10). Although boys are generally stronger than girls, both genders are relatively similar in physical performance until the age of 13-years (Malina *et al.*, 2004:216; Haywood & Getchell, 2009:221). After the pubescent growth spurt, gender differences may be attributed to factors such as body composition (increased adipose tissue for females) and hormonal changes (Haywood & Getchell, 2009:211 - 212). Findings from literature concur that irrespective of maturational status, boys perform significantly better than girls in muscular endurance and strength tests which require explosive movement of the body, while girls perform better in tests of flexibility. Loss of flexibility is a characteristic of age and by the age of 5, girls tend to be more flexible than boys, in fact most studies show a decline in flexibility by early adolescence, which occurs after 10-years for boys and 12-years for and girls (Haywood & Getchell, 2009:228) .

As reported in the literature, it is evident that biological characteristics like age and gender will affect the PF performance of children. Along with these changes, and as previously discussed, there are factors relative to the context of South Africa that affect the PF status of children in this country, which will be discussed in the next section.

2.7.3 Socio-economic and ethnic differences within South Africa

The South African context provides diversity in terms of socio-economic levels and ethnic groups (Armstrong *et al.*, 2011:1000). The legacy of apartheid and its political influences on different ethnic groups and socio-economic groups, still lingers.

South Africa is currently in a transitional period, therefore, extremes between socio-economic levels are expected (Armstrong, 2009:72). Research on the socio-economic status and PA patterns of South African children reported that White children were more active than Black African children, White children also participated in regular PE classes and higher PA levels were associated with higher socio-economic status (McVeigh *et al.*, 2004:982). In fact, the study reported that there were no White children in attendance at schools in quintiles 1 to 3, which are the lowest socio-economic quintiles. Findings concluded that for children, PA in South Africa is multi-faceted as socio-economic and cultural factors influence PA patterns (McVeigh *et al.*, 2004:987).

Limited opportunities for PA exist in low socio-economic communities and in disadvantaged schools (Walter, 2014:359). Schools in disadvantaged communities are often faced with many challenges and lack the necessary resources and infrastructure that encourage sports participation (Walter, 2011:787). In the Health of The Nation Study, Armstrong *et al.* (2011:1014) noted ethnic disparities in PF performance. In most cases, the performance of Black African and Coloured children, many of whom come from lower SES communities, was lower than that of White children.

Amusa *et al.* (2011) reported on the PF performance of traditionally rural children (all of whom were Black African) and found their general level of fitness to be poor. Therefore, it can be surmised that environmental factors influence the PF performance of children and, within the context of South Africa, the inequalities of the past have influenced the PF and PA opportunities of children.

2.8 SUMMARY AND JUSTIFICATION FOR THE PRESENT STUDY

In summary, this chapter has provided a review of the literature regarding the importance of PF for the optimal growth and development of children. The awareness of health and the interrelationship between PA and PF should start from a young age by encouraging active and healthy lifestyles. Improved PF levels in disadvantaged schools may alleviate health concerns associated with hypokinetic diseases and malnutrition, therefore PF assessments are justified. A review of relevant research was conducted on childhood PF levels and will later be considered when discussing the results of the present study. This review should assist in providing possible reasons why certain results were obtained.

The following chapter, Chapter 3, describes the research methodology used to address the aim and objectives of the present study.

CHAPTER 3

RESEARCH METHODOLOGY

3.1 INTRODUCTION

The primary aim of this study was to investigate the PF of primary schoolchildren, aged 8-to-11-years, from eight selected schools situated in lower socio-economic communities in Port Elizabeth. Appropriate research methods and procedures were applied to achieve this aim as guided by relevant literature in research methodology.

This chapter aims to describe the methods and procedures that were implemented to facilitate the outcome of this study. More specifically, this chapter outlines the research design selected for the study. A description of the population, the sampling technique employed, and the participant inclusion criteria are discussed. This chapter also describes each test or measurement, the equipment used, and the steps followed to ensure that valid and reliable data were captured and analysed. An explanation of the ethical considerations completes the chapter.

3.2 RESEARCH DESIGN

A research design is a procedure used to effectively address the aim and anticipated outcome in a coherent and logical way (de Vaus & de Vaus, 2001:10). This study employed a quantitative research approach and implemented a cross-sectional survey, as it sought to explore and describe the PF profile of primary schoolchildren from lower socio-economic communities.

In research, a cross-sectional survey design can be used to determine if a particular problem exists and what the status of the problem is within a group of participants (Strydom, 2011:156). A cross-sectional survey allowed for data collection over a short period so as not to overly disrupt the teaching schedule at the eight selected schools. The PF status of the Grade 4 learners, spanning several age groups (8-to-11-years) was determined.

In essence, the current study formed part of a two-year longitudinal cohort study, consisting of three cross-sectional surveys (baseline, mid- and final follow-up) in eight primary schools in Port Elizabeth. At each survey, the disease status, anthropometry and level of PF, cognitive performance and psychosocial health were measured. The baseline data for PF was then used and is reported on in the present study.

3.3 PARTICIPANTS AND SAMPLING TECHNIQUE

A population refers to the totality of a group of interest in a study (Bordens & Abbot, 2010:G-9). It is not always possible to assess all members of a population due to insufficient time and availability of resources. The population may also be too large to study, hence a sample is a subset of participants selected from a population for inclusion in a study (Thomas, Silverman & Nelson, 2015:99).

The population relevant to this study includes selected quintile 3 government primary schools situated in historically disadvantaged areas of Port Elizabeth, South Africa. These schools and communities have been detrimentally affected by extreme poverty, as well as other social challenges, due to past apartheid government policies (Du Plessis, 2013:80).

3.3.1 Sampling strategy

The project information was provided to 103 quintile 3 primary schools in Port Elizabeth. These were hand delivered to each school since many of these schools are without access to working telephones, fax machines or email. The intention was to be all inclusive and invite as many interested principals, Grade 4 teachers and school governing body members to an information session to discuss participation in the study. A total of 25 written responses were received from interested schools. The information session was held in October 2014, where 15 schools were represented.

Eight schools were eventually selected, based on their willingness to participate and study criteria (>100 Grade 4 learners and geographic location of the school). Meetings were held to explain the sensitive nature of the clinical part of the DASH Study and to distribute consent forms. The consent forms were collected at the end of the 2014 school year and accepted up until the morning of testing to encourage the inclusion of as many learners as possible.

Learners recruited from the eight project schools were required to meet the following inclusion criteria for testing:

- Be in Grade 4;
- Voluntarily participate;
- Have written informed consent from parents; and
- Give oral consent.

Based on the criteria above, a total of 1154 Grade 4 learners were invited to participate in the study. Consents were not received from 145 learners, resulting in 1009 participants being recruited into the study. Each learner went through a clinical examination (this involved a detailed medical history and physical examination conducted by qualified medical personnel), as well as anthropometric measurements which were conducted by biokinetics students. The learners required clearance from the medical personnel for participation in PF testing. The nurses referred a total of 70 learners to nearby clinics in the community where appropriate treatment was offered. Of the 70 learners referred, 44 learners were excluded from the PF testing. A sum of 50 records were deleted for reasons such as incomplete data. This left a total of 915 learners that participated in the study, see Figure 3.1 for participant flow chart. It must be noted that the sample sizes for the different PF tests varied, as some learners were either excluded from tests of physical exertion or absent on the day of testing. The age group tested ranged from 8-to-11-years (for analysis purposes, age was calculated according to age on test date).

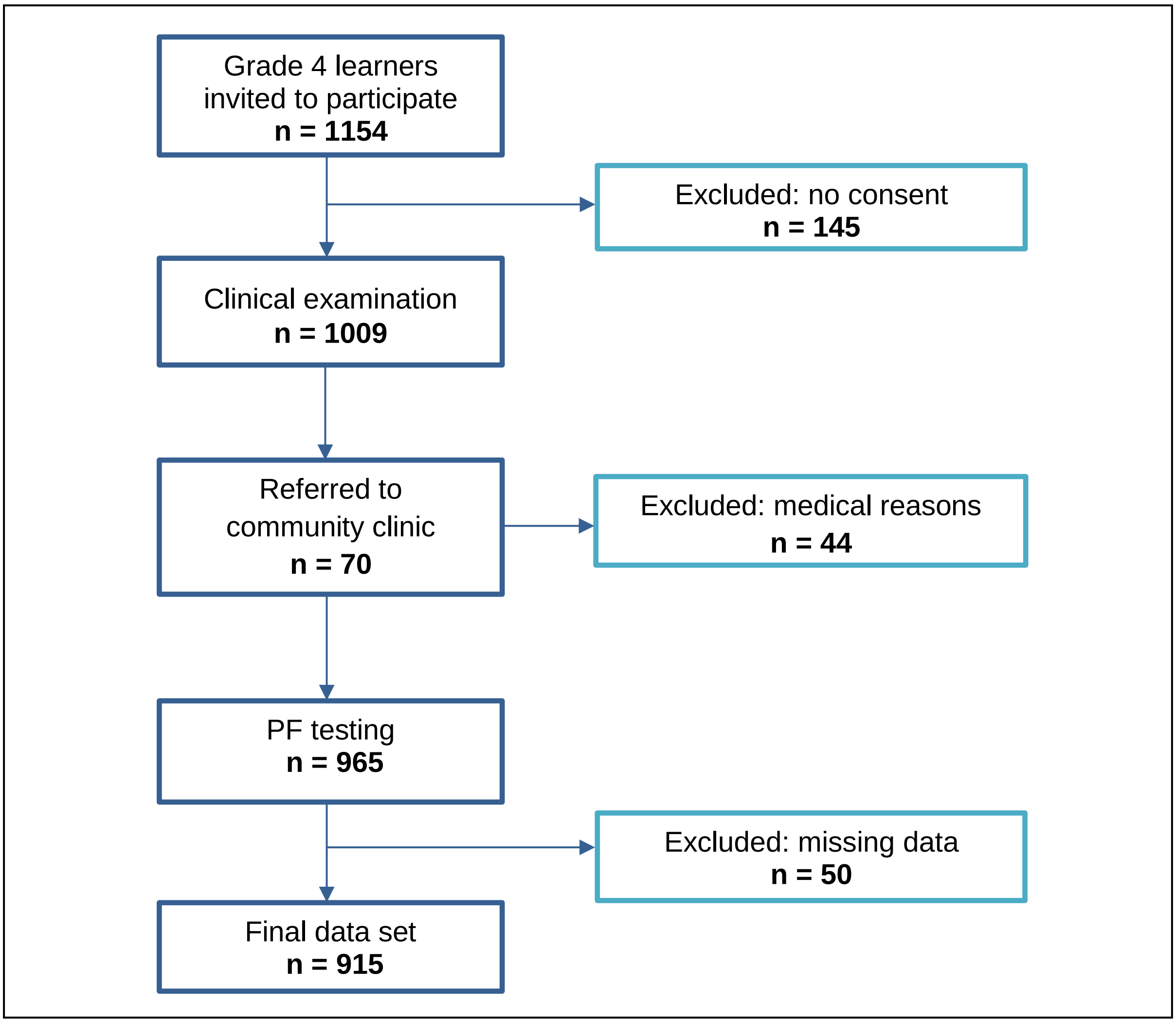

Figure 3.1: Participant flowchart

3.3.2 Geographic location

This study was conducted within socio-economically marginalised areas of Port Elizabeth, which under the law of apartheid, were reserved for non-whites, according to the Group Areas Act of 1950 (Du Plessis, 2013:79). In most cases, these areas were situated in the outlying areas of the city. In Port Elizabeth, Coloured people were moved into areas known as the Northern Areas, and Black African people were relocated to the Township Areas (Du Plessis, 2013:2). Project schools were situated in the Northern Areas of Schauderville, Helenvale, and Booysens Park and in the Township Areas of Motherwell, New Brighton and Walmer.

Schools within the Township Area comprised Black African learners only, whereas schools in the Northern Areas comprised both Coloured and Black African learners (the latter whom often commute to and attend schools in these areas). The South

African government is aware of learners who reside in Black African communities and travel to and attend schools in Coloured communities, as parents believe that these schools offer a better education (Department of Education, 2004). Schools in this study were numbered 1 to 8 in the order of testing. The order of testing was originally arranged according to geographic location and later, according to availability (see Figure 3.2 for a geographic representation of the participating schools). Schools 1, 2, 3 and 8 are Northern Area schools while schools 4, 5, 6 and 7 are Township schools. Schools 2 and 3 comprised Coloured learners only while schools 4 to 7 comprised Black African learners only, with the exception of schools 1 and 8 which had both Black African and Coloured learners.

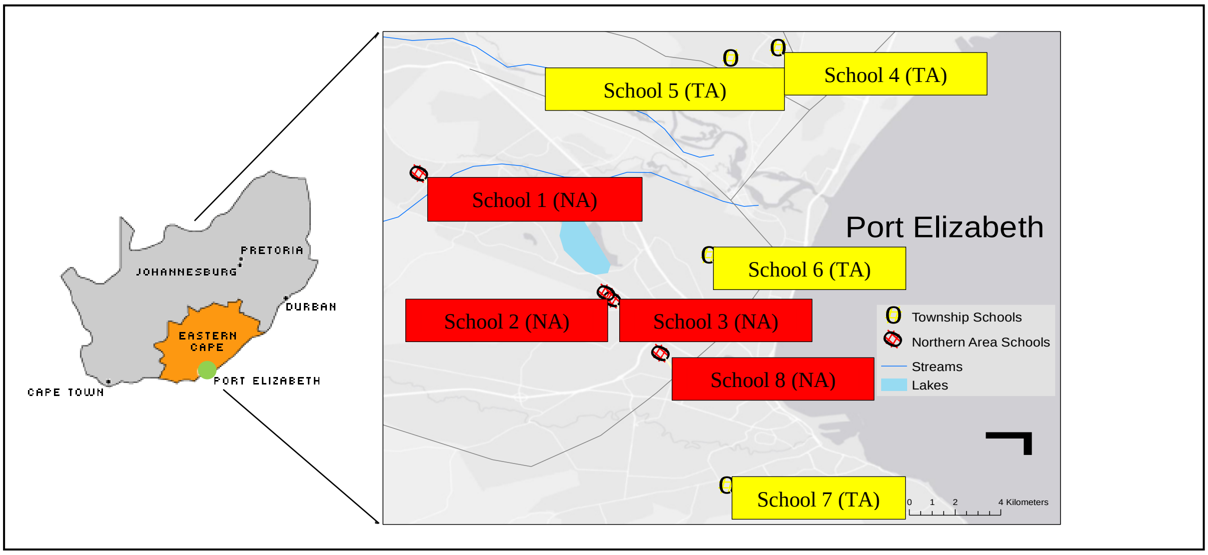

Figure 3.2: Geographical representation of participating schools

3.4 MEASURING INSTRUMENT

The following biographical information was obtained from each learner: name and surname, age (in completed years), ethnic group and home language. This information was captured on the clinical score sheet (as seen in Appendix A).

The primary focus of this study was on children's PF, specifically HRPF. The latter was, therefore, divided into two categories, namely, anthropometric measurements and PF tests. Details pertaining to the purpose of the measurement/test, equipment used, method, trials, and scoring applied, as well the validity and reliability of each of the measurements and or tests used to assess the relevant components, are provided in this section.

Each category of measurement is described by referring to the various components assessed. Anthropometric measurements include body weight (kg), height (cm), and skinfolds (mm). The following variables were calculated from the anthropometric measurements: BF%, BMI (kg/m^2), WAZ, HAZ, and BAZ.

PF tests were assessed using an adapted version of the Eurofit test battery (Morrow Jr *et al.*, 2011:288), which included SAR measured in centimetres to assess flexibility, GS measured in kilograms to test upper body strength, SBJ recorded in centimetres to measure lower body strength and the 20 m SRT recorded as per number of completed laps and used to measure maximum aerobic capacity and determine predicted VO_2max. A test battery must suit the testing requirements of the study to ensure that results are valid and reliable, this is a prerequisite to ensure reproducibility of results (Kemper & Van Mechelen, 1996:210).

Details pertaining to each of the anthropometric measurements or calculated measurements and PF tests are provided in the next sections.

3.4.1 Anthropometric measurements

Anthropometric measurements were taken as per the protocol of the International Society for the Advancement of Kinanthropometry (ISAK). The anthropometric component consisted of three measurements weight, height, and skinfolds measurements (for the purposes of this study, the terms height and weight were used instead of stature and body mass) as well as five calculated variables derived from one or more of the anthropometric measurements: BF%, BMI, WAZ, HAZ, and BAZ. Details pertaining to these anthropometric measurements and calculated variables are to follow.

3.4.1.1 Weight

Purpose of the measurement/test: To measure weight of the learners.

Equipment used:

- Micro T7E Scalemaster electronic digital scale

The Scalemaster was calibrated prior to the data collection period commenced (see Figure 3.3 below for visual details).

Figure 3.3: Microelectronic platform scale T7

Reference of the measurement/test: ISAK (2011:52).

Method: The scale was placed on a flat, even surface and set to 0.00 kg before the commencement of testing at each school. Learners were asked to remove their shoes, socks, and jerseys before standing on the digital weighing scale. Clear instructions were given: to stand with minimal movement, weight evenly distributed on both feet and to look directly ahead of them.

Trials: Weight was measured once.

Scoring: This was measured in kilograms (kg) and recorded to the nearest 0.01 kg.

Validity and reliability: Face validity was accepted. Measurements were considered reliable if measured by qualified personnel on a good quality calibrated scale.

3.4.1.2 Height

Purpose of the measurement/test: To measure height of the learners.

Equipment used:

- Portable Seca stadiometer (see Figure 3.4 for visual of deconstructed stadiometer)

Figure 3.4: Portable Seca stadiometer

Reference of the measurement/test: ISAK (2011:53-54).

Method: The free-standing stadiometer was placed on a flat, level surface, which allowed for accurate reading. Learners were instructed to remove their shoes and stand against the stadiometer facing the measurer, with their feet together, back erect and shoulders relaxed. The learner's feet, buttocks and upper part of the back were required to make contact with the scale for the measurement. The measurer then placed the learner's head in the Frankfort plane while holding his/her jawline. The sliding headboard was lowered to the vertex of the head, ensuring that the participant's hair was pressed down as much as possible, and the measurement was taken at the end of the inhalation.

Trials: Height was measured once.

Scoring: Measured in centimetres (cm) and recorded to the nearest 0.1 cm.

Validity and reliability: Face validity was accepted. Measurements were considered reliable if measured by qualified personnel using a good quality stadiometer.

3.4.1.3 Skinfolds

Purpose of the measurement/test: To measure skinfold thickness that can be used to calculate BF%.

Equipment used:

- Harpenden skinfold caliper; and
- Flexible steel tape enclosed in a case with automatic retraction (see Figure 3.5 below).

Figure 3.5: Harpenden skinfold caliper with flexible steel tape

Reference of the measurement/test: ISAK (2011:58-59).

Method: According to the ISAK protocol, the caliper should ideally be calibrated to at least 40 mm in 0.2 mm divisions. Skinfold measurements were taken at two sites, namely, triceps and subscapular, each consisting of skin double-fold along with the underlying subcutaneous adipose tissue. The triceps measurement is a vertical fold, taken on the posterior midline of the upper arm at the mid-acromiale-radiale site (ISAK, 2011:61). The subscapular measurement is a diagonal fold, taken at a 45º angle 2 cm from the inferior angle of the scapula (ISAK, 2011:62).

The skinfold site was located using the correct anatomical landmarks, and measurements were taken on the right side of the body, with the arm relaxed at the side. The measurer demonstrated the pressure of the skinfold caliper by clamping the learner's finger to indicate that the process would not hurt. Using the thumb and index finger, a double-fold of skin, along with the underlying subcutaneous adipose tissue, was grasped and the caliper was placed perpendicular to the skinfold. The reading was taken within two seconds.

Trials: Skinfold thickness was measured three times per measurement site; measurement sites were rotated.

Scoring: Measurements were recorded in millimetres (mm) and reported to the nearest 0.1 mm. The final reading was an average of the three values, used as a representative value to calculate BF% using the Slaughter, Lohman, Boileau, Horswill, Stillman, Van Loan & Bemben (1988) skinfold equation, for estimation of body fatness in children and youth.

Validity and reliability: Face validity was accepted. Measurements are considered reliable if measured by qualified personnel and with a good quality calibrated skinfold caliper.

3.4.1.4 Anthropometric calculated variables

The following are indicators of body composition and nutritional status that were derived from skinfold thickness, height, and weight measurements:

3.4.1.4.1 Body fat percentage

Reference of the measurement/test: (Slaughter *et al.* (1988): This formula is internationally accepted for children of ages between 8-to-18-years-old.

Variables used: The sum of triceps and subscapular skinfold thickness.

Calculation of measurement: Two different equations were used for boys and girls and were applied to children of all ages where the sums of skinfolds are equal to or less than 35 mm. When the sum of skinfolds is larger than 35 mm, another set of equations are used for boys and girls, respectively. BF% was assessed using the reference chart by McCarthy, Cole, Fry, Jebb & Prentice (2006:600).

Body fat percentage formula:

ΣTS = sum of triceps and subscapular skinfolds.

- The following formulas for ΣTS ≤ 35mm were applied
  - BF% for boys = $1.21 (\Sigma TS) – 0.008 (\Sigma TS)^2 - 3.2$
  - BF% for girls = $1.33 (\Sigma TS) – 0.013 (\Sigma TS)^2 - 2.5$

- <u>The following formulas for ΣTS > 35mm were applied</u>
  - BF% for ΣTS > 35 mm for boys = 0.783 (ΣTS) + 1.6
  - BF% for ΣTS > 35 mm for girls = 0.546 (ΣTS) + 9.7

3.4.1.4.2 Body mass index

Reference of the measurement/test: ACSM (2014:63).

Variables used: Weight and height measurements.

Calculation of measurement: BMI (kg/m^2) = body weight (kg) ÷ height (m^2)

Underweight and obesity prevalence was assessed using the International Obesity Task Force (IOTF) cut-off points for children as recommended by Cole *et al.* (2000:4).

3.4.1.4.3 Weight-for-age, height-for-age and BMI-for-age z-scores

The z-scores weight-for-age (WAZ), height-for-age (HAZ) and BMI-for-age (BAZ) were used to determine nutritional status. Calculations on the prevalence of malnutrition are based on a z-score cut-off of 2 standard deviations in respect of low weight-for-age (WAZ), low height-for-age (HAZ), low BMI-for-age and high BMI-for-age.

Reference of the measurement/test: de Onis (2015:11)

Variables used: WAZ and HAZ were derived from weight and height measurements while BAZ was derived from BMI measurements.

Calculation of measurement: The prevalence of underweight, stunting, thinness and the combined category of overweight and obesity were calculated according to WHO reference curves. Table 3.1 reflects the relevant cut-offs.

Table 3.1: WHO classification of nutrition conditions in children

Classification		Condition	Indicator and cut-off	
			Birth to 60 months	61 months to 19 years
Based on weight and height	WAZ	Underweight	< - 2 SD	< - 2 SD (< 10-years-old)
	HAZ	Stunting	< - 2 SD	< - 2 SD
Based on BMI	BAZ	Wasting	< - 2 SD	
		Thinness		< - 2 SD
		Normal		≥ - 2 SD
		Obese	> 3 SD	> 2 SD

WHO reference curves (de Onis, 2015:11)

3.4.2 Physical fitness assessments

For the purpose of this study, specific tests from the Eurofit test battery which are developed for children of school age (Council of Europe 1983:1) were implemented. The fitness component consisted of the following four measurements: SAR, GS, SBJ and the 20 m SRT. A composite PF score (calculated variable) was derived from the four PF measurements. Details pertaining to these PF tests and the calculated variable are to follow.

3.4.2.1 Sit- and-reach

Purpose of the measurement/test: To measure flexibility of the hip joint.

Equipment used:

- Box with measuring ruler; and
- 2 mats

Box construction (see Figure 3.6): A box was constructed with a length and width of 40 cm and height of 24 cm (see Figure 3.6 a). A long ruler of 75 cm with an overhang of 26 cm (0 cm in front of the learner, 75 cm at the end of the box) was secured on top of the box from which measurements were made (see Figure 3.6 b).

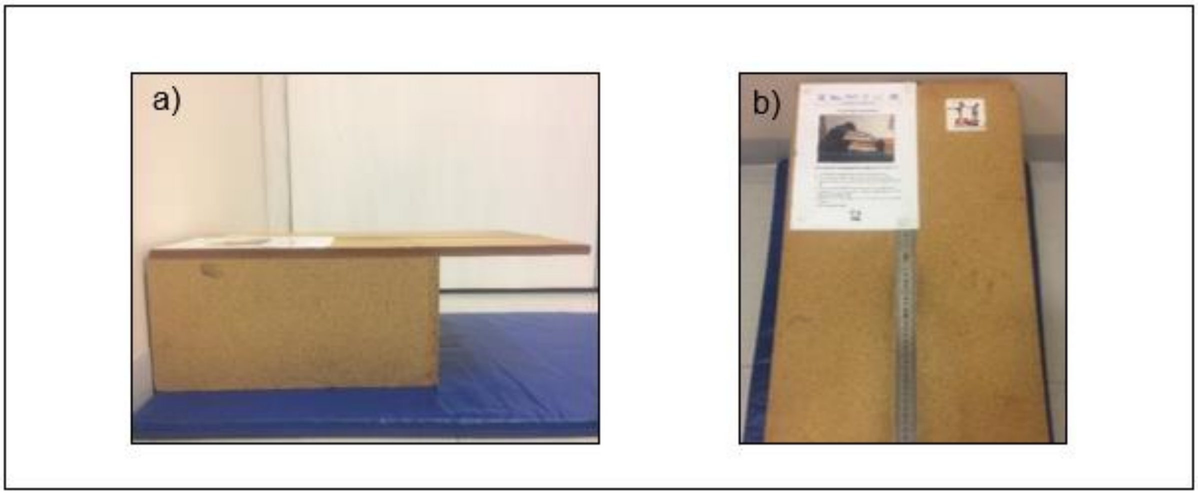

Figure 3.6: Sit-and-reach constructed box

SAR constructed box (Figure 3.6):

a) Side view of the SAR box; and
b) Ariel view of the SAR box.

Method: Seated on a mat (shoes removed), the learners were asked to stretch out their legs straight ahead of them with the soles of their feet placed flat against the box (see Figure 3.7 for a visual). Both knees were locked and pressed flat on the floor – the test administrator assisted by placing her hand on the learner's knees. The learner was asked to reach as far forward as possible along the ruler, with hands on top of each other and palms facing downward. The learner was instructed to place his/her head between his/her arms when reaching forward, then to take a deep breath in and exhale when reaching forward. The test administrator ensured that no jerky movements occurred while reaching forward. The recorded value is at the farthest point, where the fingertips touch the ruler. The learner held the position for two seconds before the distance was recorded.

Figure 3.7: Sit-and-reach method

Trials: Two trials

Scoring:

- The distance from 0 cm on the ruler to the edge of the fingertip was measured;
- Once the participant reached as far forward as possible, the position was held for two seconds after which the value was recorded.
- Scores were recorded to the nearest 0.1 cm; and
- The best score of the two trials was used.

Validity and reliability: Face validity was accepted; reliability: 0.80 – 0.96 (Safrit, 1990:22).

3.4.2.2 Grip strength

Purpose of the measurement/test: To measure upper body static strength.

Equipment used:

- 1 Saehan hydraulic hand dynamometer. See Figure 3.8 (a - c); and
- 1 stopwatch

Equipment setup: The handle of the dynamometer can be adjusted to five positions from 3.5 cm to 8.5 cm (steps of 1 cm) (see Figure 3.8). For testing purposes, the handle position remained consistent at handle position two.

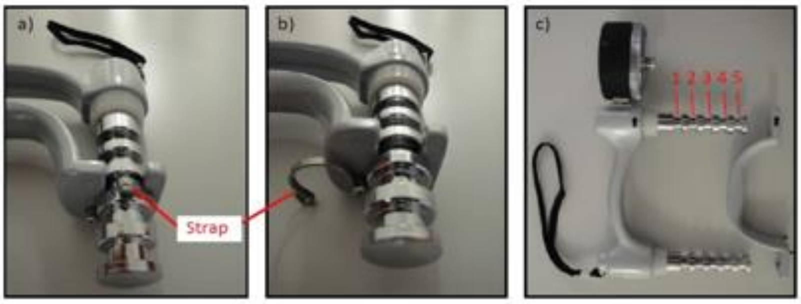

Figure 3.8: Grip strength handle positions 1 - 5

Before each measurement was taken, the needle tip of the hand dynamometer was reset to 0 kg by turning the dial on the meter display (Figure 3.9) counter-clockwise until the needle stopped.

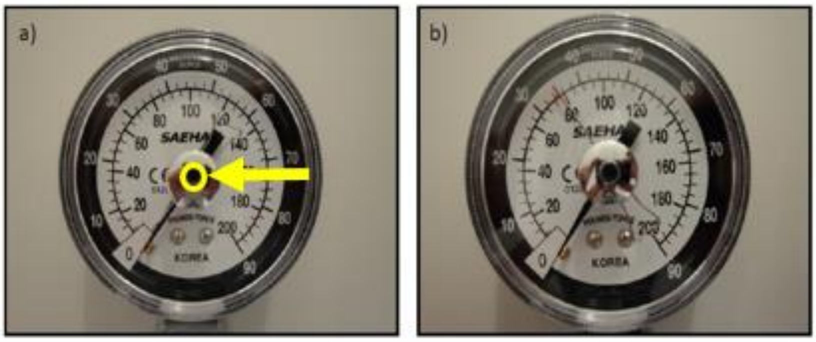

Figure 3.9: Grip strength dynamometer measurement display

GS dynamometer measurement display (Figure 3.9):

a) Display of the hand dynamometer with the red peak-hold needle tip on the zero position. The yellow arrow indicates the dial to return the peak hold needle tip to zero.
b) Gauge after use, the peak-hold needle remains at the maximum power when pressed.

Method: Starting position: The learner was seated with shoulders adducted and neutrally rotated with the arm at right angles and the elbow at the side of the body. The forearm was placed in neutral with the thumb pointing upwards and the wrist between 0 and 30° of flexion and between 0 and 15° ulnar deviation (Figure 3.10). The arm that was not in use was rested in a relaxed position.

Figure 3.10: Grip strength starting position

Measurement: There were three measurements performed on the right hand and three measurements on the left hand. Trials were performed between alternating hands. Each trial lasted five seconds, with a thirty-second break in between trials. The test administrator ensured that the learners started with their dominant hand, followed by their non-dominant hand. The test manager counted the five seconds out aloud during the test, and the scribe timed the thirty-second break between trials using the stopwatch.

Trials: Three alternate trials per hand.

Scoring:

- The final measurement was read and recorded in kilograms (kg) to the nearest 0.1 kg;
- Values from the dominant hand, and not the strongest hand, were used;
- The best score of the three trials was used; and
- The learner was strongly encouraged to give his/her maximum effort.

Validity and reliability: Face validity was accepted; reliability: 0.71 – 0.90

(Pate *et al.*, 2012:176).

3.4.2.3 *Standing broad jump*

Purpose of the measurement/test: To measure lower body dynamic strength.

Equipment used:

- A starting line marked with black spray paint;
- Black spray paint;
- 1 tent peg;
- 1 tape measure;
- 1 t-stick; and
- 1 90° triangle.

Site construction: (see Figure 3.11): A take-off line was marked using black spray paint which was used to indicate the start line. The zero of the tape measure was secured behind the start line using a tent peg while the 90º triangle was used to ensure that a 90º angle was formed between the start line and the tape measure. A T-stick was used to read values accurately from the tape measure.

Figure 3.11: Standing broad jump site construction

Method: Learners were asked to jump from the start line as far forward as possible. The learners stood exactly behind the starting line with feet placed parallel to each other before the jump. The jump was performed using counter-movement jump techniques. Participants started in an upright standing position, instructions were to simultaneously swing arms back, assume a squat position then immediately jump – there should be no pause in the squat position (see Figure 3.12 a for visual). Upon landing, feet were required to land together - the learner needed to maintain equilibrium without hands touching the floor (see Figure 3.12 b for visual). One practice trial was allowed, after which two trials were recorded. In the case of two invalid attempts, another attempt was allowed.

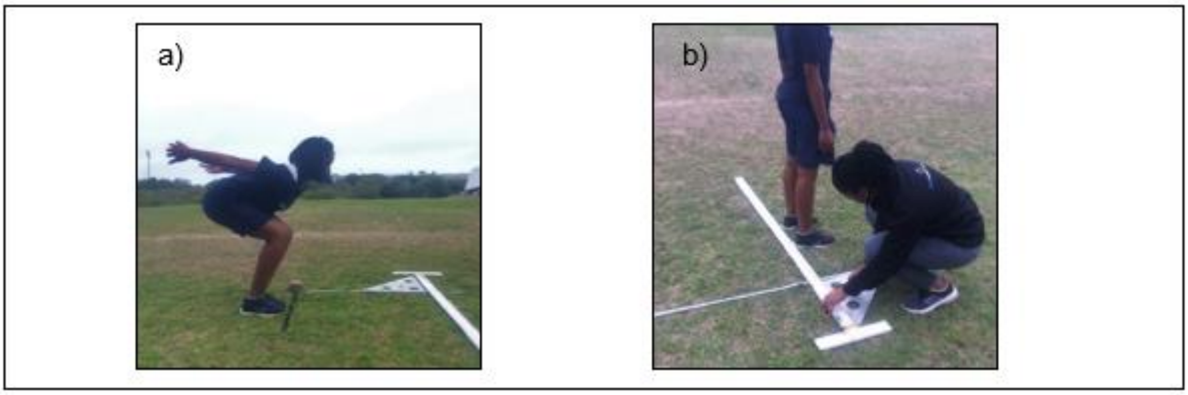

Figure 3.12: Standing broad jump starting position and measurement

SBJ starting position and measurement (Figure 3.12):

a) Counter-movement jump technique; and
b) Standing broad jump measuring method.

Trials: Two trials

Scoring:

- The T-stick was used to accurately record the distance jumped to avoid error of parallax;
- The jumped distance was measured from behind the inside border of the take-off line to the nearest planted heel;
- Values were measured in centimetres (cm) and recorded to the nearest 1 cm;
- The furthest of the two jumps was recorded; and
- The following attempts were considered invalid and another trial was given:
    - Take-off with one foot
    - Falling backward or touching the ground behind the feet when landing.

Validity and reliability: Face validity was accepted; reliability: r = 0.52 – 0.99 (Pate *et al.*, 2012:177).

3.4.2.4 20 m shuttle run test

Purpose of the measurement/test: To measure maximum aerobic capacity and determine predicted VO_2max.

Equipment used:

- 50 numbered sports bibs (1 – 50);
- 1 portable audio system;
- 1 USB stick with SRT soundtrack;
- 1 scoreboard (numbered 1-100);
- 50 colour coordinated beacons;
- 1 x 80 m rope; and
- 4 tent pegs.

Site construction: The 80 m rope was marked at every 20 m point. With four assistants, each holding the rope at a 20 m mark, a square was formed with the rope to indicate the running area. Four tent pegs were used to secure the rope to the ground and mark the 20 m x 20 m demarcated SRT area. One beacon was placed 2 m from each corner of the turn-line, which was used as a "warning point indicator" (control measure). Forty coloured cones were placed along the 20 m turn-lines (20 cones per line, which were colour coordinated), to allow one learner per meter width. Before the test started, each learner was assigned to a coloured cone to ensure that learners ran in a straight line. A test runner ran with the children to ensure that children ran at a uniform pace with the sound signal (see Figure 3.13 for the 20 m SRT site construction).

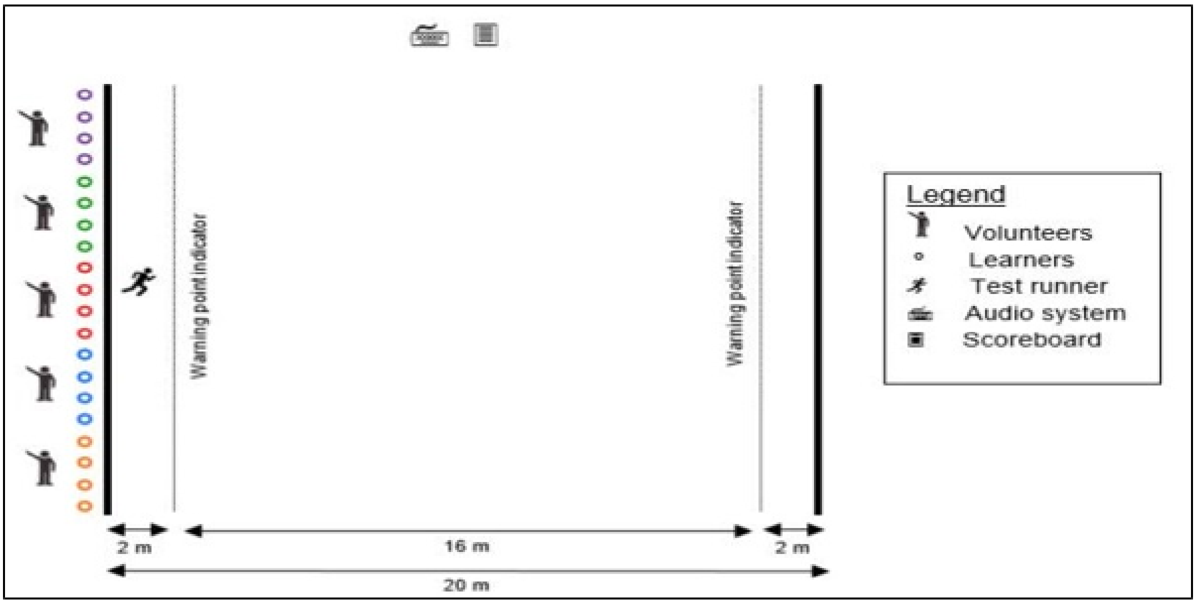

Figure 3.13: 20 m shuttle run test site construction

Method: The testing protocol was first explained and demonstrated in the classroom prior to the test being conducted outside on the field. It was important to prepare children for testing by explaining the test procedure in the learner's home language to ensure full understanding. Once the test was explained, with the help of supporting staff, the next step was to demonstrate the test to rule out misunderstanding and mistakes on the learner's part. The SRT was conducted twice per class as each class was divided into two groups (one male and one female group), and each learner was assigned a numbered sports bib. The number of the sports bib was recorded in the start number field of the fitness score sheet (as seen in Appendix B). Once the group completed the test, sports bibs were collected. The score sheets went through an end control, and the learners were given refreshments while they recovered in the shade.

The test started with the learners standing behind the 20 m turn-line facing the direction of the other turn-line. The test began with a running speed of 8.5 km/h; the frequency of the soundtrack signal (bleep) increased gradually such that every minute, the pace increased by 0.5 km/h. The children ran at a uniform pace with the test runner and did not run faster or slower than the speed specified by the sound signals (see Figure 3.14 for visual). Once learners reached the 20 m turn-line, they were required to wait until the sound signal beeped before continuing to run. If the learners stopped running, they were asked to leave the field as quickly as possible without disturbing the other learners.

Learners were required to touch the line with their foot and turn as quickly as possible. They were given a warning if they crossed the 2 m warning line but failed to reach the 20 m turn-line before the sound signal beeped. When a learner failed to keep up with the pace in two consecutive intervals (after two consecutive warnings), he/she was asked to stop, and the number of completed laps (cumulative shuttles) was recorded. Eventually, the age of the participating child and the speed at which the child stopped running was converted into the VO_2 max, which is the maximum volume of oxygen that can be utilised within one minute during exhaustive exercise.

Figure 3.14: Learner running at uniform pace with test runner

Trials: One trial

Scoring:

- During the 20 m SRT test, a volunteer displayed a scoreboard record of the number of the completed laps;
- The test result was the number of laps completed;
  - An estimated VO_2max value was calculated using the equation by Léger *et al.* (1988);
- Termination of the test:
  - If the learner stopped voluntarily due to exhaustion.
  - If the learner did not reach the 2m line twice in a row after a warning;
- Volunteers were placed on either side of the 20 m turn-line to inform the learners to run to their designated cone/not to run too fast, or not to run ahead of the test runner (a tester who ran according to the pace of the consecutive bleeps);

- Volunteers at the 20 m turn-line kept record of the number of completed laps (cumulative shuttles);
- Four learners were allowed per volunteer;
- Giving instructions before the test was advised (tying shoelaces, run in a straight line, run faster or slower, wait at the line etc.); and
- Encouraging the learners was allowed.

Validity and reliability: Validity: 0.71: reliability: 0.89 (Léger *et al.*, 1988:95)

Table 3.2 is a summary of the 20 m SRT protocol.

Table 3.2: 20 m shuttle run test protocol summary

Levels	Shuttles	Cumulative Shuttles	Speed (km/h)	Shuttle Time (s)	Distance (m)	Cumulative Distance (m)	Cumulative Time (min:s)
1	7	7	8.5	9.00	140	140	01:03
2	8	15	9.0	8.00	160	300	02:07
3	8	23	9.5	7.58	160	460	03:08
4	9	32	10.0	7.20	180	640	04:12
5	9	41	10.5	6.86	180	820	05:14
6	10	51	11.0	6.55	200	1020	06:20
7	10	61	11.5	6.26	200	1220	07:22
8	11	72	12.0	6.00	220	1440	08:28
9	11	83	12.5	5.76	220	1660	09:31
10	11	94	13.0	5.54	220	1880	10:32
11	12	106	13.5	5.33	240	2120	11:36
12	12	118	14.0	5.14	240	2360	12:38
13	13	131	14.5	4.97	260	2620	13:43
14	13	144	15.0	4.80	260	2880	14:45
15	13	157	15.5	4.65	260	3140	15:46

The age of the participating child and the speed (or level) at which the child stopped running was converted into the maximum volume of oxygen that can be utilised within one minute during exhaustive exercise (VO_2max). The following equation was used to calculate the VO_2max value:

20 m SRT prediction of VO_2max per speed and age:

*Y = 31.025 + 3.238 * X - 3.248 * A + 0.1536 * A * X*

Y = VO_2max value;
X = reached speed (km/h); and
A = rounded lower age.

3.4.2.5 Physical fitness calculated variable

3.4.2.5.1 Composite fitness score calculation

The composite score was calculated by converting each test score into a standard T-score and then to determine the average T-score for the PF test battery. Each test was equally weighted to calculate the composite score using four PF variables (SAR, GS, SBJ and the 20 m SRT results). A T-score is a standard score that has a mean of 50 and a standard deviation of 10.

3.5 DATA COLLECTION AND TESTING PROTOCOL

The DASH team (which included the researcher of the current study) conducted testing during school hours (8 am to 2 pm – due to safety reasons) on the respective school premises. The testing lasted three days per school, and all-inclusive data collection was conducted over a period of two months (February to March 2015).

Quantitative data was collected on the prevalence of intestinal parasites, measures of blood pressure and glycated haemoglobin level, psychosocial health, cognitive performance, academic performance, anthropometric variables, and PF measures. For this study, only the anthropometric and PF data was utilised. The collected data was double-entered and validated in EpiData3.1 (EpiData Association, Odense, Denmark) by the DASH team.

3.5.1 Clinical and anthropometric assessments

On day 1, each learner was issued with a 5-digit numeric ID (e.g. 01101). The first two digits indicate the school the learner was enrolled at (e.g. 01 meant School 1), the third digit indicated the class (e.g. 1 meant class A) and the last two digits indicated the unique ID (e.g. 01 referred to the first learner on the class list), which was in alphabetical order as per the class list.

Anthropometric measurements such as height, weight, and skinfolds were measured by Nelson Mandela University biokinetic interns who were trained in ISAK measurement techniques. Other measurements for the larger umbrella study included: academic performance (measured using academic reports of the previous year), psychosocial health and cognitive performance (measured using a questionnaire), a clinical examination which involved a detailed medical history and physical examination conducted by two professional nurses and parasitological examinations. Parasitological examinations were conducted independently, led by a researcher from the Swiss Tropical and Public Health Institute and examined by Nelson Mandela University laboratory technicians for detection of soil-transmitted helminth infections.

Due to the large sample size, one class was measured at a time. A strict schedule was adhered to in order to ensure that all learners had gone through clinical and anthropometric screening.

3.5.2 Physical fitness testing

Day 2 was assigned for the following tests: SAR, GS and SBJ while day 3 was devoted to the 20 m SRT. On day 2, classes were divided into four groups and each group was allocated to a fitness station. A sideways jump test was also measured to assess coordination (a skill-related fitness component) and formed part of the umbrella study. For the purposes of the present study, the sideways jump test was not included in the subsequent analyses. On day 3 of testing, one class was called out at a time for the 20 m SRT (see Appendix B for PF score sheet).

A fitness score outcome is a reliable result when the learner has a full understanding and is able to perform the test as best he or she can (Kemper & Van Mechelen, 1996:204). Children may lose concentration, so it was also important to keep the testing procedure fun and exciting, as well as appropriate for the age tested. It was vital to take these necessary measures into account when selecting and administrating a test battery to produce accurate and reliable test results (Morrow Jr *et al.*, 2011).

3.6 STATISTICAL ANALYSIS

A qualified statistician based at the Nelson Mandela University was consulted to assist with the statistical analysis of the data. Anthropometric indicators and PF components were analysed using STATISTICA Version 13 and Microsoft Excel 2010. Descriptive statistics were determined and are reflected by way of frequency distributions (for describing participant demographics) as well as values of central tendency and dispersion (for describing anthropometric and PF components).

Inferential statistics were used to indicate the significance of observed mean differences. One-way analysis of variance (ANOVA) was used to compare more than two means of numerical data. A *post hoc* analysis was conducted using the Scheffé p test to identify statistical significance ($p<.05$) when comparing two means. Practical significance was subsequently determined by means of Cohen's *d* statistic ($d<0.2$ no significance: $d=0.20-0.49$ small; $d=0.50-0.79$ medium and $d>0.80$ large significance) to indicate the effect size of the difference identified between two mean values. Where nominal data was analysed for statistical and practical significance, Chi-square and Cramer's V ($V=0.1-0.29$ small; $V=0.3-0.49$ medium; $V\geq0.5$ large practical significance) statistics were used, respectively (Gravetter & Wallnau, 2016:253,586). Tables and Figures are used to illustrate the results and values highlighted in the red bold text in the results chapter to depict statistically significant mean differences.

3.7 ETHICAL CONSIDERATIONS

In research, ethics is defined as a set of moral principles, suggested by an individual or group, which govern the rules and behavioural expectations of experimental participants and researchers. This set of moral values is widely accepted and also serves as a standard base upon which researchers should evaluate their conduct (Strydom, 2011:114).

The DASH Study was a 3-year (December 2013 – March 2017) collaborative research project between the Department of Human Movement Science from Nelson Mandela University, the Department of Sport, Exercise, and Health from the University of Basel and the Swiss Tropical and Public Health Institute from Switzerland. The paragraphs that follow discuss ethics clearance obtained from relevant institutions, as well as the ethics principles that were implemented for the DASH Study (which included the current study).

3.7.1 Ethics committee review

Ethics clearance for the DASH Study was sought from the Ethics Committee Northwest and Central Switzerland (EKNZ) and Ethics Committee in South Africa. The year 2014 focused primarily on setting the important groundwork for the research project. Permission to conduct the study and the relevant ethics clearance was obtained from the following organisations in South Africa:

- Nelson Mandela University Health Sciences Faculty Research Committee during July 2014;
- Nelson Mandela University Research Ethics Committee (Human) during July 2014 (Ethics reference number: H14-HEA-HMS-002);
- Eastern Cape Department of Education (ECDoE) during August 2014; and
- Eastern Cape Department of Health during November 2014.

For this study (a sub-set of the DASH Study), ethics clearance was obtained from the Faculty Postgraduate Studies Committee (FPGSC) at Nelson Mandela University during November 2014 (Ethics reference number: H14-HEA-HMS-017). No further ethics clearance was required from the Nelson Mandela University Research Ethics Committee – Human (REC-H) as the overall approval for the larger project (DASH Study) was sufficient (Ethics reference number: H14-HEA-HMS-002).

3.7.2 Ethics principles implemented

The following paragraphs give an account of the ethics principles undertaken to prevent harm to participants involved in the study:

- Project coordinators first contacted the relevant school authorities to obtain permission to conduct the study (details provided in point 3.7.1);
- Subsequently, principals and Grade 4 staff members who were interested in the DASH project were invited to an information meeting (held in October 2014). At the information meeting, researchers from the relevant institutions explained the study overview with regards to:

  - The study objectives and procedures;
  - Funding;
  - Potential risks and benefits associated with the project;
  - Confidentiality; and
  - Voluntary participation.
- Information letters were sent out to interested quintile 3 schools (as seen in Appendix C – letter to school principals). Once the school principal formally agreed to participate in the study, project information sheets (as seen in Appendix D) and informed consent forms (as seen in Appendix E) were sent out to all Grade 4 parents/guardians (English, Afrikaans, and Xhosa versions were made available).

3.7.2.1 Study objectives and procedures

The DASH Study analysed the burden and distribution of communicable diseases (e.g. helminth infections) and NCD's among schoolchildren in Port Elizabeth and assessed the impact diseases had on children's PF, cognitive performance and psychosocial health. The contact information of project coordinators was made available for any queries. School staff and parents/guardians concerned were informed about the following procedures required for testing:

- Clinical examination and anthropometric measurements;
- Stool and urine samples;
- Cognitive and psychosocial health questionnaires; and
- PF testing.

The current study formed part of baseline testing (T1) that required clinical and anthropometric measurements and PF data. Thereafter, the information gathered from baseline testing allowed researchers to introduce targeted health interventions for the larger DASH Study.

3.7.2.2 Consent and assent

Interested parents/guardians were required to sign individual written informed consent for the participation of their child (as seen in Appendix E). The aim, objectives, procedures and the potential risks and benefits of the study were clearly stated and explained. In addition, learners were required to give oral assent before participating in the study (as seen in Appendix F).

3.7.2.3 Voluntary participation

According to (Strydom, 2011:116, 119), respect for persons implies voluntary participation; therefore, parents/guardians had no obligation to enrol their child/children in the study, and learners were allowed the chance to decide if they wanted to participate. Furthermore, both parents/guardians and learners involved in the study could withdraw from testing, at any point, without further repercussions.

3.7.2.4 Risks and benefits

There were no risks associated with the DASH Study. When measuring skinfolds, children were assured that the calipers would not hurt. Prior to PF testing, the researchers ensured the environment was rid of objects that could potentially harm the participants. In addition, after the 20 m SRT, learners received juice and cooled off in the shade before returning to class.

For the larger study, a blood sample was required, as well as a stool and urine sample. Free treatment of helminth infection was offered to all children, regardless of participation in the study, and treatment was administered by medical staff.

3.7.2.3 Confidentiality

Researchers involved in the DASH Study ensured the accuracy and completeness of data collected. All data collected was coded with a unique personal identification number and stored safely. Parents/guardians/participants were informed that key findings of the study would be published and assured that no personal identities will be revealed.

3.7.2.4 Plagiarism

Ethics on avoiding plagiarism was maintained by ensuring that authors and sources for the data researched and used were acknowledged (Thomas *et al.*, 2015:77-78). Furthermore, the researcher has acknowledged and given reference to the author/writers used when paraphrasing words or ideas that were not her own.

The following chapter, Chapter 4, will reflect the results obtained from the research conducted to achieve the aims and objectives of the current study.

CHAPTER 4

RESULTS

4.1 INTRODUCTION

The primary aim of this study was to investigate the PF profile of primary schoolchildren, in the age-range 8-to-11-years-old, from eight selected schools in lower socio-economic communities in Port Elizabeth.

This chapter presents the results obtained from various anthropometric measurements and PF tests. The anthropometric components assessed consist of height, weight and skinfold measurements as well as calculated variables: BF%, BMI and z scores: WAZ, HAZ and BAZ. PF components (and the relevant test/s) assessed consist of flexibility using the SAR test, muscular strength using the GS and SBJ tests and CRF using the 20 m SRT. The results have been presented in relation to the objectives of the study.

Anthropometric calculations for WAZ, HAZ and BAZ were calculated using WHO AnthroPlus Version 3.2.2 (WHO, 2009). All anthropometric and PF data were analysed using STATISTICA Version 13 and Microsoft Excel 2010, and are reflected in relation to age, gender, ethnicity, school and geographic area. Descriptive statistics were determined and are reflected by way of measures of central tendency and standard deviation. Inferential statistics were used to indicate the significance of observed mean differences. One-way analysis of variance (ANOVA) was used to compare more than two means of numerical data. Post-hoc analysis was conducted using the Scheffé p test to identify statistical significance ($p<.05$) when comparing two means and practical significance was subsequently determined by means of Cohen's d values ($d<0.2$=no significance; $d=0.20-0.49$ small; $d=0.50-0.79$ medium and $d>0.80$ large) to indicate the effect size of the difference depicted between two mean values. Where nominal data were analysed for statistical and practical significance, Chi square and Cramer's V ($V=0.1-0.29$ small; $V=0.3-0.49$ medium; $V\geq0.5$ large practical significance) statistics were used (Gravetter & Wallnau, 2016:253,586). Tables and figures are used to illustrate the results. Values highlighted in red bold text show statistically significant results ($p<.05$; $d>0.2$; $V>0.1$).

4.2 PARTICIPANTS

Table 4.1 reflects descriptive statistics for the participants in relation to age, gender, ethnicity, language, and numbers per school (in a geographic area). Values are expressed as sample size and relative percentage (%) of total sample size.

Table 4.1: Participant demographics

Categories	n	%
Age (years)		
8	91	10%
9	442	48%
10	268	29%
11	114	12%
Total	915	100%
Age Category (years)		
8 – 9 combined	533	58%
10 – 11 combined	382	42%
Total	915	100%
Gender		
Boys	462	50%
Girls	453	50%
Total	915	100%
Ethnicity		
Black African	569	62%
Coloured	346	38%
Total	915	100%
Language		
Xhosa	563	62%
Afrikaans	330	36%
English	19	2%
Other African languages	3	0%
Total	915	100%
School (Geographic Area)		
School 1 (Northern Areas)	105	11%
School 2 (Northern Areas)	173	19%
School 3 (Northern Areas)	87	10%
School 4 (Township Area)	122	13%
School 5 (Township Area)	90	10%
School 6 (Township Area)	87	10%
School 7 (Township Area)	148	16%
School 8 (Northern Areas)	103	11%
Total	915	100%

The age of the study sample ranged between 8-to-11-years. The sample was grouped into two age categories, a younger age group consisting of the 8-to-9-year-olds (n=533) and an older age group consisting of the 10-to-11-year-olds (n=382). The younger age group category (8-to-9-year-olds) had a higher frequency of representation with 58% in comparison to the older age group category (10-to-11-year-olds) with 42%. The highest per single age frequency was 48% (9-year-olds group) followed by 29% (10-year-old group). The lowest and second lowest per single age frequency was 10% (8-year-old group) and 12% (11-year-old group). Therefore, the younger age group category (8-to-9-year-olds) consisted of the highest (48% in the 9-year-olds group) as well as the lowest (10% in the 8-year-old group) per single age frequencies. The average age of the participants was 9.96±0.80 years.

The study sample encompassed a balanced gender distribution consisting of 462 (50%) boys and 453 (50%) girls. A large portion of the sample were of Black African ethnicity (62%) and Xhosa speaking, while the remaining percentage of the sample were of Coloured ethnicity (38%). Most Black African learners live in Township Areas and Coloured learners live in the Northern Areas due of past apartheid laws. Post-apartheid, the Group Areas Act no longer stands, thus, geographical areas are no longer reserved for distinct ethnic groups. Although the policy was applied to schools, this is not reflected by the distribution of learners in the schools. Four of the eight participating schools are populated by Black African learners from the Township Area (49% of the total sample pool). Another two schools are attended by Coloured learners from the Northern Areas (29% of the total sample pool), and the remaining two schools – located in the Northern Areas are populated by a combination of Black African and Coloured learners (22% of the total sample pool).

4.3 ANTHROPOMETRIC COMPONENTS PER SELECTED DEMOGRAPHICS

This section presents comparisons of anthropometric components in relation to gender, ethnicity and geographical area. Descriptive and inferential statistics for anthropometric components in relation to gender, ethnicity and geographical area are displayed in Tables 4.2 to 4.18.

Table 4.2 reflects the gender comparative statistics in relation to anthropometric components per age group.

Table 4.2: Comparison between boys and girls per age group for anthropometric components

Variable	Age	Boys			Girls			Difference	Inferential Statistics			
		n	Mean	SD	n	Mean	SD		t	df	p	Cohen's d
Height (cm)	8	33	131.19	4.58	58	129.71	6.28	1.49	1.19	89	.237	n/a
	9	195	131.28	5.68	247	131.33	6.54	-0.05	-0.08	440	.933	n/a
	10	158	134.04	7.07	110	135.96	7.90	-1.92	-2.08	266	**.038**	**0.26**
	11	76	137.70	6.86	38	137.26	7.23	0.44	0.32	112	.753	n/a
	8-9	228	131.26	5.52	305	131.02	6.51	0.25	0.46	531	.645	n/a
	10-11	234	135.23	7.20	148	136.29	7.73	-1.06	-1.37	380	.172	n/a
	All	462	133.27	6.72	453	132.74	7.36	0.53	1.14	913	.255	n/a
Weight (kg)	8	33	29.02	4.64	58	29.40	6.94	-0.38	-0.28	89	.779	n/a
	9	195	29.17	6.48	247	29.86	7.78	-0.69	-0.99	440	.321	n/a
	10	158	30.52	7.43	110	32.30	9.20	-1.78	-1.75	266	.082	n/a
	11	76	32.43	7.33	38	32.54	6.81	-0.12	-0.08	112	.933	n/a
	8-9	228	29.15	6.23	305	29.77	7.62	-0.62	-1.01	531	.313	n/a
	10-11	234	31,14	7,43	148	32,36	8,63	-1,22	-1,47	380	.142	n/a
	All	462	30,16	6,93	453	30,62	8,04	-0,46	-0,93	913	.351	n/a
BMI (kg/m²)	8	33	16.81	2.29	58	17.34	3.16	-0.53	-0.84	89	.401	n/a
	9	195	16.81	2.70	247	17.15	3.30	-0.34	-1.15	440	.249	n/a
	10	158	16.84	2.86	110	17.25	3.53	-0.41	-1.05	266	.296	n/a
	11	76	16.95	2.62	38	17.13	2.57	-0.18	-0.34	112	.733	n/a
	8-9	228	16.81	2.64	305	17.18	3.27	-0.37	-1.42	531	.157	n/a
	10-11	234	16.87	2.78	148	17.22	3.31	-0.34	-1.09	380	.276	n/a
	All	462	16.84	2.71	453	17.19	3.28	-0.35	-1.77	913	.076	n/a
BF%	8	33	13.36	5.58	58	18.94	6.46	-5.58	-4.16	89	**<.0005**	**0.91**
	9	195	13.09	6.16	247	18.57	6.89	-5.48	-8.69	440	**<.0005**	**0.83**
	10	158	13.30	5.83	110	18.50	6.85	-5.20	-6.68	266	**<.0005**	**0.83**
	11	76	13.61	5.77	38	18.40	5.76	-4.78	-4.17	112	**<.0005**	**0.83**
	8-9	228	13.13	6.07	305	18.64	6.80	-5.51	-9.68	531	**<.0005**	**0.85**
	10-11	234	13.40	5.80	148	18.47	6.57	-5.07	-7.91	380	**<.0005**	**0.83**
	All	462	13.27	5.93	453	18.58	6.72	-5.32	-12.70	913	**<.0005**	**0.84**
WAZ (z-score)	8	33	0.21	1.08	58	0.13	1.25	0.08	0.31	89	.754	n/a
	9	195	-0.31	1.17	247	-0.24	1.32	-0.06	-0.53	440	.595	n/a
	8-9	228	-0.23	1.17	305	-0.17	1.31	-0.06	-0.54	531	.586	n/a
HAZ (z-score)	8	33	-0.07	0.80	58	-0.31	1.04	0.24	1.13	89	.261	n/a
	9	195	-0.66	0.91	247	-0.65	1.06	-0.01	-0.16	440	.876	n/a
	10	158	-0.93	1.06	110	-0.83	1.19	-0.11	-0.78	266	.435	n/a
	11	76	-1.12	1.00	38	-1.42	1.08	0.30	1.45	112	.149	n/a
	8-9	228	-0.58	0.92	305	-0.58	1.07	0.01	0.07	531	.944	n/a
	10-11	234	-0.99	1.04	148	-0.98	1.18	-0.02	-0.15	380	.884	n/a
	All	462	-0.79	1.00	453	-0.71	1.12	-0.08	-1.08	913	.279	n/a
BAZ (z-score)	8	33	0.29	1.18	58	0.37	1.26	-0.08	-0.29	89	.771	n/a
	9	195	0.10	1.15	247	0.13	1.22	-0.03	-0.28	440	.782	n/a
	10	158	-0.13	1.15	110	-0.15	1.34	0.02	0.13	266	.894	n/a
	11	76	-0.35	1.17	38	-0.36	1.21	0.01	0.02	112	.982	n/a
	8-9	228	0.13	1.15	305	0.18	1.23	-0.05	-0.47	531	.640	n/a
	10-11	234	-0.20	1.16	148	-0.20	1.31	0.00	0.01	380	.991	n/a
	All	462	-0.04	1.17	453	0.05	1.27	-0.09	-1.14	913	.255	n/a

As seen in Table 4.2, girls were significantly taller than boys in the 10-year-old age category. However, when combining age categories 8-to-9-year-old and 10-to-11-year-olds, there were no significant differences. Girls were heavier and had higher BMI values than boys in all age categories, but this was not statistically different. There were significant statistical and practical differences between boys and girls for BF% in all age categories, with girls having a higher BF%.

Table 4.3 depicts the comparison between Black African and Coloured boys in relation to the anthropometric components per age group.

Table 4.3: Comparison between Black African and Coloured boys per age group for anthropometric components

		Black African			Coloured				Inferential Statistics			
Variable	**Age**	**n**	**Mean**	**SD**	**n**	**Mean**	**SD**	**Difference**	**t**	**df**	**p**	**Cohen's d**
Height (cm)	8	28	131.48	4.30	5	129.60	6.27	1.88	0.84	31	.407	n/a
	9	133	132.01	5.84	62	129.70	5.01	2.31	2.69	193	**.008**	**0.41**
	10	81	135.99	7.23	77	131.98	6.32	4.01	3.70	156	**<.0005**	**0.59**
	11	41	139.97	6.76	35	135.03	6.05	4.93	3.33	74	**.001**	**0.77**
	8-9	161	131.92	5.59	67	129.69	5.05	2.23	2.81	226	**.005**	**0.41**
	10-11	122	137.33	7.30	112	132.93	6.37	4.39	4.89	232	**<.0005**	**0.64**
	All	283	134.25	6.91	179	131.72	6.10	2.53	4.00	460	**<.0005**	**0.38**
Weight (kg)	8	28	29.33	4.63	5	27.26	4.84	2.07	0.92	31	.366	n/a
	9	133	30.29	7.10	62	26.77	3.96	3.52	3.64	193	**<.0005**	**0.56**
	10	81	31.97	8.79	77	28.99	5.29	2.98	2.57	156	**.011**	**0.41**
	11	41	35.39	8.02	35	28.95	4.46	6.44	4.23	74	**<.0005**	**0.97**
	8-9	161	30.13	6.73	67	26.81	3.99	3.32	3.76	226	**<.0005**	**0.55**
	10-11	122	33.12	8.66	112	28.98	5.03	4.15	4.43	232	**<.0005**	**0.58**
	All	283	31.42	7.75	179	28.17	4.77	3.25	5.04	460	**<.0005**	**0.48**
BMI (kg/m^2)	8	28	16.93	2.33	5	16.17	2.14	0.76	0.68	31	.500	n/a
	9	133	17.25	2.98	62	15.85	1.62	1.40	3.46	193	**.001**	**0.53**
	10	81	17.12	3.47	77	16.54	2.02	0.58	1.28	156	.201	n/a
	11	41	17.92	2.91	35	15.81	1.65	2.11	3.79	74	**<.0005**	**0.87**
	8-9	161	17.20	2.88	67	15.88	1.65	1.32	3.52	226	**.001**	**0.51**
	10-11	122	17.39	3.30	112	16.31	1.93	1.08	3.02	232	**.003**	**0.39**
	All	283	17.28	3.06	179	16.15	1.84	1.13	4.46	460	**<.0005**	**0.43**
BF%	8	28	13.17	5.53	5	14.40	6.46	-1.23	-0.45	31	.657	n/a
	9	133	13.94	6.74	62	11.26	4.14	2.68	2.88	193	**.004**	**0.44**
	10	81	13.92	6.70	77	12.64	4.71	1.27	1.37	156	.172	n/a
	11	41	15.74	6.57	35	11.12	3.30	4.62	3.77	74	**<.0005**	**0.87**
	8-9	161	13.81	6.54	67	11.50	4.36	2.31	2.66	226	**.008**	**0.39**
	10-11	122	14.53	6.68	112	12.17	4.36	2.36	3.17	232	**.002**	**0.41**
	All	283	14.12	6.60	179	11.92	4.36	2.20	3.95	460	**<.0005**	**0.38**
WAZ (z-score)	8	28	0.27	1.05	5	-0.14	1.29	0.41	0.78	31	.444	n/a
	9	133	-0.05	1.18	62	-0.85	0.93	0.80	4.69	193	**<.0005**	**0.72**
	8-9	161	0.00	1.16	67	-0.80	0.97	0.80	4.98	226	**<.0005**	**0.72**

		Black African			Coloured				Inferential Statistics			
Variable	Age	n	Mean	SD	n	Mean	SD	Difference	t	df	p	Cohen's d
HAZ (z-score)	8	28	-0.05	0.69	5	-0.22	1.35	0.17	0.44	31	.665	n/a
	9	133	-0.51	0.93	62	-0.99	0.77	0.47	3.47	193	**.001**	**0.53**
	10	81	-0.60	1.06	77	-1.28	0.94	0.68	4.26	156	**<.0005**	**0.68**
	11	41	-0.75	0.94	35	-1.55	0.89	0.81	3.82	74	**<.0005**	**0.88**
	8-9	161	-0.43	0.91	67	-0.93	0.84	0.50	3.83	226	**<.0005**	**0.56**
	10-11	122	-0.65	1.02	112	-1.37	0.93	0.72	5.60	232	**<.0005**	**0.73**
	All	283	-0.53	0.96	179	-1.20	0.92	0.68	7.48	460	**<.0005**	**0.71**
BAZ (z-score)	8	28	0.34	1.20	5	-0.02	1.12	0.36	0.63	31	.532	n/a
	9	133	0.33	1.17	62	-0.40	0.94	0.73	4.27	193	**<.0005**	**0.66**
	10	81	-0.01	1.19	77	-0.26	1.10	0.25	1.39	156	.166	n/a
	11	41	0.15	1.08	35	-0.94	0.99	1.09	4.55	74	**<.0005**	**1.05**
	8-9	161	0.33	1.17	67	-0.37	0.95	0.70	4.33	226	**<.0005**	**0.63**
	10-11	122	0.05	1.15	112	-0.47	1.11	0.52	3.50	232	**.001**	**0.46**
	All	283	0.21	1.17	179	-0.43	1.05	0.64	5.97	460	**<.0005**	**0.57**

According to Table 4.3, Black African boys presented with higher values in all cases, except in the case of BF% for 8-year-olds. There were statistical and practical significant differences depicted between Black African and Coloured boys in all anthropometric components across all the age groups, except in the case of the 8-year-olds for all the variables measured and the 10-year-olds for BMI, BF% and BAZ.

Table 4.4 reflects the comparison between Black African and Coloured girls in relation to the anthropometric components per age group.

Table 4.4: Comparison between Black African and Coloured girls per age group for anthropometric components

		Black African			Coloured				Inferential Statistics			
Variable	Age	n	Mean	SD	n	Mean	SD	Difference	t	df	p	Cohen's d
Height (cm)	8	45	130.52	5.87	13	126.88	7.08	3.65	1.88	56	.065	n/a
	9	172	132.29	6.24	75	129.12	6.71	3.17	3.59	245	**<.0005**	**0.50**
	10	52	138.67	7.73	58	133.52	7.30	5.14	3.59	108	**.001**	**0.69**
	11	17	139.74	6.72	21	135.25	7.16	4.48	1.97	36	.056	n/a
	8-9	217	131.92	6.19	88	128.79	6.77	3.14	3.90	303	**<.0005**	**0.49**
	10-11	69	138.93	7.46	79	133.98	7.26	4.95	4.08	146	**<.0005**	**0.67**
	All	286	133.61	7.17	167	131.24	7.45	2.37	3.34	451	**.001**	**0.33**
Weight (kg)	8	45	29.93	6.60	13	27.57	8.02	2.36	1.08	56	.284	n/a
	9	172	30.91	8.07	75	27.47	6.50	3.44	3.26	245	**.001**	**0.45**
	10	52	36.27	9.57	58	28.74	7.26	7.53	4.67	108	**<.0005**	**0.89**
	11	17	35.86	6.22	21	29.86	6.15	6.01	2.98	36	**.005**	**0.97**
	8-9	217	30.70	7.78	88	27.48	6.69	3.22	3.41	303	**.001**	**0.43**
	10-11	69	36.17	8.82	79	29.04	6.96	7.13	5.49	146	**<.0005**	**0.90**
	All	286	32.02	8.36	167	28.22	6.85	3.81	4.98	451	**<.0005**	**0.49**
BMI (kg/m²)	8	45	17.49	3.21	13	16.84	3.03	0.65	0.65	56	.520	n/a
	9	172	17.50	3.47	75	16.32	2.72	1.18	2.62	245	**.009**	**0.36**
	10	52	18.70	3.90	58	15.94	2.56	2.76	4.43	108	**<.0005**	**0.85**

		Black African			Coloured				Inferential Statistics			
Variable	**Age**	**n**	**Mean**	**SD**	**n**	**Mean**	**SD**	**Difference**	**t**	**df**	**p**	**Cohen's d**
BMI (kg/m²)	11	17	18.30	2.67	21	16.18	2.10	2.12	2.74	36	.009	0.90
	8-9	217	17.50	3.41	88	16.40	2.76	1.10	2.69	303	.007	0.34
	10-11	69	18.60	3.62	79	16.00	2.44	2.60	5.18	146	<.0005	0.85
	All	286	17.77	3.49	167	16.21	2.61	1.55	5.00	451	<.0005	0.49
BF%	8	45	19.28	6.57	13	17.75	6.20	1.53	0.75	56	.456	n/a
	9	172	19.02	7.13	75	17.52	6.23	1.50	1.58	245	.116	n/a
	10	52	21.93	7.20	58	15.43	4.80	6.50	5.63	108	<.0005	1.07
	11	17	19.61	5.41	21	17.42	5.97	2.19	1.17	36	.249	n/a
	8-9	217	19.08	7.00	88	17.56	6.19	1.52	1.77	303	.077	n/a
	10-11	69	21.36	6.84	79	15.95	5.17	5.40	5.46	146	<.0005	0.90
	All	286	19.63	7.02	167	16.80	5.77	2.83	4.41	451	<.0005	0.43
WAZ (z-score)	8	45	0.26	1.12	13	-0.33	1.59	0.59	1.52	56	.135	n/a
	9	172	-0.02	1.26	75	-0.76	1.31	0.75	4.24	245	<.0005	0.59
	8-9	217	0.04	1.23	88	-0.70	1.36	0.74	4.62	303	<.0005	0.58
HAZ (z-score)	8	45	-0.18	0.98	13	-0.75	1.17	0.57	1.76	56	.083	n/a
	9	172	-0.48	1.02	75	-1.04	1.07	0.57	3.96	245	<.0005	0.55
	10	52	-0.35	1.08	58	-1.25	1.12	0.90	4.27	108	<.0005	0.82
	11	17	-0.99	1.00	21	-1.76	1.05	0.76	2.27	36	.029	0.74
	8-9	217	-0.42	1.02	88	-1.00	1.08	0.58	4.47	303	<.0005	0.57
	10-11	69	-0.51	1.09	79	-1.39	1.12	0.87	4.80	146	<.0005	0.79
	All	286	-0.44	1.03	167	-1.18	1.11	0.74	7.18	451	<.0005	0.70
BAZ (z-score)	8	45	0.44	1.20	13	0.12	1.49	0.32	0.81	56	.420	n/a
	9	172	0.30	1.18	75	-0.26	1.24	0.56	3.37	245	.001	0.47
	10	52	0.46	1.33	58	-0.70	1.09	1.17	5.04	108	<.0005	0.96
	11	17	0.19	1.08	21	-0.80	1.15	0.99	2.72	36	.010	0.89
	8-9	217	0.33	1.18	88	-0.20	1.28	0.53	3.48	303	.001	0.44
	10-11	69	0.40	1.27	79	-0.73	1.10	1.13	5.77	146	<.0005	0.95
	All	286	0.35	1.20	167	-0.45	1.22	0.80	6.77	451	<.0005	0.66

According to Table 4.4, Black African girls presented with higher anthropometric values than Coloured girls for all age groups. These anthropometric differences were all significant except in the case of 8-year-olds for all anthropometric variables, the 11-year-olds in the case of height, and the 11- and 8-to-9-year-olds in respect of BF%.

Table 4.5 reflects the comparison between Black African and Coloured participants (boys and girls combined) in relation to the anthropometric components per age group.

Table 4.5: Comparison between Black African and Coloured participants per age group for anthropometric components

		Black African			Coloured				Inferential Statistics			
Variable	**Age**	**n**	**Mean**	**SD**	**n**	**Mean**	**SD**	**Difference**	**t**	**df**	**p**	**Cohen's d**
Height (cm)	8	73	130.89	5.31	18	127.63	6.79	3.26	2.20	89	.030	0.58
	9	305	132.17	6.06	137	129.38	5.98	2.79	4.49	440	<.0005	0.46
	10	133	137.04	7.52	135	132.64	6.78	4.39	5.03	266	<.0005	0.61

		Black African			Coloured				Inferential Statistics			
Variable	**Age**	**n**	**Mean**	**SD**	**n**	**Mean**	**SD**	**Difference**	**t**	**df**	**p**	**Cohen's d**
Height (cm)	11	58	139.90	6.69	56	135.12	6.42	4.78	3.89	112	<.0005	0.73
	8-9	378	131.92	5.94	155	129.18	6.09	2.74	4.81	531	<.0005	0.46
	10-11	191	137.91	7.38	191	133.37	6.75	4.54	6.27	380	<.0005	0.64
	All	569	133.93	7.04	346	131.49	6.78	2.44	5.15	913	<.0005	0.35
Weight (kg)	8	73	29.70	5.89	18	27.48	7.13	2.22	1.37	89	.174	n/a
	9	305	30.64	7.65	137	27.15	5.49	3.49	4.80	440	<.0005	0.49
	10	133	33.65	9.31	135	28.88	6.19	4.77	4.95	266	<.0005	0.60
	11	58	35.53	7.49	56	29.29	5.13	6.24	5.18	112	<.0005	0.97
	8-9	378	30.46	7.35	155	27.19	5.68	3.27	4.96	531	<.0005	0.47
	10-11	191	34.22	8.82	191	29.00	5.89	5.22	6.81	380	<.0005	0.70
	All	569	31.72	8.06	346	28.19	5.86	3.53	7.09	913	<.0005	0.48
BMI (kg/m²)	8	73	17.27	2.90	18	16.65	2.77	0.62	0.82	89	.415	n/a
	9	305	17.39	3.26	137	16.11	2.29	1.28	4.17	440	<.0005	0.43
	10	133	17.74	3.71	135	16.28	2.28	1.46	3.88	266	<.0005	0.47
	11	58	18.03	2.83	56	15.95	1.82	2.08	4.66	112	<.0005	0.87
	8-9	378	17.37	3.19	155	16.17	2.35	1.20	4.22	531	<.0005	0.40
	10-11	191	17.83	3.46	191	16.18	2.16	1.65	5.58	380	<.0005	0.57
	All	569	17.52	3.29	346	16.18	2.24	1.35	6.72	913	<.0005	0.46
BF%	8	73	16.94	6.84	18	16.82	6.27	0.12	0.07	89	.947	n/a
	9	305	16.81	7.40	137	14.69	6.21	2.12	2.92	440	.004	0.30
	10	133	17.05	7.91	135	13.84	4.93	3.21	3.99	266	<.0005	0.49
	11	58	16.87	6.45	56	13.48	5.40	3.39	3.04	112	.003	0.57
	8-9	378	16.83	7.28	155	14.94	6.23	1.90	2.84	531	.005	0.27
	10-11	191	17.00	7.48	191	13.73	5.06	3.26	4.99	380	<.0005	0.51
	All	569	16.89	7.34	346	14.27	5.64	2.61	5.68	913	<.0005	0.39
WAZ (z-score)	8	73	0.27	1.09	18	-0.28	1.48	0.54	1.75	89	.083	n/a
	9	305	-0.03	1.22	137	-0.80	1.15	0.77	6.25	440	<.0005	0.64
	8-9	378	0.03	1.20	155	-0.74	1.20	0.77	6.70	531	<.0005	0.64
HAZ (z-score)	8	73	-0.13	0.88	18	-0.60	1.21	0.47	1.89	89	.062	n/a
	9	305	-0.49	0.98	137	-1.02	0.94	0.53	5.26	440	<.0005	0.54
	10	133	-0.51	1.07	135	-1.27	1.02	0.76	5.99	266	<.0005	0.73
	11	58	-0.82	0.95	56	-1.63	0.95	0.81	4.54	112	<.0005	0.85
	8-9	378	-0.42	0.97	155	-0.97	0.98	0.55	5.88	531	<.0005	0.56
	10-11	191	-0.60	1.04	191	-1.38	1.01	0.77	7.37	380	<.0005	0.75
	All	569	-0.48	1.00	346	-1.19	1.02	0.71	10.37	913	<.0005	0.71
BAZ (z-score)	8	73	0.40	1.19	18	0.08	1.36	0.32	1.01	89	.316	n/a
	9	305	0.31	1.17	137	-0.32	1.11	0.63	5.33	440	<.0005	0.55
	10	133	0.18	1.26	135	-0.45	1.11	0.63	4.32	266	<.0005	0.53
	11	58	0.16	1.07	56	-0.89	1.04	1.05	5.29	112	<.0005	0.99
	8-9	378	0.33	1.18	155	-0.27	1.15	0.61	5.43	531	<.0005	0.52
	10-11	191	0.17	1.21	191	-0.58	1.11	0.75	6.34	380	<.0005	0.65
	All	569	0.28	1.19	346	-0.44	1.14	0.72	9.04	913	<.0005	0.62

As seen in Table 4.5, Black African participants presented with higher values than Coloured participants in all anthropometric variables. The difference between Black African and Coloured learners for all these variables across all age groups is statistically and practically significant. This, however, is not the case for the 8-year-olds for weight, BMI, BF%, WAZ, HAZ and BAZ.

Table 4.6 presents the comparison between the Northern Areas and Township schools' mean scores for the anthropometric components per gender and total groups.

Table 4.6: Comparison between participants from Northern Areas and Township Area schools per gender group for anthropometric components

		Northern Areas			Township Areas				Inferential Statistics			
Variable	**Gender**	**n**	**Mean**	**SD**	**n**	**Mean**	**SD**	**Difference**	**t**	**df**	**p**	**Cohen's d**
Height (cm)	Boys	235	132.09	6.20	227	134.50	7.02	-2.41	-3.91	460	**<.0005**	**0.36**
	Girls	233	131.92	7.70	220	133.61	6.89	-1.70	-2.47	451	**.014**	**0.23**
	All	468	132.00	6.98	447	134.06	6.96	-2.06	-4.47	913	**<.0005**	**0.30**
Weight (kg)	Boys	235	29.02	5.98	227	31.34	7.63	-2.32	-3.64	460	**<.0005**	**0.34**
	Girls	233	28.93	6.92	220	32.41	8.75	-3.47	-4.70	451	**<.0005**	**0.44**
	All	468	28.98	6.46	447	31.86	8.21	-2.89	-5.92	913	**<.0005**	**0.39**
BMI (kg/m²)	Boys	235	16.52	2.40	227	17.18	2.97	-0.66	-2.63	460	**.009**	**0.24**
	Girls	233	16.46	2.57	220	17.97	3.74	-1.52	-5.06	451	**<.0005**	**0.48**
	All	468	16.49	2.48	447	17.57	3.39	-1.08	-5.53	913	**<.0005**	**0.37**
BF%	Boys	235	12.70	5.79	227	13.85	6.03	-1.14	-2.08	460	**.038**	**0.19**
	Girls	233	17.24	5.64	220	20.01	7.45	-2.77	-4.47	451	**<.0005**	**0.42**
	All	468	14.96	6.14	447	16.88	7.43	-1.92	-4.26	913	**<.0005**	**0.28**
WAZ (z-score)	Boys	109	-0.38	1.24	119	-0.10	1.08	-0.28	-1.83	226	.069	n/a
	Girls	138	-0.55	1.22	167	0.14	1.31	-0.68	-4.69	303	**<.0005**	**0.54**
	All	247	-0.47	1.23	286	0.04	1.22	-0.51	-4.82	531	**<.0005**	**0.42**
HAZ (z-score)	Boys	235	-1.01	0.99	227	-0.56	0.97	-0.45	-4.99	460	**<.0005**	**0.46**
	Girls	233	-0.98	1.14	220	-0.43	1.03	-0.56	-5.44	451	**<.0005**	**0.51**
	All	468	-1.00	1.06	447	-0.49	1.00	-0.50	-7.38	913	**<.0005**	**0.49**
BAZ (z-score)	Boys	235	-0.22	1.18	227	0.15	1.12	-0.37	-3.45	460	**.001**	**0.32**
	Girls	233	-0.29	1.19	220	0.41	1.25	-0.70	-6.05	451	**<.0005**	**0.57**
	All	468	-0.25	1.19	447	0.28	1.19	-0.53	-6.74	913	**<.0005**	**0.45**

According to Table 4.6, participants from the Township Areas presented with higher anthropometric values than participants from the Northern Areas. Table 4.6 reflects statistical and practical significant differences between Northern Area schools' learners and those from Township Area schools in all anthropometric variables, across all age groups, except in respect of WAZ for boys.

Table 4.7 shows the frequency distribution for those participants who were classified as underweight (WAZ<-2) versus non-underweight (WAZ>-2) learners.

Table 4.7: Weight-for-age z-score frequency distributions for underweight versus non-underweight categories: Total participant group

Weight-for-age				Total	
Underweight (WAZ<-2)		Non-underweight (WAZ>-2)			
n	%	n	%	n	%
31	6%	502	94%	533	100%

According to Table 4.7, only 6% of the learners were categorised as underweight.

Table 4.8 presents the frequency distribution of underweight (WAZ<-2) vs non-underweight (WAZ>-2) per gender.

Table 4.8: Weight-for-age z-score frequency distributions for underweight versus non-underweight categories: Comparison between boys and girls

Gender	Weight-for-age				Total	
	Underweight (WAZ<-2)		Non-underweight (WAZ>-2)			
	n	%	n	%	n	%
Boys	12	5%	216	95%	228	100%
Girls	19	6%	286	94%	305	100%
Total	31	6%	502	94%	533	100%
Chi^2 (df = 1. n = 533) = 0.22; p = .637						

Table 4.8 shows that girls present with slightly higher values of underweight (WAZ<-2) than boys. The WAZ percentage distributions between boys and girls are not statistically significant.

Table 4.9 reflects the frequency distribution of underweight (WAZ<-2) vs non-underweight (WAZ>-2) per geographic area.

Table 4.9: Weight-for-age z-score frequency distributions for underweight versus non-underweight categories: Comparison between geographic areas

Area	Weight-for-age				Total	
	Underweight (WAZ<-2)		Non-underweight (WAZ>-2)			
	n	%	n	%	n	%
Northern Areas	24	10%	223	90%	247	100%
Township Areas	7	2%	279	98%	286	100%
Total	31	6%	502	94%	533	100%
Chi² (df = 1. n = 533) = 12.78; p < .0005; V = 0.15 Small						

According to Table 4.9, schools in the Northern Areas present with a significantly higher frequency of underweight (WAZ<-2) in comparison with schools in the Township Areas.

Table 4.10 presents the frequency distribution of underweight (WAZ<-2) vs non-underweight (WAZ>-2) for each of the eight schools involved in the study.

Table 4.10: Weight-for-age z-score frequency distributions for underweight versus non-underweight categories: Comparison between schools

School	WAZ				Total	
	Underweight (WAZ<-2)		Non-underweight (WAZ>-2)			
	n	%	n	%	n	%
School 1 (NA)	2	3%	74	97%	76	100%
School 2 (NA)	10	18%	45	82%	55	100%
School 3 (NA)	9	21%	33	79%	42	100%
School 4 (TA)	2	2%	96	98%	98	100%
School 5 (TA)	1	2%	59	98%	60	100%
School 6 (TA)	1	2%	42	98%	43	100%
School 7 (TA)	3	4%	82	96%	85	100%
School 8 (NA)	3	4%	71	96%	74	100%
Total	31	6%	502	94%	533	100%
Chi² (df = 7. n = 533) = 42.07; p < .0005; V = 0.28 Small						

Table 4.10 reflects the comparison between the eight schools regarding WAZ classifications: underweight and non-underweight. The frequency distribution of learners who present with underweight (WAZ<-2) is significantly different among the eight schools. School 3 presented with the highest frequency with 21% followed by School 2 with 18%. Both these schools are situated in the Northern Areas. The

incidence of underweight is four to five times more in these schools compared to the other schools included in the study.

Table 4.11 presents the growth status in respect of HAZ for the total participant group as reflected in the two categories: Stunted (HAZ<-2) versus non-stunted (HAZ>-2).

Table 4.11: Height-for-age z-score frequency distributions for stunted versus non-stunted categories: Total participant group

Height-for-age				Total	
Stunted (HAZ<-2)		Non-stunted (HAZ>-2)			
n	%	n	%	n	%
96	10%	819	90%	915	100%

Table 4.11 shows that 10% of the participants involved in this study were classified as growth-stunted.

Table 4.12 indicates the HAZ frequency distribution per gender for stunted (HAZ<-2) versus non-stunted (HAZ>-2) growth.

Table 4.12: Height-for-age z-score frequency distributions for stunted versus non-stunted categories: Comparison between boys and girls

Gender	Height-for-age				Total	
	Stunted (HAZ<-2)		Non-stunted (HAZ>-2)			
	n	%	n	%	n	%
Boys	47	10%	415	90%	462	100%
Girls	49	11%	404	89%	453	100%
Total	96	10%	819	90%	915	100%
Chi^2 (d.f. = 1. n = 915) = 0.10; p = .751						

Table 4.12 shows that while girls presented the higher value in terms of stunting (HAZ<-2), the frequency distribution for HAZ per gender for stunted growth versus non-stunted growth is not significantly different.

Table 4.13 depicts the growth status in respect of HAZ according to the two geographic areas in which the eight schools were situated.

Table 4.13: Height-for-age z-score frequency distributions for stunted versus non-stunted categories: Comparison between geographic areas

Area	Height-for-age				Total	
	Stunted (HAZ<-2)		Non-stunted (HAZ>-2)			
	n	%	n	%	n	%
Northern Areas	73	16%	395	84%	468	100%
Township Areas	23	5%	424	95%	447	100%
Total	96	10%	819	90%	915	100%
Chi² (d.f. = 1. n = 915) = 26.60; p < .0005; V = 0.17 Small						

According to Table 4.13, the distribution of stunting (HAZ<-2) among the Northern Areas schools is significantly higher with a frequency of 16% in comparison with the Township Areas schools who display a 5% incidence of stunting.

Table 4.14 depicts a comparison between the eight schools involved in the study in relation to the frequency distribution of the HAZ categories: stunted (HAZ<-2), versus non-stunted (HAZ>-2).

Table 4.14: Height-for-age z-score frequency distributions for stunted versus non-stunted categories: Comparison between schools

School	Height-for-age					
	Stunted (HAZ<-2)		Non-stunted (HAZ>-2)		Total	
	n	%	n	%	n	%
School 1 (NA)	9	9%	96	91%	105	100%
School 2 (NA)	40	23%	133	77%	173	100%
School 3 (NA)	18	21%	69	79%	87	100%
School 4 (TA)	1	1%	121	99%	122	100%
School 5 (TA)	2	2%	88	98%	90	100%
School 6 (TA)	8	9%	79	91%	87	100%
School 7 (TA)	12	8%	136	92%	148	100%
School 8 (NA)	6	6%	97	94%	103	100%
Total	96	10%	819	90%	915	100%
Chi² (df = 7. n = 915) = 61.58; p < .0005; V = 0.26 Small						

According to Table 4.14, the frequency distribution of learners who display stunting is significantly different among the eight schools, with School 2 presenting with the highest frequency of 23%, followed by School 3 with 21%. Both these schools are situated in the Northern Areas.

Table 4.15 shows the frequency distribution for the incidence of each of the three BAZ categories for the total participant group. The participants' BAZ scores were divided into one of three categories: thin (BAZ<-2), normal (-2≥BAZ≤+2), overweight and obese (BAZ>+2). The overweight and obese categories were combined. This was done to avoid analysing small sample sizes.

Table 4.15: BMI-for-age z-score frequency distributions for thin versus normal versus overweight and obese categories: Total participant group

BMI-for-age						Total	
Thin (BAZ<-2)		Normal (-2≥BAZ≤+2)		Overweight and Obese (BAZ>+2)			
n	%	n	%	n	%	n	%
36	4%	830	91%	49	5	915	100%

According to Table 4.15, most of the learners fall into the normal weight category with almost equal distributions of 4% and 5% for thinness and obesity respectively.

Table 4.16 reflects the BAZ frequency distribution per gender for the three BAZ categories: thin (BAZ<-2), normal (-2≥BAZ≤+2), overweight and obese (BAZ>+2).

Table 4.16: BMI-for-age z-score frequency distributions for thin versus normal versus overweight and obese categories: Comparison between boys and girls

Gender	BMI-for-age						Total	
	Thin (BAZ<-2)		Normal (-2≥BAZ≤+2)		Overweight and Obese (BAZ>+2)			
	n	%	n	%	n	%	n	%
Boys	16	3%	429	93%	17	4%	462	100%
Girls	20	4%	401	89%	32	7%	453	100%
Total	36	4%	830	91%	49	5%	915	100%
Chi^2 (df = 2. n = 915) = 5.89; p = .053								

Table 4.16 indicates that girls presented with a greater incidence of thinness, and overweight and obesity than boys. However, the BAZ percentage distribution for gender, although close (p=.053), was found to be non-significant.

Table 4.17 represents the comparison between the two geographic areas in respect of the frequency distribution per BAZ category for participants from the schools in these areas.

Table 4.17: BMI-for-age z-score frequency distributions for thin versus normal versus overweight and obese categories: Comparison between geographic areas

Area	BMI-for-age						Total	
	Thin (BAZ<-2)		Normal (-2≥BAZ≤+2)		Overweight and Obese (BAZ>+2)			
	n	%	n	%	n	%	n	%
Northern Areas	30	6%	421	90%	17	4%	468	100%
Township Areas	6	1%	409	91%	32	7%	447	100%
Total	36	4%	830	91%	49	5%	915	100%
Chi^2 (df = 2. n = 915) = 20.29; p <.0005; V = 0.15 Small								

Table 4.17 clearly indicates that the frequencies for the three BAZ categories are significantly different for the two geographic areas. The highest value of thinness is presented by learners from the Northern Areas with an incidence of 6% versus 1%, while learners from the Township Areas display the highest value for overweight and obesity of 7% versus 4%.

Table 4.18 depicts a comparison between the eight schools involved in the study in relation to the three BAZ categories: thin (BAZ<-2), normal (-2≥BAZ≤+2), overweight and obese (BAZ>+2).

Table 4.18: BMI-for-age z-score frequency distributions for thin versus normal versus overweight and obese categories: Comparison between schools

School	BMI-for-age						Total	
	Thin (BAZ<-2)		Normal (-2≥BAZ≤+2)		Overweight and Obese (BAZ>+2)			
	n	%	n	%	n	%	n	%
School 1 (NA)	2	2%	98	93%	5	5%	105	100%
School 2 (NA)	12	7%	157	91%	4	2%	173	100%
School 3 (NA)	11	13%	75	86%	1	1%	87	100%
School 4 (TA)	1	1%	115	94%	6	5%	122	100%
School 5 (TA)	1	1%	81	90%	8	9%	90	100%
School 6 (TA)	3	3%	74	85%	10	11%	87	100%
School 7 (TA)	1	1%	139	94%	8	5%	148	100%
School 8 (NA)	5	5%	91	88%	7	7%	103	100%
Total	36	4%	830	91%	49	5%	915	100%
Chi^2 (df = 14. n = 915) = 46.52; p <.0005; V = 0.16 Small								

The frequency distribution of learners who display low weight-for-height (BAZ<-2) is significantly and differently distributed among the eight schools. School 3 presented with the highest frequency of thinness with 13%, followed by School 2 with 7%. Both schools are situated in the Northern Areas. The frequency distribution of obesity among the eight schools is highest in School 6 with 11%, followed by School 5 with 9%. Both schools are situated in the Township areas.

4.4 PHYSICAL FITNESS COMPONENTS PER SELECTED DEMOGRAPHICS

This section presents a comparison of PF components in relation to gender, ethnicity and geographical area. Descriptive and inferential statistics for PF components in respect of gender, ethnicity and geographical area are displayed in Tables 4.19 to 4.23.

Table 4.19 reflects the gender comparative statistics in relation of the PF components per age groups.

Table 4.19: Comparison between boys and girls per age group for physical fitness components

		Boys			Girls				Inferential Statistics			
Variable	**Age**	**n**	**Mean**	**SD**	**n**	**Mean**	**SD**	**Difference**	**t**	**df**	**p**	**Cohen's d**
Flexibility (SAR) (cm)	8	32	32.98	5.34	55	34.74	5.85	-1.76	-1.40	85	.166	n/a
	9	181	31.24	5.71	234	33.78	5.21	-2.54	-4.72	413	<.0005	0.47
	10	146	29.74	5.79	103	34.21	5.87	-4.47	-5.97	247	<.0005	0.77
	11	65	30.14	5.61	34	32.17	5.66	-2.03	-1.71	97	.091	n/a
	8-9	213	31.50	5.68	289	33.96	5.34	-2.46	-4.97	500	<.0005	0.45
	10-11	211	29.87	5.72	137	33.71	5.87	-3.84	-6.06	346	<.0005	0.66
	All	424	30.69	5.75	426	33.88	5.51	-3.19	-8.27	848	<.0005	0.57
Upper body strength (GS) (kg)	8	31	12.48	3.12	55	12.13	2.91	0.36	0.53	84	.596	n/a
	9	181	13.31	3.17	234	12.11	2.94	1.21	4.01	413	<.0005	0.40
	10	146	14.41	3.10	103	13.33	3.38	1.08	2.61	247	.010	0.34
	11	66	15.65	4.01	34	14.32	3.44	1.33	1.65	98	.103	n/a
	8-9	212	13.19	3.17	289	12.11	2.93	1.08	3.95	499	<.0005	0.36
	10-11	212	14.80	3.45	137	13.58	3.41	1.22	3.24	347	.001	0.36
	All	424	14.00	3.40	426	12.58	3.17	1.41	6.27	848	<.0005	0.43
Lower body strength (SBJ) (cm)	8	32	133.78	13.51	55	117.35	20.28	16.44	4.08	85	<.0005	0.91
	9	181	134.27	17.54	234	120.80	16.04	13.47	8.14	413	<.0005	0.81
	10	144	139.02	17.85	103	126.30	16.52	12.72	5.70	245	<.0005	0.73
	11	63	140.63	20.11	34	124.06	19.32	16.58	3.93	95	<.0005	0.84
	8-9	213	134.19	16.97	289	120.14	16.95	14.05	9.18	500	<.0005	0.83
	10-11	207	139.51	18.53	137	125.74	17.21	13.77	6.94	342	<.0005	0.76
	All	420	136.81	17.93	426	121.94	17.21	14.87	12.31	844	<.0005	0.85
CRF (SRT) (VO_2max) (ml/kg/min)	8	31	51.01	3.15	55	46.79	2.81	4.22	6.40	84	<.0005	1.44
	9	175	49.29	3.94	231	45.45	2.94	3.84	11.26	404	<.0005	1.13
	10	142	48.08	4.28	102	44.95	3.76	3.13	5.92	242	<.0005	0.77
	11	66	48.42	4.91	32	43.11	3.12	5.31	5.58	96	<.0005	1.20
	8-9	206	49.55	3.88	286	45.70	2.96	3.84	12.48	490	<.0005	1.14
	10-11	208	48.19	4.48	134	44.51	3.69	3.68	7.92	340	<.0005	0.88
	All	414	48.87	4.24	420	45.32	3.25	3.54	13.54	832	<.0005	0.94
Composite fitness score	8	30	52.82	4.35	54	48.43	5.94	4.38	3.54	82	.001	0.81
	9	171	51.58	6.10	227	47.68	4.76	3.91	7.17	396	<.0005	0.73
	10	138	51.60	6.35	100	49.19	5.47	2.40	3.05	236	.003	0.40
	11	61	53.02	7.20	32	47.92	5.92	5.10	3.44	91	.001	0.75
	8-9	201	51.77	5.88	281	47.82	5.01	3.95	7.93	480	<.0005	0.73
	10-11	199	52.03	6.64	132	48.88	5.58	3.15	4.49	329	<.0005	0.50
	All	400	51.90	6.26	413	48.16	5.22	3.74	9.26	811	<.0005	0.65

According to Table 4.19, boys presented with higher values for all fitness components across all ages, except for the flexibility test in which girls presented with higher values across all ages. Significant statistical and practical differences were found between boys and girls for all variables across all age groups, except for the 8-year-olds and 11-year-olds age groups for flexibility and upper body strength.

Table 4.20 presents the comparison between Black African and Coloured boys in respect of the PF components per age group.

Table 4.20: Comparison between Black African and Coloured boys per age group for physical fitness components

		Black African			Coloured				Inferential Statistics			
Variable	**Age**	**n**	**Mean**	**SD**	**n**	**Mean**	**SD**	**Difference**	**t**	**df**	**p**	**Cohen's d**
Flexibility (SAR) (cm)	8	28	33.01	5.57	4	32.75	3.92	0.26	0.09	30	.930	n/a
	9	123	31.83	5.46	58	29.99	6.06	1.84	2.04	179	**.043**	**0.33**
	10	78	31.39	5.58	68	27.85	5.47	3.54	3.86	144	**<.0005**	**0.64**
	11	37	31.77	5.58	28	27.99	4.97	3.78	2.83	63	**.006**	**0.71**
	8-9	151	32.05	5.48	62	30.17	5.96	1.88	2.22	211	**.028**	**0.33**
	10-11	115	31.51	5.56	96	27.89	5.30	3.62	4.81	209	**<.0005**	**0.66**
	All	266	31.82	5.51	158	28.79	5.66	3.03	5.42	422	**<.0005**	**0.54**
Upper body strength (GS) (kg)	8	27	12.63	3.22	4	11.50	2.38	1.13	0.67	29	.508	n/a
	9	123	13.85	3.17	58	12.17	2.87	1.68	3.43	179	**.001**	**0.55**
	10	78	15.04	3.13	68	13.69	2.93	1.35	2.67	144	**.008**	**0.44**
	11	37	17.00	4.37	29	13.93	2.70	3.07	3.32	64	**.001**	**0.82**
	8-9	150	13.63	3.20	62	12.13	2.83	1.50	3.21	210	**.002**	**0.49**
	10-11	115	15.67	3.67	97	13.76	2.85	1.91	4.16	210	**<.0005**	**0.57**
	All	265	14.52	3.55	159	13.13	2.94	1.39	4.15	422	**<.0005**	**0.42**
Lower body strength (SBJ) (cm)	8	28	133.61	13.07	4	135.00	18.57	-1.39	-0.19	30	.851	n/a
	9	123	134.30	16.93	58	134.19	18.92	0.11	0.04	179	.968	n/a
	10	76	140.11	19.27	68	137.81	16.18	2.30	0.77	142	.443	n/a
	11	36	139.14	22.19	27	142.63	17.16	-3.49	-0.68	61	.500	n/a
	8-9	151	134.17	16.25	62	134.24	18.75	-0.07	-0.03	211	.978	n/a
	10-11	112	139.79	20.15	95	139.18	16.52	0.62	0.24	205	.812	n/a
	All	263	136.57	18.19	157	137.23	17.54	-0.66	-0.37	418	.715	n/a
VO_2 max (ml/kg/min) (SRT)	8	27	51.36	3.13	4	48.59	2.23	2.77	1.69	29	.101	n/a
	9	117	49.71	3.93	58	48.44	3.86	1.28	2.04	173	**.043**	**0.33**
	10	72	48.94	4.56	70	47.21	3.82	1.73	2.45	140	**.016**	**0.41**
	11	34	48.85	4.47	32	47.96	5.37	0.89	0.73	64	.467	n/a
	8-9	144	50.02	3.84	62	48.45	3.76	1.58	2.72	204	**.007**	**0.41**
	10-11	106	48.91	4.51	102	47.44	4.35	1.47	2.38	206	**.018**	**0.33**
	All	250	49.55	4.17	164	47.82	4.16	1.73	4.13	412	**<.0005**	**0.42**
Composite fitness score	8	26	53.17	4.49	4	50.54	2.51	2.62	1.13	28	**.268**	**0.61**
	9	114	52.54	6.12	57	49.67	5.64	2.87	2.96	169	**.003**	**0.48**
	10	72	53.52	6.77	66	49.50	5.14	4.02	3.90	136	**<.0005**	**0.66**
	11	34	54.43	7.66	27	51.23	6.27	3.20	1.75	59	**.085**	**0.45**
	8-9	140	52.65	5.84	61	49.73	5.48	2.93	3.33	199	**.001**	**0.51**
	10-11	106	53.81	7.05	93	50.00	5.51	3.81	4.20	197	**<.0005**	**0.60**
	All	246	53.15	6.40	154	49.89	5.49	3.26	5.23	398	**<.0005**	**0.54**

According to Table 4.20, Black African boys performed better than Coloured boys across all age groups in the flexibility and upper body strength tests. Statistical and practical significance was found for all age groups, except in the case of the 8-year-olds. Black African boys presented with higher values across all age groups for

VO_2max. Statistical and practical significance was indicated for all age groups, except in the case of the 8-year-olds and the 11-year-olds. All age groups showed statistical and practical significance for the composite fitness score. Black African boys presented with higher values in all age groups. Coloured boys performed better than Black African boys across all age groups for lower body strength, except in the case of the 9-year-olds, 10-year-old and combined 10-to-11-year-old groups but none of these differences were statistically significant.

Table 4.21 depicts the comparison between Black African and Coloured girls in relation to the components per age group.

Table 4.21: Comparison between Black African and Coloured girls per age group for physical fitness components

		Black African			Coloured				Inferential Statistics			
Variable	**Age**	**n**	**Mean**	**SD**	**n**	**Mean**	**SD**	**Difference**	**t**	**df**	**p**	**Cohen's d**
Flexibility (SAR) (cm)	8	44	35.23	5.28	11	32.78	7.71	2.44	1.25	53	.218	n/a
	9	163	34.21	5.22	71	32.80	5.07	1.41	1.91	232	.057	n/a
	10	49	35.16	6.10	54	33.36	5.58	1.81	1.57	101	.120	n/a
	11	13	35.92	5.07	21	29.85	4.75	6.07	3.53	32	**.001**	**1.25**
	8-9	207	34.42	5.24	82	32.80	5.44	1.62	2.35	287	**.019**	**0.31**
	10-11	62	35.32	5.87	75	32.37	5.56	2.95	3.01	135	**.003**	**0.52**
	All	269	34.63	5.39	157	32.60	5.48	2.03	3.73	424	**<.0005**	**0.38**
Upper body strength (GS) (kg)	8	44	12.25	2.94	11	11.64	2.84	0.61	0.62	53	.536	n/a
	9	163	12.72	2.92	71	10.70	2.49	2.01	5.06	232	**<.0005**	**0.72**
	10	49	14.37	3.53	54	12.39	2.97	1.98	3.09	101	**.003**	**0.61**
	11	13	16.62	2.99	21	12.90	2.93	3.71	3.56	32	**.001**	**1.26**
	8-9	207	12.62	2.93	82	10.83	2.54	1.79	4.86	287	**<.0005**	**0.63**
	10-11	62	14.84	3.53	75	12.53	2.95	2.31	4.17	135	**<.0005**	**0.72**
	All	269	13.13	3.21	157	11.64	2.86	1.49	4.80	424	**<.0005**	**0.48**
Lower body strength (SBJ) (cm)	8	44	116.52	22.04	11	120.64	10.82	-4.11	-0.60	53	.552	n/a
	9	163	120.21	16.39	71	122.14	15.24	-1.93	-0.84	232	.400	n/a
	10	49	121.65	17.56	54	130.52	14.42	-8.87	-2.81	101	**.006**	**0.55**
	11	13	122.15	19.93	21	125.24	19.33	-3.08	-0.45	32	.658	n/a
	8-9	207	119.43	17.75	82	121.94	14.68	-2.51	-1.14	287	.257	n/a
	10-11	62	121.76	17.91	75	129.04	15.99	-7.28	-2.51	135	**.013**	**0.43**
	All	269	119.97	17.78	157	125.33	15.68	-5.36	-3.14	424	**.002**	**0.31**
VO_2 max (ml/kg/min) (SRT)	8	43	46.75	2.83	12	46.92	2.88	-0.17	-0.18	53	.856	n/a
	9	156	45.41	3.10	75	45.53	2.59	-0.13	-0.31	229	.758	n/a
	10	49	44.09	3.11	53	45.74	4.15	-1.65	-2.26	100	**.026**	**0.45**
	11	12	43.34	3.56	20	42.97	2.91	0.37	0.32	30	.751	n/a
	8-9	199	45.70	3.09	87	45.72	2.65	-0.03	-0.07	284	.941	n/a
	10-11	61	43.94	3.19	73	44.98	4.03	-1.04	-1.63	132	.105	n/a
	All	260	45.28	3.19	160	45.39	3.36	-0.10	-0.31	418	.756	n/a
Composite fitness score	8	43	48.61	5.88	11	47.75	6.42	0.86	0.43	52	**.672**	**0.14**
	9	156	48.30	4.92	71	46.31	4.09	1.98	2.96	225	**.003**	**0.42**
	10	48	49.30	5.51	52	49.10	5.48	0.20	0.18	98	**.858**	**0.04**

		Black African			Coloured				Inferential Statistics			
Variable	Age	n	Mean	SD	n	Mean	SD	Difference	t	df	p	Cohen's d
Composite fitness score	11	12	50.86	5.92	20	46.15	5.30	4.72	2.33	30	**.027**	**0.85**
	8-9	199	48.36	5.13	82	46.51	4.45	1.86	2.86	279	**.005**	**0.38**
	10-11	60	49.61	5.58	72	48.28	5.55	1.33	1.37	130	**.174**	**0.24**
	All	259	48.65	5.26	154	47.34	5.06	1.32	2.50	411	**.013**	**0.25**

According to Table 4.21, Black African girls presented with higher values than Coloured girls across all ages for the composite fitness score. All age groups indicated practical and statistical significance. Significant statistical and practical differences were found for upper body strength across all ages, except the 8-year-olds group, in which Black African girls performed better than Coloured girls. Statistical significance was found for flexibility in the 11-year-old group, the two combined age groups and the total group. Black African girls performed better than Coloured girls across all age groups. Coloured girls performed better than Black African girls in the test of lower body strength across all ages and VO_2max across all ages, except the 11-year-old age group. For the test of lower body strength, the 10-year-old, 10-to-11-year-old and the total group showed statistically significant differences. For VO_2max, statistically significant differences were found for the 10-year-old group only.

Table 4.22 reflects the comparison between Black African and Coloured participants (boys and girls combined) in relation of the PF components per age group.

Table 4.22: Comparison between Black African and Coloured participants per age group for physical fitness components

		Black African			Coloured				Inferential Statistics			
Variable	Age	n	Mean	SD	n	Mean	SD	Difference	t	df	p	Cohen's d
Flexibility (SAR) (cm)	8	72	34.36	5.47	15	32.77	6.77	1.59	0.98	85	.329	n/a
	9	286	33.19	5.45	129	31.54	5.69	1.65	2.81	413	**.005**	**0.30**
	10	127	32.85	6.05	122	30.29	6.14	2.56	3.31	247	**.001**	**0.42**
	11	50	32.85	5.71	49	28.79	4.92	4.06	3.79	97	**<.0005**	**0.76**
	8-9	358	33.42	5.46	144	31.67	5.80	1.76	3.20	500	**.001**	**0.32**
	10-11	177	32.85	5.94	171	29.86	5.84	2.99	4.73	346	**<.0005**	**0.51**
	All	535	33.23	5.63	315	30.69	5.88	2.55	6.27	848	**<.0005**	**0.45**
Upper body strength (GS) (kg)	8	71	12.39	3.04	15	11.60	2.64	0.79	0.94	84	.350	n/a
	9	286	13.21	3.08	129	11.36	2.76	1.84	5.82	413	**<.0005**	**0.62**
	10	127	14.78	3.29	122	13.11	3.00	1.66	4.16	247	**<.0005**	**0.53**
	11	50	16.90	4.03	50	13.50	2.82	3.40	4.89	98	**<.0005**	**0.98**
	8-9	357	13.04	3.08	144	11.39	2.74	1.66	5.61	499	**<.0005**	**0.55**
	10-11	177	15.38	3.63	172	13.23	2.95	2.15	6.07	347	**<.0005**	**0.65**
	All	534	13.82	3.45	316	12.39	2.99	1.43	6.12	848	**<.0005**	**0.43**

		Black African			Coloured				Inferential Statistics			
Variable	**Age**	**n**	**Mean**	**SD**	**n**	**Mean**	**SD**	**Difference**	**t**	**df**	**p**	**Cohen's d**
Lower body strength (SBJ) (cm)	8	72	123.17	20.72	15	124.47	14.17	-1.30	-0.23	85	.818	n/a
	9	286	126.27	18.01	129	127.56	17.96	-1.29	-0.67	413	.501	n/a
	10	125	132.87	20.63	122	134.58	15.79	-1.71	-0.73	245	.466	n/a
	11	49	134.63	22.71	48	135.02	19.95	-0.39	-0.09	95	.929	n/a
	8-9	358	125.65	18.60	144	127.24	17.59	-1.59	-0.88	500	.380	n/a
	10-11	174	133.37	21.18	170	134.71	17.00	-1.34	-0.65	342	.519	n/a
	All	532	128.17	19.80	314	131.28	17.64	-3.11	-2.29	844	**.022**	**0.16**
VO_2 max (ml/kg/min) (SRT)	8	70	48.53	3.70	16	47.34	2.76	1.19	1.21	84	.229	n/a
	9	273	47.25	4.08	133	46.80	3.50	0.45	1.10	404	.272	n/a
	10	121	46.98	4.68	123	46.58	4.02	0.40	0.72	242	.475	n/a
	11	46	47.41	4.87	52	46.04	5.17	1.37	1.34	96	.182	n/a
	8-9	343	47.51	4.03	149	46.86	3.43	0.66	1.73	490	.084	n/a
	10-11	167	47.10	4.72	175	46.42	4.38	0.68	1.38	340	.169	n/a
	All	510	47.38	4.27	324	46.62	3.97	0.76	2.56	832	**.011**	**0.18**
Composite fitness score	8	69	50.33	5.81	15	48.49	5.70	1.83	1.11	82	**.270**	**0.32**
	9	270	50.09	5.84	128	47.81	5.11	2.28	3.78	396	**<.0005**	**0.41**
	10	120	52.36	6.56	118	49.91	5.20	2.44	3.18	236	**.002**	**0.41**
	11	46	53.50	7.36	47	49.07	6.35	4.43	3.11	91	**.002**	**0.65**
	8-9	339	50.14	5.83	143	47.88	5.15	2.26	4.01	480	**<.0005**	**0.40**
	10-11	166	52.29	6.84	165	49.25	5.58	3.04	4.43	329	**<.0005**	**0.49**
	All	505	50.84	6.26	308	48.61	5.42	2.23	5.18	811	**<.0005**	**0.37**

According to Table 4.22, Black African learners performed better than Coloured learners for all fitness components across all ages, except for the lower body strength test in which Coloured learners performed better. Except in the case of 8-year-olds, results for flexibility and upper body strength was significantly different across all age groups. These differences were both statistically and practically significant. For the composite fitness score, statistical and practical significance was indicated across all age groups. However, statistical and practical significant differences between lower body strength and VO_2max was only indicated for the total group.

Table 4.23 presents the comparison between the Northern Areas and Township Area schools' mean scores for the PF components per gender and total groups.

Table 4.23: Comparison between participants from the Northern Areas and Township Area schools per gender group for physical fitness components

		Northern Areas			Township Areas				Inferential Statistics			
Variable	Gender	n	Mean	SD	n	Mean	SD	Difference	t	df	p	Cohen's d
Flexibility (SAR) (cm)	Boys	210	29.53	6.10	214	31.83	5.16	-2.30	-4.20	422	**<.0005**	**0.41**
	Girls	219	33.29	5.45	207	34.51	5.51	-1.22	-2.30	424	**.022**	**0.22**
	All	429	31.45	6.07	421	33.15	5.49	-1.70	-4.28	848	**<.0005**	**0.29**
Upper body strength (GS) (kg)	Boys	211	13.52	3.26	213	14.47	3.48	-0.95	-2.91	422	**.004**	**0.28**
	Girls	219	11.95	3.09	207	13.26	3.11	-1.31	-4.36	424	**<.0005**	**0.42**
	All	430	12.72	3.27	420	13.87	3.35	-1.16	-5.09	848	**<.0005**	**0.35**
Lower body strength (SBJ) (cm)	Boys	209	135.91	17.80	211	137.71	18.06	-1.80	-1.03	418	.304	n/a
	Girls	219	124.51	16.67	207	119.23	17.40	5.27	3.20	424	**.001**	**0.31**
	All	428	130.07	18.13	418	128.56	19.98	1.51	1.16	844	.248	n/a
VO_2 max (ml/kg/min) (SRT)	Boys	214	47.90	4.08	200	49.89	4.18	-1.99	-4.90	412	**<.0005**	**0.48**
	Girls	219	45.27	3.13	201	45.39	3.39	-0.12	-0.38	418	.704	n/a
	All	433	46.57	3.86	401	47.63	4.42	-1.06	-3.71	832	**<.0005**	**0.26**
Composite fitness score	Boys	202	50.31	5.92	198	53.52	6.20	-3.22	-5.31	398	**<.0005**	**0.53**
	Girls	212	47.72	5.05	201	48.63	5.36	-0.90	-1.77	411	**.078**	**0.17**
	All	414	48.98	5.64	399	51.06	6.28	-2.07	-4.96	811	**<.0005**	**0.35**

According to Table 4.23, Township Area learners performed better than Northern Area learners in all fitness components, except in the case of girls and the total group in the lower body strength test. There were significant statistical and practical differences between Northern Area schools' learners and learners from Township Area schools in all fitness components, except in the case of boys and the total group for lower body strength and girls for the VO_2max test.

4.5 COMPARISON OF ANTHROPOMETRIC COMPONENTS AND PHYSICAL FITNESS COMPONENTS ACROSS SCHOOLS

School comparisons in relation to the anthropometric and PF components across schools for the whole group for gender, ethnicity and geographical area are reflected in Tables 4.24 to 4.35. All the Northern Area schools are indicated by "NA" and Township Area schools are indicated by "TA" in Tables 4.24 to 4.35. Where statistically significant differences between schools in respect of a particular variable were identified, post-hoc analyses were conducted to establish between which schools the relevant significant differences were applicable.

The latter are indicated in red in subsequent Tables by a paired superscripted alphabetic letter (for example Table 4.25: School 2 – 28.43[a] and School 5 – 32.84[a], depicting a statistically significant difference between the mean values of School 2 and School 5).

Table 4.24 reflects the comparison of the eight schools in relation to participants' height.

Table 4.24: Descriptive and inferential statistics: Height (cm) across schools

Group	All schools	School 1 (NA)	School 2 (NA)	School 3 (NA)	School 4 (TA)	School 5 (TA)	School 6 (TA)	School 7 (TA)	School 8 (NA)
n	915	105	173	87	122	90	87	148	103
Mean	133.01	132.15	131.59	130.88	133.24	134.62	134.57	134.10	133.50
SD	7.04	7.40	6.93	7.10	6.17	7.10	7.81	6.97	6.33

ANOVA: (F=4.358; df=7; p<.0005)

Although ANOVA (F=4.358; df=7; p<.0005) as reflected in Table 4.24 identified significant differences across the schools in relation to height, the post-hoc Scheffé test did not reveal any specific statistical differences between any schools.

Table 4.25 presents the comparison of the eight schools in relation to participants' weight.

Table 4.25: Descriptive and inferential statistics: Weight (kg) across schools

Group	All	School 1 (NA)	School 2 (NA)	School 3 (NA)	School 4 (TA)	School 5 (TA)	School 6 (TA)	School 7 (TA)	School 8 (NA)
n	915	105	173	87	122	90	87	148	103
Mean	30.39	29.94	28.43 [ab]	26.96 [cde]	30.80	32.84 [ac]	33.18 [bd]	31.37 [e]	30.62
SD	7.50	6.96	5.86	5.73	6.15	9.33	10.10	7.63	6.96

Post-hoc statistics

a (p=.003; d=0.61) medium; b (p=.001; d=0.63) medium; c (p=<.0005; d=0.76) medium; d (p=<.0005; d=0.76) medium; e (p=.006; d=0.63) medium.

All the Northern Area schools' learners in Table 4.25 reflect lower mean body weight values than learners from Township Area schools. ANOVA (F=8.302; df=7; p<.0005) identified a significant difference across the schools in relation to weight. Post-hoc tests revealed that two of the Northern Area schools' (2 and 3) values were significantly lower than three of the Township Area schools' (5, 6 and 7) values.

Table 4.26 depicts the comparison across the eight schools in relation to participants' BMI.

Table 4.26: Descriptive and inferential statistics: Body mass index (kg/m^2) across schools

Group	All	School 1 (NA)	School 2 (NA)	School 3 (NA)	School 4 (TA)	School 5 (TA)	School 6 (TA)	School 7 (TA)	School 8 (NA)
n	915	105	173	87	122	90	87	148	103
Mean	17.02	17.00	16.29 ^{ab}	15.62 ^{cdef}	17.27 ^{c}	17.92 ^{ad}	18.07 ^{be}	17.31 ^{f}	17.04
SD	3.01	2.64	2.24	2.04	2.80	3.80	3.86	3.25	2.80

Post-hoc statistics

a (p=.011; 0.57) medium; b (p=.004; d=0.62) medium; c (p=.024; d=0.66) medium; d (p=<.0005; d=0.75) medium; e (p=<.0005; d=0.79) medium; f (p=.012; d=0.59) medium.

ANOVA (F=7.504; df=7; p<.0005) identified differences across the schools in relation to BMI mean values presented in Table 4.26. All Northern Areas schools reflect lower BMI values than those of the Township Area schools' values. Post-hoc tests revealed that two of the Northern Areas schools' (2 and 3) values were significantly lower than all of the Township Area schools' values.

Table 4.27 indicates a comparison of the eight schools in relation to participants' BF%.

Table 4.27: Descriptive and inferential statistics: Body fat percentage across schools

Group	All	School 1 (NA)	School 2 (NA)	School 3 (NA)	School 4 (TA)	School 5 (TA)	School 6 (TA)	School 7 (TA)	School 8 (NA)
n	915	105	173	87	122	90	87	148	103
Mean	15.90	15.60	14.33 ^{a}	12.87^{bcde}	15.73	18.97 ^{ab}	17.37 ^{cd}	16.27 ^{d}	17.14 ^{e}
SD	6.87	6.70	5.36	5.28	6.42	8.91	7.54	6.92	6.74

Post-hoc statistics

a (p=<.0005; d=0.68) medium; b (p=<.0005; d=0.83) large; c (p=.007; d=0.69) medium; d (p=.050; d=0.53) medium; e (p=.008; d=0.70) medium.

ANOVA (F=7.817; df=7; p<.0005) identified significant differences across the schools in relation to BF% mean values as depicted in Table 4.27. Post-hoc tests revealed that two Northern Area schools' (2 and 3) values were significantly lower than three Township Area schools' (5, 6 and 7) values. Post-hoc tests further revealed that two of the Northern Areas schools' (3 and 8) values were also significantly different from each other with School 3 reflecting lower BF%.

Table 4.28 shows the comparison of the eight schools in relation to participants' WAZ.

Table 4.28: Descriptive and inferential statistics: Weight-for-age z-scores across schools

Group	All	School 1 (NA)	School 2 (NA)	School 3 (NA)	School 4 (TA)	School 5 (TA)	School 6 (TA)	School 7 (TA)	School 8 (NA)
n	533	76	55	42	98	60	43	85	74
Mean	-0,20	-0,18[a]	-0,76[bc]	-1,15[adefgh]	0,06[bd]	0,24[ce]	-0,06[f]	-0,08[g]	-0,18[h]
SD	1,25	1,13	1,30	1,01	1,07	1,38	1,20	1,28	1,21

Post-hoc statistics

a (p=.014; d=0.89) large; b (p=.022; d=0.71) medium; c (p=.006; d=0.75) medium; d (p= <.0005; d=1.15) large; e (p= <.0005; d=1.13) large; f (p= .015; d=0.99) large; g (p= .003; d=0.89) large; h (p= .015; d=0.86) large.

In Table 4.28, ANOVA (F=7.536; df=7; p<.0005) identified significant differences across the schools in relation to WAZ. All the Northern Areas schools (1, 2, 3 and 8) reflect lower WAZ values than those of the Township Area schools' values. Post-hoc tests revealed that the WAZ value for School 3 (from the Northern Areas) was significantly lower than all the Township Area schools' values.

Table 4.29 presents a comparison of the eight schools in relation to participants' HAZ.

Table 4.29: Descriptive and inferential statistics: Height-for-age z-scores across schools

Group	All	School 1 (NA)	School 2 (NA)	School 3 (NA)	School 4 (TA)	School 5 (TA)	School 6 (TA)	School 7 (TA)	School 8 (NA)
n	915	105	173	87	122	90	87	148	103
Mean	-0.75	-0.67 [ab]	-1.35 [acdefg]	-1.26 [bhijkl]	-0.33 [ch]	-0.38 [di]	-0.66 [ej]	-0.60 [fk]	-0.52 [gl]
SD	1.06	1.05	1.04	0.97	0.90	1.05	1.07	0.99	0.91

Post-hoc statistics

a (p=<.0005; d=0.65) medium; b (p=.018; d= 0.59) medium; c (p=<.0005; d=1.03) large; d (p=<.0005; d=0.93) large; e (p=<.0005; d=0.65) medium; f (p=<.0005; d=0.74) medium; g (p=<.0005; d=0.83) large; h (p=<.0005; d=1.00) large; i (p=<.0005; d=0.88) large; j (p=.028; d=0.59) medium; k (p=.001; d=0.68) medium; l (p=.001; d=0.79) medium.

ANOVA (F=18.401; df=7; p<.0005) presented significant differences across the schools in relation to HAZ as seen in Table 4.29. Three of the Northern Areas schools (1, 2 and 3) reflect lower HAZ values than those of the Township Area schools' values. Post-hoc tests revealed that three Northern Area schools' HAZ values were significantly lower but only two of those three are significantly lower than all the Township schools' values. Post-hoc tests also revealed that the Northern Areas schools' values were also significantly different from each other (1 and 2, 1 and 3, 2 and 8).

Table 4.30 indicates the comparison of the eight schools in relation to participants' BAZ.

Table 4.30: Descriptive and inferential statistics: BMI-for-age z-scores across schools

Group	All	School 1 (NA)	School 2 (NA)	School 3 (NA)	School 4 (TA)	School 5 (TA)	School 6 (TA)	School 7 (TA)	School 8 (NA)
n	915	105	173	87	122	90	87	148	103
Mean	0.01	0.12 [ab]	-0.43[acdef]	-0.74 [bghijk]	0.28 [cg]	0.42 [dh]	0.37 [ei]	0.13 [fj]	0.08 [k]
SD	1.22	1.12	1.14	1.08	1.08	1.21	1.30	1.20	1.23

Post-hoc statistics

a (p=.048; d=0.48) small; b (p=.001; d=0.78) medium; c (p=.001; d=0.64) medium; d (p=<.0005; d=0.73) medium; e (p=<.0005; d=0.67) medium; f (p=.011; d=0.48) small; g (p=<.0005; d=0.95) large; h (p=<.0005; d=1.01) large; i (p=<.0005; d=0.93) large; j (p=<.0005; d=0.75) medium; k (p=.002; d=0.70) medium.

ANOVA (F=12.788; df=7; p<.0005) identified significant differences across the schools in relation to BAZ as depicted in Table 4.30. Three of the Northern Areas schools (2, 3 and 8) reflect lower BAZ values than those of the Township Area schools' values. Post-hoc tests revealed that all the Northern Areas schools' BAZ values were significantly different from each other (1 and 2, 1 and 3, 3 and 8).

Table 4.31 reflects a comparison of the eight schools in relation to participants' flexibility.

Table 4.31: Descriptive and inferential statistics: Flexibility (cm) across schools

Group	All	School 1 (NA)	School 2 (NA)	School 3 (NA)	School 4 (TA)	School 5 (TA)	School 6 (TA)	School 7 (TA)	School 8 (NA)
n	850	98	154	83	117	86	82	136	94
Mean	32.29	32.79[a]	29.36[abcde]	31.54	32.33[b]	34.77[c]	31.80	33.63[d]	33.39[e]
SD	5.85	6.14	5.67	6.17	4.82	5.92	5.86	5.26	5.54

Post-hoc statistics

a (p=.003; d=0.59) medium; b (p=.011; d=0.59) medium; c (p=<.0005; d=0.94) large; d (p=<.0005; d=0.78) medium; e (p=<.0005; d=0.72) medium.

Table 4.31 shows that ANOVA (F=10.348; df=7; p<.0005) identified significant differences across the schools in relation to flexibility. Post-hoc tests revealed that one Northern Area school (2) was significantly lower for flexibility than three of the

Township Area schools (4, 5 and 7). Post-hoc tests also revealed that three Northern Areas schools' values were significantly different from each other (1 and 2, 2 and 8).

Table 4.32 depicts the comparison of the eight schools in relation to participants' upper body strength.

Table 4.32: Descriptive and inferential statistics: Upper body muscular strength (kg) across schools

Group	All	School 1 (NA)	School 2 (NA)	School 3 (NA)	School 4 (TA)	School 5 (TA)	School 6 (TA)	School 7 (TA)	School 8 (NA)
n	850	98	155	83	116	86	82	136	94
Mean	13.29	12.79 [a]	12.66 [b]	11.46 [cdefg]	13.61 [c]	14.71 [abd]	13.77 [e]	13.63 [f]	13.85 [g]
SD	3.36	3.34	3.01	2.70	3.37	3.06	3.80	3.17	3.68

Post-hoc statistics

a (p=.027; d=0.60) medium; b (p=.003; d=0.68) medium; c (p=.004; d=0.69) medium; d (p=<.0005; d=1.13) large; e (p=.005; d=0.70) medium; f (p=.002; d=0.72) medium; g (p=.001; d=0.74) medium.

In Table 4.32, ANOVA (F=8.242; df=7; p<.0005) identified significant differences across the schools in relation to GS. Three of the Northern Areas schools (1, 2 and 3) reflect lower GS values than those of the Township Area schools. Post-hoc tests revealed that three of the Northern Areas schools' (1, 2 and 3) GS values were significantly lower than all the Township schools' values. Post-hoc tests also revealed that two of the Northern Areas schools' (3 and 8) values were significantly different from each other.

Table 4.33 reflects the comparison of the eight schools in relation to participants' lower body strength.

Table 4.33: Descriptive and inferential statistics: Lower body muscular strength (cm) across schools

Group	All	School 1 (NA)	School 2 (NA)	School 3 (NA)	School 4 (TA)	School 5 (TA)	School 6 (TA)	School 7 (TA)	School 8 (NA)
n	846	98	154	82	117	86	82	133	94
Mean	129.33	126.88	133.75	124.90	127.32	130.08	126.84	129.73	131.90
SD	19.07	19.60	17.10	17.66	19.88	22.12	18.56	19.53	17.20

ANOVA (F=2.739; df=7; p<.008)

Although ANOVA (F=2.739; df=7; p<.008) identified significant differences across the schools in relation to SBJ in Table 4.33. The post-hoc Scheffé test did not reveal any specific statistical differences between any schools.

Table 4.34 indicates a comparison of the eight schools in relation to participants' CRF.

Table 4.34: Descriptive and inferential statistics: VO_2max (ml/kg/min) across schools

Group	All	School 1 (NA)	School 2 (NA)	School 3 (NA)	School 4 (TA)	School 5 (TA)	School 6 (TA)	School 7 (TA)	School 8 (NA)
n	834	92	162	82	116	81	77	127	97
Mean	47.08	46.43	46.22	46.86	47.63	47.89	48.26	47.10	47.04
SD	4.17	3.79	4.16	3.91	4.29	4.13	4.66	4.54	3.33

ANOVA (F=2.739; df=7; p<.004)

ANOVA (F=2.981; df=7; p<.004) identified significant differences across the schools in relation to the 20 m SRT in Table 4.34. The post-hoc Scheffé test did not reveal any specific statistical differences between any schools.

Table 4.35 presents a comparison of the eight schools in relation to participants' composite fitness.

Table 4.35: Descriptive and inferential statistics: Composite fitness score across schools

Group	All	School 1 (NA)	School 2 (NA)	School 3 (NA)	School 4 (TA)	School 5 (TA)	School 6 (TA)	School 7 (TA)	School 8 (NA)
n	813	91	151	82	114	81	77	127	90
Mean	50.00	49.01 [a]	48.36 [b]	47.71 [cdf]	50.39	52.77 [abc]	50.41	50.95 [d]	51.17 [f]
SD	6.05	5.43	5.72	5.33	6.30	6.87	5.61	6.13	5.44

Post-hoc statistics

a (p=.015; d=0.61) medium; b (p=<.0005; d=0.72) medium; c (p=<.0005; d=0.82) large; d (p=.036; d=0.56) medium; e (p=.040; d=0.64) medium.

In Table 4.35, ANOVA (F=7.499; df=7; p<.0005) identified significant differences across the schools in relation to composite fitness values. Post-hoc tests revealed that three of the Northern Areas schools' (1, 2 and 3) values for the composite fitness score were significantly lower than one of the Township Area schools' (5) values. Post-hoc tests also revealed that two of the Northern Areas schools' (3 and 8) values were significantly different from each other.

4.6 RELATIONSHIP BETWEEN CARDIORESPIRATORY FITNESS AND SELECTED ANTHROPOMETRIC VARIABLES

This section will cover the relationship between nutritional status (as reflected by WAZ, HAZ and BAZ) and VO_2max for gender. Tables 4.36 to 4.41 depict this relationship for underweight, stunting and thinness/obese status.

The tables in this section reflect the t-test results for the comparison of two mean values for WAZ and HAZ. BAZ results are reflected by way of Chi square for the comparison of three mean values.

Table 4.36 depicts the relationship between mean VO_2max of boys in the underweight (WAZ<-2) versus non-underweight (WAZ>-2) categories.

Table 4.36: Relationship between VO_2max (ml/kg/min) and weight-for-age z-scores for boys

Variable	Weight-for-age	n	Mean	SD	Difference	t	df	p	Cohen's d
VO2max	Underweight (WAZ<-2)	11	49.80	5.29	0.27	0.22	204	.822	n/a
	Non-underweight (WAZ>-2)	195	49.53	3.80					

Table 4.36 shows that while the boys in the non-underweight category reflected a lower mean VO_2max than those in the underweight category, the difference between the two categories was not statistically significant.

Table 4.37 reflects the relationship between mean VO_2max of boys in the stunted (HAZ<-2) versus non-stunted (HAZ>-2) categories.

Table 4.37: Relationship between VO_2max (ml/kg/min) and height-for-age z-scores for boys

Variable	Height-for-age	n	Mean	SD	Difference	t	df	p	Cohen's d
VO_2max	Stunted (HAZ<-2)	43	49.09	4.27	0.26	0.37	412	.709	n/a
	Non-stunted (HAZ>-2)	371	48.84	4.24					

Table 4.37 shows a non-significant difference between the VO_2max of those boys who presented with stunted growth and those who were not-stunted.

Table 4.38 represents the descriptive and inferential statistics for the relationship between mean VO_2max of boys for the three weight categories: thin (BAZ<-2), normal weight (-2≥BAZ≤-2), overweight and obese (BAZ>+2).

Table 4.38: Descriptive and inferential statistics: Relationship between VO_2max (ml/kg/min) and BMI-for-age z-scores for boys

Group	All	Thin (BAZ<-2)	Normal (-2≥BAZ≤+2)	Overweight and Obese (BAZ>+2)	
n	414	14	385	15	
Mean	48.87	47.67	49.11	43.82	
SD	4.24	3.97	4.16	3.25	
Post-Hoc analysis					
Category 1	**Category 2**	**Diff. M1-M2**	**Scheffé p**	**Cohen's d**	
Thin (BAZ<-2)	Normal (-2≥BAZ≤+2)	-1.43	.444	n/a	n/a
Thin (BAZ<-2)	Overweight and Obese (BAZ>+2)	3.85	.044	1.07	Large
Normal (-2≥BAZ≤+2)	Overweight and obese (BAZ>+2)	5.29	<.0005	1.28	Large

According to Table 4.38, ANOVA (F=12.439; df=2; p<.0005) revealed a significant difference between the VO_2max values of the three BAZ categories. Post-hoc analyses revealed a significant difference statistically and practically between the VO_2max value of the overweight and obese combined category and that of the thin and normal category, respectively. The overweight and obese boys presented with a significantly lower VO_2max value.

Table 4.39 presents the relationship between mean VO_2max of girls in the underweight (WAZ<-2) versus non-underweight (WAZ>-2) categories.

Table 4.39: Relationship between VO_2max (ml/kg/min) and weight-for-age z-scores for girls

Variable	Weight-for-age	n	Mean	SD	Difference	t	df	p	Cohen's d
VO2max	Underweight (WAZ<-2)	19	45.76	2.61	0.06	0.09	284	.930	n/a
	Non-underweight (WAZ>-2)	267	45.70	2.98					

According to Table 3.39, inferential analysis indicated no significant relationship between VO_2max and WAZ even though the girls in the underweight category presented with a higher VO_2max than those in the non-underweight category.

Table 4.40 reflects the relationship between mean VO_2max for girls in the stunted (HAZ<-2) versus non-stunted (HAZ>-2) categories.

Table 4.40: Relationships between VO_2max (ml/kg/min) and height-for-age z-scores for girls

Variable	Height-for-age	n	Mean	SD	Difference	t	df	p	Cohen's d
VO2max	Stunted (HAZ<-2)	44	44.98	3.06	-0.38	-0.74	418	0.459	n/a
	Non-stunted (HAZ>-2)	376	45.36	3.28					

In Table 4.40 there is no significant difference between the VO_2max of the girls in the stunted and those in the non-stunted category even though the latter category showed a higher value.

Table 4.41 represents the descriptive and inferential statistics for the relationship between mean VO_2max of girls for the three weight categories: thin (BAZ<-2), normal weight (-2≥BAZ≤-2), overweight and obese (BAZ>+2).

Table 4.41: Descriptive and inferential statistics: Relationship between VO_2max (ml/kg/min) and BMI-for-age z-scores for girls

Group	All	Thin (BAZ<-2)	Normal (-2≥BAZ≤+2)	Overweight and Obese (BAZ>+2)
n	420	19	371	30
Mean	45.32	45.96	45.50	42.75
SD	3.25	3.51	3.20	2.60
Post-Hoc analysis				
Category 1	**Category 2**	**Diff. M1-M2**	**Scheffé p**	**Cohen's d**
Thin (BAZ<-2)	Normal (-2≥BAZ≤+2)	0.46	.828	n/a
Thin (BAZ<-2)	Overweight and Obese (BAZ>+2)	3.21	.003	1.07 Large
Normal (-2≥BAZ≤+2)	Overweight and Obese (BAZ>+2)	2.75	<.0005	0.87 Large

ANOVA ($F=10.744$; $df=2$; $p<.0005$) revealed a significant difference between the VO_2max values of the three BAZ categories in Table 4.41. Post-hoc analyses were subsequently conducted. As is seen in Table 4.41, there is no significant difference between the VO_2max of the thin and the normal categories. However, the overweight and obese category showed significantly lower VO_2max values than both the thin and normal categories for girls.

Chapter 5 will discuss and interpret the results that were presented in Chapter 4. Only significant mean differences will be discussed.

CHAPTER 5

DISCUSSION, CONCLUSION AND RECOMMENDATIONS

5.1 INTRODUCTION

The aim of this study was to investigate the PF status of primary schoolchildren, aged 8-to-11-years, from eight selected schools situated in lower socio-economic communities in the Port Elizabeth area. This chapter discusses the results reflected in Chapter 4 in order to achieve the objectives of the study. Each anthropometric and PF component presented in Chapter 4 is discussed in relation to the following demographics: gender, ethnicity and geographical area. Statistical and practical significance, when comparing two means, were set at $p<.05$ and $d>0.2$ or $V>0.1$, respectively. The exact p-values and effect sizes have been indicated in the comparisons reflected in Chapter 4. However, significance in this chapter is only indicated where practical significance was proved, and is reflected as $p<.05$, even though the actual calculation indicated a lower value. The discussion of the results will be related back to the literature in Chapter 2 and interpreted accordingly. This chapter concludes with a summary of the findings and the overall conclusion. The limitations of the study are also presented and from there, recommendations are presented for future research.

5.2 PARTICIPANTS

The South African context provides a unique platform for researching health issues within a diverse cultural and ethnic setting. The country's socio-economic groups are largely a result of the segregation from apartheid laws (McVeigh *et al.*, 2004:987) as the majority of lower socio-economic groups living in disadvantaged areas consist of the non-white population (Black African, Coloured and Indian) (Armstrong *et al.*, 2011:1000). Disadvantaged areas, much like the Township Areas and Northern Areas in the city of Port Elizabeth, are still largely populated by Black African and Coloured people. Children living in these disadvantaged communities are often limited to public transport or active commuting (walking) (McVeigh *et al.*, 2004:986) to get to school. The area of residence was of relevance to the current sample as Coloured children from the Northern Areas attend schools within their communities. However, as mentioned in chapter 3, many Black African children living in Township Areas may also attend schools in the Northern Areas. Discussions in the subsections to follow describe and compare the eight schools participating in the study in respect of the study variables. Therefore, it is necessary to echo what was eluded to in Chapter 3 regarding the ethnic and geographical differences of the eight schools. Schools 2 and 3 in the Northern Areas are populated mainly by Coloured children only. However, School 1 and 8 in the Northern Areas have a combination of Coloured and Black African learners. The remaining four schools (Schools 4, 5, 6 and 7) are from urban informal Township Areas and are attended by Black African learners only.

The population relevant to the current study was homogeneous in terms of the lower socio-economic background, but diverse in terms of ethnicity. A larger portion of the sample were of Black African ethnicity (62%) when compared to Coloured ethnicity (38%). Table 4.1 reflects the descriptive statistics for the target sample group, which encompassed a balanced gender distribution of 462 (50%) boys and 453 (50%) girls. The mean age of the Grade 4 learners was 9.96±0.80 years. In order to successfully achieve the aim of the study, the subsections to follow will describe and discuss the status of anthropometric and PF components for the sample group. The aforementioned components will also be compared for the whole group across the eight schools and the relationship between CRF and selected anthropometric variables, will be illustrated.

5.3 ANTHROPOMETRIC INDICATORS

Results from this study revealed the dual-burden of malnutrition prevalent among the sample of Grade 4 learners, living in disadvantaged areas of Port Elizabeth. Given the concern regarding the burden of malnutrition, it is considered important to discuss the results pertaining to the indicators of malnutrition (WAZ, HAZ and BAZ) before focusing on the other anthropometric variables assessed. Findings from this study corroborate that of Armstrong *et al.* (2011:835) which stated that children living in socio-economically deprived environments were susceptible to nutritional disorders that are likely to impair their growth and development (Kimani-Murage *et al.*, 2010:2; Armstrong *et al.*, 2011:835). Details of the nutritional status followed by body composition are provided in the following subsections.

5.3.1 Nutritional status

This subsection describes the nutritional status of the learners with respect to selected demographics. For the present study WAZ, HAZ and BAZ comparisons revealed significant differences in relation to ethnicity and geographical areas in particular. Figures 5.1 to 5.3 depict a graphic representation of the mean z-score results.

5.3.1.1 Weight-for-age z-score comparisons

Comparisons for mean WAZ results are depicted in Figure 5.1, in relation to gender, ethnicity and geographical area. According to Table 4.7, 6% of the learners in the current study presented with low WAZ values. The frequency distribution per gender, in Table 4.8 revealed that girls (6%) presented with a slightly higher (p=.637) prevalence of underweight for age than boys (5%). The non-significant differences between the girls and boys were also depicted in the weight-for-age mean z-scores reflected in Figure 5.1. This finding is in contrast with other South African studies as a higher incidence of underweight is usually reported for boys in comparison to girls (Reddy *et al.*, 2008:37; Monyeki *et al.*, 2015:1166).

In relation to ethnic comparisons, South African demographics often report a higher prevalence of underweight for Coloured children than Black African children (Reddy *et al.*, 2008:37; Monyeki *et al.*, 2015:1167). The present study substantiates findings from the latter studies as significant differences (p<.05) were identified for ethnicity per gender group (Table 4.3 and 4.4) and the total group (Table 4.5). Coloured learners (boys and girls) had significantly lower WAZ values (p<.05) when compared to Black African learners (boys and girls). Significant differences are also depicted in the weight-for-age mean z-scores (Figure 5.1). With reference to the geographical area, the results of the comparisons per gender (Table 4.6) showed that Coloured girls presented with significantly lower (p<.05) WAZ values in comparison to Black African girls. For the total group, children attending schools in the Northern Areas had significantly lower WAZ scores (p<.05) when compared to children attending Township Area schools. Furthermore, a significantly higher frequency of underweight for age values (p<.05) were identified for Northern Area schools (10%) (Table 4.9) in comparison to Township Areas schools (2%). The significantly higher mean WAZ value found for Township Area schools when compared to Northern Areas schools, is also evident in Figure 5.1.

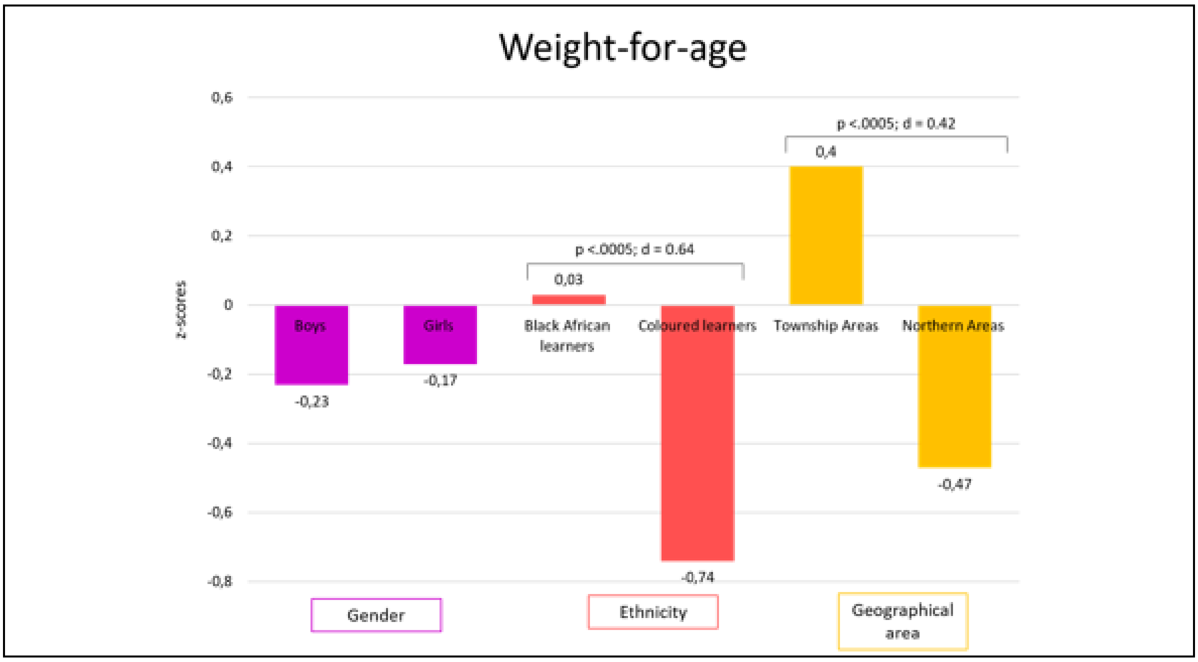

Figure 5.1: Weight-for-age mean z-scores comparisons per gender, ethnicity and geographical area

5.3.1.2 Height-for-age z-score comparisons

Mean HAZ comparisons are depicted in Figure 5.2, in relation to gender, ethnicity and geographical area. According to Table 4.11, 10% of the learners were categorised as stunted. In relation to gender differences as seen in Table 4.12, the frequency of stunting for girls (11%) versus boys (10%) was non-significant (p=.751). The non-significant gender difference tendency with respect to height-for-age mean z-scores is also reflected in Figure 5.2.

In terms of ethnicity, Coloured and Black African children, according to literature, were found to be more stunted in comparison to White children (Reddy *et al.*, 2008:37). For the present study, ethnic comparisons as seen in Table 4.5, identified that Coloured learners (overall) had significantly lower height-for-age z-scores than 9-to-11-year-old Black African learners (p<.05). The latter differences are also evident in the mean HAZ scores depicted in Figure 5.2. When gender was compared to ethnicity in Tables 4.3 and 4.4, the same tendencies were found. Coloured boys and girls (overall) both presented with significantly lower (p<.05) HAZ scores in comparison to Black African boys and girls, the differences per age category were all significant (p<.05), except in the case of the 8-year-old age group. In relation to geographic areas, Table 4.6 identified that Northern Area school learners had significantly lower HAZ values in comparison to both boys and girls that attend Township Area schools (p<.05). The latter tendency is also visually depicted in Figure 5.2 in the significantly different (p<.05) mean HAZ scores (-1.00 versus -0.49). It was, therefore, not surprising to find a significantly (p<.05) higher frequency of stunted growth among Northern Area schools (16%) than amongst schools in the Township Areas (5%) as confirmed by the results reflected in Table 4.13.

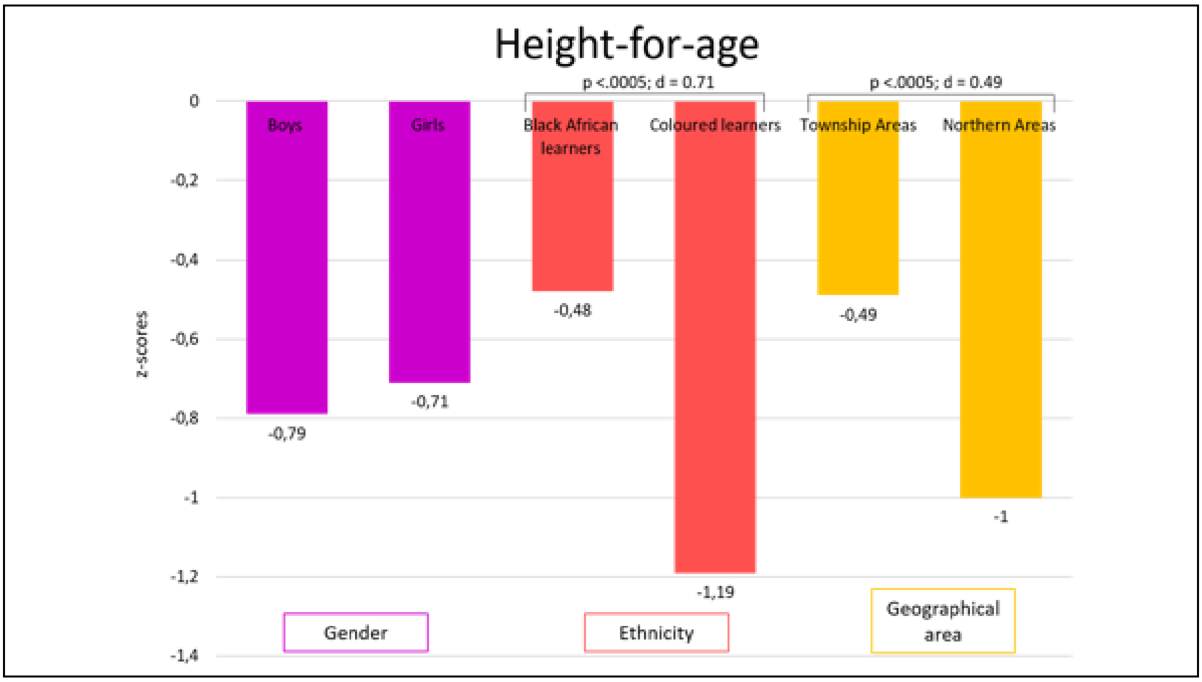

Figure 5.2: Height-for-age mean z-scores comparisons per gender, ethnicity and geographical area

5.3.1.3 BMI-for-age z-score comparisons

A comparison for mean BAZ values in relation to gender, ethnicity and geographical area is depicted in Figure 5.3. Although girls overall presented with higher mean BMI and BAZ values than boys, these differences were not significant (see Table 4.2 and Figure 5.3). According to Table 4.15, most learners were categorised as normal weight, while 4% had low BAZ scores and 5% were placed in the combined overweight and obese category for BAZ. The higher percentage of combined overweight and obesity may be a result of the higher proportion of Black African learners (62%) in comparison to Coloured learners (38%) (Table 4.1). The significantly higher BAZ values (p<.05) presented by the Black African learners are also visually depicted by the mean BMI-for-age z-score values in Figure 5.3. These findings concur with other South African studies that reported higher incidences of overweight and obesity among Black African children when compared to Coloured children (Reddy *et al.*, 2008:38; Monyeki *et al.*, 2015:1166-1167). For the current study, ethnic comparisons In Table 4.5, identified significant differences (p<.05) from the age of 9-years and older. By the age of 9 years and older, Coloured boys and girls presented with significantly lower (p<.05) BMI-for-age z-score values than Black African boys and girls, respectively (Tables 4.3 and 4.4). The latter finding was true for the overall group of boys and girls and for all specific ages except in the case of the 8 and 10-year-old boys and the 8-year-old girls in which case the differences were in the same direction as the overall group, however they were not significantly different. These findings concur with that of Monyeki *et al.* (2015:1167) who indicated that children of Black African origin usually presented with higher values of overweight and obesity.

In relation to gender differences, more girls are usually reported as overweight or obese when compared to boys (Monyeki *et al.*, 2015:1166-1167). In the present study, in Table 4.16, girls presented with a higher incidence of combined overweight and obesity (7%) (high BMI-for-age z-score) as well as thinness (4%) (low BMI-for-age z-score) when compared to boys (with 4% combined overweight and obesity; 3% thinness). Although close, there was no significant difference between the two frequency distributions found (p=.053). The frequency distribution of the three BAZ categories was, however, significantly (p<.05) different for the two geographical areas as depicted in Table 4.17 and as confirmed by the BMI-for-age mean z-scores reflected in Figure 5.3. Children attending Northern Area schools presented with the highest prevalence of thinness (6%) while learners attending schools in the Township Areas displayed the highest prevalence for the combined category of overweight and obesity (7%). This suggests that learners from the Northern Areas are at risk of undernutrition while learners from the Township Areas are at risk of overnutrition.

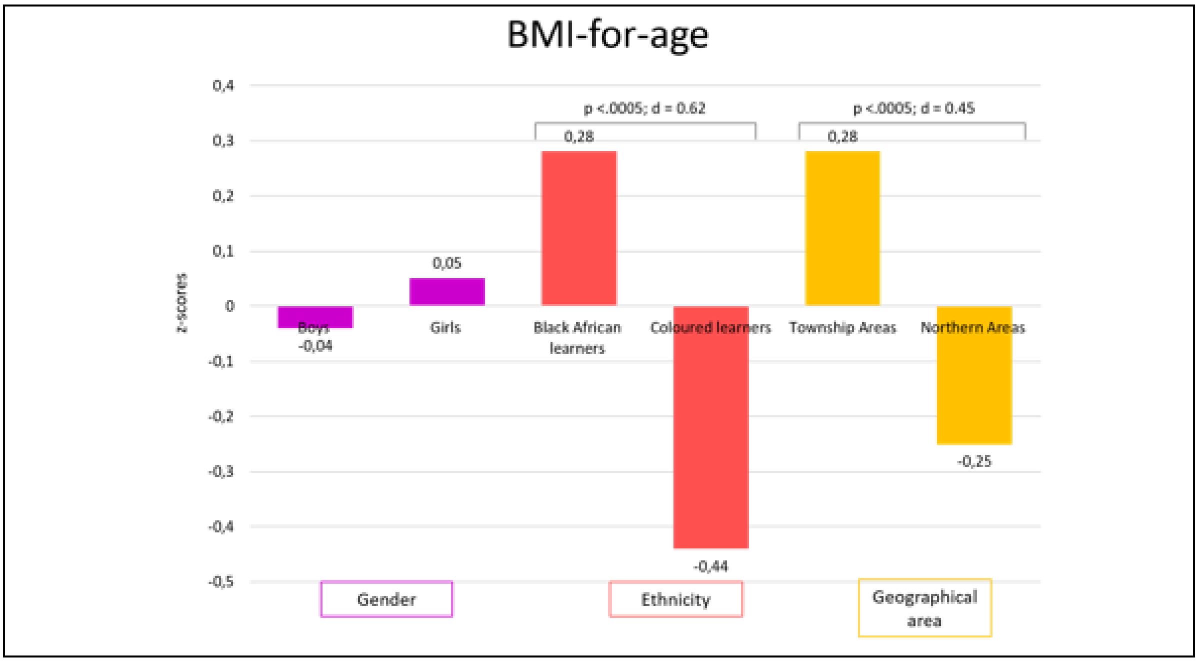

Figure 5.3: BMI-for-age mean z-scores comparisons per gender, ethnicity and geographical area

According to Monyeki *et al.* (2015:1166-1167), higher incidences of overnutrition are found among children in formal urban settings, whereas undernutrition is usually reported for children from urban informal settlements and rural environments. In a rural setting, the study by Moselakgomo, Monyeki & Toriola (2015:343), identified that 74.7% of children were underweight while 1.6% were categorised as overweight (classified in accordance with BMI cut-offs as stated by Cole, Flegal, Nicholls & Jackson (2007:198). For the present study, the geographic location of the sample is a combination of formal and informal urban settings. A higher prevalence of stunted-growth (10%) was found followed by underweight (6%), combined overweight and obesity (5%) and thinness (4%).

An age-related trend was also identified (Tables 4.2 to 4.5) however, no significant differences were presented at 8-years of age. Varying significant differences were reflected from the age of 9-years and older. The prevalence of stunting, underweight and thinness, therefore, increased with age which suggests chronic undernutrition for the target sample group. The latter finding may be a reflection of inadequate food portions and a lack of nutritious food as eluded to in Chapter 2. Children from poverty-stricken homes are generally exposed to poor diets and poor sanitation. For the wider DASH Study, researchers Müller, Yap, Steinmann, Damons, Schindler, Seelig, Htun, Probst-Hensch, Gerber & du Randt (2016:488) reported that overall, 144 learners (15% of the sample) were infected with soil-transmitted helminth infections, with at least one type of intestinal protozoan species (Müller *et al.*, 2016:491), which has implications for the growth and development of children. According to the 2016 HAKSA report, high levels of undernutrition are still prevalent among children from poverty-stricken homes within lower socio-economic communities (Uys *et al.*, 2016:S269-S270). Findings from the present study found no significant gender differences in relation to the nutritional indicators. Furthermore, the outcome of this study and the wider DASH Study revealed that learners of Coloured ethnicity tend to show a higher incidence of undernourishment as a result of poor diets and parasitic infections than their Black African counterparts. While Black African learners who attend Township Area schools depict a higher incidence of overweight and obesity than Coloured children, with girls, in particular, being at higher risk in this regard. Of concern is the risk of exposure to long-term undernutrition leading to underdeveloped and stunted growth while overnutrition increases the risk of NCD's and other obesity-related concerns (Rossouw *et al.*, 2012:5).

5.3.2 Body composition

The following subsection describes the body composition of the learners for the current study in respect of the selected demographics. Height and weight are first discussed followed by the indicators of body composition.

5.3.2.1 Height comparisons

A comparison of the participants' mean height results is depicted in Figure 5.4 in relation to selected demographics. Although not significant, Table 4.2 showed that the boys' mean height for the sample (133.27±6.72 cm) was higher (p=.255) than that of the girls (132.74±7.36 cm) (see Figure 5.4). When stratified by age the following was found: at 8-years-old, boys (131.19±4.58 cm) were taller than girls (129.71±6.28 cm), but, by 10-years-old, girls (135.96±7.90 cm) were significantly taller (p=0.38) than boys (134.04±7.07 cm). Therefore, a growth spurt was apparent on average at the age of 10-years for girls. The growth rate during middle childhood is said to be gradual and occurs at a steady rate until the onset of puberty after which the growth rate rapidly increases (Gallahue & Ozmun, 1998:176). Therefore, the significant increase in the girls' height at 10-years-old may suggest hormonal changes (growth spurt) associated with puberty, however maturation cannot conclusively be attributed to this finding as it was not recorded for the purpose of this study.

In Tables, 4.5 ethnic comparisons revealed that Black African learners (133.93±7.04 cm) were significantly taller ($p<.05$) than Coloured learners (131.49±6.78 cm) overall (see Figure 5.4) and across each age group category. With reference to gender per ethnicity in Tables 4.3 and 4.4 – Black African boys and girls were significantly taller than Coloured learners for all age group categories, except at 8-years of age for both genders and at 11-years of age for girls. These findings were contrary to findings reported by Armstrong (2009:151) in which Black African children were shorter than children of Coloured and White ethnicity. The comparison between the two geographical areas in Table 4.6, identified learners from Township Area (134.06±6.96 cm) schools as significantly taller ($p<.05$) than learners who attend schools in the Northern Areas (132.00±6.98 cm) (see Figure 5.4).

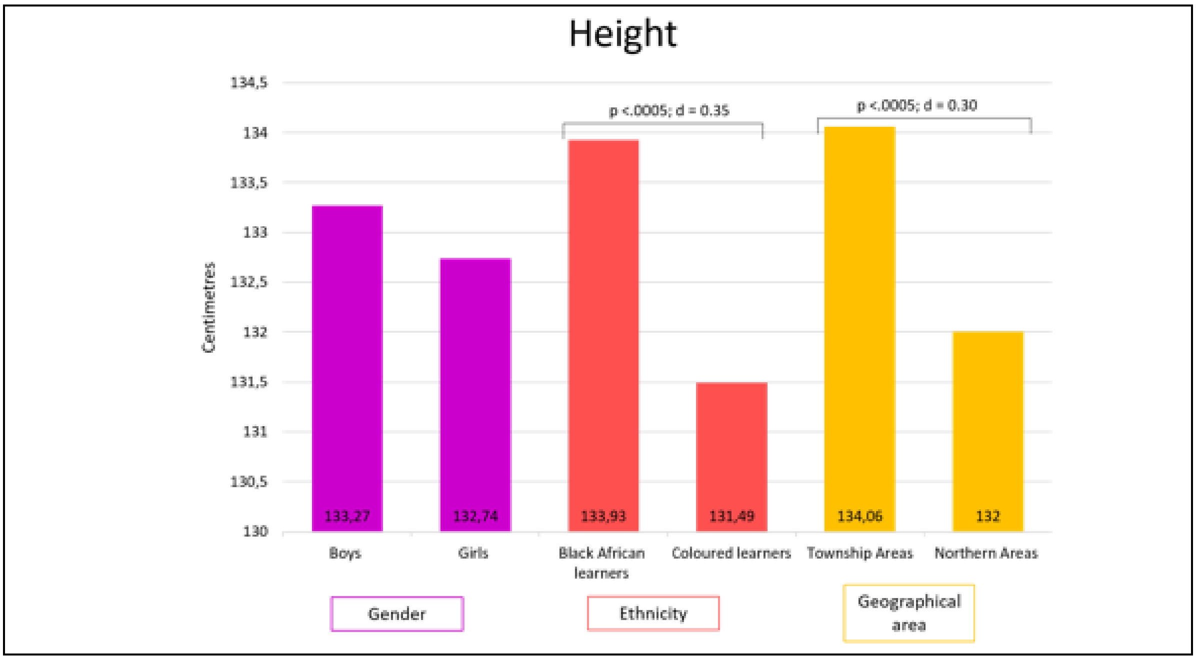

Figure 5.4: Mean height comparisons per gender, ethnicity and geographical area

5.3.2.2 Weight comparisons

Figure 5.5 depicts a comparison in relation to the participants' mean weight values per selected demographics. Findings for weight in Table 4.2 showed successive increases with age among boys and girls and although insignificant, girls (30.62±8.04 kg) overall were heavier than boys (30.16±6.93 kg) (see Figure 5.5). These findings are substantiated by literature as females tend to demonstrate a higher prevalence of overweight and obesity, especially Black African females (Reddy *et al.*, 2008:42). Ethnicity-related gender differences in Tables 4.3 and 4.4 showed that Black African boys and girls were significantly heavier (p<.05) than Coloured learners for each age group category (except at 8-years-old). For the total group (see Table 4.5), Black African learners (31.72±8.06 kg) were significantly heavier (p<.05) than Coloured learners (28.19±5.86 kg) for each age group (see Figure 5.5). As discussed in Chapter 2, cultural perceptions of body weight often differ across ethnicity which may explain the variance in body weight (Rossouw *et al.*, 2012:5). In relation to geographical area, Table 4.6 revealed that learners from Township Area (31.86±8.21 kg) (p<.05) schools (who are majority of Black African ethnicity) were significantly heavier than learners who attended schools in the Northern Areas (28.98±6.46 kg) (see Figure 5.5).

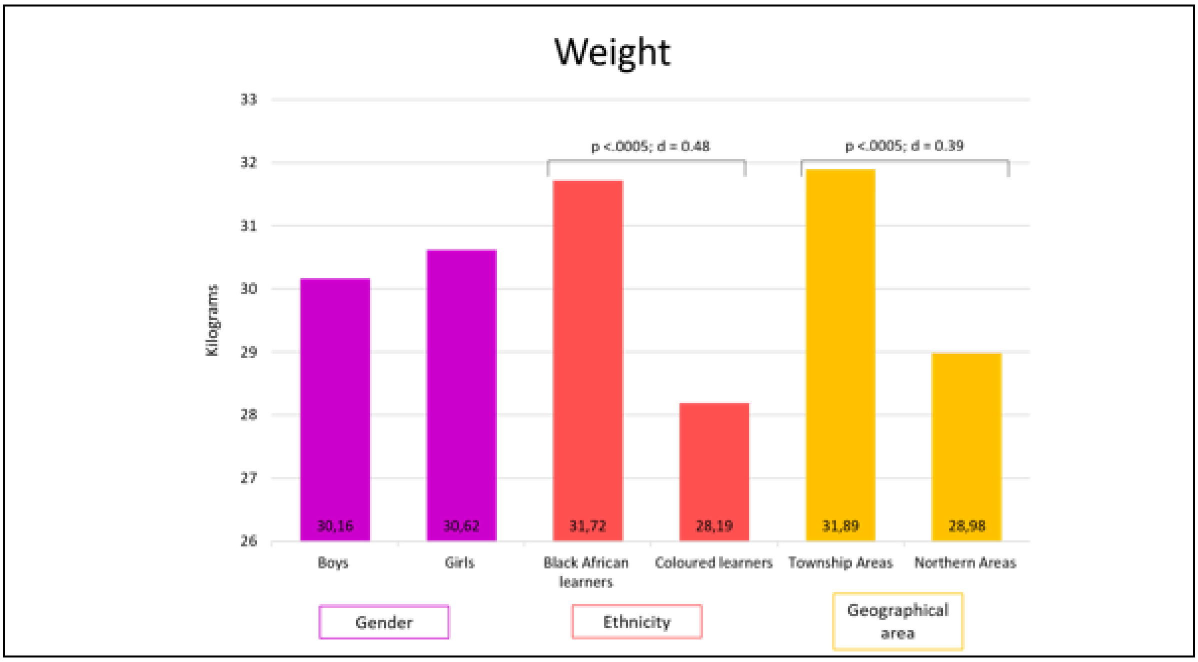

Figure 5.5: Mean weight comparisons per gender, ethnicity and geographical area

5.3.2.3 Body mass index comparisons

Results for the comparison of the participants' mean BMI are depicted in Figure 5.6 per selected demographic. BMI of the target sample group was categorised as normal according to the international cut-off points stated by Cole *et al.* (2000:1244). Although not significant, girls (17.19±3.28 kg/m^2) presented with higher BMI values than boys (16.84±2.71 kg/m^2) as depicted in Table 4.2 and as reflected in Figure 5.6. Ethnic comparisons in terms of BMI in Table 4.5 indicated significant differences for all age group categories, except the 8-year-old age group. Children of Black African ethnicity (17.52±3.29 kg/m^2) had significantly higher BMI values ($p<.05$) than children of Coloured ethnicity (16.18±2.24 kg/m^2) (see Figure 5.6). In relation to geographical area, Table 4.6 revealed that children from Township Area schools (17.57±3.39 kg/m^2) had significantly higher BMI values ($p<.05$) than children from the Northern Area schools (16.49±2.48 kg/m^2) (see Figure 5.6).

In comparison to international studies, the research by Sacchetti *et al.* (2012:636) reported the BMI values of Italian children, aged 8-to-9-years-old as 17.80±2.90 kg/m^2 for boys and 17.90±3.10 kg/m^2 for girls. Using a two-sample t-Test analysis, comparison of the mean values between the aforementioned study and the present study revealed no significance ($p>.05$) for boys' and a small significance in relation to girls ($p=.000$). In comparison to local South African studies, the results from Truter *et al.* (2010:230) reported an average BMI of 17.20±1.70 kg/m^2 for normal-weight learners aged 9-to-12-years-old from the North West province. Findings for the present study revealed that the mean BMI of the target sample was 17.02±3.01 kg/m^2. Although small, the difference is significant ($p=.001$). Considering that the current study sample is from a lower socio-economic group when compared to the sample from the North West which included a distribution of socio-economic levels, it does seem that socio-economic status may have contributed to the differences found.

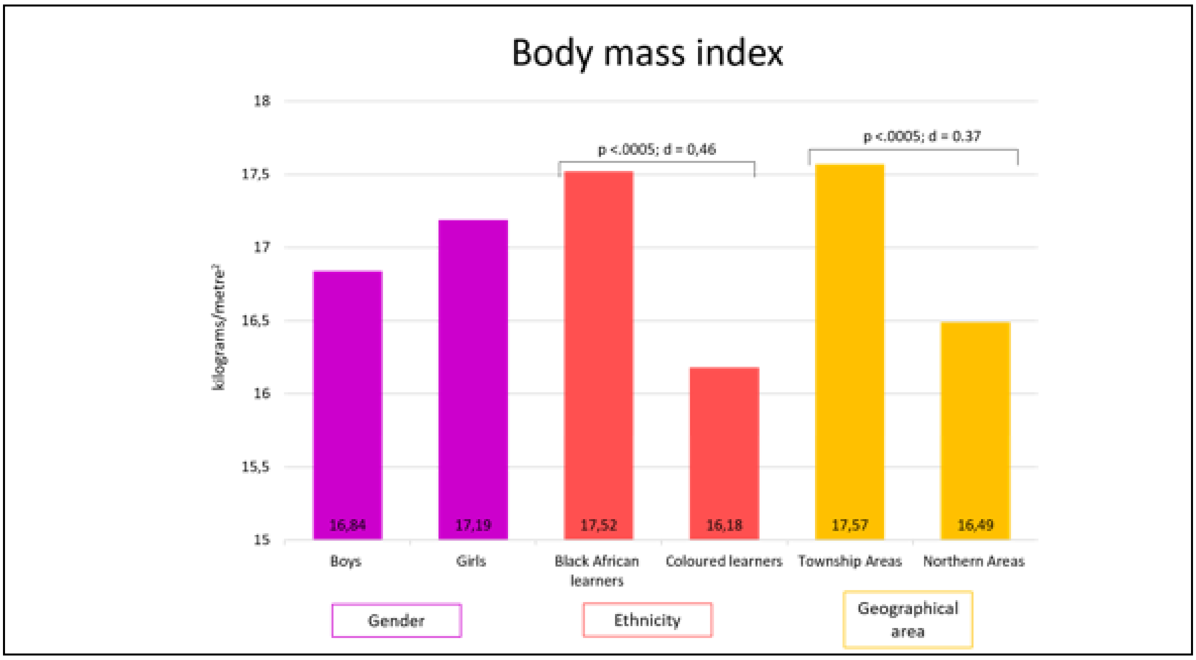

Figure 5.6: Mean body mass index comparisons per gender, ethnicity and geographical area

5.3.2.4 Body fat percentage comparisons

Results for the comparison of the participants' mean BF% values are depicted in Figure 5.7 per the selected demographics. Findings for BF% in Table 4.2 showed that girls (18.58±6.72%) overall had a significantly higher BF% value (p<.05) than boys (13.27±5.93%) (see Figure 5.7) and this tendency was relevant at any given age. The BF% of these learners was categorised as 'normal' based on the BF% reference chart of McCarthy *et al.* (2006:600) for a sample of 1 985 children, aged between 5 and 18 years from Southern England. Of all the anthropometric findings, BF% was the only anthropometric indicator that showed a significant difference for gender comparisons in the present study. Ethnic comparisons in Table 4.5 showed that Black African learners (16.89±7.34%) had significantly higher (p<.05) BF% values overall when compared to Coloured learners (14.27±5.64%) overall (see Figure 5.7). The latter finding was also the case for all age group categories, except for the 8-year-old group. Comparisons between the two geographical areas in Table 4.6, showed that learners attending Township Area schools (16.88±7.43%) had significantly higher BF% values (p<.05) overall than learners who attend Northern Area schools (14.96±6.14%) (see Figure 5.7). Study findings by Travill (2007:283) and Amusa *et al.* (2011:4668) reported that girls had significantly higher BF% values than boys. The population from which the sample was drawn for the study by Travill (2007:280) was based on a Township demographic from the Western Cape province. The results reported by Travill (2007:283) could not be compared statistically against the results of the present study as the sample sizes were not indicated by Travill (2007:283). The BF% for boys in the present study was lower in comparison to the findings of Travill (2007:283), while the values for girls were higher in comparison to the findings by Travill (2007:283) (see Table 2.4).

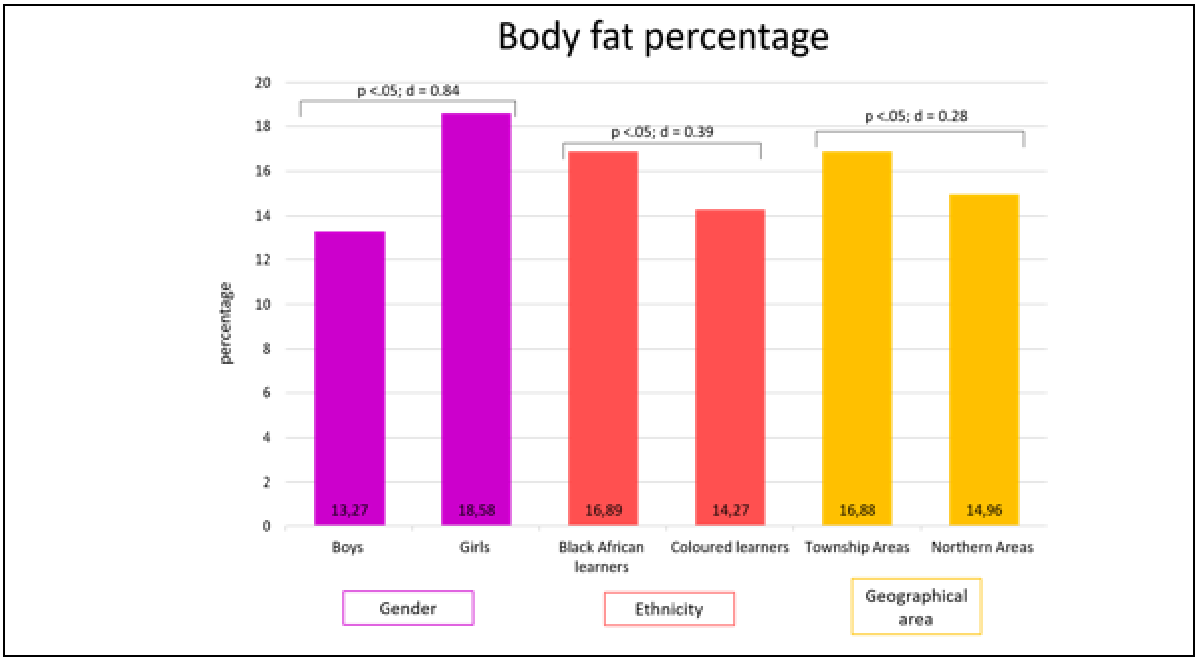

Figure 5.7: Mean body fat percentage comparisons per gender, ethnicity and geographical area

In summary, the body composition of the current sample group was normal, based on BMI and BF% findings. In most cases (except for the Black African children) a decline in the BMI and BF% was identified at 9-years of age. However, by the age of 10, children of Black African ethnicity were significantly taller and heavier ($p<.05$) and had significantly higher ($p<.05$) BMI and BF% values than Coloured children (see Table 4.5). Children (particularly the girls) attending Township Area schools had significantly higher ($p<.05$) body composition values than children attending schools in the Northern Areas (Table 4.6). These findings may not be a cause for immediate concern, however in addition to the high BAZ values, children of Black African ethnicity may be at risk of overweight and obesity.

These results have given a clear indication of the status of the nutritional health and body composition of the current sample. The significant effect of ethnicity, culture, socio-economic status as well as the area of residence are all factors which may influence the anthropometric characteristics of the target population.

5.4 PHYSICAL FITNESS COMPONENTS

There is a paucity of representative data which reports on the HRPF of children from lower socio-economic communities in the Eastern Cape, South Africa. This study investigated the PF status of children from disadvantaged communities and compared the learners' performance with reference to the studies presented in Tables 2.3 and 2.4. The subsections to follow will discuss three functional factors of PF, namely aerobic fitness (CRF), muscular strength and flexibility.

5.4.1 Cardiorespiratory fitness comparisons

Estimated VO_2max using the 20 m SRT data are reported for gender, ethnicity and geographical area. These mean results are depicted in Figure 5.8 per the selected demographics.

In Table 4.19, results showed that boys (48.87±4.24 ml/kg/min) presented with a significantly higher ($p<.05$) mean VO_2max value compared to the girls (45.32±3.25 ml/kg/min) (also see Figure 5.8) for the total group, as well as at any given age. The superior performances of boys were consistent with findings from other studies (Olds *et al.*, 2006:1030; Truter *et al.*, 2010:232). In relation to age and when VO_2max is expressed relative to body mass values, these are essentially stable in boys across childhood years while girls tend to show a progressive decline (Rowland, 2007:201). These tendencies amongst boys and girls where supported by the findings of this study (see Table 4.19).

When the results were stratified by ethnicity (Table 4.22), statistical significance was only reported for the total group. Although of small significance, Black African learners (47.38±4.27 ml/kg/min) reflected higher VO_2max values ($p=.011$) than Coloured learners (46.62±3.97 ml/kg/min) (for the total group only) (also see Figure 5.8, the middle comparison). In relation to gender, for the total group in Table 4.20, Black African boys (49.55±4.17 ml/kg/min) produced significantly higher ($p<.05$) VO_2max

values than Coloured boys (47.82±4.16 ml/kg/min). However, for the total group, although not significant, Coloured girls (45.39±3.36 ml/kg/min) produced slightly higher VO_2max values than Black African girls (45.28±3.19 ml/kg/min). Excess inert fat tissue is expected to cause a decline in the VO_2max performance of children (Rowland, 2007:206) and this is a possible reason why Black African girls did not perform as well as Black African boys. Due to the fact that the Coloured children were lighter, it is probable that the Coloured children would perform better than the Black African children who weighed more (Rowland, 2007:200). However, the performance of Coloured learners in the 20 m SRT may have been compromised as a result of the reduced nutritional health. When values where compared in relation to the geographical area, (Table 4.23) as is visually depicted in Figure 5.8, learners (boys in particular) attending Township Area schools (49.89±4.18 ml/kg/min) presented with significantly higher VO_2max values ($p<.05$) than learners attending schools in the Northern Areas (47.90±4.08 ml/kg/min).

Results of the present study were compared with the findings from the international studies presented in Table 2.3. The IDEFIC Study conducted by De Miguel-Etayo *et al.* (2014:S57) used a sample of 18 745 European children (aged 6-to-9-years-old) to provide a PF reference standard. The younger 8 and 9-year-old age groups from the present study were compared to these references standards. At 8-years of age, boys (51.01 ml/kg/min) were rated good at the 90^{th} percentile and 9-year-old boys (49.29 ml/kg/min) were rated average in the 75^{th} percentile. For girls, both the 8-year-old (46.79 ml/kg/min) and 9-year-old (45.45 ml/kg/min) age groups were rated average in the 50^{th} percentile. Olds *et al.* (2006:1030) compared scores amongst various countries and compiled a global average using these scores. It was only the 8, 9 and 11-year-old boys who scored above the global average. Whereas all the girls of the current study scored below the global average.

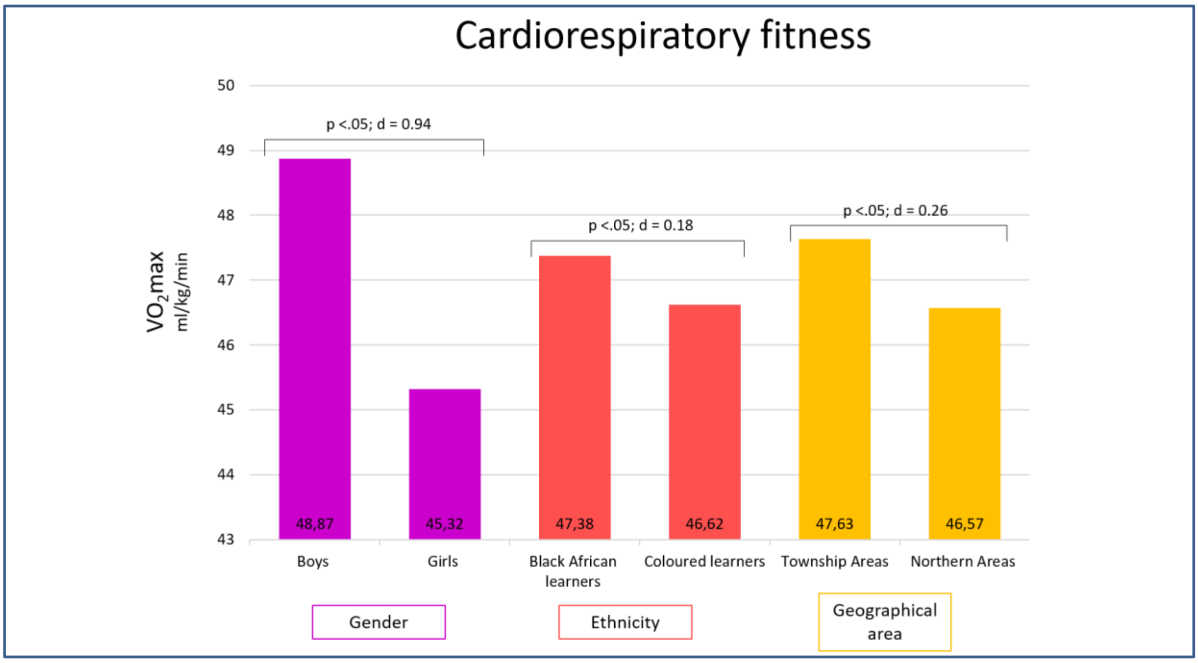

Figure 5.8: Mean cardiorespiratory fitness expressed as mean VO_2max value comparisons per gender, ethnicity and geographical area

5.4.2 Muscular strength comparisons

Results for the comparison of the learners' upper and lower body strength performance is depicted in Figures 5.9 and 5.10 respectively, per selected demographic.

The GS test is most commonly used to represent upper body maximal strength and is related to total muscle strength (Ortega *et al.*, 2008:2; Wind, Takken, Helders & Engelbert, 2010:285). Although this test is commonly used, different methodologies were used to measure GS in the research review reflected in Tables 2.3 and 2.4. Most studies measure GS with the participant in a standing position and their arms in complete extension, holding the dynamometer as in the case of the studies conducted by Ara *et al.* (2007:1920) and De Miguel-Etayo *et al.* (2014:S59). The type of dynamometer can also affect the methodology and outcome of the results. Apart from age and gender, GS would also be influenced by factors such as posture and joint angle (Ruiz, España-Romero, Ortega, Sjöström, Castillo & Gutierrez, 2006:1367). The angle at which the shoulder, elbow and wrist are placed are likely to bring about different muscle forces because of the change in lever lengths.

The study by Catley & Tomkinson (2013:104) measured GS with the participant in a seated position. Therefore, GS scores of the current study were analysed against the normative HRPF data of Australian children (Catley & Tomkinson, 2013:104). Learners from the current study scored below the 20th percentile, meaning they scored very low on upper body GS. For the present study, results for the total age group in Table 4.19 found that boys (14.00±3.40 kg) were significantly stronger (p<.05) than girls (12.58±3.17 kg) (also see Figure 5.9). In relation to the two geographic areas, (Table 4.23 and Figure 5.9) Township Area learners (13.87±3.35 kg) were significantly stronger (p<.05) than learners from the Northern Areas (12.72±3.27 kg). Furthermore, these results were echoed in relation to ethnicity in Table 4.22, as Black African participants (13.82±3.45 kg) performed significantly better (p<.05) than Coloured participants (12.39±2.99 kg) for all age groups (excluding the youngest 8-year-old age group) (Figure 5.9). As reported by Müller *et al.* (2016:492), learners who were not infected by soil-transmitted helminth infections were able to generate higher values of isometric strength than children who were infected. The Northern Areas children were adversely affected by soil-transmitted helminth infections.

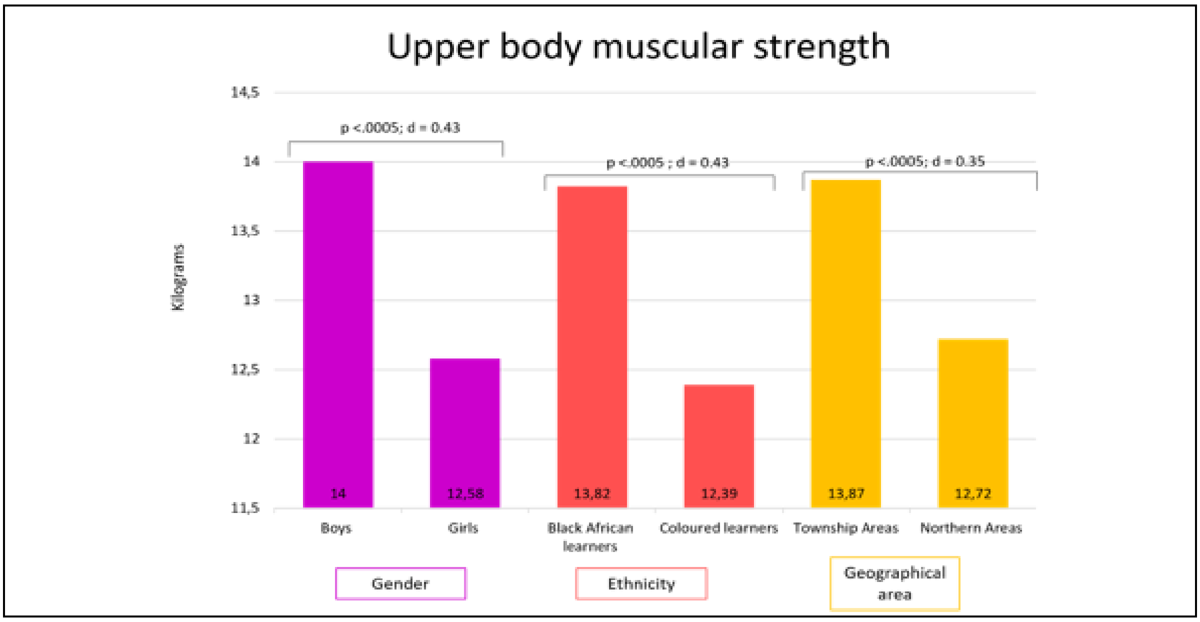

Figure 5.9: Mean upper body muscular strength comparisons per gender, ethnicity and geographical area

For the DASH Study, Müller *et al.* (2016:492) found no association between helminth infection and a reduced performance of the SBJ test, representative of lower body muscular strength. According to the results of the present study, Table 4.22 revealed that Coloured learners (131.28±17.64 cm) (who weighed less), jumped significantly further (p=.022) than Black African learners (128.17±19.84 cm) for the total group. The latter comparison is also visually reflected in Figure 5.10. This suggests that reduced explosive (dynamic) strength may be as a result of increased body weight and not as a result of the helminth infection status. Figure 5.10 depicts the lower body explosive strength comparison in relation to gender, ethnicity and geographical area.

Results in Table 4.19 and Figure 5.10 shows that boys (136.81±17.93 cm) jumped significantly further (p<.05) than girls (121.94±17.21 cm) overall as well as for each age group in the SBJ test. Performance increased with age for boys, but not for girls, as their performance decreased from the 10- to 11-year-old age group. As mentioned in Chapter 2, boys are expected to perform better than girls in weight-bearing tests and fitness tests which require physical exertion, much like their performance in the 20 m SRT (as previously discussed).

When values were compared in relation to the geographical area as seen in Table 4.23 and as visually reflected in Figure 5.10, girls from the Northern Areas (124.51±16.67 cm) jumped significantly further than girls (119.23±17.40 cm) from the Township Areas (p=.001). Possible reasons for this could be excess weight as girls from the Northern Areas were lighter while girls from the Township Area had significantly higher BF% values overall (p<.05) (see Table 4.4). Therefore, it would seem that increased body fat is associated with reduced explosive (dynamic) strength as the excess weight has a negative effect on activities which require movement against gravity (Travill, 2007:290; Truter *et al.*, 2010:232).

In the Health of the Nation study, Black African children (who were reported to be the lightest), jumped the shortest distance, whereas children of White ethnicity jumped the furthest, even though they were heavier (Armstrong *et al.*, 2011:1007). A possible explanation for this discrepancy could be the difference in muscle mass, however this is not conclusive. Therefore, the findings are suggestive that performance in the SBJ test is largely related to body composition. Both boys and girls reflected lower performances (across all ages) when the results of the present study were compared with the results of The Health of the Nation Study. At 11-years of age, Coloured children in the aforementioned study (168.5 cm) jumped significantly further (p<.05) than Coloured children from the present regional study (135.02 cm). Black African children from the Health of the Nation Study (154.4 cm) also jumped significantly further (p<.005) than Black African children (134.63 cm) from the current study. Most of the Black African children in the present study live in urban Township Areas therefore it was interesting to compare the SBJ scores of these children to the results of the study conducted by Moselakgomo *et al.* (2014:877) for rural Black African participants. It was only the 11-year-old girls (127 cm) from the Limpopo province who managed to jump further than their same age counterparts (124.06 cm) in the current study (although they were not significantly different).

When compared to the normative data by Catley & Tomkinson (2013:103), boys (aged 9, 10 and 11-years-old) scored average (P_{40} – P_{60}) for explosive strength. For girls, the 9 and 10-year-olds also scored average (P_{40} – P_{60}), however the 11-year-olds were rated low (P_{20} – P_{40}) for explosive strength.

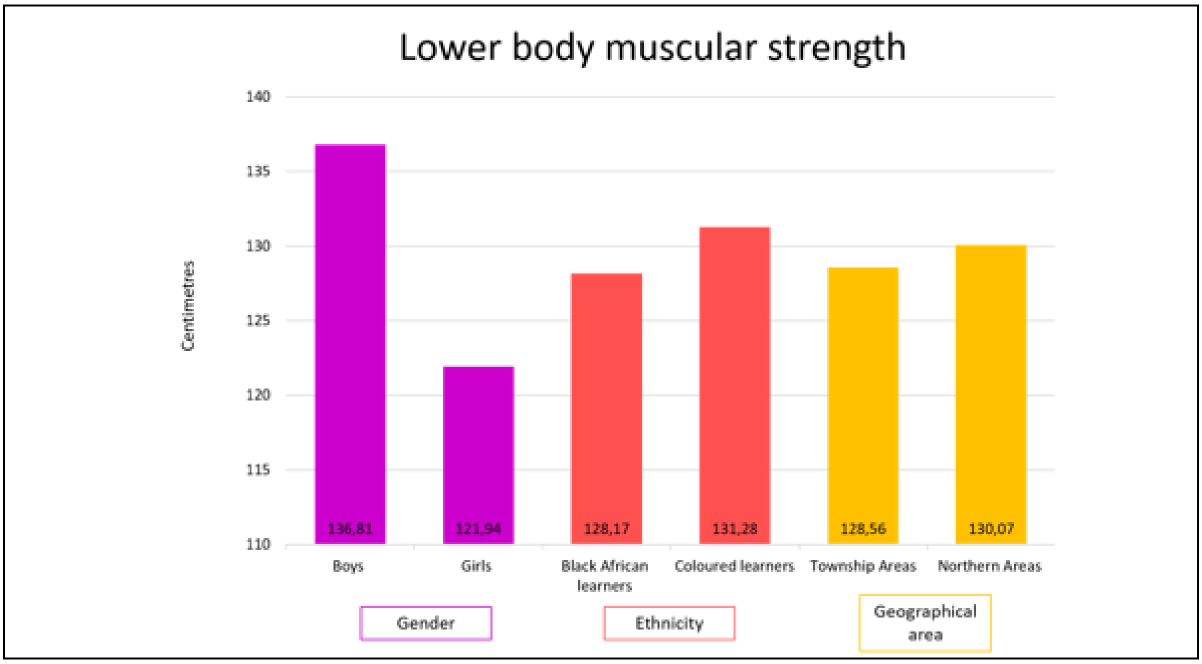

Figure 5.10: Mean lower body muscular strength comparisons per gender, ethnicity and geographical area

5.4.3 Flexibility comparisons

Flexibility is a functional component of PF as it contributes to the quality of life for everyday activities of daily living. The results of the current study suggest that flexibility may not be influenced by body weight, unlike the weight-bearing activities previously discussed. Body weight may limit movement around a joint, but it does not seem to have a direct influence on flexibility. Figure 5.11 depicts the comparisons of the mean flexibility in relation to gender, ethnicity and the geographical area. Results of the present study found statistically significant differences for each of the selected demographics. Girls in the current study had significantly higher ($p<.05$) BF% yet, for the total group, girls (33.88±5.51 cm) presented with significantly better ($p<.05$) results for flexibility than boys (30.69±5.75 cm) (Table 4.19 and Figure 511). The same trend was found for ethnicity in Table 4.22, also visually reflected in Figure 5.11, as Black African children (33.23±5.63 cm) presented with significantly superior ($p<.05$) flexibility scores than Coloured children (30.69±5.88 cm) even though they weighed significantly more ($p<.05$) and had significantly higher BMI and BF% values ($p<.05$) (Table 4.5). Learners from the Township Areas (33.15±5.49 cm) also presented with significantly better scores for flexibility than learners from the Northern Areas (31.45±6.07 cm) (Table 4.23 and Figure 5.11)

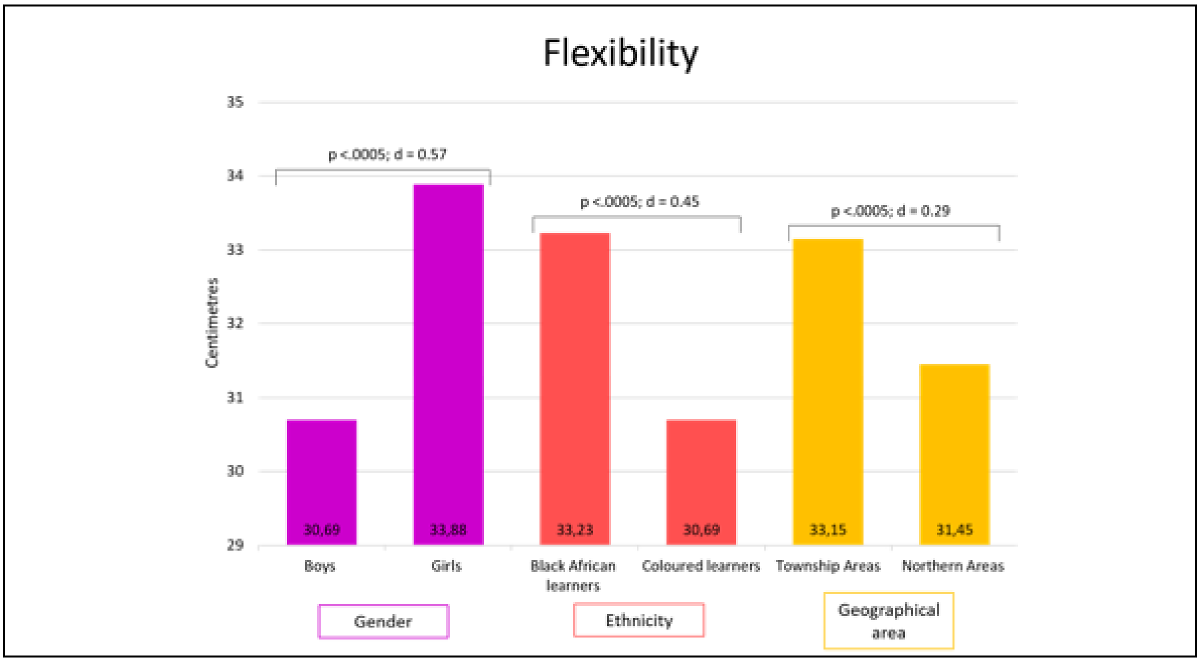

Figure 5.11: Mean flexibility comparisons per gender, ethnicity and geographical area

The SAR test is commonly used as a measure of flexibility, although the methodology for this test may vary. The back-saver SAR test is included in the Fitnessgram and uses a box with a ruler on top, much like the SAR test included in the Eurofit test battery. However, the measurement of the back-saver test is taken with one leg at a time. In the back-saver test protocol, the participant is required to flex the untested leg at the knee while the leg being tested is extended with the foot flat against the box. The Eurofit protocol requires both legs to be fully extended and both feet flat against the box, at which point the participant reaches forward without bending either of their knees. Measurements of the constructed box can also have implications on the results. The current study used an SAR box which had a ruler of 75 cm with an overhang of 26 cm. The distance from 0 cm on the ruler to the edge of the fingertip was measured. The study by Sacchetti *et al.* (2012:635) used the feet as point zero, therefore if the child did not reach their toes, a negative score was recorded and all measures beyond the toes were recorded as positive values. Consequently, comparisons between studies can be difficult when considering the different methodologies involved. Results of the current study were compared with two local studies. The study by Travill (2007:279) measured 720 urban participants (8-to-17-years-old) from socially disadvantaged backgrounds, while Moselakgomo *et al.* (2014:878) assessed 1 361 rural participants aged 9-to-12-years. Children from the present study scored low for all comparisons. Therefore, it could be surmised that the flexibility of the target population is poor. This may be due to the fact that children from the current study do not engage in regular PE activities.

5.4.4 Composite fitness score comparison

A composite fitness score was calculated by converting each test value from the SAR, GS, SBJ and the 20 m SRT results into a standard T-score. The T-score has a mean of 50 and a standard deviation of 10. Each test was equally weighted and from this score, an average T-score for the PF test battery was determined. In relation to gender (Table 4.19 and Figure 5.12), the boys (51.90±6.26) performed significantly better than the girls (48.16±5.22) overall. Ethnic comparisons revealed that Black African children (50.84±6.26) performed significantly better ($p<.05$) than Coloured children (48.61±5.42), as seen in Table 4.22 and visually reflected in Figure 5.12. When values were compared in relation to the geographical area (Table 4.23 and Figure 5.12), children from the Township Areas (51.06±6.28) (boys in particular) performed significantly better ($p<.05$) than children from the Northern Areas (48.98±5.64).

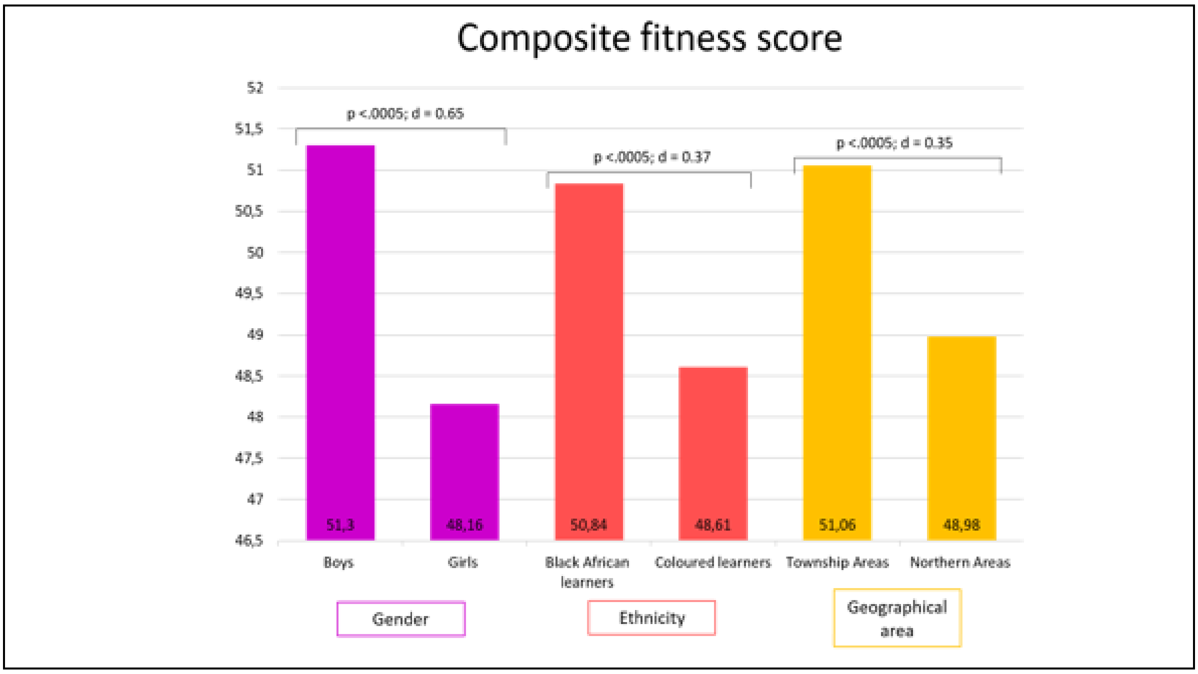

Figure 5.12: Mean composite fitness score comparisons per gender, ethnicity and geographical area

In summary, boys performed better than girls in the PF tests which required muscular strength and CRF, while girls showed superior performance in the flexibility test. Children of Black African ethnicity performed better than Coloured children for flexibility, CRF and upper body isometric strength, however not for dynamic lower body strength, which required explosive movement of the body against gravity. Furthermore, children from the Northern Areas only excelled in the lower body strength test which required dynamic strength and was influenced by lower body weight. Overall, the CRF and dynamic strength of the target population was rated average in relation to the international comparisons. However, isometric muscular strength and flexibility were considered to be poor in comparison to the international studies. Findings from this study revealed that the performance in the 20 m SRT and the SBJ test were largely affected by body weight, however this was not the case for the GS and SAR test.

5.5 COMPARISON OF ANTHROPOMETRIC AND PHYSICAL FITNESS COMPONENTS ACROSS THE EIGHT SCHOOLS

A comparison of the eight schools was conducted for each of the anthropometric parameters and PF components. The communities in which these schools are based are often exposed to high levels of crime and gang violence which is especially prevalent in the Northern Areas. Many of the children in these disadvantaged communities are exposed to poor sanitation habits which relates to why infectious diseases are closely associated with poverty. To reiterate at this stage, Schools 1, 2, 3 and 8 are Northern Area schools while Schools 4 to 7 are Township Area schools.

The WAZ frequency distribution in Table 4.10, identified School 3 (21%) and School 2 (18%) with the highest and second highest incidence of children classified as underweight (WAZ<-2). According to Table 4.28, School 3 presented with significantly lower ($p<.05$) WAZ values than all the Township schools. In relation to HAZ comparisons, Table 4.14 indicated that the highest and second highest incidence of stunting (HAZ<-2) was at School 2 (23%) and School 3 (21%). Descriptive and inferential statistics presented in Table 4.29 revealed that two of the Northern Area schools (School 2 and School 3) presented with significantly lower HAZ values than all the Township schools. Furthermore, the BAZ comparison in Table 4.18 showed a significantly higher ($p<.05$) prevalence of undernutrition for Northern Area schools (particularly in School 3 with 13%) and overnutrition for Township Area schools (especially School 6 with 11%). Body composition, depicted in Tables 4.26 revealed that School 3 (15.62±2.04 kg/m^2) and School 2 (16.29±2.24 kg/m^2) had significantly lower ($p<.05$) BMI values than all the Township Area schools. Differences across the schools in relation to BF% (Table 4.27) also identified that School 2 (14.33±5.36%) and School 3 (12.87±5.28%) had significantly lower ($p<.05$) BF% values in comparison to three of the Township Area schools.

Comparison of the eight schools in relation to muscular strength in Tables 4.32 and 4.33, showed significant differences for upper body ($p<.05$) and lower body ($p<.006$) strength. Post-hoc tests revealed specific differences for upper body strength but not for lower body strength. For the GS test, three of the Northern Areas schools (School 1: 12.79±3.34 kg, School 2: 12.66±3.01 kg and School 3: 11.46±2.70 kg) scored lower than all the Township Area schools. In relation to flexibility in Table 4.31, only one Northern Area school (School 2: 29.36±5.67 cm) scored significantly lower ($p<.05$) than three of the Township Area schools. The VO_2max school comparisons as seen in Table 4.34, identified no differences between any of the schools. The composite fitness score (Table 4.35) revealed that three Northern Area schools (School 1:

49.01±5.43, School 2: 48.36±5.72 and School 3: 47.71±5.33) had significantly lower results for the composite fitness than one Township Area school.

In summary, the three schools may be considered as high risk in terms of malnutrition. Two Northern Area schools (Schools 2 and 3) presented with the highest ($p<.05$) frequencies of undernutrition, while one Township Area school (School 5) presented with the highest frequency for the combined overweight and obesity category. In relation to PF, three Northern Area schools had significantly lower ($p<.05$) upper body muscular strength and one Northern Area school (School 2) presented with a significantly lower ($p<.05$) flexibility fitness score.

5.6 RELATIONSHIP BETWEEN CARDIORESPIRATORY FITNESS AND SELECTED ANTHROPOMETRIC INDICATORS

Results of the current study investigated the learners' nutritional status as expressed by their WAZ, HAZ and BAZ values in relation to VO_2max per gender. Physical differences in body size, muscle mass or excess weight were expected to cause variations in the results as per the discussions in the literature review in Chapter 2. See Figures 5.10 and 5.11 for the relationship between CRF and selected anthropometric variables for boys and girls, respectively.

According to the results depicted in Figures 5.13 and 5.14, no significant difference was found between the CRF of underweight (Tables 4.36 and 4.39), stunted (Tables 4.37 and 4.40), and thin (Tables 4.38 and 4.41) children when compared to the CRF of children with normal weight status (for both boys and girls). However, it was only when the results of the combined category for overweight and obese children were compared against the CRF of normal weight children (Tables 4.38 and 4.31) that significant differences were revealed ($p<.05$). This was the case for both boys and girls alike. These findings are also in agreement with previous research which states that overnutrition would negatively affect performance when children are required to move their body weight against gravity (Armstrong *et al.*, 2017:211). Overweight and obese children were mostly at a disadvantage. For the current study sample, girls who were categorised as stunted (Table 4.40) and boys who were categorised as thin (Table 4.38) performed poorly when compared to normal weight children. Therefore, it can be deduced that malnutrition seems to affect the CRF of children from socio-economically deprived communities.

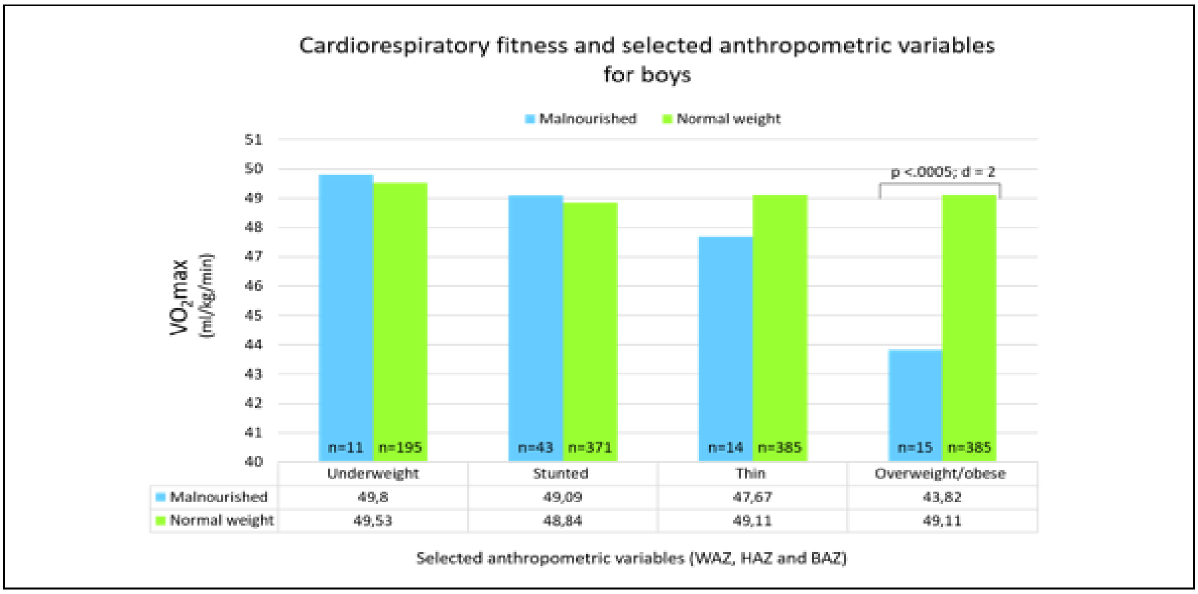

Figure 5.13: Relationship between mean cardiorespiratory fitness values and selected anthropometric variables for boys

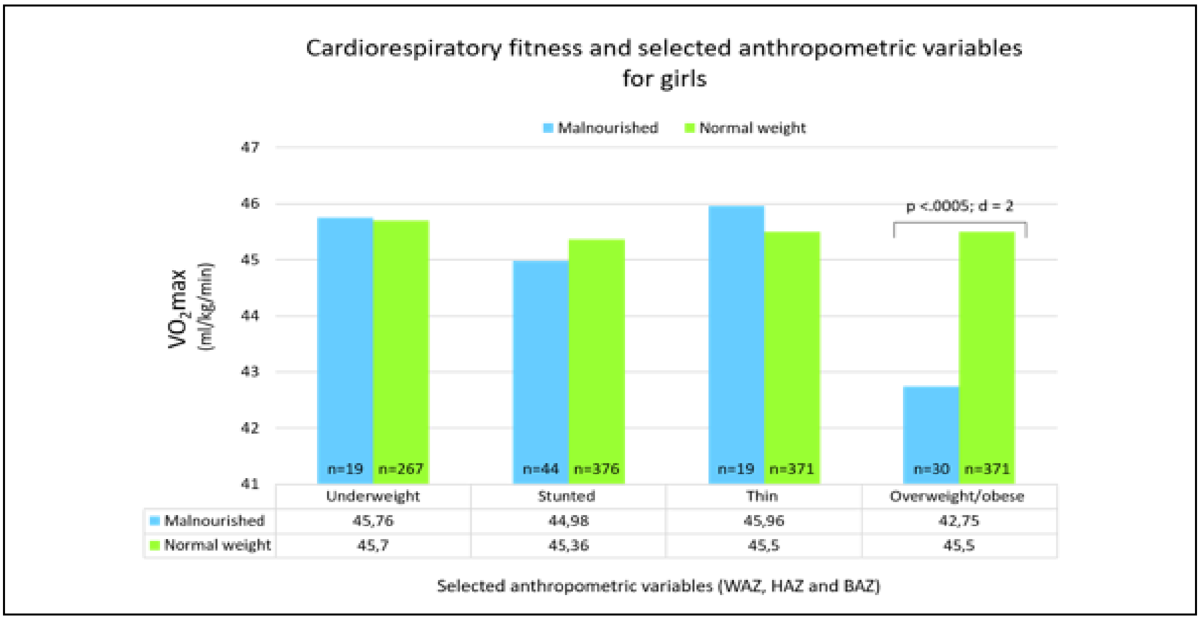

Figure 5.14: Relationship between mean cardiorespiratory fitness values and selected anthropometric variables for girls

5.7 SUMMARY OF FINDINGS

In summary, the relevant findings of the current study are presented below.

In respect of nutritional indicators:

- A prevalence of stunting (10%) underweight (6%), overweight and obesity combined (5%) and thinness (4%) was identified for the overall group.
- An age-related trend was identified as the frequency of WAZ, HAZ and BAZ increased with age, suggestive of chronic undernutrition (particularly amongst Northern Areas learners – where Coloured children predominately reside).
- Non-significant higher frequencies of underweight (6% vs 5%), stunting (11% vs 10%), thinness (4% vs 3%) and combined overweight and obesity (7% vs 4%) were identified amongst girls in comparison to boys.
- By the age of 9 and older, Coloured children presented with significantly low WAZ, HAZ and BAZ in comparison to Black African children. In contrast, Black African learners (girls in particular) were identified with significantly higher BMI-for-age z-scores in comparison to their Coloured counterparts.
- Higher frequencies of underweight (10% vs 2%), stunting (16% vs 5% and thinness (6% vs 1%) were identified amongst Northern Area learners in comparison to Township Area learners. While learners from Township Area schools displayed the highest frequency of combined overweight and obesity than learners from Northern Area schools (7% vs 4%).

In respect of body composition:

- The BMI and BF% of the target sample was identified as normal.
- A significant gender-related difference was only identified for BF%. Girls (18.58±6.72%) presented with significantly higher BF% values than boys (13.27±5.93%).
- By 9-years-old, Black African children (BMI: 17.52±3.29 kg/m^2, BF%: 16.89±7.34) presented with significantly higher body composition values than Coloured children (BMI: 16.18±2.24 kg/m^2, BF%: 14.27±5.64).

- Children (especially girls) from Township Areas (BMI: 17.57±3.39 kg/m^2, BF%: 16.88±7.43) were identified with a significantly higher body composition than children from Northern Areas (BMI: 16.49±2.48 kg/m^2, BF%: 14.96±6.14).

In respect of PF components:

- Performance improved with age for all fitness components except relative CRF.
- For CRF, the younger 8-to-9-year-old age group (boys: 49.55±3.88 ml/kg/min; girls: 45.70±2.96 ml/kg/min) performed better on relative VO_2max score than the older 10-to-11-year-old age group (boys: 48.19±4.48 ml/kg/min; girls: 44.51±3.69 ml/kg/min).
- Boys performed significantly better for CRF (boys: 48.87±4.24 ml/kg/min; girls: 45.32±3.25 ml/kg/min), upper body (boys: 14.00±3.40 kg; girls: 12.58±3.17 kg) and lower body (boys: 136.81±17.93 cm; girls: 121.94±17.21 cm) muscular strength and the composite fitness score (boys: 51.90±6.26; girls: 48.16±5.22). Girls (33.88±5.51 cm) presented with significantly superior performance for flexibility in comparison to boys (30.69±5.75 cm).
- For the total group, Black African learners reflected significantly higher CRF (47.38±4.27 ml/kg/min vs 46.62±3.97 ml/kg/min), upper body muscular strength (13.82±3.45 kg vs 12.39±2.99 kg), flexibility (33.23±5.63 cm vs 30.69±5.88 cm) and composite fitness score (50.84±6.26 vs 48.61±5.42) than Coloured learners. However, in relation to lower body muscular strength (131.28±17.64 cm vs 128.17±19.80 cm), Coloured learners performed significantly better than Black African learners.
- Township Area learners performed significantly better in the CRF (49.89±4.18 ml/kg/min vs 47.90±4.08 ml/kg/min), upper body muscular strength (13.87±3.35 kg vs 12.72±3.27 kg), flexibility (33.15±5.49 cm vs 31.45±6.07 cm) and the composite fitness score (51.06±6.28 vs 48.98±5.64) in comparison to learners from the Northern Areas. Girls (124.51±16.67) from the Northern Areas performed significantly better than girls (119.23±17.40) from the Township Areas.

In respect of the schools' comparison:

- School 3 (WAZ<-2: 21%; HAZ<-2: 21%) and School 2 (WAZ<-2: 18%; HAZ<-2: 23%) presented with the highest frequencies of underweight and stunting while School 3 presented with the highest frequency of thinness (13%).
- School 6 from the Township Area schools was found to have the highest frequency of overweight and obesity combined (11%).
- Significant differences were identified in relation to upper body strength, flexibility and the composite fitness score only. In relation to upper body muscular strength, three Northern Area schools (School 1: 12.79±3.34, School 2: 12.66±3.01 and School 3: 11.46±2.70) presented with significantly lower values in comparison to all the Township Area schools. With reference to flexibility, only School 2 (29.36±5.67) from the Northern Areas presented with significantly lower values than three of the Township Area schools. In relation to the composite fitness score, three Northern Area schools (School 1: 49.01±5.43, School 2: 48.36±5.72 and School 3: 47.71±5.33) presented with significantly lower values than only one Township Area school.

In respect of CRF and selected anthropometric indicators:

- Overweight and obese children (boys: 43.82±3.25 ml/kg/min; girls: 42.75±2.60 ml/kg/min) presented with significantly lower VO_2max values than their thin (boys: 47.67±3.97 ml/kg/min; girls: 45.96±3.51 ml/kg/min) and normal weight (boys: 49.11±4.16 ml/kg/min; girls: 45.50±3.20 ml/kg/min) counterparts.

5.8 CONCLUSIONS

In conclusion, distinct ethnic and geographical differences were identified for both anthropometric and PF components. Coloured learners (who predominantly reside in the Northern Areas) were significantly more underweight and stunted than their Black African counterparts, whereas Black African learners had significantly higher BF% values and BMI values. In terms of PF, Coloured learners had significantly lower PF levels than Black African learners. Therefore, based on these results it can be deduced that Coloured children may be at a higher risk of disease due to poor nutrition and low PF levels. In contrast, Black African learners with higher BF% values are more susceptible to NCD's. These findings subsequently highlight the significance of promoting dual interventions for healthy eating and PE. Understanding the importance of PF has an educational purpose and ensures the optimum physical development of children. Based on these findings, PF assessments serve as a useful and relevant measure of current health status and as a predictor of adult health in children.

5.9 LIMITATIONS

The following are factors which were identified as relevant limitations:

- The school selection was not based on randomised sampling but on specific DASH Study criteria instead (>100 Grade 4 learners and geographical location) and a willingness of schools to participate.
- The level of motivation can play a significant role when testing PF in children (Malina & Katzmarzyk, 2006:S305). The DASH team and all volunteers made special efforts to encourage all the children to do their best, however, children with apathetic attitudes were not forced to participate.
- Different weather conditions over the 6-week data collection period could also have affected performances, more specifically rainy weather may have affected the performance of the 20 m SRT and the SBJ test, as children may have had some difficulty running or jumping for distance.

Despite these limitations, the results of this research study are still relevant and have provided further baseline data for the larger DASH Study. It can also serve as reference data against which the impact of deliberate interventions or changes in the school curriculum could be compared. Furthermore, the PF status of children living in disadvantaged areas of Port Elizabeth is now known.

5.10 RECOMMENDATIONS

The following are recommendations for future research related to a similar focus as the present study:

- The implementation and impact assessment of relevant school-based interventions such as nutrition education and PA at schools, particularly in historically disadvantaged areas, and more especially in the Northern Areas of Port Elizabeth, are recommended to improve children’s health.

- The implementation and impact assessment of low cost community-based PA programmes is recommended to facilitate the provision of extra-curricular PA opportunities within disadvantaged schools.
- Regular monitoring of the learner’s health and PF at disadvantaged schools is also recommended in order to identify children at risk for NCD’s and to educate the learners about the value of healthy lifestyles.

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APPENDICES

Annexure A: Clinical examination form

Test date (dd/mm): ________/________/2015

ID: ☐ ☐ ☐ ☐ ☐

First name: ___________________Surname: ___________________

❑ Consent ❑ No consent

Completed by researcher:

- Did you have something to eat at home this morning before school? ❑ yes ❑ no
- How many meals did you eat yesterday? ________
- Did you go to bed hungry last night? ❑ yes ❑ no
- Do you feel hungry after meals because the meals are too small? ❑ yes ❑ no

Completed by a nurse:

- Temperature: ___________ °C

Functional signs:

Fever	❑ yes ❑ no	Vertigo	❑ yes ❑ no
Nervousness	❑ yes ❑ no	Cough	❑ yes ❑ no
Headache	❑ yes ❑ no	Constipation	❑ yes ❑ no
Nausea	❑ yes ❑ no	Itching	❑ yes ❑ no
Vomiting	❑ yes ❑ no	Blood in the stool	❑ yes ❑ no
Diarrhea	❑ yes ❑ no	Problems with breathing	❑ yes ❑ no
Belly ache	❑ yes ❑ no		

- Menarche (to ask girls): ❑ yes ❑ no (If "yes"): Starting date____/_____ (mm/yyyy)
- **Taking medication (last week):** ❑ yes ❑ no
  If "yes", please specify the name or description of medication.

  Against worms: ____

- **Hemoglobin (Hb) test using HemoCue® Hb 301 system:** __________ g / mL
- **Blood glucose test using Accu-Check® blood glucose monitoring system:** __________ mmol / L
- **Physical examination:**
  Conjunctiva ____
  (0=normal, 1 = moderately colored, 2 = slightly colored, 3 = pale or slightly colored)

  Jaundice (0 = no, 1 = sub-jaundice, jaundice franc = 2) _______________________

  Splenomegaly (0 - 5) ____

  Hepatomegaly (0 - 4) ____

  Pulse (# / min) ____ / minute

  Blood pressure (mmHg) _________________________________Systolic/ Diastolic

  Skin lesions (0 = no, 1 = presence, specify) _______________________________

  Pulmonary auscultation (0 = no, 1 = presence, specify) _______________________

  Cardiac auscultation (0 = no, 1 = presence, specify) _________________________

  Conclusion: Included: (yes/no): ____________________
  Excluded (referral reason): ____________________

Name of the nurse (block letters): ____

Signature of the nurse: ____

Annexure B: Fitness score sheet

FITNESS SCORE SHEET

BIOGRAPHICAL INFORMATION			
ID	☐☐☐☐☐	**Test date**	(dd/mm): _____/_____/ 2015
Name		**Surname**	
Birthday	(dd / mm /yyyy) _____/_____/20____	**Gender**	☐ Female ☐ Male
Class		**Test site / School**	

PHYSICAL FITNESS COMPONENTS			
ANTHROPOMETRY			
Stature (cm)		**Body mass (kg)**	
Skinfolds (mm)	**Trial 1**	**Trial 2**	**Trial 3**
Triceps (mm)			
Subscapular (mm)			

PHYSICAL FITNESS TESTS			Trial 1	Trial 2
Flexibility	Sit-and reach (cm)			
Muscle strength	Grip strength (kg)			
	Standing broad jump (cm)			
Cardiorespiratory fitness	20 m shuttle run test	**Start number**		
		Stage		
		Level		

Annexure C: Letter to principals

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• Port Elizabeth • 6031 • South Africa • www.nmmu.ac.za

Nelson Mandela Metropolitan University

for tomorrow

South Campus

Department of Human Movement Science

Faculty of Health Sciences

1 September 2014

Dear School Principals

Research project on Children's Health

We hereby wish to draw your attention to a research project entitled *"Impact of disease burden and setting-specific interventions on schoolchildren's physical fitness and psychosocial health in Port Elizabeth, South Africa."*

The study focusses on the burden and distribution of communicable diseases (e.g. helminth infections) and non-communicable chronic conditions (e.g. malnutrition) among school-aged children in selected schools near Port Elizabeth, and their impact on children's physical fitness, cognitive performance and psychosocial health. The findings will allow us to improve overall child health by designing targeted health interventions and rendering the school infrastructure more inviting for physical activity.

This is a joint research project, lasting from April 2014 until March 2017, between the Department of Human Movement Science at the Nelson Mandela Metropolitan University, the Department of Sport, Exercise and Health, University of Basel and the Swiss Tropical and Public Health Institute, Switzerland. Permission to conduct the research has been received from the Eastern Cape Department of Education (see attached letter) and ethical clearance has been granted by the Ethics Commission Northwest and Central Switzerland EKNZ (reference no: 2014-179) and the NMMU Research Ethics Committee (reference no: H14-HEA-HMS-002).

The study is led by: Prof Rosa du Randt and Prof Cheryl Walter (NMMU); Mr Bruce Damons, (principal of the Sapphire Road Primary School), and Prof Uwe Pühse (Basel University, Switzerland) and Prof Jürg Utzinger (Swiss TPH, Switzerland). The study is funded by both the Swiss National Science Foundation and the National Research Foundation of South Africa.

Approximately 100 primary schools in the Port Elizabeth area are being invited to apply to be a part of the study. All schools submitting a positive written feedback and indicating that they would like to participate in the study will be contacted for follow up information.

In brief, clinical examination and measurements of anthropometric indicators (e.g. height, weight and body composition) will be performed. In addition, each child will be asked to submit a single stool and urine sample to assess the prevalence of communicable diseases. Furthermore, levels of physical fitness and cognitive performance will be determined, and the children's psychosocial health will be assessed. Based on these results, interventions will be specifically designed and implemented to improve children's health and wellbeing (e.g. treatments, physical fitness programme, health education programme, and nutritional interventions). Participation of the school and individual schoolchild/children of your school in the study are entirely voluntary, free of charge and the school as well as the children can withdraw any time, even after signing the consent form. Treatments within the study will be administered for free by medical staff from the district clinic according to national treatment guidelines.

If you are interested in your school participating in the research, please complete the attached form and email, fax or post the form back to me by 30 September 2014.

Kind regards and looking forward to hearing from you

Danielle Smith
Department of Human Movement Science
Nelson Mandela Metropolitan University

Annexure D: Project information sheet

PROJECT INFORMATION SHEET

Project title: *Impact of disease burden and setting-specific interventions on schoolchildren's cardio-respiratory physical fitness and psychosocial health in Port Elizabeth, South Africa*

Identity of researchers and sponsoring institution: This study will be carried out in collaboration with Prof. Rosa du Randt and Prof. Cheryl Walter from the Nelson Mandela Metropolitan University and Bruce Peter Damons from the Sapphire Road Primary School. The following institutions will form the rest of the study team, namely the Swiss Tropical and Public Health Institute and the Department of Sport, Exercise and Health, University of Basel, Switzerland. The study is funded by the Swiss National Science Foundation and will last for 3 years (December 2013 – March 2017).

Study objectives: We would like to include your child/children in our study that analyses the burden and distribution of communicable diseases (e.g. helminth infections) and non-communicable chronic conditions (e.g. type 2 diabetes and malnutrition) among school-aged children in selected schools near Port Elizabeth, and to assess their impact on children's physical fitness, cognitive performance and psychosocial health. This information will allow us to improve overall child health by designing and introducing targeted health interventions and rendering the school infrastructure more suitable for physical activity.

Research procedures: Approximately 1,000 schoolchildren of the Port Elizabeth area will be selected for participation in a first assessment in early 2015. Out of these 1,000 schoolchildren, 600 schoolchildren will be selected with the highest prevalence of diseases for further participation in 2015 until end of 2016 assessing the impact of health intervention on overall child health. In both stages of the study, each child will be asked to submit a single stool and urine sample to assess prevalence of communicable diseases. Clinical examination and measurement of anthropometric indicators (e.g. height, weight and body composition) will be performed. Furthermore, levels of physical fitness and cognitive performance will be determined, and the children's psychosocial health will be rated. Based on these results, the intervention will be specifically designed and implemented to improve your child's health and wellbeing.

Risk and benefits: There are no specific risks associated with this study. Submission of stool and urine samples by schoolchildren as study participants might be perceived as shameful. Fingerprick, in which a finger is pricked with a small lancet to obtain a small quantity of blood for testing regarding anaemia, is a not painful procedure. Appropriate treatment will be offered for free to all individuals from the selected schools regardless of participation in study.

Treatment will be administered by medical staff from the district hospital according to national treatment guidelines. The proposed research will provide a broad update on the status of communicable diseases (e.g. helminth infections) and non-communicable chronic conditions (e.g. type 2 diabetes and malnutrition) in the selected communities nearby Port Elizabeth. Since such data is currently not available in this area, there will be a need to generate more evidence. By linking them with the physical fitness, cognitive performance and psychosocial health of children, this wealth of information will help to shed light on the true health consequences incurred by this potential dual burden of diseases and provide guidance for further health interventions to be implemented among school children in this area. In the year 2017, the study population will be informed about the results and knowledge gained through our study.

Confidentiality: All information collected in this study will be coded with a unique personal identification number and stored at a safe place. Stool and urine samples will be labelled with this code for analysis. Only members of the study will have access to the samples and data. The officials of the national committee of ethics and research can ask for access to the collected information for the monitoring of good clinical practice. We will publish the key findings of this study, but your names and personal identities will not be revealed.

Consent: There is absolutely no obligation to participate in this study, but your consent is required for the participation of your child/children. Participation of your child/children in this study is entirely voluntary, free of charge and they can withdraw any time even after you have signed the consent form. Please note that no monetary reimbursement will be provided for study participation.

Alternative to participation: If you do not wish for your child/children to participate or your child decides not to participate, it will not affect you, your family or child's/children's relation to anybody on the study team.

Consequences if you decide to withdraw your child/children from the study and the methodical procedure at the end of the participation: You can decide to withdraw your child/children from the study at any time of the study. However, we would like to inform you that the data gather before withdrawal could be used for reports and publications.

Any other questions?

Do not hesitate to contact me if you have any further questions under the following address:

Danielle Smith
Department of Human Movement Science
Summerstrand Campus (South)
Nelson Mandela Metropolitan University
Port Elizabeth 6031, South Africa
Cell: 078 222 7252

Annexure E: Informed consent form

INFORMED CONSENT FORM

Project title: *Impact of disease burden and setting-specific interventions on schoolchildren's cardio-respiratory physical fitness and psychosocial health in Port Elizabeth, South Africa*

Statement by the researcher/person taking consent

I have accurately outlined the purpose, objectives and procedures of the study and given enough information including the potential benefits and risks to the parent/legal guardian of the potential participant.

I confirm that the parent/legal guardian of participant Mr/Ms: ___________________________

School Nr.: ________________________ Telephone Nr.: ________________________________ was given an opportunity to ask questions and that all questions have been answered correctly. I confirm that the participant has not been forced into giving consent, and consent has been given freely and voluntarily.

Name of researcher: ____

Place: _______________ Date: _______________ Signature: _______________________________

Statement by the parent/legal guardian

I have read the letter of information of the study or it has been read to me in a language that I understand. I had the opportunity to ask questions about it and any questions I have asked have been answered to my satisfaction. I know the purpose, objectives and procedures, risk and benefits of the study. I understand that I can withdraw my child from the study at any time without further consequences. I have also an additional letter of information that I can keep for future reference.

Name of schoolchild: ____

Name of parent/legal guardian: ____

Place: _______________ Date: _______________ Signature: ______________________________

If participant is **illiterate**

I have witnessed the accurate reading of the consent form to the potential participant and the individual had the opportunity to ask questions. I confirm that the individual has given consent freely.

Name of witness: ____

Place: _______________ Date: _______________ Signature: _______________________________

Thumb print of participant:

____

Study doctor or responsible nurse of the study

The purpose, objectives and procedures of the study has been accurately outlined and enough information was given including the potential benefits and risks to the parent/legal guardian of the potential participant.

Name of the doctor / nurse:

____

Place: _______________ Date: _______________ Signature: _______________________________

----------------------------- Thank you very much for your invested time! ------------------------------------

Annexure F: Assent form

ASSENT FORM FOR CHILD PARTICIPANTS

Project title: *Impact of disease burden and setting-specific interventions on schoolchildren's cardio-respiratory physical fitness and psychosocial health in Port Elizabeth, South Africa.*

Directions: These explanations will be discussed verbally with the children.

Explanation of the Study (What will happen to me in this study?)
The purpose of this study is to see how healthy and fit children are so that we can make them healthier. We need a sample of your stool and urine to analyse and your parents or caregiver will help in collecting this. We will also ask you to take part in running, jumping and exercise activities as well as answer some questions about how you enjoy school work and other aspects. There are no wrong answers to any of the questions. If you do not understand anything, please ask questions.

Risks or Discomforts of Participating in the Study (Can anything bad happen to me?)
You may feel shy about giving a stool and urine sample, but you will do this at home and your parents will help you with this. You may feel a bit tired during and after the exercises. If you feel sick or have any pain after the exercises, please tell your parents or your teacher.

Benefits of Participating in the Study (Can anything good happen to me?)
If you are found to be ill or sick, doctors will give you medication to get better.

Confidentiality (Will anyone know I am in the study?)
Nobody will know that you were in the study. We will not list your name on any of the reports.

Compensation for Participation/Medical Treatment (What happens if I get hurt?)
Your parents or caregiver have been given information about the study. You should not get hurt in any way. But if you do, your parents will let us know and you will be taken to a doctor for treatment.

Contact Information (Who can I talk to about the study?)
You can contact Danielle Smith on 078 222 7252, if you have any questions about the study.

Voluntary Participation (What if I do not want to do this?)
You can stop being in the study at any time without getting in trouble.

Do you understand this study and are you willing to participate? YES NO

_________________________ ____________________
Signature of Child Date