NELSON MANDELA UNIVERSITY

# THE EFFECT OF SCHOOL-BASED PHYSICAL ACTIVITY INTERVENTIONS ON BODY COMPOSITION OF GRADE 4 CHILDREN FROM LOWER SOCIO-ECONOMIC COMMUNITIES IN PORT ELIZABETH

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

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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.

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**SIGNATURE**

....18-12-2017.........

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| | |
|---|---|
| BAZ | BMI-for-age z-score |
| BF% | Body fat percentage |
| BMI | Body mass index |
| DASH | Disease Activity and Schoolchildren's Health |
| HAZ | Height-for-age z-score |
| MVPA | Moderate-to-vigorous physical activity |
| NSNP | National School Nutrition Programme |
| PA | Physical activity |
| PE | Physical education |
| RUSF | Ready-to-Use Supplementary Food |
| TBF | Tiger Brand Foundation |
| WAZ | Weight-for-age z-score |
| WHO | World Health Organisation |

# ABSTRACT

South Africa is classified as a low- to middle-income country and is amongst countries affected by the double burden of disease. This double burden may occur in the same household and may be related to food insecurity, nutritional transition and economic inequalities. While the prevalence of underweight has been reduced in the country, stunting and the rise in overweight and obesity in children still remains a problem. The study aimed to determine the effect of various combinations of school-based interventions on the body composition of Grade 4 children from lower socio-economic communities in Port Elizabeth.

A cluster randomized controlled trial was conducted with eight schools which were randomly assigned to the experimental group (n=442) and control group (n=437). A ten-week school-based intervention was implemented, consisting of three components, namely: a physical activity (PA) intervention including physical education lessons, dance-to-music lesson and in-class PA breaks, a health and hygiene education intervention, and a nutrition intervention. Body composition measures, pre- and post the intervention included height, weight and skinfolds (triceps & subscapular). Body mass index (BMI), percentage body fat, and BMI-for-age (BAZ), height-for-age (HAZ), and weight-for-age (WAZ) z-scores were also calculated.

Baseline data indicated that Coloured children were more likely to be underweight and stunted than Black African children, who were more likely to be obese. After the ten-week intervention, children exposed to the PA intervention showed significantly ($p<.05$; $d>0.2$) lower BF% and higher HAZ scores. The nutrition intervention resulted in significantly ($p<.05$; $d>0.2$) higher BMI and BAZ scores, indicating an increase in the prevalence of obesity in children. The health and hygiene education intervention had a significant effect on children's underweight status (WAZ), showing higher WAZ scores. Findings suggest that participating in various combinations of school-based interventions had beneficial effects on children's body composition and nutritional status. Therefore, strategies to implement school-based interventions are recommended as a means to improve children's health status.


Key words: *Body composition, nutritional status, primary schoolchildren, school-based intervention*

# CHAPTER 1

# PROBLEM IDENTIFICATION

## 1.1 INTRODUCTION

This chapter introduces the background literature that facilitated the conceptualization and the focus of this study. It provides an overview of the state of children's nutritional health in lower socio-economic communities in both international and national contexts. The double burden of malnutrition is discussed, as well as how this burden affects children. Additionally, studies assessing children's body composition and the association of body composition with physical activity (PA) and nutrition are provided. This chapter also identifies the research aim and the objectives of the study, as well as on its scope. Relevant concepts that pertain to the study are clarified. Finally, the significance of the study is explained.

## 1.2 CONTEXTUALIZATION OF THE STUDY

Twenty years ago de Onis and Blossner (1997:30) reported that the prevalence of stunting in children younger than five years had decreased in low- to middle-income countries. In a more recent comparison, it was reported that the prevalence of stunting in children younger than five years had decreased from 40% in 1990 to 28% in 2011 (Black, Victora, Walker, Bhutta, Christian, De Onis, Ezzati, Grantham-McGregor *et al.*, 2013:443). This has positive health implications because nutrition and growth are important for children's health and stature (WHO, 2010b:1). Despite the improvements in conditions associated with undernutrition, overnutrition related to diet and income is on the rise in low-income countries undergoing rapid transition (Popkin, Adair & Ng, 2012:10). The level of physical inactivity is increasing in many countries, which impacts further on the prevalence of non-communicable diseases (NCDs). Physical inactivity is reported to be the fourth leading risk factor for mortality worldwide (WHO, 2010a:10). Moreover, childhood obesity is linked with a number of risk factors for chronic disease, such as heart disease, diabetes and hyperlipidemia, in adulthood (Cole, Bellizzi, Flegal & Dietz, 2000:1240).

In South Africa a double burden of malnutrition (underweight and overweight) co-exists, which may occur in the same household or community and it is partly related to nutritional transition and economic inequalities (Popkin *et al.*, 2012:10; Kimani-Murage, 2013:202; Tathiah, Moodley, Mubaiwa, Denny & Taylor, 2013:720). The National Food Consumption Survey (Labadarios, Steyn, Maunder, MacIntryre, Gericke, Swart, Huskisson, Dannhauser *et al.*, 2005:536) provided an insight into the nutritional status of young children in South Africa, identifying stunting as the most common nutritional disorder at national level, reporting that stunting (22%) affects one in five children. Overweight (10%) affects one in ten children and wasting (4%) affects one in twenty children (Labadarios *et al.*, 2005:536).

In both children and adolescents body composition is an important indicator of health status (de Onis & Habicht, 1996:652). Subsequently, researchers in South Africa have been investigating the body composition of children. Monyeki, Koppes, Kemper, Monyeki, Toriola, Pienaar and Twisk (2005:880) studied body composition and physical fitness in undernourished rural primary school children in South Africa, and found that undernourished children performed poorly on physical fitness tests compared to nourished children. Additionally, in this study undernourished children who were found to have a high body mass index (BMI) were thought to have high muscle mass rather than high body fat due to the fact that they performed well in sprinting and broad jump (Monyeki *et al.*, 2005:882). Iversen, Du Plessis, Marais, Morseth and Herselman (2011:72) looked at the nutritional health of children after the first 16 years of democracy in South Africa and concluded that undernutrition and hunger were still a challenge resulting from poverty and inequality. Adding to this challenge is the double burden of disease seen in young children (Iversen *et al.*, 2011:76). Through their investigations into the association between over- and undernutrition, Mukuddem-Petersen and Kruger (2004:850) found girls who were stunted exhibited fat accumulation around the abdominal area, indicating the co-existence of both stunting and overweight. The consequence of overweight coupled with stunting is adverse, as it causes children to be prone to chronic diseases (diabetes, cardiovascular disease) later in life (Popkin, Richards & Montiero, 1996:3014), hence the need for strategies to implement school-based and community-based PA and nutrition interventions targeting children.

According to WHO (2010a), participation in regular PA is beneficial because it improves bone health, cardiorespiratory and muscular fitness, and cardiovascular and metabolic health. Additionally, PA helps in weight control and reduces the risk of heart disease, diabetes and hypertension, as well as of stress and depression. Children have the opportunity to participate in regular PA at school through physical education (PE) lessons. The basic objective of PE is to involve school children in moderate-to-vigorous physical activity (MVPA) which is aimed at benefiting each child through developing their overall health and motor skill abilities (McKenzie, Sallis, Faucette, Roby & Kolody, 1993:181). The school environment has been identified as an optimal setting for the implementation of PE as learners spend a considerable amount of time at school (Verstraete, Cardon, De Clercq & De Bourdeaudhuij, 2007:32). However, in South African schools the implementation of PE faces a number of challenges. PE is marginalized in the school curriculum; there is a lack of qualified PE teachers; facilities and equipment are inadequate and there are limited financial resources (Du Toit, Van der Merwe & Rossouw, 2007; Prinsloo, 2007; Van Deventer, 2009, 2011, 2012). These factors contribute to the declining level of PA, especially in poorer schools. The South African school curriculum has made the school environment less conducive to PA because of the marginalization of PE at schools (Armstrong, Lambert & Lambert, 2011:839).

Given the major health risks faced by children in low- to middle-income countries such as South Africa, regular assessment of children's body composition and nutritional status is important for identifying those at risk of malnutrition.  Nutrition and growth are necessary for developing children, and it is important to monitor children suffering from undernutrition, overnutrition, and especially those afflicted by the double burden of over- and undernutrition. Countries such as South Africa are undergoing a nutrition transition and are faced with a challenge of overweight and obesity coupled with stunting in children and adolescents, indicating major risks related to chronic disease in adulthood. School-based PA and nutrition interventions are required, followed by an assessment of the effectiveness of the intervention to address children's current health status. Hence, the aim of the study was to investigate the effect of various school-based interventions on the body composition of children from lower socio-economic communities in Port Elizabeth.

## 1.3 AIM AND OBJECTIVES

### 1.3.1 Aim

This study falls under the auspices of a larger three-year research project funded by the Swiss South African Joint Research Programme (SSAJRP), entitled 'The impact of disease burden and setting-specific interventions on school children's cardio-respiratory physical fitness and psychosocial health in Port Elizabeth, South Africa'.

This study aims to determine the effect of various combinations of school-based interventions on the body composition of Grade 4 children from lower socio-economic communities in Port Elizabeth.

### 1.3.2 Objectives

In order to achieve the primary aim of this study, the following objectives were addressed.

- To explore, describe and compare the effect of the PA intervention, and no intervention, on the body composition of experimental and control groups, respectively. (E1 and C1)
- To explore, describe and compare the effect of the PA intervention in combination with health and hygiene education, and no intervention, on the body composition of experimental and control groups, respectively. (E2 and C2)
- To explore, describe and compare the effect of the health and hygiene education and nutrition intervention, versus no intervention, on the body composition of experimental and control groups, respectively. (E3 and C3)
- To explore, describe and compare the effect of the PA intervention in combination with health and hygiene education and nutrition, versus no intervention, on the body composition of experimental and control groups, respectively. (E4 and C4)
- To determine the overall effect of each individual intervention on body composition, with the view to identifying the most effective intervention.

### 1.3.3 Research Hypothesis

- The ten-week school-based PA intervention, on its own or in combination with health and hygiene education and/or nutrition, has a positive effect (i.e. a shift to normal ranges according to international growth reference for underweight, stunting and obesity, and a decrease in body fat percentage) on the body composition of Grade 4 children from lower socio-economic communities in Port Elizabeth
- The ten-week school-based intervention combining the health and hygiene education and nutrition, has a positive effect on the body composition of Grade 4 children from lower socio-economic communities in Port Elizabeth.

## 1.4 SCOPE OF THE STUDY

As mentioned earlier, this study falls under the auspices of a larger three-year research project funded by the Swiss South African Joint Research Programme (SSAJRP), entitled 'The impact of disease burden and setting-specific interventions on schoolchildren's cardio-respiratory physical fitness and psychosocial health in Port Elizabeth, South Africa'. Phase one of the research project, a cross-sectional survey, was implemented and the collection of the baseline data completed in March 2015. The current study formed part of Phase two of the larger study which included the intervention phase. The data collection of Phase two (post-intervention) was completed in November 2015.

The study is a cluster randomized controlled trial, employing a quantitative research approach. The population under investigation consisted of schoolchildren aged 8 to 11 years from eight socio-economically disadvantaged schools in Port Elizabeth.

Setting specific interventions consisting of PA, health and hygiene education and nutrition intervention were developed. The eight schools were match paired and each of the pair allocated to either an experimental or control school. Thereafter, various combinations of the intervention were allocated to experimental schools. The intervention was implemented over ten-weeks at the experimental schools.

The PA intervention consisted of two 40 minute weekly PE lessons, one weekly 45 minute dancing-to-music lesson, daily in-class PA breaks and the adaptation of the school environment with painted games and PA stations. The health and hygiene education intervention consisted of lesson plans about general health and hygiene, health promoting posters and class activities for children. For the nutrition intervention, in addition to the National School Nutrition Programme (NSNP) which all eight schools received, schoolchildren in the experimental group were given a Ready-to-Use Supplementary Food (RUSF) supplement to consume daily. Lessons on healthy eating habits were also developed and relevant posters were provided.

The data collection of Phase two of the study began in September and ended in November 2015. Due to the September school holidays, data collection was split for the intervention and control groups. The intervention group was tested before the September school holidays and, for the control group, data was collected immediately after the September school holidays. The collection of data followed the same protocol used for the baseline testing. Data pertaining to the body composition of the children was subsequently analysed for the purposes of this study. Anthropometric measurements of each participant were taken to assess their body composition and this was derived from their weight, height, BMI and skinfold thickness (at two sites, namely triceps and subscapular).

Descriptive statistics were used to describe and analyse body composition data. Measures of central tendency (mean and median) and measures of distribution (standard deviation) were used for this purpose. Inferential statistics used to compare the experimental and control groups in respect to pre- and post-test results were ANOVA and ANCOVA and subsequent post hoc analyses where appropriate. Furthermore, where statistically significant differences were identified, practical significance by means of Cohen’s d tests or Cramér’s V tests were applied. A qualified statistician based at the Nelson Mandela University was consulted for the accurate analysis and interpretation of the data obtained.

## 1.5 CONCEPT CLARIFICATION

The following concepts are clarified in order to avoid any misinterpretation of terms used in the study.

Body Composition

Body composition is defined as the relative proportion of the major components of the body, comprising of muscle, fat, bone and other tissues of the body (Corbin, Welk, Corbin & Welk, 2012:8).

Malnutrition

Malnutrition refers to imbalances or deficiencies in energy, protein and micronutrient intake and the body's demand for these nutrients to meet optimal growth and function. This nutrient imbalance could either be excessive or inadequate (overnutrition or undernutrition). Undernutrition means inadequate consumption of nutrients and is expressed as underweight, stunting and wasting. On the other hand, overnutrition is the excessive intake of nutrients and is associated with overweight and obesity. A number of factors are associated with malnutrition in children, many of which are related to poor food quality, insufficient food intake or severe and recurrent infections (de Onis & Blossner, 1997:46; Shetty, 2003:18; Blössner, de Onis, Prüss-Üstün, Campbell-Lendrum, Corvalán & Woodward, 2005:1).

Overweight and Obesity (high BMI-for-age)

Overweight refers to weight-for-height (BAZ) above plus one Standard Deviations (> +1 SD) and obesity refers to above plus two Standard Deviations (>+2 SD) of the WHO Child Growth Standards median (de Onis & Blossner, 1997:46). Overweight and obesity is expressed as percentage of body fat or fat weight. It refers to excessive accumulation of fat or total adipose tissue found in the body (de Onis & Blossner, 1997:46; WHO, 2010b:10).

### Underweight (low weight-for-age)

Underweight refers to weight-for-age (WAZ) below minus two Standard Deviations (< –2 SD) of the WHO Child Growth Standards median (de Onis & Blossner, 1997:46).

### Stunting (low height-for-age)

Stunting refers to height-for-age (HAZ) below minus two Standard Deviations (< –2 SD) of the WHO Child Growth Standards median. Stunting is also known as growth retardation where a child fails to reach linear growth for their age and it is caused by long term food deprivation, poor food quality or repeated infectious diseases. Because of the inadequate health and nutrition, stunted children may have delayed mental development, poor school performance and reduced intellectual capacity. Poor socio-economic conditions and poor food conditions, as well as recurrent illness, are closely related to stunting in children (de Onis & Blossner, 1997:46).

### Thinness (low BMI-for-age)

Thinness refers to weight-for-height (BAZ) below minus two Standard Deviations (< –2 SD) of the WHO Child Growth Standards median. Thinness describes severe weight loss resulting from inadequate food intake and severe or repeated infectious diseases. The immune system is weakened in children who are thin and this, in turn, may make them vulnerable to infectious diseases (de Onis & Blossner, 1997:46).

### Physical Activity (PA)

Caspersen, Powell and Christenson (1985:126) defined PA as any bodily movement that results in energy expenditure, produced by working muscles. This includes full range of human movement, from sports, exercise, walking or activities of daily living.

### Quintile ranking

In the South African context, quintiles are used to classify government schools according to their socio-economic status. Quintiles 1 to 5 are used to categorize the schools, ranging from Quintile 1, the poorest, to Quintile 5 the least poor schools (Kanjee & Chudgar, 2009:4). Quintile ranking 1 to 3 are classified as “no fee paying schools’, from previously disadvantaged communities, and ranking 4 to 5 are classified as “fee paying schools”, from advantaged communities (Sayed & Motala, 2012:676).

## 1.6 SIGNIFICANCE OF THE STUDY

The discussion of the study context in this chapter demonstrates that body composition is an important indicator of the health status of children. Given South Africa’s double burden of disease in relation to over- and undernutrition, regular assessments of children’s body composition and nutritional status and subsequent remedial interventions are justified. As far as could be ascertained, there are no studies reporting on children’s nutritional status in the Port Elizabeth area, its effect on body composition and how an intervention can affect the current status. However, research from other provinces in South Africa have investigated the effect of school-based interventions on children’s body composition. In the Western Cape, the HealthKick nutrition and PA intervention was implemented at primary schools in low-income communities (Draper, de Villiers, Lambert, Fourie, Hill, Dalais, Abrahams & Steyn, 2010:399); in Gauteng, the effect of a ten-month PA intervention on body composition was investigated (Monyeki, De Ridder, Du Preez, Toriola & Malan, 2012:243); and a study by Naidoo, Coopoo, Lambert and Draper (2009:7); and another by Naidoo and Coopoo (2012:77) assessed the impact of a school-based nutrition and PA intervention on children in KwaZulu Natal. In the North-West, Kruger, Vorster, Stegman, Doak and Margetts (2012:253) investigated the beneficial effects of a PA intervention on adolescents’ linear growth. All the studies were limited in size and scope and reported that PA and nutrition school-based interventions had a beneficial effect on children’s body composition and health status.

The present study contributes to this body of knowledge as a randomized controlled trial that assessed the effect of a school-based PA intervention, on its own, or in combination with health and hygiene education and/or nutrition on the body composition of children from lower socio-economic communities in Port Elizabeth. The study is set in post-apartheid South Africa and highlights the challenges related to body composition and children’s health that exist in areas formerly set aside under the apartheid Group Areas Act for Black Africans and Coloured South Africans, more than 20 years after democracy.

Besides adding to the body of knowledge it was assumed that if the study were to indicate that implementing such interventions could improve children's health status by impacting on their body composition, the results could be used to convince policy makers from the Departments of Education and Health about the benefits of PA and nutrition interventions for schoolchildren and to implement interventions for the benefit of children's health. The latter could be implemented through participation in regular PA in PE classes and recommended adaptations to the NSNP.

The chapter to follow provides a review of literature and background information on the topic under investigation.

# CHAPTER 2

# LITERATURE REVIEW

## 2.1 INTRODUCTION

Body composition serves as a major indicator of children's health and nutritional status (de Onis & Habicht, 1996:652). Since the assessment of child growth is recognised internationally as an indicator of health and nutritional status, anthropometric measurements to assess growth and development, particularly in children, are the most universally used methods (WHO, 2010b:1), with weight-for-age, weight-for-height and height-for-age being the most widely used anthropometric indexes (de Onis & Habicht, 1996:652). In South Africa, impoverished communities suffer from a double burden of malnutrition, underweight and overweight, and these may occur in the same household or community. This burden is associated with nutritional transition (a change in nutritional behaviour) and economic inequalities, particularly in low-to middle-income countries (Reddy, Resnicow, James, Kambaran, Omardien & Mbewu, 2009:206; Popkin *et al.*, 2012:10). While the prevalence of wasting and underweight has been reduced in South Africa, stunting still remains a problem with only slight increases recorded (Shisana, Labadarios, Rehle, Simbayi, Zuma, Dhansay, Reddy, Parker *et al.*, 2014:211).

The double burden of malnutrition is found in both low and middle-income countries, across different ethnic groups, ages, gender and socio-economic status, but worrying proportions are found in lower socio-economic communities undergoing a change in nutrition behaviour from a traditional diet low in fat and sugar, to a Western diet (Iversen *et al.*, 2011:74).

The aim of this study was to determine the effect of various combinations of school-based interventions on the body composition of Grade 4 children from lower socio-economic communities in Port Elizabeth. This chapter discusses background literature to facilitate an understanding of the focus of this study. An overview of body composition and the different methods used to assess body composition are highlighted. Internationally recognised measurements used to assess body composition in laboratory and field settings are discussed. Malnutrition and the possible causes and consequences to children's health are explained. The chapter also examines the association of body composition with socio-economic status. Lastly, empirical studies conducted nationally and internationally on the effect of school-based interventions on body composition are discussed.

## 2.2 BODY COMPOSITION

### 2.2.1 Defining body composition

Body composition describes the relative proportion of the major components of the body (Corbin *et al.*, 2012:8). The theoretical model underlying body composition is that the body is made up of fat, water, protein (muscle) and mineral (bone) components. According to the two-component model, the body is divided into fat and fat-free/lean body components, where fat-free mass is composed of residual chemicals and tissue such as water, muscle and bone (Wells & Fewtrell, 2006:612; Heyward, 2006:173; Hoeger & Hoeger, 2013:121).

Body composition and growth serve as major indicators of health in individuals and populations. Due to the prevalence of overnutrition in children and adults, the importance of balanced body composition for short and long term health has been emphasized, making its measurements highly valuable in clinical practice (Wells & Fewtrell, 2006:613). As much as excess fat is seen as a health risk, too little body fat is also detrimental as too little body fat can cause physiological dysfunction (Heyward, 2006:171). It is, however, ideal for individuals to have more lean mass than fat mass to prevent the risk of developing non-communicable disease. Lean mass goes through chemical maturation between birth and adulthood, and the relative proportions of water, muscle and bone are altered with age and pubertal status. However, the two-component model addresses these changes by assuming that at a given age and sex, lean mass has constant characteristics (Wells & Fewtrell, 2006:613).

The site where fat is distributed is reported to be more critical than the quantity of fat stored. Fat around the abdominal areas is a risk factor for cardiovascular disease (Hoeger & Hoeger, 2013:120). The body's main form of storing energy is fat. The body is sensitive to acute malnutrition, therefore, any change in body fat content gives an indirect estimate of alterations in energy balance (Gibson, 2005:273).

On the other hand, body muscle which mainly consists of protein, is a major component of fat-free mass. Thus, body muscle represents the amount of protein reserves in the body. During chronic undernutrition, protein reserves become depleted and this results in muscle wasting (Gibson, 2005:273). This partly explains why undernourished children have low weight and lack energy. In developing countries where there is a high prevalence of childhood malnutrition, body composition is the single growth assessment measurement that clearly defines the health and nutritional status of a child (Blössner *et al.*, 2005:4). Body composition is therefore assessed on a regular basis to monitor the children's health and nutritional status.

### 2.2.2 Methods used for the assessment of body composition

Anthropometric measurements are used to identify people at risk for developing or already suffering from, a pathology. The measurements are also used in health interventions to monitor the effects of the intervention (Norton & Olds, 2006:366). The assessment of body composition in growing children is complicated by the rapid height and weight changes children undergo. A number of methods have been used to assess body composition in children in the laboratory and in field and clinical settings. In the following sections, a critical explanation of the following commonly used methods is provided:

- Laboratory methods: Densitometry (Hydrostatic Weighing and Air Displacement Plethysmography) and Dual-Energy X-ray Absorptiometry (DXA)
- Field and clinical methods: Anthropometry (Circumference, Skinfolds and BMI).

#### *2.2.2.1 Laboratory Methods*

Laboratory methods of evaluating body composition offer reference measures to derive and evaluate field methods and prediction equations. These methods are generally more accurate than field methods. However, they are more expensive, time consuming and not convenient for assessing large numbers of people (Heyward, 2006:171). The most frequently used laboratory methods include: Hydrostatic weighing, Air Displacement Plethysmography and Dual-Energy X-ray Absorptiometry (DXA).

Densitometry is a measure of body density using hydrostatic weighing and air displacement plethysmography. Body density is calculated by dividing body mass by body volume (Db= BM/BV). Hydrostatic weighing and air displacement plethysmography are used to measure body volume (Heyward, 2006:171).

##### *2.2.2.1.1 Hydrostatic Weighing*

In the past decades, hydrostatic weighing was the most commonly used technique to determine body composition. This method requires the individual's weight to be measured before the test. The system consists of a chair, a scale or platform attached to four loading cells and a stainless steel weighing tank. The individual sits on the chair, exhales all the air in his or her lungs and then the body is submerged in the water tank. During the test the person is instructed to sit still underwater while the measurement is recorded (Heyward, 2006:175).

Hydrostatic weighing is based on the Archimedes' principle which states that the volume of an object submerged in water equals the volume of water displaced by the object. Thus, when a body is fully submerged in water it can provide an estimate of total body volume from the water displaced by the body. To get an accurate estimation of body volume, residual lung volume (amount of air left in the lungs after maximum expiration) must be measured during the test in conjunction with hydrostatic weighing. This will in turn give an accurate estimation of body density (Lukaski, 1987:540).

Hydrostatic weighing is accepted as a valid measurement to estimate body volume and body density. Body density is converted to BF% using a two-component or multicomponent model equation. However, the error in this method increases when it is used to calculate BF%. This method is difficult to administer as it requires technical skills and it can take up to 30 minutes. It has limitations when it is administered to very overweight individuals and young children, and it requires compliance from the client (Heyward & Wagner, 2004:109; Hoeger & Hoeger, 2013:123).

##### *2.2.2.1.2 Air Displacement Plethysmography*

Air Displacement Plethysmography is used to measure body volume and body density, but it uses air displacement instead of water to estimate body volume. The Bod Pod, an egg-shaped large fiberglass chamber is used, making use of air displacement and pressure volume relationship to calculate body volume. This method is based on the relationship between volume and pressure and it attempts to control for temperature and gas pressure changes that take place when an individual is placed in an enclosed chamber (Heyward, 2006:179).

According to Boyle's law [$P_1/P_2= (V_2/V_1)$] volume and pressure are inversely related. Therefore, the Bod Pod measures changes in pressure within an enclosed chamber in order to determine body volume. Accuracy and validity of this method is similar to that of hydrostatic weighing method. Unlike hydrostatic weighing, this method is relatively quick (approximately 5-10 minutes), requires less technical skill and compliance from the client and is easy to perform (Heyward, 2006:179).

#### *2.2.2.1.3 Dual-Energy X-ray Absorptiometry (DXA)*

The DXA is a radiographic technique typically used to detect osteoporosis and other bone diseases in females going through menopause, as well as to measure bone mineral density in men and children. Additionally, it is used for body composition assessment. An X-ray tube with a filter is used to create low-energy (40kV) and high-energy (70-100kV) photons. The machine releases X-rays with two different energies (high and low photon energies) through the body and they are absorbed by soft tissue and bone. The absorption of X-ray energies through soft tissue (fat and lean tissue) and bone differs due to the different densities and chemical compositions of these tissues. This absorption is expressed as a ratio of the lower energy relative to the higher energy. Once soft tissue has absorbed the energy, the amount is subtracted from the total and the difference is recorded as the individual's bone mineral density (Pietrobelli, Formica, Wang & Heymsfield, 1996:E948).

The DXA is used to measure total body bone mineral and bone mineral density and also estimates total fat mass, fat-free mass, soft tissue mass and BF%. Additionally, DXA can measure regional body composition. It is based on the principle that the attenuation of X-rays with low-and-high photon energies can be measured and that it depends on the thickness, density and chemical composition of the underlying tissue. The DXA is considered as a "gold standard technique" for body composition assessment, because it is non-invasive and it requires less effort from the client and does not require too much technical skill. However, it uses expensive equipment and it is difficult to use with large sample groups (Hoeger & Hoeger, 2013:122).

#### *2.2.2.2 Field and Clinical setting methods*

Anthropometry is a common method used for assessing body composition. It describes body mass, body size, shape and level of fitness. Anthropometry can be defined as measurements of proportion and size of the human body. Body size can be measured by taking body weight and height, while body proportion is represented by the ratio of body weight to height (Hills, Lyell & Byrne, 2001:8). Skinfold thickness and circumference are some of the methods used to measure the size and proportion of body segments, total body and regional body composition. Anthropometry, as a measure of body composition, is the most widely used method in children and adolescents. When looking at child growth and development, anthropometry is accepted as a general indicator. The advantages of using nutritional anthropometric assessments are that they are simple and non-invasive, they enable the assessment of large sample sizes, require inexpensive and minimal equipment and the methods are accurate and precise if done with proper standards (Hills *et al.*, 2001:9; Gibson, 2005:273). Even though anthropometry is accepted as a good indicator for child growth and development, Gibson (2005:273) identified some limitations with using anthropometric measurements: they fail to detect changes in nutritional status resulting from inadequacy of food over short periods, they fail to differentiate between specific nutrient deficiencies that affect child growth and they are unable to pinpoint the exact cause of undernutrition.

##### *2.2.2.2.1 Circumference/Girth Measurements*

Circumference measurement is a frequently used technique to estimate body fat. It is a measure of the girth of the body segments (e.g. chest, arm, abdomen, waist and hip). Measurements are taken on the right side of the body. This technique is very easy to perform as it requires only a standard measuring tape (Hoeger & Hoeger, 2013:126). The procedure starts by accurately identifying a landmark (e.g. acromiale and radiale) and using this landmark to locate the site of measurement (e.g. mid-acromiale radiale) and using an anthropometric tape measure to take the girth. Tension is applied on the site using the tape while ensuring that the tape does not indent or compress the skin and subcutaneous tissue (Norton & Olds, 2006:53).

Waist and hip circumference (waist-to-hip ratio) are the most commonly assessed girth measurements to estimate upper and lower body fat distribution. This technique can either over-estimate or under-estimate average body density (Heyward & Wagner, 2004:77). Another circumference measurement used in children and adolescents is mid-upper arm circumference (MUAC) and it is related to changes in age and sexual development. This method has also been used for the screening of adults for the prevalence of undernutrition because it is simple and easy to measure. It has also been used in adolescents. However, no direct correlation has been found between MUAC and other body fat and undernutrition measures, such as BMI (Woodruff & Duffield, 2002:1112). To avoid measurement error in this method, training and supervision is required to ensure the field worker does not hold the measuring tape too tight or too loosely around the arm. Using circumference to measure body composition is inexpensive and simple to perform, requires low technical skill and is suitable for clinical purposed and large-scale epidemiological surveys.

*2.2.2.2.2 Skinfold measurements*

Skinfold thickness is another anthropometric measurement used to estimate total body fatness through surface anthropometric measurements (Norton & Olds, 2006:172-372). A skinfold measurement measures a double compressed fold of skin and subcutaneous adipose tissue and is taken with a caliper on a predetermined landmark, using constant pressure over a range of thickness (Hills *et al.*, 2001:9; Krebs, Himes, Jacobson, Nicklas, Guilday & Styne, 2007:S193; Eston & Reilly, 2013:14). The distribution of subcutaneous fat is usually mapped by performing specific skinfold measurements (i.e. triceps and subscapular) and this provides a suitable indication for disorders associated with body composition (Norton & Olds, 2006:372-76). Certain basic relationships are assumed when using skinfolds to derive body fat percentage (BF%) from estimated total body fat. Firstly, the distribution of fat subcutaneously as well as internally is relatively similar for same gender individuals. Total body fat can be estimated from the sum of several skinfolds, due to the relationship between subcutaneous fat and total body fat. Lastly, there is a relationship between body density and the sum of skinfolds (Lukaski, 1987:541; Hills *et al.*, 2001:9).

Skinfold measurements have been used extensively in body composition and nutrition research. Skinfold thickness is a good predictor of body fatness because 40-60% of the body's total fat is represented by subcutaneous fat (Rodriguez, Moreno, Blay, Blay, Fleta, Sarria & Bueno, 2005:1159). Besides its ability to predict total body fat, it also gives information that may indicate risk for disease (Krebs *et al.*, 2007:S193). The skinfold technique is used primarily because it requires inexpensive and minimal equipment, it is relatively quick to administer and it is non-invasive (Hills *et al.*, 2001:9; Gibson, 2005:273). In order to perform skinfold measurements, one needs basic training and there are international standards already in place that researchers can use against which to compare results (Rodriguez *et al.*, 2005:1159; Hoeger & Hoeger, 2013:124).

Because subcutaneous fat is estimated to represent 40-60% of total body fat in males and females, studies have used skinfold thickness to estimate BF% in conjunction with girth measurements/circumference, such as triceps skinfold and MUAC (Lukaski, 1987:542). Generally, when predicting BF% with multiple skinfold measurements, it is recommended to use a selection of limb and trunk skinfold measurement sites (e.g. triceps and subscapular) (Norton & Olds, 2006:177). This helps to account for differing subcutaneous fat distribution. However, there is no consensus as to the best single or multiple skinfold site(s) to estimate body fat: it is said to be dependent on age, gender and ethnicity/race of the population under investigation.

#### *2.2.2.2.3 Body Mass Index (BMI)*

BMI is the ratio of weight to height ($kg/m^2$) and it combines these two measurements in order to estimate critical fat values at which the risk of disease increases (Hoeger & Hoeger, 2013:127). The use of BMI to estimate body fatness in children and adolescents has been questioned (Hills *et al.*, 2001:8) because it is height dependent over some age ranges and it is affected by relative leg length. Additionally, BMI reflects both fat and fat-free tissue to a comparable degree (Garn, Leonard & Hawthorne, 1986:996; Norton & Olds, 2006:370). Despite these limitations, BMI can still be used to identify individuals at risk for developing disease (Norton & Olds, 2006:372). Risk for disease starts to increase when BMI exceeds $25kg/m^2$ (Flegal, Carroll, Kuczmarski & Johnson, 1998:45).

BMI precisely defines excess weight relative to height rather than the amount/size of body fat present. BMI has been used extensively in adults. However, it becomes difficult when looking at BMI in children due to the natural changes that occur during growth and maturation (Hills *et al.*, 2001:8), as these drastic changes alter BMI (Cole *et al.*, 2000:1240). This has led to BMI norms and cut-offs for children being defined per year of age (e.g. BMI-for-age) (Cole *et al.*, 2000:1242; WHO, 2007:665; Cole & Lobstein, 2012:289). A strong relationship between BMI and body fatness exists, hence BMI has been used by several studies over the years.

BMI has a high correlation with body composition and this is associated with fat mass, rather than fat-free mass, thus making BMI a good indicator of body composition (Cameron, Jones, Griffiths, Norris & Pettifor, 2009:1068). Waist circumference is one of the methods used to assess body composition and it has been proposed as a good indicator for health risk in populations. However, Cameron *et al.* (2009:1065) argued that, because centralization of fat commences only after the onset of puberty, BMI is a better screening technique for fatness than waist circumference. Additionally, it is stated that while earlier research suggested that waist circumference was the most important indicator of body composition in children, it however fails to distinguish between pre-pubertal and pubertal children. Cameron *et al.* (2009:1068) found BMI to strongly correlate with body composition for pre-pubertal children. BMI has been the most commonly used method in children to determine thinness and excessive fatness due to its being a relatively easy method to conduct and the consistency it provides across populations (Hoeger & Hoeger, 2013:128).

## 2.3 MALNUTRITION (OVERNUTRITION AND UNDERNUTRITION) IN CHILDREN

Malnutrition refers to imbalances or deficiencies in energy, protein and micronutrient intake and the body’s demand for these nutrients to meet optimal growth and function. This nutrient imbalance could be either excessive or inadequate (overnutrition or undernutrition) (de Onis & Blossner, 1997:3). Undernutrition means there is inadequate consumption of nutrients and this can be expressed as underweight, stunting and wasting. Undernutrition decreases physical and mental capacity and it reduces resistance to disease. It is most common in developing countries and it results from inadequate food consumption over a period of time (de Onis & Blossner, 1997:3; Shetty, 2003:18). On the other hand, overnutrition is the excessive intake of nutrients and is associated with overweight and obesity. A number of factors are associated with malnutrition in children, many of which are related to poor food quality, insufficient food intake or severe and recurrent infections (de Onis & Blossner, 1997:46; Shetty, 2003:18; Blössner *et al.*, 2005:1).

**Overweight and obesity**

Overweight and obesity are defined as having excessive weight for your age and height. Overweight and obesity are measured by BMI-for-age. BMI-for-age plus one standard deviations above the WHO Child Growth Standards median (> +1 SD) is classified as overweight, and BMI-for-age plus two standard deviations above the median (>+2 SD) is classified as obese (de Onis & Blossner, 1997:46; WHO, 2010b:1).

**Underweight**

Underweight is defined as weight-for-age below minus two standard deviations (< –2 SD) of the WHO Child Growth Standards median. It is defined as having low weight for your age and height and is seen in individuals who experience medium to long term undernutrition (de Onis & Blossner, 1997:46).

**Stunting**

Stunting is defined as height-for-age below minus two standard deviations (< –2 SD) of the WHO Child Growth Standards median. It can also be expressed as height-for-age z-score of -2. Stunting is also known as growth retardation, where a child fails to reach linear growth for their age. Factors contributing to stunting include long term food deprivation, poor food quality, repeated infectious diseases and low socio-economic status. In children younger than five years of age stunting shows insufficient provision of basic needs during infancy and pre-school years. Thus, widespread stunting can identify poverty in a population (de Onis & Blossner, 1997:46; Reinhard & Wijeratne, 2000:12; WHO, 2010b:1).

**Thinness**

Thinness is weight-for-height below minus two standard deviations (< –2 SD) of the WHO Child Growth Standards median. Thinness describes severe weight loss resulting from insufficient nutrient intake and severe or repeated infectious diseases.

Thinness is commonly seen in times of food security crises. The immune system is weakened in children that are thin and this in turn makes them vulnerable to infectious diseases and thus puts them at an increased risk of death (de Onis & Blossner, 1997:46; WHO, 2010b:1).

### 2.3.1 Underweight, stunting and wasting prevalence among children in South Africa

In South Africa a double burden of malnutrition (underweight and overweight) exists. This double burden may occur in the same household or community and it is partly related to food insecurity, nutritional transition and economic inequalities (Jinabhai, Taylor & Sullivan, 2003:364; Kimani-Murage, Kahn, Pettifor, Tollman, Dunger, Gómez-Olivé & Norris, 2010:164; Tathiah *et al.*, 2013:720).

Food insecurity affects many households and in 2012 it was reported that within the South African population, 26% experiences hunger and a further 28.3% is at risk of hunger (Shisana *et al.*, 2014:10). This has implications for the health of many children living in South Africa as they have inadequate access to food. Statistics South Africa has reported that out of 18 million children between the ages of 0 – 18 years, 22.8% have inadequate access to food and an additional 7.8% have severely inadequate access to food (Statistics South Africa, 2013:20). The North West, Northern Cape and Eastern Cape provinces are the most affected by food insecurity in South Africa (Graham, Hochfeld, Stuart & Van Gent, 2015:49). The food insecurity prevalence in the Eastern Cape was found to be 36.2% (Shisana *et al.*, 2014:146).

In 1999, the National Food Consumption Survey (NFCS) was conducted in South Africa, focusing on children aged one to nine years old, and investigated the nutritional status and dietary intake of children. The survey identified stunting as the most common nutritional disorder at the national level, reporting that stunting affects one in five children (23 %). Furthermore, the prevalence of overweight was one in ten children; wasting showed less prevalence, with one in twenty children affected (Labadarios *et al.*, 2005:533).

Similar findings were revealed in a review reporting on the nutritional status of young children in South Africa from 1994 to 2010 (Iversen *et al.*, 2011:76). This review documented findings from studies conducted in smaller geographical areas as well as in countrywide population-based surveys. Collectively, the findings revealed that South African children have an inadequate nutritional status. Of concern was the high rate of stunting and underweight, which results in impaired growth (Iversen *et al.*, 2011:76). Added to this is food insecurity, reflected by the high frequency of hunger experienced daily. A high prevalence of overweight and obesity was also noted in the reviewed studies and this was even higher than the level of stunting. The high level of overnutrition in children could be caused by a nutrition transition from traditional diets low in fat and sugar to diets with more energy dense food (Iversen *et al.*, 2011:76).

After 1994, several nutrition intervention programmes were implemented with the aim of alleviating malnutrition in young children. Such programmes include the primary school food programme that was later taken over by the Department of Education in 2004, the NSNP (Buhl, 2010:8). A study was conducted to evaluate the NSNP and Tiger Brands Foundation (TBF) in-school breakfast feeding programme in the Lady Frere and Qumbu districts in the Eastern Cape Province, and the findings were positive. Even though the level of poverty is high in these areas, the schoolchildren investigated showed a lower prevalence for underweight and wasting compared to averages reported for children in the Eastern Cape Province. When looking at stunting, schools that received both the NSNP and TBF nutritional interventions showed lower rates of stunting compared to national averages for children aged 4-14 years (9% and 13% respectively) (Graham *et al.*, 2015:7).

From these surveys, it is clear that South Africa still faces a problem in nutritional conditions associated with lack, rather than excess, pertaining to young children. Even though the prevalence of wasting was low, stunting and underweight are still of great concern. Addressing these nutritional conditions in children calls for action across a broad front as the conditions are not related only to food insecurity or socio-economic status, but to many inter-related factors, as discussed below.

### 2.3.2 Causes and consequences of undernutrition on children's health

The co-existence of conditions associated with excess as well as lack of nutritional resources is associated with urbanization. This is evident in low-income countries that are experiencing rapid urbanization and are subject to a double burden of malnutrition (both lack and excess of nutrition), while at the same time facing increased prevalence of both non-communicable disease (NCD) and infectious disease (Vorster, Bourne, Venter & Oosthuizen, 1999:341; Jinabhai *et al.*, 2003:364). Poor nutrition in a community is reflected by the shortage of food and recurrent bouts of disease, and these are determined by: ease of access to food, level of education, caring capacity, health infrastructure, housing and the environment (Reinhard & Wijeratne, 2000:2). This has negative implications in children as food security, inadequate care and health are identified as determinants of children's nutritional status (Black, Allen, Bhutta, Caulfield, De Onis, Ezzati, Mathers, Rivera & Group, 2008:246).

Children who are inadequately nourished are unable to reach their development milestones at an appropriate age. Children who are undernourished can have significantly impaired physical and mental growth, to varying extents, depending on the period of malnutrition onset, duration and severity (Soul-City-Institute, 2005:4). Poor health and nutrition in stunted children may lead to poor school performance and reduced intellectual capacity due to delayed mental development (de Onis & Blossner, 1997:5; Reinhard & Wijeratne, 2000:15). If undernutrition occurs at a period of maximum brain growth, this can result in permanent brain damage (Soul-City-Institute, 2005:4). Malnutrition during infancy and childhood can make the children susceptible to infectious disease in addition to its effect on growth and development (Soul-City-Institute, 2005:4). A consequence of this is an increase in the burden of life-threatening diseases, increased health care costs and the risks of mortality in individuals with inadequate health care in low-income/developing countries (Pelletier, Frongillo, Schroeder & Habicht, 1995:448).

As undernourished children grow they are exposed to changes in lifestyle, and studies suggest that individuals in low- to middle-income countries that are experiencing rapid transition are likely to have rapid weight gains if they are exposed to changes in lifestyle that include increases in food availability. This places them at a higher risk of being overweight or obese than their normal height-for-age counterparts (Popkin *et al.*, 1996:3009; Victora, Adair, Fall, Hallal, Martorell, Richter, Sachdev & Group, 2008:353). Overweight and obesity is associated with a number of risk factors for chronic diseases, including heart disease later in life, and mortality (Cole *et al.*, 2000:1240), which makes this a concern for the health system of a country and, hence, the country's economy. Therefore, countries undergoing a nutritional transition should take the necessary actions to address the negative consequences associated with rapid weight gain in late childhood following undernutrition (Victora *et al.*, 2008:353).

Effects associated with malnutrition are thought to span at least 3 generations (Victora *et al.*, 2008:352). Research has shown that stunted children will grow to be short adults, who in turn are likely to give birth to low birthweight children who themselves will be stunted, causing a cycle of malnutrition. Additionally, undernourishment in childhood leads to permanent impairments in adulthood. Undernutrition is also associated with low academic achievement and reduced productivity due to reduced intellectual capacity and delayed mental development in childhood, and finally lower economic status in adulthood. This in turn has severe consequences on social and economic development (Reinhard & Wijeratne, 2000:13-14; Victora *et al.*, 2008:352).

Findings of Pelletier *et al.* (1995:448) indicate that malnutrition, by virtue of its relationship with infectious disease, has a strong effect on mortality in children. Contrary to the popular belief that malnutrition-related deaths are attributed to severe malnutrition, Pelletier *et al.* (1995:448) revealed in his study that 83% of deaths were attributable to effects of mid-to-moderate malnutrition. The alleviation of malnutrition should thus focus on all levels, and not only on severe cases of stunting.

## 2.4 BODY COMPOSITION AND SOCIO-ECONOMIC STATUS

Socio-economic status is one of the most commonly studied constructs in the field of social science, and is used to classify people/families according to their social and economic position within the society. The most widely used measurements of socio-economic status are education attainment, income level and occupation (Bradley & Corwyn, 2002:371; Galobardes, Shaw, Lawlor, Lynch & Smith, 2006:7).

The presence of socio-economic inequality in malnutrition is found in both developing and developed countries. Van de Poel, Hosseinpoor, Speybroeck, Van Ourti and Vega (2008:289) investigated the relationship between socio-economic inequality and average malnutrition rates in childhood malnutrition in developing countries: however, no relationship was found. Countries with low and high average levels of malnutrition were not different in terms of socio-economic inequality. However, individuals or communities with better living conditions were found to be less likely to suffer from malnutrition (Van de Poel *et al.*, 2008:286). On the other hand, children from lower socio-economic areas are faced with a bigger burden of malnutrition (Zere & McIntyre, 2003:11).

South Africa is faced with a major challenge of undernutrition and hunger in children caused by poverty and social inequalities (Iversen *et al.*, 2011:72). The health system in South Africa plays a role in this challenge stemming from the country's history of apartheid, dispossession and the transition into the post-apartheid period (Coovadia, Jewkes, Barron, Sanders & McIntyre, 2009:817). Race and gender discrimination and the vast income inequalities, amongst others, have also affected children's health and health services in South Africa (Coovadia *et al.*, 2009:817). As a result, because of the rate of inequality, research in South Africa is focusing on socio-economic status and the effect it has on children's health.

A study that assessed the level of inequality in under-five year old child malnutrition, found children residing in the poorest 10% of households had a higher prevalence of underweight and stunting compared to those from the richest 10%. These high rates of undernutrition were highest in the African population group. Conversely, wasting did not show any significant differences in terms of socio-economic status (Zere & McIntyre, 2003:11). Results of socio-economic status and body composition in an urban setting in South Africa showed that in children at ages nine or ten years, low socio-economic status was associated with fat mass, while in younger children it was associated with lean mass (Griffiths, Rousham, Norris, Pettifor & Cameron, 2008:865).

The highest prevalence of stunting was found in the Eastern Cape and the Northern Province, which are provinces with the highest rates of poverty in South Africa (Zere & McIntyre, 2003:11). This further shows the strong association between hunger and undernutrition. Even though stunting is associated with lower socio-economic status and poverty, Ali and Crowther (2009:82) found that, with low socio-economic status, there was a particular increase of weight gain through adulthood. This may be partly explained by the fact that people from lower socio-economic communities have limited access to healthy foods and their diets are made up of unhealthy but more affordable food choices (Spruijt-Metz, 2011:132).

Among South African provinces, Eastern Cape, Limpopo and North West have the lowest number of people who have attained matric (13.8%, 15.9% and 15.9%) (Shisana *et al.*, 2014:66). Studies have found an association between maternal education and childhood undernutrition (Chopra, 2003:650; Abuya, Ciera & Kimani-Murage, 2012:8). In a study by Abuya *et al.* (2012:8), it was found that close to 40% of children aged 0 to 42 months were stunted and results indicated that a mother's education level was a significant predicator for stunting in these children. They suggested that improving a mother's education level could significantly influence the child's nutritional status and thus change the poverty cycle as stunting is an important predicator of human capital. Additionally, Ali and Crowther (2009:82) found that less educated females are more likely to be underweight and give birth to low-birth weight children, and the converse is valid for more educated females. Thus, programmes that increase schooling are necessary as schooling has been found to affect nutrition later in life due to its direct impact on the individual's earnings as well as on national income (Ruel, Alderman & Group, 2013:545).

A household's economic position is said to have a significantly high impact on the likelihood of a child's underweight and on stunting (Zere & McIntyre, 2003:13). In the SANHANES-1, the Eastern Cape Province, a province with high poverty and low education rates, showed 42.6% of the population reporting that they do not have an income (Shisana *et al.*, 2014:69). This has negative implications for health as individual or household income is associated with food security. It also has a direct impact on the household's financial access to sufficient and nutritious food (Shisana *et al.*, 2014:146). Zere and McIntyre (2003:7) found a strong correlation between stunting and income-related inequalities, but no such correlation for wasting. This is because stunting, which is indicated by chronic malnutrition, is linked with socio-economic deprivation. On the other hand, wasting is less likely to be affected by income because it is associated with unexpected environmental factors/diseases.

When household income increases, a notable decrease in the rate of stunting is observed. Malnutrition, specifically stunting, has a more significant socio-economic element compared to underweight and wasting. Socio-economic inequalities have greater consequences in child malnutrition, such as reduced income in later life.

Consequently, this is likely to add to the high income inequalities that already exist in the country (Zere & McIntyre, 2003:14).

## 2.5 SOUTH AFRICA IN TRANSITION AND ITS EFFECT ON BODY COMPOSITION

Nutrition transition is associated with shifts in diet, with societies consuming diets high in fats, sugar and refined carbohydrates, but low in starch, fiber and vegetable (Popkin *et al.*, 2012:8). This shift is also seen in PA patterns, where individuals lead lives characterized by low levels of activity (Popkin & Gordon-Larsen, 2004:S2).

Lee (2003:167) studied fundamental changes over three centuries and explained demographic transition as a shift in population dynamics related to developments in socio-economic status such as increasing income, education, employment, improvements in health status and life expectancy and changes in standards of living. Furthermore, this demographic transition is followed by an epidemiological transition. The nutrition transition is said to be connected to the epidemiologic and demographic transitions (Popkin & Gordon-Larsen, 2004:S2).

In South Africa, Black Africans predominate numerically over other racial groups and represent approximately 80% of the population, followed by White (10%), Coloured (9%) and Asian 1% (mainly Indian). Approximately 56.7% of the Black African population resides in non-urban areas and 43.3% live in informal housing in the urban areas, on the outskirts of the cities (Bourne, Lambert & Steyn, 2002:157). This ethnic group is the most impoverished of all groups, experiencing food insecurity and a double burden of malnutrition. Bourne (1996) studied dietary trends in urban Black Africans, aged 19 to 44 years, living in Cape Town and found changes in diet from a traditional to a more western diet. Results showed increases in mean fat intake from 23% to 30%, while carbohydrate intake decreased from 68% to 58% and protein intake was stable. Even though protein was relatively stable, high proportions of it were from animal sources. Furthermore, there was a decrease in total fiber intake to 16.7 grams per day from 20.7 grams. The trends reported are characteristic of the nutrition transitions taking place in other developing countries (Temple & Steyn, 2016:57).

Due to a number of Black African South Africans moving to urban areas, seeking jobs and better living conditions, studies in South Africa have reported that the risk of developing nutritional disorders is high in poor families facing industrialization. Additionally, a double burden of under- and overnutrition may co-exist in the same household (Reinhard & Wijeratne, 2000:11). This phenomenon is a result of a shift from consuming traditional low sugar and fat, and high-fiber diet to a more Western diet typified by low-fiber and high in animal fat and sugar (Vorster *et al.*, 1999:342). This nutrition transition is said to mostly affect people in poor urban areas and the Black African population in particular because they are now exposed to processed fast foods, thus increasing their fat intake (Bourne *et al.*, 2002:158).

A high prevalence of degenerative disease has been associated with the Western diet, while the traditional diet is associated with low prevalence in these diseases. When looking at individuals who had recently moved to urban areas and those who were more urbanized, the former were associated with a low level of formal education and atherogenicity, informal housing and poor diets consisting of low intakes of vitamins and minerals. In contrast, the more urbanized individuals had more formal education, resided in formal housing and consumed foods relatively high in micronutrients, but had significantly high atherogenicity (Steyn, Kazenellenbogen, Lombard & Bourne, 1997:140). This suggests that when an individual's socio-economic status improves, it does not inevitably mean that they will have an improved nutritional status, but will rather shift to an alternative nutritional pattern that may not be beneficial and may lead to the development of atherosclerosis (Steyn *et al.*, 1997:141).

## 2.6 THE EFFECT OF SCHOOL-BASED INTERVENTIONS ON BODY COMPOSITION

In the past decades, the way people eat, drink and move has changed drastically, creating major changes in body composition (Popkin *et al.*, 2012:4). In many low-and middle-income countries there are large inequalities despite substantial economic growth. These countries face issues of food insecurity, hunger, low education rates and malnutrition (Popkin *et al.*, 2012:12). In low-and middle-income countries it is not uncommon to witness underweight, stunting and micronutrient deficiencies alongside increasing levels of obesity within communities and even within households (Popkin *et al.*, 2012:10). In developing countries like Mexico, Brazil, Chile and China, means to minimize acute malnutrition have been implemented through programmes that target vulnerable populations, and thus hunger and malnutrition have been minimized. The programmes in these countries have been tailored to address malnutrition without increasing obesity in children (Popkin *et al.*, 2012:10).

In South Africa, majority of children still live in poverty and they face inequalities that continue to limit their access to better living conditions, improved levels of education and health outcomes (Statistics South Africa, 2013:4). Children in South Africa are affected by poverty. Of all South Africans, 52.7% live in low-income households, with 64.5% of children staying in such households (Statistics South Africa, 2013:13). When looking at the different provinces in terms of poverty rate, Limpopo, Eastern Cape and KwaZulu Natal (78.2%, 77.8% and 73.5%, respectively) were at the top with people living in poor households: Black African children are more likely to live in these conditions (70.5%) than Coloured (44.3%), Indian/Asian (16.6%) and White children (4.4%) (Statistics South Africa, 2013:14). Hunger and inadequate access to food are other major problems in South Africa that affect children's health, with North West, Northern Cape, Eastern Cape and Mpumalanga having the highest rates of inadequate access to food.

Children spend most of their time at school, which makes the school setting an ideal environment to promote PA and healthy lifestyle, and also to encourage lifelong participation in sport and healthy behaviour (Kahn, Ramsey, Brownson, Heath, Howze, Powell, Stone, Rajab & Corso, 2002:81; Demetriou & Höner, 2012:187). The school setting makes it possible for a large number of learners to be reached through school-based interventions (Verstraete *et al.*, 2007:21). Furthermore, teachers have continuous and intensive contact with the learners (Brown & Summerbell, 2009:110). During a school day, children can be physically active during PE classes, during break-time and after school (Saris, Blair, Van Baak, Eaton, Davies, Di Pietro, Fogelholm, Rissanen *et al.*, 2003:111; Mota, Silva, Santos, Ribeiro, Oliveira & Duarte, 2005:273; Verstraete *et al.*, 2007:21).

According to the WHO (2010a), participation in regular PA is beneficial because it improves bone health, cardiorespiratory and muscular fitness, as well as cardiovascular and metabolic health. Additionally, PA helps in weight control and reduces the risk of heart disease, diabetes and hypertension, as well as stress and depression. The basic objective of PE is to involve schoolchildren in MVPA which is aimed at benefiting each child through developing his or her overall health and motor skill abilities (McKenzie *et al.*, 1993).

In developing countries, schoolchildren have limited opportunities for in-school PA (Hardman, 2008:8).This is a world-wide problem: as in the South African context, PE is not allocated enough time in the curriculum, it is not prioritized, it receives limited funding, and there is a lack of personnel and adequate resources for its implementation (Prinsloo, 2007; Hardman, 2008; Van Deventer, 2004, 2011, 2012). In a world-wide survey of PE, Hardman (2008:8) reported that PE was given an examinable status in more than half of the countries (61%), ranging from 20% in Africa to 67% in Latin America, Europe and the Middle East regions. Despite this examinable status of PE, it still lacks official assessment and still has low priority compared to other academic subjects in the curriculum. The main concern relates to the fact that children are being denied the opportunity to participate in PA that has benefits later in life (Hardman, 2008:8).

In South Africa, children do not participate in regular PA, however, the 2016 Healthy Active Kids South Africa Report Card revealed that more than 50% of children achieve the daily PA recommendation, moving from a D grade in 2014 to a C grade in 2016 (Uys, Bassett, Draper, Micklesfield, Monyeki, De Villiers, Lambert & Group, 2016:S267). Even with this improvement in PA, sedentary behaviour and screen time is still a major concern, as well as the rise in overweight levels of schoolchildren, which scored a D grade (Uys *et al.*, 2016:S269). PE classes during school hours could help increase PA participation in schoolchildren. However, children coming from lower socio-economic communities face challenges due to a lack of sport facilities and equipment and inadequate provision of extra-mural activities and sport (Walter, 2014:358). This causes major concerns as PE is essential in the early years to develop children's fundamental motor skills during crucial stages of growth and maturation and, consequently, providing the opportunity for sustained PA participation throughout the entire lifespan (Hardman, 2008:7).

In the South African context, during apartheid, PE and school sport participation were available only to a segment of the population, with the rest of the children receiving very few PA opportunities (Rajput & Van Deventer, 2010:147). South Africa had 19 different education departments during apartheid, which were separated by race, geography and ideology (Department of Education, 2002). Post-apartheid, in 1994, there was curriculum change when the National Education and Training Forum began a process of syllabus revision and subject rationalization, which saw the removal of PE as a stand-alone subject in the curriculum (Van Deventer, 2011:825). According to Du Toit *et al.* (2007:241), the reasons were primarily due to the lower educational and non-examinable status of PE compared to other academic subjects. A new curriculum was introduced at schools, known as Curriculum 2005 (C2005), an Outcomes-Based Education (OBE) system, and PE was to be taught in a new subject area called Life Orientation (LO). The department of education defined OBE as the foundation of the South African curriculum that serves to encourage a learner-centered and active-based approach to education (Department of Education, 2003:2). The aim of the new curriculum was to bridge educational gaps and correct the injustices of apartheid. However, PE remained a marginalized subject with less time allocated to it (Van Deventer, 2004:111). What was once a stand-alone, non-examinable subject, became a learning area so diverse that educators could not fully implement (Van Deventer, 2011:825-26). This is a concern for the quality of PE and sport in South African schools. Consequently, children are not acquiring the recommended amount of daily PA because of the limited time spent participating in PE lessons, if any time at all.

South Africa is faced with a challenge of childhood malnutrition and low fitness levels in children (Moselakgomo, Monyeki & Toriola, 2014:353). Coupled with this is the rising prevalence of overweight and obesity (Truter, Pienaar & Du Toit, 2010:231; Uys *et al.*, 2016:S269). Because of concerns about this double burden, public health and school-based interventions focusing on PA participation, health and nutrition have been implemented to target schoolchildren. Studies that have used school-based PA interventions focused on modifying the school curriculum and policies so as to increase PA participation during PE lessons and outside school. Additionally, these interventions focus on altering body composition and thus impacting on the health and growth status of children (Draper *et al.*, 2010; Naidoo & Coopoo, 2012; Monyeki *et al.*, 2012; Walter, 2014). South African school-based interventions are usually designed to align with LO, since PE is presented as part of LO learning area in the intermediate phase.

Nutrition and supplementation interventions are most commonly implemented among younger children (birth to 12 months). Although undernourished children who participate in supplementation interventions achieve catch-up growth, the impact of these benefits may be temporary unless the intervention is sustained over a long period (Walker, Grantham-McGregor, Himes, Powell & Chang, 1996:3022). Despite these reports, nutritional interventions are still implemented because of the high prevalence of undernutrition (Moselakgomo *et al.*, 2014:353) and food insecurity in lower socio-economic communities (Bourne *et al.*, 2002:159). Nutritional interventions focus on nutrition education, raising awareness about healthier food options, especially those sold at school tuck shops, and providing supplementation and food aid (Walsh, Dannhauser & Joubert, 2002:3; Naidoo *et al.*, 2009:10; Jacobs & Mash, 2013:391). The NSNP is an initiative that was introduced in South Africa with the aim of alleviating hunger and improving the nutritional status of schoolchildren (Buhl, 2010:8). Results of the SANHANES-1 (Shisana *et al.*, 2014:204) showed that nutrition-specific and nutrition-sensitive interventions are needed among South African children in order to address the double burden of chronic undernutrition and the increasing prevalence of overweight and obesity.

In conjunction with PA and nutrition, a health and hygiene education intervention is another important aspect of school-based interventions and is linked to communicable diseases. In school-based interventions, health education usually addresses PA, nutrition, communicable disease and smoking, providing information to effect behavioural changes (Kahn *et al.*, 2002:79). Duijster, Monse, Dimaisip-Nabuab, Djuharnoko, Heinrich-Weltzien, Hobdell, Kromeyer-Hauschild, Kunthearith *et al.* (2017:309) proposed that in low- and middle-income countries, school health programmes have the potential to contribute to improved health in children. Due to lower socio-economic communities being associated with a high rate of communicable diseases as a result of poor sanitation and litter (Müller, Yap, Steinmann, Damons, Schindler, Seelig, Htun, Probst-Hensch *et al.*, 2016:493), health education should also address issues of health and hygiene, clean water and sanitation.

Reasons have been proposed for the importance and benefits of school-based interventions for promoting healthy habits in children. A study which supports the importance of school-based interventions is that of Demetriou and Höner (2012:194), who showed results that school-based interventions can have a positive influence on children's PA, knowledge about PA and health, but reported limited positive results for BMI (Demetriou & Höner, 2012:194). These results are in line with a review by Kahn *et al.* (2002:81), who evaluated school-based PE interventions and found them to be effective at increasing children's PA levels. Ruel *et al.* (2013:545) suggested that school interventions are suitable for introducing programmes that focus on promoting PA and healthy lifestyle. Thus, school-based interventions are recommended as a means to improve overall PA and healthy behaviour in children.

## 2.7 SCHOOL-BASED INTERVENTIONS

The following section describes international and national school-based intervention studies conducted in primary schools. The results pertaining specifically to body composition are reported and summarised in Table 2.1. The studies have been arranged from the oldest to the most recently published, under the subheadings related to the type of intervention implemented, namely, PA only, nutrition only, PA and nutrition, and PA, health and nutrition.

**Table 2.1: Current research on the effect of school-based interventions on the body composition of primary school-aged children**

| Author and publication year | Sample size | Participants and demographics | Intervention duration and no. of sessions | Main findings |
|---|---|---|---|---|
| | | **Physical activity only** | | |
| Sallis, McKenzie, Alcaraz, Kolody, Faucette and Hovell (1997) | n= 955<br>• n= 264 specialist-led PE<br>• n= 331 teacher-led PE<br>• n= 360 control | Fourth grade learners.<br><br>Mean age: 9.49-9.62 years<br><br>United States. | Two-years PE intervention.<br><br>PE classes- 3 times a week, each for 30 min.<br><br>Health-fitness and skill-fitness activities | There were no significant effects on skinfold measurements post-intervention. |
| Kriemler, Zahner, Schindler, Meyer, Hartmann, Hebestreit, Brunner-La Rocca, van Mechelen and Puder (2010) | n= 502<br>• n= 297 intervention<br>• n= 205 control | First and fifth grade learners.<br><br>Urban and rural regions<br><br>Switzerland. | 9-month intervention school-based PA programme.<br><br>Two additional 45-min PE classes per week (5 lessons in total).<br><br>Daily three-five short PA breaks during class (2-5min each).<br><br>Daily PA homework for at least 10 min. | Intervention group had a smaller increase in sum of skinfolds (2mm) compared to control group (95% confidence interval -0.21 to -0.03) (significance not stated)<br><br>Intervention group had smaller increase in BMI compared to the control group. (significance not stated) |
| Monyeki *et al.* (2012) | n= 322 (boys only)<br>• n= 173 intervention<br>• n= 149 control | 9 to 13 years.<br><br>South Africa (Gauteng Province). | A ten-month PA intervention.<br><br>Two 30-min PA lessons per week. | Slight decrease in BF % in intervention group, but not significant.<br><br>The control group significantly increased BF % in all age groups.<br><br>BMI decreased in the intervention group, though it was non-significant. |

| Author and publication year | Sample size | Participants and demographics | Intervention duration and no. of sessions | Main findings |
| --- | --- | --- | --- | --- |
| Meyer, Schindler, Zahner, Ernst, Hebestreit, van Mechelen, Brunner-La Rocca, Probst-Hensch *et al.* (2014) | n=289 (58% of the original sample) | First and fifth grade learners.<br><br>Urban and rural regions<br><br>Switzerland. | 9-month intervention school-based PA programme.<br><br>Two additional 45-min PE classes per week (5 lessons in total).<br><br>Daily three-five short PA breaks during class (2-5min each).<br><br>Daily PA homework for at least 10 min. | Sum of skinfolds (12%) and waist circumference (10%) were significantly lower at follow-up for the intervention group 5th graders (p<0.03)<br><br>BMI did not show any significant results at follow-up, though the intervention group had lower values. |
| **Nutrition only** | | | | |
| Taljaard, Covic, Van Graan, Kruger, Smuts, Baumgartner, Kvalsvig, Wright *et al.* (2013) | n= 399<br>• n= 102 micronutrients with sugar<br>• n= 96 Micronutrients with a non-nutritive sweetener<br>• n= 100 control (non-nutritive sweetener)<br>• n= 101 control (beverage with sugar) | 6 to 11 years.<br><br>Peri-urban settlement.<br><br>South Africa (North-West Province). | 8.5 months (provided for 141 days)<br><br>National School Nutrition Programme<br><br>Consume beverages containing:<br>Micronutrients with sugar;<br>Micronutrients with a non-nutritive sweetener;<br>Control beverage with sugar or<br>Control beverage with a non-nutritive sweetener<br>Beverages (200 ml per child per day) | 11.8% of participants were stunted<br><br>14% were underweight<br><br>8.5% were wasted<br><br>After the intervention, no effects were found for HAZ and BAZ, but WAZ showed significant results, indicating a trends towards a positive direction. |

| Author and publication year | Sample size | Participants and demographics | Intervention duration and no. of sessions | Main findings |
|---|---|---|---|---|
| Graham *et al.* (2015) | n= 1390<br>• n= 570 NSNP<br>• n= 541 NSNP and TBF breakfast programme<br>• n= 276 control | Primary schoolchildren<br><br>Rural areas<br><br>South Africa (Eastern Cape Province, Lady Frere and Qumbu district). | The NSNP offers one mid-morning meal.<br>It contained a protein, one starch and one vegetable.<br><br>The TBF in-school breakfast programme provided a breakfast daily. It consisted of either a fortified sorghum, maize or oats-based porridge. | Height-for-age:<br>14.5% of learners in NSNP schools were stunted,<br>9% were stunted from schools receiving both interventions.<br>6.5% of learners from the control school were stunted.<br><br>Weight-for-age<br>There were low rates of underweight learners and no significant differences were found between the schools.<br><br>BMI-for-age<br>Learners from the control school were more overweight or obese compared to the other two groups (p=0.005). |
| **Physical activity and Nutrition** | | | | |
| Hollar, Messiah, Lopez-Mitnik, Hollar, Almon and Agatston (2010) | n= 1197<br>• n= 974 intervention<br>• n= 199 control | 6 to 13 years<br><br>Hispanic, White and Black children<br><br>USA (Osceola, Florida). | Two-year intervention (PA and nutrition)<br><br>Daily 10-15-min desk-side PA program.<br><br>Structured PA during break-time<br><br>Modifications to school-provided breakfasts, lunches, and extended-day snacks.<br><br>Fruit and vegetable gardens were implemented | Significantly more intervention than control children stayed within normal BMI percentile<br><br>More obese children in the intervention (4.4%) than in the control (2.5%) decreased their BMI percentiles, however, this was not significant. |

| Author and publication year | Sample size | Participants and demographics | Intervention duration and no. of sessions | Main findings |
|---|---|---|---|---|
| Naidoo and Coopoo (2012) | n= 798<br>• n= 633 intervention<br>• n= 165 control | Grade 6 learners<br><br>9-15 years<br><br>7 Rural, 3 peri-urban and 1 urban school<br><br>South Africa (KwaZulu-Natal). | 18-month school-based intervention programme (PA and nutrition). Did not report on nutrition.<br><br>Daily 1-min PA in class before each lesson<br><br>PA during lunch-breaks (sport and games) | Though not significant, the intervention group had a larger BMI increase post-intervention.<br><br>Intervention: 18.90 to 19.60<br>Control: 18.90 to 19.15 |
| Jacobs and Mash (2013) | n= 325<br>• n= 140 intervention<br>• n= 185 control | Grade 4 learners<br><br>Urban and rural regions (low-to middle-income communities)<br><br>South Africa (Western Cape Province). | The Making the Difference Programme (PA and nutrition)<br><br>For the curricular component of the intervention programme, EduModules were included and covered topics on PA and nutrition<br><br>Importance of exercise, healthy, balanced diet, healthy snacking and promoting PA. | Even though the MTDP did not have a significant impact on learners activity outcomes relating to nutrition and PA, it still made a small impact in their healthy eating behaviour. |
| **Physical activity, Health and Nutrition** | | | | |
| Manios, Moschandreas, Hatzis and Kafatos (1999) | n= 471<br>• n= 288 intervention<br>• n= 183 control | First and Fourth grade learners<br><br>Greece (Crete). | Three-year intervention (Health, Nutrition, Physical fitness and activity)<br><br>Two 45 min PE lessons per week<br><br>13 to 17 hours per year (health and nutrition) | The intervention group showed significantly higher average height gains compared to the control group<br><br>The control group had significantly higher mean BMI changes after intervention compare to intervention group |

The empirical studies included in the data extraction table include ten international and South African studies. The studies investigated the effects of various interventions and combinations of interventions on promoting regular PA during class and after school, improving fitness, promoting healthy dietary habits and improving children's body composition. For the purpose of this study, only the results pertaining to body composition will be discussed. From the ten studies, four studies included a PA/PE intervention only, two on nutrition only, three on PA and nutrition, and lastly, one on PA, health and nutrition.

Four studies, three international (Sallis *et al.*, 1997; Kriemler *et al.*, 2010; Meyer *et al.*, 2014) and one South African (Monyeki *et al.*, 2012), implemented a PA/PE only intervention. The interventions included PE lessons, some with added in-class activity breaks and ranged in duration from two years (Sallis *et al.*, 1997:1328) to nine months (Kriemler *et al.*, 2010:c786; Meyer *et al.*, 2014:e87930). From the four studies, three had specialist PE teachers conduct PE lessons at interventions schools (Sallis *et al.*, 1997:1329; Kriemler *et al.*, 2010:c786; Meyer *et al.*, 2014:e87930) and one study had a qualified Biokineticist conduct PE lessons (Monyeki *et al.*, 2012:244).

The common body composition indicators used by these studies were BMI and skinfold measurements. There was a non-significant decrease in BMI towards a positive direction for the intervention group in the South African study (Monyeki *et al.*, 2012:245), whereas in the two Swiss studies, though not significant, the intervention groups had smaller increases in BMI compared to the control groups (Kriemler *et al.*, 2010:c789; Meyer *et al.*, 2014:e87931).

In terms of BF%, varying results were reported. Monyeki *et al.* (2012:245) reported a small non-significant decrease in BF% in the intervention group, while the control group showed a significant increase of 4,21 in BF% at age nine. In the two Swiss studies, though a non-significant, low increase in sum of skinfold was observed in the intervention group compared to the control group, (Kriemler *et al.*, 2010:c788) and low BF% scores were maintained in 5$^{th}$ graders of the intervention group at the three-year follow-up (Meyer *et al.*, 2014:e87931). In the study of Sallis *et al.* (1997:1332), results showed non-significant effects on BF% scores post-intervention for all groups.

Two of the four PA intervention studies were able to show a tendency of improved healthy behaviour in schoolchildren through increased PA, which resulted from the increased time spent being active in PE classes (Sallis *et al.*, 1997:1331; Kriemler *et al.*, 2010:c789). Participating in regular PA may have a positive impact on body composition (Kriemler *et al.*, 2010:c790; Monyeki *et al.*, 2012:245).

Two South African studies investigated the impact of the NSNP on schoolchildren's nutritional status and overall health. Both studies reported on WAZ, HAZ and BAZ scores of schoolchildren. In addition,  both studies reflected a general trend of undernutrition in schoolchildren (Taljaard *et al.*, 2013; Graham *et al.*, 2015), with underweight being the most prevalent nutritional indicator (Taljaard *et al.*, 2013:2283). In the Eastern Cape, the NSNP together with the TBF breakfast feeding programme was evaluated in two districts to measure their impact on learners' anthropometric measurements, school attendance and performance (Graham *et al.*, 2015:11). Furthermore, a second nutrition intervention study was conducted in the North West Province which assessed the effects of the NSNP and a multi-micronutrient-fortified beverage, with and without sugar, on growth and cognition in schoolchildren (Taljaard *et al.*, 2013:2272).

In the Graham *et al.* (2015:34) study, findings indicated that both nutrition programmes had an effect on reducing underweight and wasting in schoolchildren, and stunting was lower in children receiving the TBF breakfast compared to those receiving the NSNP only. Obesity levels were reduced at control schools (these schools received the NSNP at a later stage). Post-intervention, no significant results were found for stunting and wasting, however, changes in stunting were towards a positive direction. Significant results were seen for underweight scores, with lower incidence values post-intervention due to the effect of micronutrient fortification and sugar ($p=0.026$; $p=0.043$, respectively) (Taljaard *et al.*, 2013:2280-82).

The breakfast and lunch provided the learners with nutrients that improved their nutrition status (Graham *et al.*, 2015:46-49), and both nutrition programmes (NSNP and TBF breakfast) had a beneficial impact on learners' anthropometric variables. From the results in Taljaard *et al.* (2013:2282), it can be assumed that the micronutrients and sugar may have helped increase children's energy levels, making them more active, and thus impacting on their weight gain.

Three school-based interventions investigating the effects of combined PA and nutrition programmes were reviewed. Two interventions were implemented in low-income communities in South Africa: KwaZulu Natal (Naidoo *et al.*, 2009:7) and Cape Town (Jacobs & Mash, 2013:391). A six month PA and nutrition intervention was designed to increase participation in PA during PE classes and after school and to promote healthy eating habits and a positive attitude towards PA (Naidoo *et al.*, 2009:8). Results showed improvements in learners' nutritional behaviour and PA participation during PE classes, at break-time and after school. Jacobs and Mash (2013:392) assessed the effectiveness of an existing school-based PA and nutrition intervention which was designed to improve learners' knowledge, attitudes and behaviour regarding nutrition and PA. The intervention made a small impact in the learners' healthy eating behaviour, with learners in the intervention schools eating more vegetables and carrying lunch boxes to school, and with lowered perceived barriers to PA (Jacobs & Mash, 2013:396). However, in both studies, there was no information reported on body composition.

In the USA study (Hollar *et al.*, 2010:646), a two-year intervention was implemented and consisted of structured PA during recess, modifications to school-provided breakfasts, lunches, and extended-day snacks. The intervention also had a curriculum component that focused on holistic nutrition and healthy lifestyle management. Results revealed that significantly more intervention than control children stayed within normal BMI percentile ranges both years (P = .02). More obese children in the intervention (4.4%) than in the control (2.5%) decreased their BMI percentiles, however, this was not significant.

A PA, health and nutrition education intervention implemented in primary schoolchildren in Crete over three years had a positive effect on anthropometric variables and other measured variables (Manios *et al.*, 1999:150). Average height increased in the intervention group after three years, compared to the control group. BMI and suprailiac skinfold increased but the control group had significantly higher mean changes compared to the intervention group. Overall, the PA, health and nutrition intervention with PE classes yielded positive results after three years (Manios *et al.*, 1999:154).

From the summarized results above, it can be noted that among the international studies the main concern related to body composition was more specifically focused on increasing PA levels and decreasing overweight and obesity. This is different from studies found in low-and middle-income countries, such as South Africa, where children's body composition profiles fall in both spectrums of under- and overweight (Popkin *et al.*, 2012:10).

This chapter provided an in depth discussion of the background information pertaining to children's body composition and nutritional status. It also gave information on widely used measurements to assess body composition, the methods used to obtain these measurements, as well as relevant reference data that can be utilized when comparing the current study's results. The next chapter provides a detailed description of the methods and procedures used to achieve the aims and objectives of the study.

# CHAPTER 3

# METHODS AND PROCEDURES

## 3.1 INTRODUCTION

This chapter outlines the methods and procedures used in the study. The primary aim of the study was to determine the effect of various school-based interventions on the body composition of Grade 4 learners from lower socio-economic communities in Port Elizabeth. The chapter commences with a discussion of the research design employed. This is followed by details of the population, the sampling technique and the measuring instruments used, the school-based interventions employed in the study, and the data collection process and data analysis techniques applied. Lastly, ethical considerations are discussed.

This study falls under the auspices of a larger three-year joint research project funded by the Swiss South African Joint Research Programme (SSAJRP), entitled ‘The impact of disease burden and setting-specific interventions on schoolchildren’s cardio-respiratory physical fitness and psychosocial health in Port Elizabeth, South Africa’. The larger study is a collaborative project between Nelson Mandela Metropolitan University in Port Elizabeth, South Africa, University of Basel in Switzerland and the Swiss Tropical and Public Health Institute. The methods and procedures reflected in this chapter coincide with the relevant sections of the overall protocol already published (Yap, Müller, Walter, Seelig, Gerber, Steinmann, Damons, Smith *et al.*, 2015:1285).

## 3.2 RESEARCH DESIGN

The study employed a quantitative research approach, using a cluster randomized controlled trial design. The study is part of a three-year longitudinal cohort study, 2015 to 2016, with preparatory work done in 2014 and the dissemination of results planned for 2017. The longitudinal cohort study consisted of three cross-sectional surveys (baseline, mid and final follow-up) in eight Quintile 3 primary schools in Port Elizabeth. The disease status, anthropometry and levels of physical fitness, cognitive performance and psychosocial health were measured at each survey time point. The present study was part of the first intervention phase and used the baseline (T1) and mid-follow-up (T2) data to determine the effect of school-based PA interventions on the body composition of Grade 4 children from lower socio-economic communities in Port Elizabeth (see Figure 3.1).

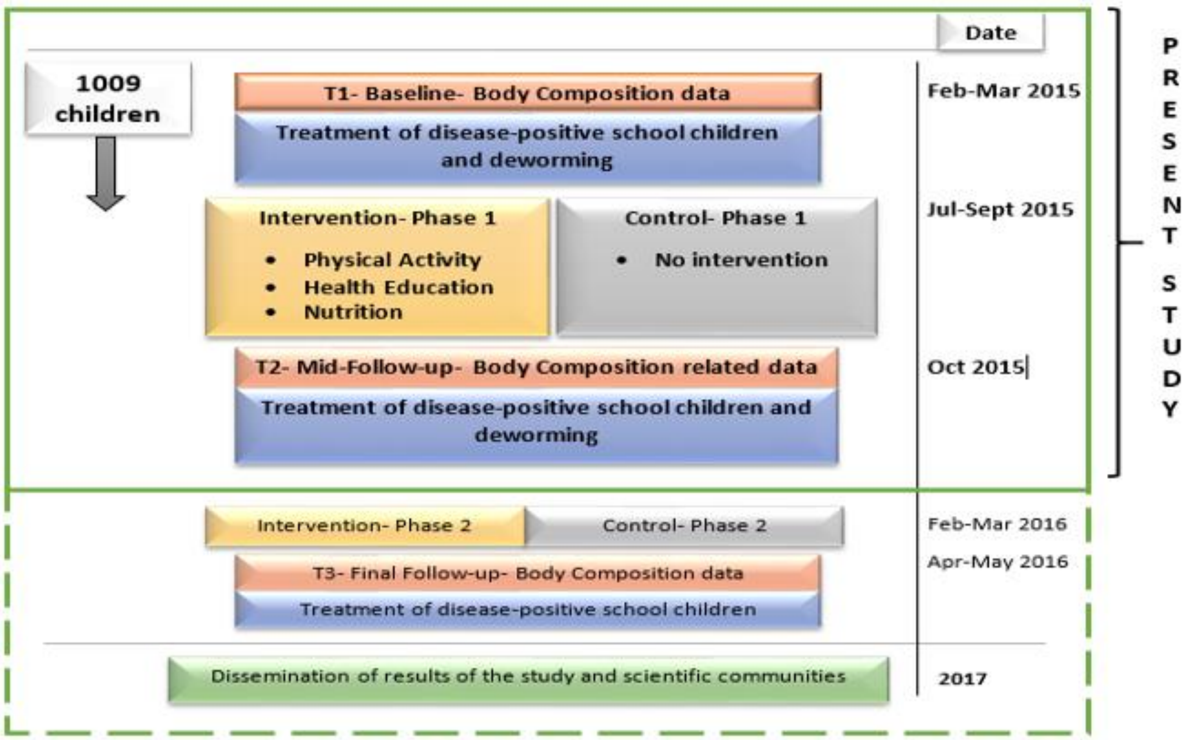


**Figure 3.1: Design and timeline of the DASH study (adapted from the DASH protocol)(Yap et al., 2015).**

### 3.3 PARTICIPANTS AND SAMPLING

A population is defined as a set or group of individuals that have characteristics that can be investigated and measured (Levy & Lemeshow, 1991:10). In research, it is difficult to study an entire population due to limited time and resources, therefore, a sample that is representative of the entire population is selected. This makes it easier for the study to be conducted (Levy & Lemeshow, 1991:11; Thomas, Silverman & Nelson, 2005:99). Participants were Grade 4 learners from eight Quintile 3 schools situated in historically Black African and Coloured areas that have been adversely affected by high unemployment rates and extreme poverty. The social challenges in these areas are as a result of injustices from past apartheid government policies as well as the current government's health and economic challenges (Walter, 2011:786; Du Plessis, 2013:80).

In South Africa, Quintiles 1 to 5 are used to classify government schools according to their socio-economic status. Categories range from Quintile 1, the poorest, to Quintile 5 the least poor schools (Kanjee & Chudgar, 2009:4). This classification allows the government to allocate funds to schools, with schools from poorer communities receiving more funds than less poor schools. The funding system is based on Quintile scores calculated from national census data for the school catchment areas, which looks at income, level of unemployment and the level of education of individuals in the community in which the school is located (Kanjee & Chudgar, 2009:4; Sayed & Motala, 2012:676). Schools from Quintile 1 to 3 categories are classified as "no fee paying schools" and therefore receive a higher subsidy than schools in Quintile 4 and 5 categories which are fee charging schools (Sayed & Motala, 2012:676).

### 3.3.1 Sampling strategy

Before the study commenced, letters with information about the project were hand delivered to 103 primary schools in the Port Elizabeth region because most schools did not have access to working fax machines and emails. Written responses were received from 25 schools who were then invited to an information sharing meeting about the project. Fifteen schools were represented at the meeting. Eight primary schools were finally selected to participate in the project based on the geographic location of schools and them having at least 100 Grade 4 learners. A meeting was held with project schools and the principals and teachers were informed about the objectives, procedures and potential risks and benefits of participating in the study. Thereafter, schoolchildren and parents/guardians of learners were informed of the study and all learners were encouraged to participate. The names and contact addresses of the main investigators on site were provided, so that they could be contacted should any questions arise about the study. Consent forms were given out to schools and were later collected at the end of the 2014 school year. Assent from the learners was also required (see Appendices 1 and 2).

Schoolchildren were selected to participate in the study if they met all the following inclusion criteria:

- Willingness to participate in the study;

- In possession of a written informed consent by a parent/guardian, as well as oral assent from the learner;
- Not participating in other clinical  trials during the study period;
- Being a primary school child in Grade 4;
- Not suffering from medical conditions which prevent participation in the study, as determined by qualified medical personnel.

The eight schools were match-paired, based on geographic location, level of helminthic infection and affiliation to a particular ethnic group. Thereafter, each school in a pair was randomly assigned to either the experimental or control groups. According to Thomas *et al.* (2005:327), the matched pair technique is an alternative way, besides random sampling, to minimize threats to internal validity.

A total of 1009 learners (with written informed consents and assents) participated in the study at baseline testing (T1). A total of 130 learners were excluded for a number of reasons, including changing schools, absenteeism and incomplete data (see Fig 3.2). A total representative sample size of 879 was used for the current study, of which 50% were boys and 50% were girls. Furthermore, 62% were Black African and 38% were Coloured.

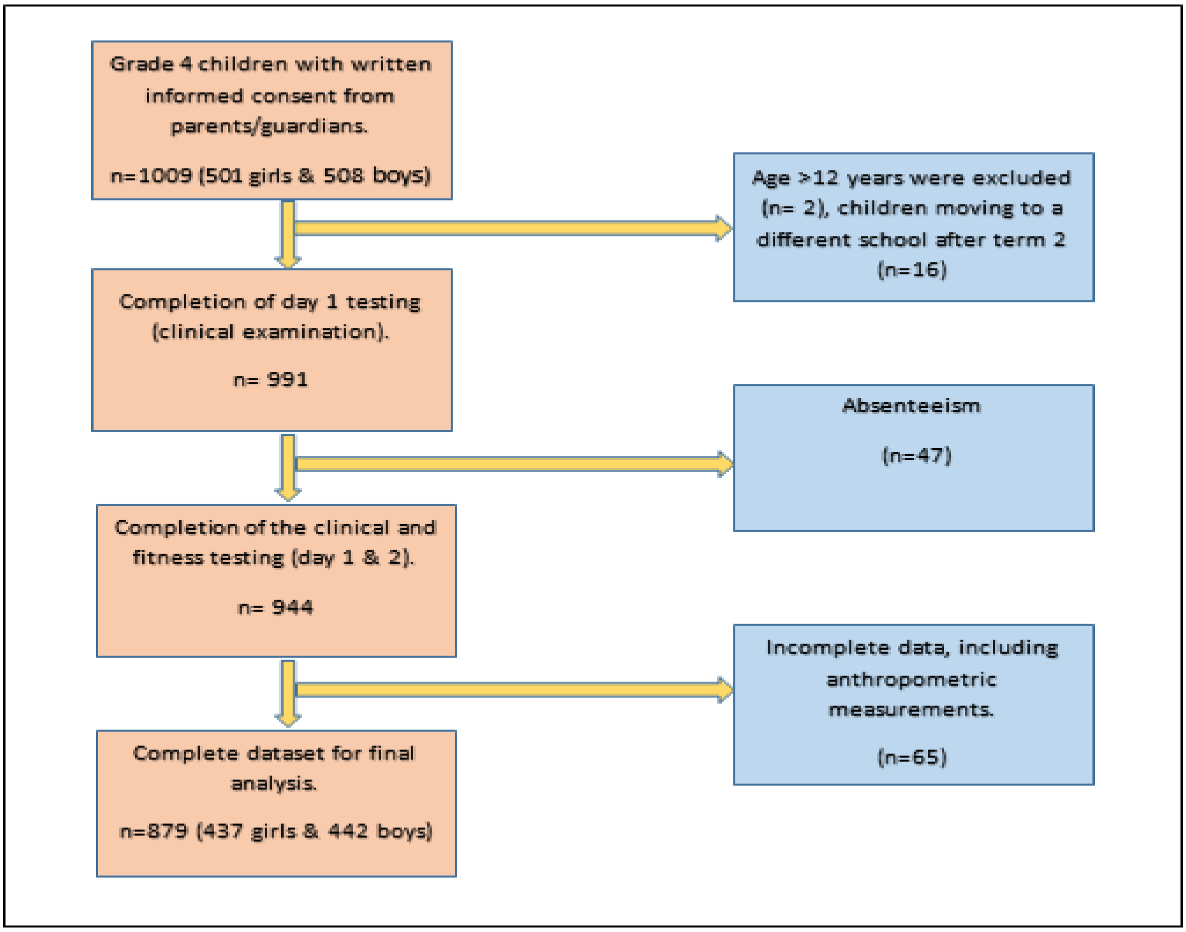


**Figure 3.2: Study cohort of Grade 4 schoolchildren**

### 3.3.2 Geographic location

The study was conducted in historically Black and Coloured primary schools from areas in Port Elizabeth (see Figure 3.3). In Port Elizabeth, areas populated by Black Africans are known as "Township areas" and those populated by Coloured people are referred to as "Northern areas". These areas are situated on the outskirts of Port Elizabeth due to forced removal of people from the central areas of the city to outlying areas (Du Plessis, 2013:1 & 2). Schools in the present study were located in the Northern areas of Hillcrest, Helenvale, Schauderville and Booysens Park and in the Township areas of Motherwell, KwaZakhele and Walmer. Township schools consist only of Black African, Xhosa speaking learners, whereas two schools in the Northern areas (Schauderville and Booysens Park) had a combination of Coloured (Afrikaans and English speaking) and Black African (Xhosa speaking) learners.

Schools were referred as E (experimental) and C (control) schools. The numbers 1 to 4 were based on the four objectives of the study, with schools E1 and C1 being the first pair of schools in the objectives listed in Chapter 1. Since one of the criteria for pairing schools was geographic location and ethnicity, schools E1, C1, E3 and C3 were located in Township areas with only Black African learners. Schools E2, C2, E4 and C4 were located in the Northern areas, however, schools E2 and C2, located in the Northern areas had both Black African and Coloured learners. This allowed the two schools to be paired together as they presented with a mixed learner population.

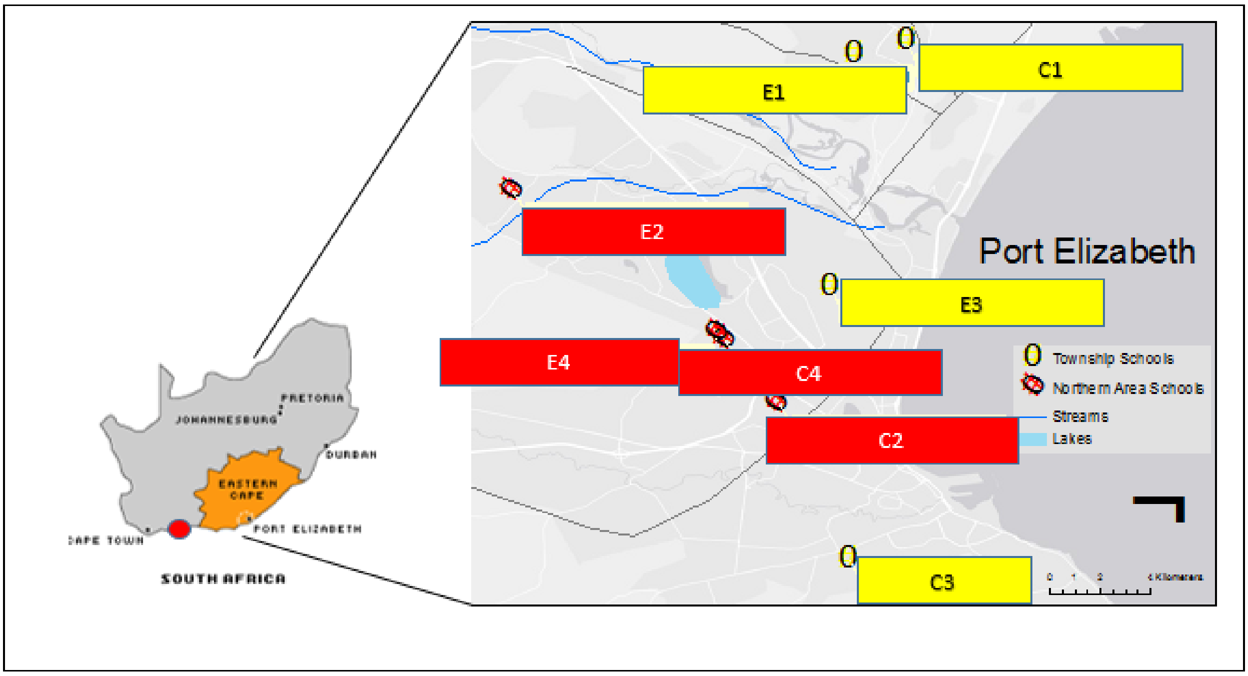


**Figure 3.3: Geographic location of the four experimental (E) and four control (C) schools (adapted from the DASH protocol) (Yap et al., 2015)**

## 3.4 GROUPING OF SCHOOLS AND RELEVANT INTERVENTIONS ALLOCATED

The eight schools were match paired and each of the pairs allocated either experimental or control group status. The match pairing of schools was based on similar geographic location, level of helminthic infection and affiliation to a particular ethnic group. Various combinations of the intervention were allocated to different schools based on findings of the baseline study (see table 3.1). However, all of the participating schools received the medication treatment for helminthic infections, including the control group.

**Table 3.1: Grouping of schools with the relevant interventions allocated**

| Experimental Group | Control Group | School Area |
|---|---|---|
| E1 (n= 86)<br>• Physical Activity Intervention<br>• Deworming medication | C1 (n= 112)<br>• Deworming medication | **Township area** |
| E2 (n= 101)<br>• Physical Activity Intervention<br>• Health and Hygiene, and Education Intervention<br>• Deworming medication | C2 (n= 96)<br>• Deworming medication | **Northern Area** |
| E3 (n= 87)<br>• Health and Hygiene Education Intervention<br>• Nutrition Intervention<br>• Deworming medication | C3 (n= 147)<br>• Deworming medication | **Township area** |
| E4 (n= 168)<br>• Physical Activity Intervention<br>• Health and Hygiene, and Education Intervention<br>• Nutrition Intervention<br>• Deworming medication | C4 (n= 82)<br>• Deworming medication | **Northern Area** |

## 3.5 MEASURING INSTRUMENTS

The following anthropometric variables were assessed for the present study: weight (kg), height (cm), and skinfolds (mm) at two sites. From the measured anthropometric variables the following variables were subsequently calculated: BMI, BF%, BMI-for-age z-score (BAZ), height-for-age z-score (HAZ), and weight-for-age z-score (WAZ). Details pertaining to these anthropometric measurements and calculated variables are described in the following section.

These variables were all measured by qualified Biokineticists according to the standards of the International Society for the Advancement of Kinanthropometry (ISAK) (Norton & Olds, 2006:25-76). Research assistants were used during the testing period. The assistants were trained before testing commenced and were informed about the testing procedure and taught how to scribe for the researchers.

The measuring instruments and relevant protocols to assess the identified variables are discussed with reference to the following:

- Reference of measurement
- Purpose of measurement
- Equipment used
- Measuring procedure
- Number of trials
- Scoring
- Reliability and validity

### 3.5.1 Body weight

**Reference of measurement:** (Norton & Olds, 2006:37).

**Purpose of the measurement:** To measure the overall body weight of the participant and to provide information pertaining to one of the variables required to calculate BMI of the participants.

**Equipment used:** A calibrated digital weighing scale (Micro T7E Scalemaster electronic platform scale) was used (Figure 3.4).

**Measuring procedure:**

- The digital weighing scale was placed on level ground during the assessment, and checked that it was reading zero to ensure accurate results.
- Weight was taken with the participants wearing minimal clothing, each participant was asked to take his/her shoes and school jersey off before the measurement was taken.
- Participants were instructed to stand in the center of the scale with minimal movement, no support and weight evenly distributed on both feet.
- The head had to be up and eyes looking directly ahead when the measurement was recorded.

**Number of trials:** One measurement was taken.

**Scoring:** A value was recorded once the number on the scale was stable. Body weight was measured in kilograms to the nearest 0.1 kg.

**Reliability and validity:** Face validity is accepted. If a qualified individual takes an anthropometric measurement, it is considered reliable.

**Figure 3.4: Micro T7E electronic platform scale**

### 3.5.2 Height

**Reference of measurement:** (Norton & Olds, 2006:35-37).

**Purpose of the measurement:** This is a measurement of maximum distance from the floor to the highest point on the head (the vertex). The standing height was measured as part of description of the sample as well as to calculate BMI of the participants.

**Equipment used:** Body height was taken with a Seca portable stadiometer model 213 (see Figure 3.5).

**Measuring procedure:**

- With the shoes off, each participant stood against a stadiometer with his/her feet together, back erect and shoulders relaxed.
- The participant's feet, buttocks and upper part of the back were required to make contact with the stadiometer for the measurement to be taken.

- Weight was distributed evenly on both feet and the head held in the Frankfurt plane.
- The researcher lowered the moveable arm of the stadiometer to the vertex, applying gentle pressure to compress hair before taking the measurement.

**Number of trials:** One measurement was taken.

**Scoring:** A measurement was recorded after the moving arm of the stadiometer was placed on the participant's head, recorded to the nearest 0.1 cm.

**Reliability and validity:** Face validity is accepted. If a qualified individual takes an anthropometric measurement, it is considered reliable.

**Figure 3.5: Seca portable stadiometer (model 213)**

### 3.5.3 Skinfolds

Two skinfold measurements were assessed, namely triceps and subscapular skinfolds. The relevant skinfold site was carefully located using the correct anatomical landmarks. The skinfold was grasped and lifted so that a double fold of skin along with the underlying subcutaneous adipose tissue was held between the thumb and index finger.

#### *3.5.3.1 Triceps skinfold*

**Reference of measurement:** (Norton & Olds, 2006:38-39).

**Purpose of the measurement:** Skinfolds were measured in order to determine the participants' total BF% and further indicate their body composition.

**Equipment used:**

- A calibrated Harpenden Skinfold Caliper (see Figure 3.6) and a flexible steel measuring tape (see Figure 3.7) was used to take measurements.
- The skinfold caliper has a constant spring pressure of $10g/mm^{-2}$ through its entire range.

**Measuring procedure:**

- Before the measurement was taken, the researcher showed the Harpenden skinfold caliper to the participant and clamped it normally on the participant's finger to show that the process would not hurt.
- During the measurement, the participant stood with arms and shoulders relaxed. The researcher located the landmarks by palpating the acromiale and radiale landmarks and using a steel measuring tape to find the mid-distance between the two landmarks (mid-acromiale-radiale) and marking the most posterior part with a pen.
- With the thumb and forefinger, the researcher gently pinched the skin (a vertical skinfold) slightly above the middle of the back of the arm (triceps) and clipped the caliper at approximately 1 cm below the thumb and forefinger (mouth of caliper perpendicular to the long axis of the skinfold at all times).
- The skinfold measurement was taken after two seconds and the whole process repeated three times. This was done to reduce compressibility of the skinfold and to ensure validity.
- The three values obtained had to be no more than ±5% different from each other. If this was not the case, the measurements had to be repeated.

**Number of trials:** Three measurements were taken and averaged.

**Scoring:** A skinfold reading was taken after two seconds and the value was recorded in millimeters to the nearest 0.1mm. The final reading was taken as an average of the three values.

**Reliability and validity:** Face validity is accepted. If a qualified individual takes an anthropometric measurement, it is considered reliable. Reliability of skinfolds rely on the individual's skill level, so the individual taking the measurement has to be trained.

#### *3.5.3.2 Subscapular skinfold*

**Reference of measurement:** (Norton & Olds, 2006:47).

**Purpose of the measurement:** Skinfolds were measured in order to determine the participants' total BF% and further indicate their body composition.

**Equipment used:**

- A calibrated Harpenden Skinfold Caliper (see Fig 3.6) and a flexible steel measuring tape (see Fig 3.7) was used to take measurements.
- The skinfold caliper has a constant spring pressure of $10g/mm^2$ through its entire range.

**Measuring procedure:**

- Before the measurement was taken, the researcher showed the Harpenden skinfold caliper to the child and clamped it normally on the child's finger to show that the process would not hurt.
- The participant stood erect with arms relaxed by the sides. The researcher palpated the inferior angle of the scapula to locate the lower-most tip and mark it with a pen.
- A steel measuring tape was used to mark 2 cm adjacent to the tip in a line running obliquely and laterally at 45 degrees. With the thumb and forefinger, the researcher gently pinched the skin (an oblique skinfold) and clipped the caliper at approximately 1 cm below the thumb and forefinger.

- After counting for two seconds, the reading was taken and the value recorded. The skinfold measurement was taken three times. This was done to reduce compressibility of the skinfold and to ensure validity.
- The three values obtained had to be no more than ±5% different from each other. If this was not the case, the measurements had to be repeated

**Number of trials:** Three measurements were taken and averaged.

**Scoring:** A skinfold reading was taken after two seconds and the value was recorded in millimeters to the nearest 0.1mm. The final reading was calculated as an average of the three values.

**Reliability and validity:** Face validity is accepted. If a qualified individual takes an anthropometric measurement, it is considered reliable. Reliability of skinfolds rely on the individual's skill level, so the individual taking the measurement has to be trained.

**Figure 3.6: Harpenden Skinfold Caliper**

**Figure 3.7: Flexible steel measuring tape**

## 3.6 CALCULATED VARIABLES

The anthropometric measurements described above needed further calculations in order for the researcher to interpret and compare these to normative values. Specific equations were used to calculate these variables and these indicators of body composition and nutritional status are described below.

### 3.6.1 Body Fat Percentage

Triceps and subscapular skinfolds were the two variables used to calculate the percentage of body fat using the following equations (Slaughter, Lohman, Boileau, Horswill, Stillman, Van Loan & Bemben, 1988:719) which are internationally accepted for children 8 to 18 years old:

- For girls: BF% = 1.33 (triceps + subscapular) - .013 $(\text{triceps + subscapular})^2$ – 2.5
- For boys: BF% = 1.21 (triceps + subscapular) - .008 $(\text{triceps + subscapular})^2$ – 3.2

For the sum of triceps and subscapular >35 mm, the following equation is used to calculate BF%:

- For girls: BF% = .546 (triceps + subscapular) + 9.7
- For boys: BF% = .783 (triceps + subscapular) + 1.6

### 3.6.2 BMI

BMI is known as the measure of body mass relative to height (Hoeger & Hoeger, 2013:127) and it is a measure of body composition. BMI was calculated using the following formula:

- BMI ($kg/m^2$) = weight (kg) / (standing height in meters (m))$^2$

### 3.6.3 WAZ, HAZ and BAZ cut-off values

The z-score classification system was used to interpret the following body composition/nutrition indicators: WAZ; HAZ; and BAZ. Z-scores express the anthropometric value as a number of standard deviations or Z-scores above or below the reference mean value. The World Health Organization (WHO) AnthroPlus software was used to assess the children's growth (Naidoo & Coopoo, 2012).

The following formula was used to calculate z-scores (WAZ, HAZ and BAZ) (WHO, 1995:7):

- $$\text{Z-score} = \frac{\text{observed value - median value of the reference population}}{\text{Standard deviation value of reference population}}$$

#### *3.6.3.1 WAZ*

Weight-for-age z-score values were calculated and used to identify underweight children. Cut-off values for WAZ are tabulated below.

**Table 3.2: Weight-for-age z-score (WAZ) cut-off values for underweight**

| **Classification** | | **Condition** | **Indicator and cut-off** | |
|---|---|---|---|---|
| | | | Birth to 60 months | 61 months to ten years |
| **Based on weight** | Weight-for-age z-score (WAZ) | Underweight | < - 2 SD | < - 2 SD |

Adapted from WHO (2007) Growth Reference for school-aged children and adolescents: http://www.who.int/growthref/en/

Weight-for-age (WAZ) beyond ten years is not a good indicator for monitoring growth past the childhood stage as it fails to distinguish between relative height and body mass in an age period where many children are going through a pubertal growth spurt and may appear to be overweight (by weight for age), when they are just tall (de Onis, Onyango, Borghi, Siyam, Nishida & Siekmann, 2007:665).

#### *3.6.3.2 HAZ*

Height-for-age z-score values were calculated and used to classify stunting levels in children. Cut-off values are tabulated in Table 3.3.

**Table 3.3: Height-for-age z-score (HAZ) cut-off values for stunting**

| Classification | | Condition | Indicator and cut-off | |
|---|---|---|---|---|
| | | | Birth to 60 months | 61 months to 19 years |
| **Based on height** | Height-for-age z score (HAZ) | Stunting | < - 2 SD | < - 2 SD |

Adapted from WHO (2007) Growth Reference for school-aged children and adolescents: http://www.who.int/growthref/en/

#### *3.6.3.3 BAZ*

BAZ was calculated and used to identify overweight and obesity in children. Table 3.4 shows the cut-off values for BAZ in children from 5-19 years of age. BAZ is used to classify children as thin, overweight or obese.

**Table 3.4: BMI-for-age z-score (BAZ) cut-off values for obesity and thinness**

| Classification | Condition | Age 5-19 years indicator and cut-off |
|---|---|---|
| **Based on BMI** | Obese | BMI-for-age z-score > +2SD (equivalent to BMI 30kg/m$^2$ at 19 years |
| | Thinness | BMI-for-age z-score < -2SD to -3SD |

Adapted from WHO (2007) Growth Reference for school-aged children and adolescents: http://www.who.int/growthref/en/

### 3.7 SCHOOL-BASED INTERVENTION

Based on the findings from baseline testing, a toolkit of setting specific interventions were developed and designed by the DASH study team from NMMU and Basel

University. The toolkit consisted of three main components, namely: a PA intervention; a health and hygiene education intervention; and a nutrition intervention. The intervention duration was ten weeks (July to mid-September 2015). The equipment and learning material required to conduct the PA intervention as well as the health and hygiene education and nutrition intervention were provided by the research team to each intervention school.

Prior to the implementation of the intervention at schools, a two-day workshop was held for life skills teachers and classroom teachers from the four intervention schools. Teachers were presented with all the information and material needed to conduct the intervention programme. On the first day, only the health and hygiene education and nutrition intervention was presented. The workshop was interactive and teachers had to participate in activities (e.g. demonstrate handwashing as they would to their learners). The second day focused on the PA intervention and included demonstrations of PE lessons, with the assistance from a qualified PE teacher.

### 3.7.1 PA intervention

The PA intervention consisted of four components: (i) two weekly 40 minute PE lessons; (ii) one weekly 40 minute dancing-to-music lesson; (iii) regular in-class activity breaks; and (iv) adaptation of the school playground to provide a PA friendly environment. The research team monitored the schools on a weekly basis and provided schools with equipment such as: skipping ropes, bean bags, relay batons, tennis balls, soccer and netball balls, hoola-hoops, colour bands, cones, a whistle and a stopwatch. Below is a description of the four components included in the PA intervention:

#### *3.7.1.1 PE lessons*

The intervention entailed two 40 minute PE lessons per week presented during school hours. These lessons were taught by life skills teachers (none of whom were PE specialists). To assist teachers, a trained PE teacher was used to teach one lesson out of the two weekly lessons. Thereafter, the classroom teachers taught the second lesson alone without assistance. The teachers received a printed manual containing PE lesson plans, information about the benefits of PA, PA recommendations for children, and ideas on how to manage a large PE class. As mentioned before a demonstration lesson by a qualified PE teacher was conducted at each school in the first week of the intervention. This was done again after two weeks. The DASH study team developed 20 PE lesson plans (see example in Appendix 3) which consisted of the following:

- Introduction and Warm-up (5 to 10 minutes) – this comprised a low-intensity aerobic activity to prepare the muscles for activity. Dynamic stretches also formed part of the warm-up to promote flexibility. Examples include whistle freeze, traffic lights, Simon says, follow the leader and practice grouping and formation.
- Fitness component (10 to 15 minutes) – this incorporated the following components of physical fitness, namely cardiorespiratory endurance, muscular strength, and muscular endurance and body composition. Examples included a running circuit, team relay, and fitness exercise circuit and timed team relays.
- Modified Invasion Games (10 to 15 minutes) – this introduces the learners to sport specific skills through modified games and team sports such as soccer and netball. Examples include hand soccer, robbing the nest and piggy in the middle.
- Cool-down (5 to 10 minutes) – this involved slow moving activities and static stretches to help the heart and body return to a normal state.

#### *3.7.1.2 Dancing-to-music lessons*

The dancing lessons consisted of one weekly 40 minute lesson presented after school hours to the whole grade (ranging from 80 to 160 learners at one time). The dancing lesson was conducted by NMMU dance students. Lessons were structured with a fast paced dance in the beginning as a form of a warm-up, followed by aerobic type dance to music. The lesson ended with a cool-down routine to music.

#### *3.7.1.3 In-class PA breaks*

This entailed regular PA breaks (two to three times a day) incorporated into the school day and presented for two to three minutes between lessons. These activities were done to help with learner's concentration in class. Classroom teachers were responsible for selecting a few exercises to be done each day. Posters were provided and hung up in class (see example in Appendix 3), illustrating the various in-class PA exercises.

#### *3.7.1.4 PA friendly playground*

Finally, to create a PA friendly environment at schools, playgrounds were adapted in order to promote PA during break time and after school. This included activity stations (monkey bars, jungle gym and tyre obstacles) and a variety of painted games (refer to Appendix 3).

### 3.7.2 Health and hygiene education intervention

The health and hygiene education intervention consisted of three components: (i) lesson plans; (ii) handwashing; and (iii) upgrade of school toilets. The research team provided schools with teacher manuals and material for the intervention. Below is a description of the three components entailed in the health and hygiene education intervention:

#### *3.7.2.1 Health and hygiene education lessons*

The health and hygiene education intervention included lessons covering seven topics that were taught by classroom teachers during class time as part of the school curriculum. Classroom teachers received a printed manual containing information about health and hygiene topics. Each topic comprised of a lesson plan, class tasks to be completed by learners and health promoting posters to be displayed in class (see handwashing poster in Appendix 4). The health and hygiene education lessons covered the following topics:

- Intestinal parasites: This consisted of two lessons about parasites that may be found in the stomach. Learners also learnt about why they may have these parasitic infections and ways to prevent infections (wearing shoes when walking on soil, washing hands before and after eating, after using the toilet, and drinking clean water).
- Handwashing: This lesson focused on encouraging learners to wash their hands properly before eating, after using the toilet, after playing outside, and after sneezing and coughing. This raised awareness about how to prevent the

spreading of germs from dirty hands. They also learnt about washing hands before preparing food.

- Little toilet experts: This consisted of two lessons. It focused on teaching the children about the different types of toilets and included assessment of their school and home toilets to see if they are in good condition.
- Detecting germs (germ detective): The purpose was to raise awareness about germs and their occurrence at school and at home.
- Clean water and food: This lesson was to raise awareness about safe handling, storing and preparing of raw fruits and vegetables.

#### *3.7.2.2 Handwashing*

In addition to the health and hygiene education lesson plans provided to schools, each of the intervention schools received washing basins and handwashing soap for all Grade 4 classes. This was to encourage the learners to wash their hands regularly and teach them the importance of handwashing to prevent the spread of germs. The classroom teachers had to monitor and remind their learners to wash their hands.

#### *3.7.2.3 Upgrade of school toilets*

Three schools were involved in the health and hygiene intervention. Two of the schools had newly renovated toilets, funded by the department of education, whereas one of the schools needed an upgrade. Prior to the intervention, the project participated in an upgrading of the third schools' toilets to support the health and hygiene intervention. The upgrade entailed painting of walls and floors, and repairs to toilets to ensure they were functioning and safe to use.

### 3.7.3 Nutrition intervention

The nutrition intervention consisted of three components: (i) evaluation of the NSNP; (ii) weekly lesson plans; and (iii) supplementation programme. The research team provided schools with teacher manuals and material for the intervention. Below is a description of the three components included in the nutrition intervention:

#### *3.7.3.1 Evaluation of the NSNP*

The NSNP was evaluated at the eight project schools. The analysis identified the following common areas of weakness: food preparers had no training in basic hygiene; they used the same utensils for meat and vegetables; and the schools lacked basic kitchen utensils. The intervention took these weaknesses into consideration and basic cooking utensils were donated by the project to the two school (cutting boards and knives). Additionally, a qualified dietitian conducted training for food preparers, which consisted of basic hygiene and safety in food handling and preparation.

#### *3.7.3.2 Nutrition lessons*

In addition to the training of food preparers, lessons for nutrition education were developed by the research team. The nutrition intervention comprised of lessons covering six topics and was taught by classroom teachers during class time as part of the school curriculum. Classroom teachers received a printed manual containing information about nutrition and healthy eating. Each topic consisted of a lesson plan, class tasks for learners and posters to be displayed in class every week (see example in Appendix 5). The following topics were covered:

- Eat well - food groups: Fruit and vegetables, carbohydrates, protein, fat, sugar and salt). Learners had to complete a class task (crossword puzzle) about food groups.
- Carbohydrates: This lesson focused on the sources of carbohydrates, their importance and their function.
- Fruit and vegetables: The focus of the lesson was on the importance of eating fruit and vegetables every day and their function (they boost energy, strengthen the immune system, and provide vitamins and minerals).
- Protein: The focus of the lesson was on the different types of proteins and their function (for growth, improvement of the immune system, giving strong teeth and bones). The learners had to do a crossword task about food sources of protein.
- Fat, sugar and salt: The lesson focus was on different types of fat (good and bad fat) and what children should eat. There were examples of foods that have high sugar (sweets, chocolate and cool-drinks) and how these foods are

harmful to their teeth. The last part was about salt and how a high consumption of salt causes high blood pressure (hypertension).

- Lunch box and plates: This lesson was used to recap the previous lessons on food groups and what a food plate should look like. Additionally, the learners were taught about what their school lunch box should have, as well as healthier food options.

#### *3.7.3.3 Supplementation*

Additionally, a UNICEF approved nutritional supplement was given to schools. The RUSF is a peanut butter based supplement in vegetable oil and has added vitamins, minerals and protein and comes in a sachet. The learners had to consume one sachet daily and they were requested to ingest it slowly over a 30 minute period at the beginning of the school day.

## 3.8 DEWORMING MEDICATION

In addition to the three intervention components developed for intervention schools, a deworming programme was implemented for all eight participating schools. From the results obtained from the laboratory testing, affected learners from both the experimental and control schools were treated for soil-transmitted helminth infections (STH) based on the World Health Organization's treatment guidelines (Crompton, 2006:10-41):

> When STH infections are less than 20%, infected individuals are to be provided treatment on a case by case basis. When STH infections are equal or more than 20% but less than 50%, mass treatment (with a single dose of Albendazole 400mg) are to be administered. When STH infections are equal to or more than 50%, mass treatment is administered and should be repeated within the same year.

## 3.9 DATA COLLECTION

In order to conduct the study at primary schools in Port Elizabeth, permission was sought from and granted by the NMMU Research Ethics Committee (reference no. H14-HEA-HMS002), Eastern Cape Department of Health (DoH) and Department of Education (DoE) (refer to Appendices 6, 7 and 8).

The data collection process commenced on 17 September 2015. Testing was conducted on the respective schools' premises during school hours, with Grade 4 teachers helping to supervise the learners. Explanations and demonstrations were given prior to starting with the testing procedure in order to help with the smooth running of the day. The present study formed part of a broader study which focused on clinical and physical assessments, which was conducted over two days. Anthropometry, which included height, weight, and skinfold measurement, and which is part of the current study was assessed on day one (data collection sheet in Appendix 9). Physical fitness tests were conducted on day two. In addition, the cognitive and psychosocial tests were done in the classroom during day one and completed on day two.

## 3.10 STATISTICAL ANALYSIS

A qualified statistician based at the Nelson Mandela Metropolitan University was consulted for assistance with the analysis and interpretation of the data obtained. Descriptive statistics were used to describe and analyse body composition and other anthropometric data. Measures of central tendency (mean and median) and measures of distribution (range and standard deviation) were used for this purpose. Inferential statistics were used to compare the control and experimental groups in respect to pre- and post-test results. A t-test was used to determine whether observed mean differences between two variables were significant. Where statistical significance was identified, practical significance by means of a Cohen's d tests was applied. Chi-square tests and Cramér's V tests were also used to determine significant statistical and practical differences between categorical variables, respectively. Practical significance was interpreted according to the following criteria: for Cohen's d: $d<0.2$ not significant; $0.2\leq d<0.5$ small; $0.5\leq d<0.8$ medium and $d\geq0.8$ large, and for Cramér's V: $V<0.1$ not significant; $0.1\leq V<0.30$ small; $0.3\leq V<0.5$ medium; and $V\geq0.5$ large (Gravetter & Wallnau, 2016:253 & 586).

## 3.11 ETHICAL CONSIDERATIONS

Ethics are concerned with conducting research in a way that respects the dignity of participants, avoiding any practices that could cause harm to participants in a study. This is done by appropriately applying the four pillars of ethics (autonomy, beneficence, non-malificence and justice) (Orb, Eisenhauer & Wynaden, 2001). These principles should be upheld in order to ensure that participants are not harmed and that they benefit from the study and their confidentiality and anonymity are maintained.

The current study involved the participation of children under the age of 18 years, therefore certain additional ethical considerations needed to be adhered to. The following principles were considered and explained to the parents/guardians of the concerned children as well as to the children.

*Voluntary participation:* No one would be forced to take part in the research study and participation was voluntary at all times (de Vos, Strydom, Fouche & Delport, 2011). Although learners were encouraged to participate in the study, it was explained to each child that participation is voluntary and if they wish to withdraw from the study at any point in time, there would be no further consequences.

*Informed consent and assent:* A consent form (Appendix 1) and an assent form (Appendix 2) were given to parents/guardians and children, with information about the aims of the study and its duration. The procedures which were to be followed during the study as well as possible advantages and disadvantages they may have been exposed to were clearly explained. Parents/guardians were required to sign individual written consent for the participation of their child, and children were required to give oral assent prior to participating in the study.

*Privacy/Anonymity/Confidentiality:* A unique identity number was allocated to each participant to keep the personal data anonymous and the information collected was stored in a safe place. It was explained that all the data collected would be used exclusively for scientific research and only key findings would be reported. When publishing the findings of the study it was undertaken that no names or personal identities would be revealed.

*Actions and competence of researcher*: The investigator has undertaken the investigation in an honest, accurate manner and did everything possible to ensure competent reporting of the findings of the study. All authors and sources used in this research report have been acknowledged in the references, including where citations were used.

Prior to data collection, a proposal was submitted to both the NMMU Department of Human Movement Science Research Committee and the Faculty Postgraduate Studies Committee to obtain permission for the research. The authorization to carry out the larger project was obtained from the following committees.

- NMMU Faculty Research, Technology and Innovation Committee
- NMMU Research Ethics Committee: Human (REC-H)
- Eastern Cape Department of Health
- Eastern Cape Department of Education (to conduct research at schools)

In summary the content of this chapter reflects a detailed description of the testing methods and procedures utilized in the study and they are aligned with the aim and objectives set for the study. This chapter also provided an explanation of the processes followed during data collection as well as ethical considerations adhered to. The next chapter provides a detailed description of the results obtained from the study.

# CHAPTER 4

# RESULTS

## 4.1 INTRODUCTION

Chapter 4 presents the results of the study which aimed to explore, describe and compare the effect of various combinations of school-based interventions (PA, Health Education and Nutrition) on the body composition of Grade 4 children from lower socio-economic communities in Port Elizabeth. Eight schools participated in the study, with four schools assigned to the experimental group (E1 – E4) and match-paired to four control group schools (C1 – C4). This chapter provides descriptive statistics pertaining to the entire participant group before focusing on the outcome of inferential statistical analyses to determine the effect of the various interventions on body composition.

## 4.2 PARTICIPANT INFORMATION

### 4.2.1 Descriptive statistics in respect of age, gender and ethnicity distribution over experimental and control schools

#### *4.2.1.1 Age*

Table 4.1 reflects the distribution of the participants according to two age categories for each of the eight schools (four experimental and four control schools) involved in the study at pre-intervention (T1).

**Table 4.1: Descriptive statistics of age distribution for experimental and control schools in T1**

| School | Age Category T1 | | | | | |
|---|---|---|---|---|---|---|
| | 8 – 9 years | | 10 – 11 years | | Total | |
| E1 | 57 | 66% | 29 | 34% | 86 | 100% |
| C1 | 91 | 81% | 21 | 19% | 112 | 100% |
| E2 | 73 | 72% | 28 | 28% | 101 | 100% |
| C2 | 70 | 73% | 26 | 27% | 96 | 100% |
| E3 | 44 | 51% | 43 | 49% | 87 | 100% |
| C3 | 87 | 59% | 60 | 41% | 147 | 100% |
| E4 | 53 | 32% | 115 | 68% | 168 | 100% |
| C4 | 40 | 49% | 42 | 51% | 82 | 100% |
| Total | 515 | 59% | 364 | 41% | 879 | 100% |

Table 4.1 reflects that almost 60% of the children from both the experimental and control schools fell in the younger age category (8-9 years old). School groups 1 to 3 reflected the mean distribution of age, but for schools E4 and C4 the majority of the participants fell in the older, 10-11 year age group. When looking at the age distribution between experimental and control schools, the control group schools (C1 to C3) had a larger distribution of learners in the younger age group (8-9 years old), compared to their respective intervention group schools. While the experimental group had a larger distribution of learners in the older, 10-11 year, age group.

#### *4.2.1.2 Gender*

Table 4.2 shows gender distribution within the experimental and control schools.

**Table 4.2: Descriptive statistics of gender distribution for experimental and control schools**

| School | Gender | | | | | |
|---|---|---|---|---|---|---|
| | Boys | | Girls | | Total | |
| E1 | 38 | 44% | 48 | 56% | 86 | 100% |
| C1 | 57 | 51% | 55 | 49% | 112 | 100% |
| E2 | 48 | 48% | 53 | 52% | 101 | 100% |
| C2 | 44 | 46% | 52 | 54% | 96 | 100% |
| E3 | 45 | 52% | 42 | 48% | 87 | 100% |
| C3 | 80 | 54% | 67 | 46% | 147 | 100% |
| E4 | 87 | 52% | 81 | 48% | 168 | 100% |
| C4 | 43 | 52% | 39 | 48% | 82 | 100% |
| Total | 442 | 50% | 437 | 50% | 879 | 100% |

The gender of children from experimental and control schools was relatively evenly distributed, with all schools having approximately 50% girls and 50% boys.

#### *4.2.1.3 Ethnicity*

Table 4.3 reflects the distribution of the two ethnic groups participating in the study.

**Table 4.3: Descriptive statistics of ethnicity distribution for experimental and control schools**

| School | Ethnicity | | | | | |
|---|---|---|---|---|---|---|
| | Black African | | Coloured | | Total | |
| E1 | 86 | 100% | 0 | 0% | 86 | 100% |
| C1 | 112 | 100% | 0 | 0% | 112 | 100% |
| E2 | 67 | 66% | 34 | 34% | 101 | 100% |
| C2 | 50 | 52% | 46 | 48% | 96 | 100% |
| E3 | 87 | 100% | 0 | 0% | 87 | 100% |
| C3 | 146 | 99% | 1 | 1% | 147 | 100% |
| E4 | 1 | 1% | 167 | 99% | 168 | 100% |
| C4 | 0 | 0% | 82 | 100% | 82 | 100% |
| Total | 549 | 62% | 330 | 38% | 879 | 100% |

Frequency distribution in Table 4.3 shows that 62% of the children were Black African and 38% were Coloured. One of the criteria for pairing the schools was ethnicity.

Geographical location was the other criterium used. All the experimental schools were match paired with control schools with children of the same ethnicity and geographical location. However, schools E2 and C2 were the only schools that had a mix of both ethnicities, which is the reason they were paired together.

### 4.2.2 Descriptive statistics in respect of underweight; stunting; and thinness, normal weight and obesity prevalence over experimental and control schools

#### *4.2.2.1 Underweight*

Table 4.4 and 4.5 reflect the distribution of the participants according to underweight prevalence for each of the eight schools (four experimental and four control schools) involved in the study at pre-intervention (T1) and post-intervention (T2) respectively. A WAZ value of < -2 z-scores is considered as an indicator of underweight.

**Table 4.4: Descriptive statistics of underweight prevalence for experimental and control schools in T1**

| School | Underweight T1 | | | | | |
|---|---|---|---|---|---|---|
| | No | | Yes | | Total | |
| E1 | 58 | 98% | 1 | 2% | 59 | 100% |
| C1 | 91 | 99% | 1 | 1% | 92 | 100% |
| E2 | 75 | 96% | 3 | 4% | 78 | 100% |
| C2 | 68 | 94% | 4 | 6% | 72 | 100% |
| E3 | 45 | 98% | 1 | 2% | 46 | 100% |
| C3 | 88 | 97% | 3 | 3% | 91 | 100% |
| E4 | 45 | 80% | 11 | 20% | 56 | 100% |
| C4 | 34 | 81% | 8 | 19% | 42 | 100% |
| Total | 504 | 94% | 32 | 6% | 536 | 100% |

Table 4.4 reflects that only 6% of the children from experimental and control schools were underweight, with schools E4 and C4 having the highest prevalence of underweight in children at pre-intervention (n=11 (20%) and n=8 (19%)), respectively. Furthermore, schools in the Northern areas (E2, C2, E4 and C4) had a higher prevalence of underweight in children than schools in the Township areas (E1, C1, E3 and C3).

**Table 4.5: Descriptive statistics of underweight prevalence for experimental and control schools in T2**

| School | Underweight T2 | | | | | |
|---|---|---|---|---|---|---|
| | No | | Yes | | Total | |
| E1 | 33 | 94% | 2 | 6% | 35 | 100% |
| C1 | 66 | 100% | 0 | 0% | 66 | 100% |
| E2 | 46 | 100% | 0 | 0% | 46 | 100% |
| C2 | 35 | 97% | 1 | 3% | 36 | 100% |
| E3 | 22 | 96% | 1 | 4% | 23 | 100% |
| C3 | 43 | 96% | 2 | 4% | 45 | 100% |
| E4 | 16 | 94% | 1 | 6% | 17 | 100% |
| C4 | 17 | 89% | 2 | 11% | 19 | 100% |
| Total | 278 | 97% | 9 | 3% | 287 | 100% |

Table 4.5 shows that the prevalence of underweight children decreased from a mean of 6% in T1 to that of 3% in T2 at experimental and control schools. School C4 had the highest percentage (11%) of underweight children compared to the other schools at T2.

#### *4.2.2.2 Stunting*

Table 4.6 and 4.7 reflects the distribution of the participants according to stunting prevalence for each of the eight schools (four experimental and four control schools) involved in the study at pre-intervention (T1) and post-intervention (T2) respectively. A HAZ value of < -2 z-scores is considered as an indicator of stunting.

**Table 4.6: Descriptive statistics of stunting prevalence for experimental and control schools in T1**

| School | Stunting T1 | | | | | |
|---|---|---|---|---|---|---|
| | No | | Yes | | Total | |
| E1 | 84 | 98% | 2 | 2% | 86 | 100% |
| C1 | 112 | 100% | 0 | 0% | 112 | 100% |
| E2 | 92 | 91% | 9 | 9% | 101 | 100% |
| C2 | 90 | 94% | 6 | 6% | 96 | 100% |
| E3 | 79 | 91% | 8 | 9% | 87 | 100% |
| C3 | 135 | 92% | 12 | 8% | 147 | 100% |
| E4 | 128 | 76% | 40 | 24% | 168 | 100% |
| C4 | 66 | 80% | 16 | 20% | 82 | 100% |
| Total | 786 | 89% | 93 | 11% | 879 | 100% |

Table 4.6 reflects the prevalence of stunting among children from both experimental and control schools. The prevalence of stunting was 11% in T1, with schools E4 and C4 having the highest prevalence of stunting in children compared to the other schools (24% and 20%, respectively).

**Table 4.7: Descriptive statistics of stunting prevalence for experimental and control schools in T2**

| School | Stunting T2 | | | | | |
|---|---|---|---|---|---|---|
| | No | | Yes | | Total | |
| E1 | 81 | 94% | 5 | 6% | 86 | 100% |
| C1 | 112 | 100% | 0 | 0% | 112 | 100% |
| E2 | 91 | 90% | 10 | 10% | 101 | 100% |
| C2 | 88 | 92% | 8 | 8% | 96 | 100% |
| E3 | 78 | 90% | 9 | 10% | 87 | 100% |
| C3 | 132 | 90% | 15 | 10% | 147 | 100% |
| E4 | 117 | 70% | 51 | 30% | 168 | 100% |
| C4 | 63 | 77% | 19 | 23% | 82 | 100% |
| Total | 762 | 87% | 117 | 13% | 879 | 100% |

Table 4.7 shows the prevalence of stunting among children in T2 and it can be observed that there was an increase in prevalence for experimental and control schools (to a value of 13%). Schools E4 and C4 again showed the highest prevalence

of stunting among children (30% and 23% respectively). Furthermore, experimental schools (E1-4) had the higher number of stunting in children compared to their respective control schools (C1-4).

#### *4.2.2.3 Thinness, Normal Weight and Obesity*

Table 4.8 and 4.9 reflect the distribution of the participants according to thinness, normal weight and obesity prevalence for each of the eight schools (four experimental and four control schools) involved in the study at pre-intervention (T1) and post-intervention (T2) respectively. In terms of BAZ, thinness was identified by BAZ values of < -2 to -3 z-scores, normal weight -2 <BAZ< +2, and obesity identified by BAZ > +2 z-scores.

**Table 4.8: Descriptive statistics of thinness, normal weight and obesity prevalence for experimental and control schools in T1**

| School | Thin Normal Obese T1 | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Thin | | Normal | | Obese | | Total | |
| E1 | 1 | 1% | 76 | 88% | 9 | 10% | 86 | 100% |
| C1 | 1 | 1% | 106 | 95% | 5 | 4% | 112 | 100% |
| E2 | 2 | 2% | 92 | 91% | 7 | 7% | 101 | 100% |
| C2 | 4 | 4% | 86 | 90% | 6 | 6% | 96 | 100% |
| E3 | 3 | 3% | 75 | 86% | 9 | 10% | 87 | 100% |
| C3 | 1 | 1% | 139 | 95% | 7 | 5% | 147 | 100% |
| E4 | 12 | 7% | 152 | 90% | 4 | 2% | 168 | 100% |
| C4 | 10 | 12% | 71 | 87% | 1 | 1% | 82 | 100% |
| Total | 34 | 4% | 797 | 91% | 48 | 5% | 879 | 100% |

Table 4.8 shows that overall, the majority of the participants were in the normal weight category (91%), with 4% falling in the thin category and 5% in the obese category. Schools E4 and C4 had the highest prevalence of thinness, whereas schools E1 and E3 had the highest prevalence of obesity among children.

**Table 4.9: Descriptive statistics of thinness, normal weight and obesity prevalence for experimental and control schools in T2**

| School | Thin Normal Obese T2 | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Thin | | Normal | | Obese | | Total | |
| E1 | 2 | 2% | 76 | 88% | 8 | 9% | 86 | 100% |
| C1 | 1 | 1% | 104 | 93% | 7 | 6% | 112 | 100% |
| E2 | 0 | 0% | 91 | 90% | 10 | 10% | 101 | 100% |
| C2 | 4 | 4% | 87 | 91% | 5 | 5% | 96 | 100% |
| E3 | 0 | 0% | 73 | 84% | 14 | 16% | 87 | 100% |
| C3 | 0 | 0% | 139 | 95% | 8 | 5% | 147 | 100% |
| E4 | 8 | 5% | 151 | 90% | 9 | 5% | 168 | 100% |
| C4 | 10 | 12% | 71 | 87% | 1 | 1% | 82 | 100% |
| Total | 25 | 3% | 792 | 90% | 62 | 7% | 879 | 100% |

Table 4.9 reflects that in T2, the prevalence of thinness decreased to 3% and obesity increased to 7%. Schools E4 and C4 still had the highest prevalence of thinness, whereas schools E2 and E3 now had the highest prevalence of obesity among children.

### 4.2.3 Descriptive statistics for the total sample in respect of age and anthropometric variables

In this section, tables are used to show the results of the variables measured. A brief explanation of each variable is provided, highlighting mean values and standard deviations for the total sample. Table 4.48 in Appendix 10 depicts descriptive statistic for individual schools in respect of age and anthropometric variables.

Table 4.10 provides the descriptive statistics of the total sample for the variables assessed (height, weight, BMI and BF%) from pre-intervention (T1) and post-intervention (T2), and also shows pre-to-post-intervention differences for the relevant variables (referred to as D2-1).

**Table 4.10: Descriptive statistics for the total sample at pre-intervention, post-intervention and for pre-to-post-intervention differences (n = 879)**

| Variable | Mean | S.D. | Minimum | Quartile 1 | Median | Quartile 3 | Maximum |
|---|---|---|---|---|---|---|---|
| Height T1 (cm) | 133.02 | 7.03 | 109.20 | 128.15 | 132.60 | 137.50 | 165.30 |
| Weight T1 (kg) | 30.41 | 7.51 | 15.80 | 25.90 | 28.70 | 33.30 | 87.40 |
| BMI T1 ($kg/m^2$) | 17.03 | 3.03 | 11.46 | 15.25 | 16.34 | 18.03 | 41.74 |
| Body Fat% T1 (%) | 15.96 | 6.91 | 3.25 | 11.04 | 14.30 | 18.95 | 66.23 |
| Height T2 (cm) | 136.09 | 7.52 | 110.00 | 130.75 | 135.60 | 140.55 | 188.00 |
| Weight T2 (kg) | 33.14 | 8.40 | 17.40 | 27.90 | 31.30 | 36.20 | 95.10 |
| BMI T2 ($kg/m^2$) | 17.73 | 3.27 | 9.25 | 15.78 | 16.92 | 18.77 | 41.16 |
| Body Fat% T2 (%) | 17.12 | 8.57 | 5.24 | 11.40 | 14.90 | 20.38 | 82.93 |
| Height D2-1 (cm) | 3.07 | 2.31 | -16.50 | 2.20 | 3.00 | 3.70 | 55.00 |
| Weight D2-1 (kg) | 2.73 | 1.73 | -8.10 | 1.60 | 2.40 | 3.50 | 14.00 |
| BMI D2-1 ($kg/m^2$) | 0.70 | 0.92 | -7.65 | 0.26 | 0.63 | 1.08 | 7.17 |
| Body Fat% D2-1 (%) | 1.16 | 4.29 | -26.06 | -1.09 | 0.57 | 2.69 | 46.67 |

Table 4.10 reflects that all the relevant variables had increased from pre-to-post-intervention.

Table 4.11 shows the nutritional status (in z-scores) of the children, for T1, T2 and the difference between T2 and T1 (D2-1) as expressed WAZ, HAZ and BAZ.

**Table 4.11: Descriptive statistics for the total sample in respect of WAZ, HAZ and BAZ**

| Variable | n | Mean | S.D. | Minimum | Quartile 1 | Median | Quartile 3 | Maximum |
|---|---|---|---|---|---|---|---|---|
| WAZ T1 | 536 | -0.21 | 1.25 | -4.33 | -0.97 | -0.37 | 0.46 | 5.56 |
| HAZ T1 | 879 | -0.75 | 1.06 | -4.37 | -1.47 | -0.80 | -0.04 | 3.13 |
| BAZ T1 | 879 | 0.01 | 1.22 | -3.67 | -0.79 | -0.08 | 0.74 | 5.45 |
| WAZ T2 | 287 | 0.04 | 1.25 | -3.05 | -0.81 | 0.03 | 0.71 | 4.33 |
| HAZ T2 | 879 | -0.81 | 1.11 | -4.74 | -1.55 | -0.82 | -0.09 | 6.22 |
| BAZ T2 | 879 | 0.16 | 1.22 | -6.82 | -0.63 | 0.07 | 0.86 | 5.07 |
| WAZ D2-1 | 285 | 0.07 | 0.31 | -2.81 | -0.09 | 0.08 | 0.23 | 1.14 |
| HAZ D2-1 | 879 | -0.06 | 0.34 | -3.08 | -0.18 | -0.07 | 0.03 | 7.50 |
| BAZ D2-1 | 879 | 0.15 | 0.46 | -6.88 | -0.06 | 0.15 | 0.36 | 3.18 |

WAZ beyond ten years (that is past the childhood stage) is not a good indicator for monitoring growth as it cannot distinguish between relative height and body mass in an age period where many children are going through pubertal growth spurt and may appear to be overweight (by weight for age) when they are just tall (de Onis *et al.*, 2007:665). Hence, the number of participants for WAZ (T1, T2 and D2-1) reflected in Table 4.11 is lower than that for the other variables (HAZ and BAZ).

In Table 4.11, only small improvements can be seen from pre- to post-intervention for WAZ and BAZ with mean differences of M=0.07±0.31 and M=0.15±0.46, respectively. HAZ showed a decrease from T1 to T2 with a mean difference of M=-00.6±0.34.

## 4.3 INFERENTIAL STATISTICS

Inferential statistics were used to compare the control and experimental groups in respect to pre- and post-test results. Details of which are depicted in Chapter 3. In the sub-sections to follow, the results are reported according to the objectives of the study as described in Chapter 1. Tables will be used to show the results and a short description will be provided to explain the tables. The values highlighted in red represent results that showed statistical significant differences and relevant effect sizes (small to large).

### 4.3.1 Inferential statistics for comparisons between experimental and control schools per each of three interventions

#### *4.3.1.1 Inferential statistics for comparing schools: PA intervention (E1) versus no PA intervention (C1)*

Tables 4.12 to 4.15 show inferential statistics comparing two schools, the experimental school receiving PA intervention only (E1) and its control school (C1) for pre-intervention (T1), post-intervention (T2), and pre-to-post-intervention differences (D2-1) respectively.

**Table 4.12: Inferential statistics: Comparison between E1 and C1 schools in respect of all variables assessed at pre-intervention (T1)**

| Variable | School | n | Mean | S.D. | Diff. | t | p | Cohen's d |
|---|---|---|---|---|---|---|---|---|
| Age T1 (years) | E1 | 86 | 9.82 | 0.82 | 0.33 | 2.94 | **.004** | **0.42** |
| | C1 | 112 | 9.49 | 0.76 | | (df=196) | | **Small** |
| Height T1 (cm) | E1 | 86 | 134.60 | 7.07 | 1.12 | 1.20 | .232 | n/a |
| | C1 | 112 | 133.48 | 6.07 | | (df=196) | | |
| Weight T1 (kg) | E1 | 86 | 32.85 | 9.52 | 1.94 | 1.74 | .083 | n/a |
| | C1 | 112 | 30.91 | 6.10 | | (df=196) | | |
| BMI T1 ($kg/m^2$) | E1 | 86 | 17.93 | 3.88 | 0.64 | 1.35 | .179 | n/a |
| | C1 | 112 | 17.29 | 2.81 | | (df=196) | | |
| Body Fat% T1 (%) | E1 | 86 | 19.11 | 9.08 | 3.30 | 2.98 | **.003** | **0.43** |
| | C1 | 112 | 15.82 | 6.48 | | (df=196) | | **Small** |
| Triceps T1 (mm) | E1 | 86 | 12.41 | 6.56 | 2.03 | 2.61 | **.010** | **0.37** |
| | C1 | 112 | 10.38 | 4.36 | | (df=196) | | **Small** |
| Subscapular T1 (mm) | E1 | 86 | 9.81 | 7.13 | 2.21 | 2.73 | **.007** | **0.39** |
| | C1 | 112 | 7.59 | 4.21 | | (df=196) | | **Small** |
| Sum Skinfolds T1 (mm) | E1 | 86 | 22.22 | 13.39 | 4.25 | 2.74 | **.007** | **0.39** |
| | C1 | 112 | 17.97 | 8.27 | | (df=196) | | **Small** |
| WAZ T1 | E1 | 59 | 0.21 | 1.39 | 0.09 | 0.48 | .635 | n/a |
| | C1 | 92 | 0.11 | 1.04 | | (df=149) | | |
| HAZ T1 | E1 | 86 | -0.39 | 1.04 | -0.10 | -0.76 | .451 | n/a |
| | C1 | 112 | -0.28 | 0.89 | | (df=196) | | |
| BAZ T1 | E1 | 86 | 0.41 | 1.24 | 0.12 | 0.74 | .458 | n/a |
| | C1 | 112 | 0.29 | 1.07 | | (df=196) | | |

Table 4.12 reflects that in T1, five of the 11 variables compared, showed statistical significant different results ($p<.05$; $d>0.20$) between E1 (experimental school) and C1 (control school) with all revealing small practical significance. These differences were in terms of age with E1 revealing the larger age, BF%, and triceps skinfold, subscapular skinfold and sum of skinfolds.

**Table 4.13: Inferential statistics: Comparison of age distribution among E1 and C1 schools at pre-intervention (T1)**

| School | Age Category T1 | | | | | |
|---|---|---|---|---|---|---|
| | 8 – 9 years | | 10 – 11 years | | Total | |
| E1 | 57 | 66% | 29 | 34% | 86 | 100% |
| C1 | 91 | 81% | 21 | 19% | 112 | 100% |
| Total | 148 | 75% | 50 | 25% | 198 | 100% |
| $Chi^2(df = 1, n = 198) = 5.78$; $p = .016$; $V = 0.17$ Small | | | | | | |

According to Table 4.13 both E1 and C1 presented with a larger number of 8-9 than 10-11 year olds. The Chi-Square ($Chi^2$) test, however, revealed a statistically significant difference ($p<.05$, $V>0.1$) between the age distribution of E1 and C1 with C1 presenting with a significantly larger percentage of younger participants (8-9 year olds).

**Table 4.14: Inferential statistics: Comparison between E1 and C1 schools in respect of all variables assessed at post-intervention (T2)**

| Variable | School | n | Mean | S.D. | Diff. | t | p | Cohen's d |
|---|---|---|---|---|---|---|---|---|
| Height T2 (cm) | E1 | 86 | 137.58 | 7.57 | 0.43 | 0.43 | .666 | n/a |
| | C1 | 112 | 137.15 | 6.42 | | (df=196) | | |
| Weight T2 (kg) | E1 | 86 | 35.08 | 10.18 | 1.29 | 1.05 | .296 | n/a |
| | C1 | 112 | 33.79 | 7.13 | | (df=196) | | |
| BMI T2 ($kg/m^2$) | E1 | 86 | 18.32 | 3.96 | 0.44 | 0.88 | .380 | n/a |
| | C1 | 112 | 17.88 | 3.08 | | (df=196) | | |
| Body Fat% T2 (%) | E1 | 86 | 18.64 | 7.54 | -1.02 | -0.81 | .420 | n/a |
| | C1 | 112 | 19.66 | 9.63 | | df=196) | | |
| Triceps T2 (mm) | E1 | 86 | 12.53 | 5.32 | -0.58 | -0.64 | .524 | n/a |
| | C1 | 112 | 13.12 | 7.06 | | (df=196) | | |
| Subscapular T2 (mm) | E1 | 86 | 8.88 | 5.46 | -1.34 | -1.34 | .181 | n/a |
| | C1 | 112 | 10.22 | 7.92 | | (df=196) | | |
| Sum Skinfolds T2 (mm) | E1 | 86 | 21.42 | 10.52 | -1.92 | -1.03 | .304 | n/a |
| | C1 | 112 | 23.34 | 14.67 | | (df=196) | | |
| WAZ T2 | E1 | 35 | -0.02 | 1.33 | -0.35 | -1.43 | .157 | n/a |
| | C1 | 66 | 0.33 | 1.09 | | (df=99) | | |
| HAZ T2 | E1 | 86 | -0.47 | 1.08 | -0.19 | -1.39 | .167 | n/a |
| | C1 | 112 | -0.27 | 0.89 | | (df=196) | | |
| BAZ T2 | E1 | 86 | 0.41 | 1.25 | 0.03 | 0.19 | .848 | n/a |
| | C1 | 112 | 0.38 | 1.09 | | (df=196) | | |

Table 4.14 shows that no significant differences were observed between the two schools for all the variables in T2.

**Table 4.15: Inferential statistics: Comparison between E1 and C1 schools for differences between T2 and T1 (D2 – 1)**

| Variable | School | n | Mean | S.D. | Diff. | t | p | Cohen's d |
|---|---|---|---|---|---|---|---|---|
| Height D2-1 (cm) | E1 | 86 | 2.98 | 1.33 | -0.69 | -3.62 | **<.0005** | **0.52** |
| | C1 | 112 | 3.68 | 1.33 | | (df=196) | | **Medium** |
| Weight D2-1 (kg) | E1 | 86 | 2.23 | 1.95 | -0.65 | -2.44 | **.016** | **0.35** |
| | C1 | 112 | 2.88 | 1.79 | | (df=196) | | **Small** |
| BMI D2-1 (kg/m$^2$) | E1 | 86 | 0.40 | 1.03 | -0.20 | -1.51 | .132 | n/a |
| | C1 | 112 | 0.60 | 0.84 | | (df=196) | | |
| Body Fat% D2-1 (%) | E1 | 86 | -0.47 | 4.05 | -4.32 | -6.72 | **<.0005** | **0.96** |
| | C1 | 112 | 3.84 | 4.78 | | df=196) | | **Large** |
| Triceps D2-1 (mm) | E1 | 86 | 0.13 | 3.08 | -2.61 | -5.29 | **<.0005** | **0.76** |
| | C1 | 112 | 2.74 | 3.70 | | (df=196) | | **Medium** |
| Subscapular D2-1 (mm) | E1 | 86 | -0.93 | 3.83 | -3.55 | -5.68 | **<.0005** | **0.81** |
| | C1 | 112 | 2.63 | 4.74 | | (df=196) | | **Large** |
| Sum Skinfolds D2-1 (mm) | E1 | 86 | -0.80 | 6.39 | -6.17 | -5.83 | **<.0005** | **0.84** |
| | C1 | 112 | 5.37 | 8.05 | | (df=196) | | **Large** |
| WAZ D2-1 | E1 | 35 | -0.10 | 0.54 | -0.18 | -2.33 | **.022** | **0.49** |
| | C1 | 66 | 0.08 | 0.24 | | (df=99) | | **Small** |
| HAZ D2-1 | E1 | 86 | -0.08 | 0.21 | -0.09 | -3.12 | **.002** | **0.45** |
| | C1 | 112 | 0.01 | 0.20 | | (df=196) | | **Small** |
| BAZ D2-1 | E1 | 86 | 0.00 | 0.60 | -0.09 | -1.38 | .170 | n/a |
| | C1 | 112 | 0.09 | 0.31 | | (df=196) | | |

When comparing E1 and C1 in terms of T2 minus T1 mean differences for each of the variables measured as depicted in Table 4.15, it can be observed that all the anthropometric variables showed both a statistical and practical significant difference ($p<.05$; $d>0.20$) except for BMI. Additionally, WAZ and HAZ also reflected significant differences, but for BAZ there were no significant differences. In all variables C1, the control school reflected the higher increases between T1 and T2.

#### *4.3.1.2 Inferential statistics for comparing schools: PA and Health Education intervention (E2) versus no PA and Health Education intervention (C2)*

Tables 4.16 to 4.19 illustrate inferential statistics comparing two schools, E2 receiving PA and health education intervention and C2 with no intervention for pre-intervention

(T1), post-intervention (T2), and pre-to-post-intervention differences (D2-1) respectively.

**Table 4.16: Inferential statistics: Comparison between E2 and C2 schools in respect of all variables assessed at pre-intervention (T1)**

| Variable | School | n | Mean | S.D. | Diff. | t | p | Cohen's d |
|---|---|---|---|---|---|---|---|---|
| Age T1 (years) | E2 | 101 | 9.67 | 0.64 | -0.07 | -0.73 | .467 | n/a |
| | C2 | 96 | 9.74 | 0.66 | | (df=195) | | |
| Height T1 (cm) | E2 | 101 | 132.24 | 7.52 | -1.01 | -1.04 | .300 | n/a |
| | C2 | 96 | 133.25 | 5.99 | | (df=195) | | |
| Weight T1 (kg) | E2 | 101 | 30.08 | 7.05 | -0.36 | -0.38 | .708 | n/a |
| | C2 | 96 | 30.44 | 6.54 | | (df=195) | | |
| BMI T1 (kg/m$^2$) | E2 | 101 | 17.05 | 2.67 | 0.02 | 0.06 | .952 | n/a |
| | C2 | 96 | 17.02 | 2.75 | | (df=195) | | |
| Body Fat% T1 (%) | E2 | 101 | 15.81 | 6.73 | -1.23 | -1.28 | .201 | n/a |
| | C2 | 96 | 17.05 | 6.73 | | (df=195) | | |
| Triceps T1 (mm) | E2 | 101 | 9.96 | 4.11 | -1.45 | -2.44 | **.015** | **0.35** |
| | C2 | 96 | 11.41 | 4.23 | | (df=195) | | **Small** |
| Subscapular T1 (mm) | E2 | 101 | 7.82 | 4.59 | 0.03 | 0.05 | .959 | n/a |
| | C2 | 96 | 7.79 | 4.60 | | (df=195) | | |
| Sum Skinfolds T1 (mm) | E2 | 101 | 17.79 | 8.28 | -1.42 | -1.19 | .237 | n/a |
| | C2 | 96 | 19.20 | 8.48 | | (df=195) | | |
| WAZ T1 | E2 | 78 | -0.23 | 1.15 | -0.03 | -0.17 | .866 | n/a |
| | C2 | 72 | -0.20 | 1.23 | | (df=148) | | |
| HAZ T1 | E2 | 101 | -0.65 | 1.06 | -0.10 | -0.68 | .495 | n/a |
| | C2 | 96 | -0.55 | 0.88 | | (df=195) | | |
| BAZ T1 | E2 | 101 | 0.14 | 1.12 | 0.06 | 0.34 | .731 | n/a |
| | C2 | 96 | 0.08 | 1.22 | | (df=195) | | |

Table 4.16 indicates that in T1, only one variable showed a statistical significant different result (p<.05; d>0.20) between E2 and C2, indicating a small practical significance for triceps skinfolds, with C2 reflecting the larger skinfold thickness.

**Table 4.17: Inferential statistics: Comparison of frequency distribution of age for E2 and C2 schools at pre-intervention (T1)**

| School | Age Category T1 | | | | | |
|---|---|---|---|---|---|---|
| | 8 – 9 years | | 10 – 11 years | | Total | |
| E2 | 73 | 72% | 28 | 28% | 101 | 100% |
| C2 | 70 | 73% | 26 | 27% | 96 | 100% |
| Total | 143 | 73% | 54 | 27% | 197 | 100% |
| $Chi^2(df = 1, n = 197) = 0.01; p = .920$ | | | | | | |

Table 4.17 reflects that both E2 and C2 presented with a larger number of 8-9 than 10-11 year olds in T1. The Chi-Square ($Chi^2$) test, confirmed no statistical significant difference between the age distribution of E2 and C2.

**Table 4.18: Inferential statistics: Comparison between E2 and C2 schools in respect of all variables assessed at post-intervention (T2)**

| Variable | School | n | Mean | S.D. | Diff. | t | p | Cohen's d |
|---|---|---|---|---|---|---|---|---|
| Height T2 (cm) | E2 | 101 | 134.93 | 7.19 | -1.39 | -1.43 | .153 | n/a |
| | C2 | 96 | 136.32 | 6.32 | | (df=195) | | |
| Weight T2 (kg) | E2 | 101 | 32.57 | 7.84 | -0.26 | -0.24 | .810 | n/a |
| | C2 | 96 | 32.83 | 7.27 | | (df=195) | | |
| BMI T2 ($kg/m^2$) | E2 | 101 | 17.72 | 2.93 | 0.19 | 0.45 | .656 | n/a |
| | C2 | 96 | 17.53 | 2.94 | | (df=195) | | |
| Body Fat% T2 (%) | E2 | 101 | 15.83 | 7.29 | -2.22 | -1.97 | **.050** | **0.28** |
| | C2 | 96 | 18.05 | 8.49 | | (df=195) | | **Small** |
| Triceps T2 (mm) | E2 | 101 | 10.39 | 4.63 | -1.47 | -1.99 | **.048** | **0.28** |
| | C2 | 96 | 11.86 | 5.67 | | (df=195) | | **Small** |
| Subscapular T2 (mm) | E2 | 101 | 7.54 | 5.16 | -1.57 | -1.91 | .057 | n/a |
| | C2 | 96 | 9.11 | 6.35 | | (df=195) | | |
| Sum Skinfolds T2 (mm) | E2 | 101 | 17.93 | 9.46 | -3.04 | -2.01 | **.046** | **0.29** |
| | C2 | 96 | 20.97 | 11.71 | | (df=195) | | **Small** |
| WAZ T2 | E2 | 46 | -0.13 | 0.91 | -0.15 | -0.59 | .555 | n/a |
| | C2 | 36 | 0.02 | 1.44 | | (df=80) | | |
| HAZ T2 | E2 | 101 | -0.75 | 1.01 | -0.15 | -1.08 | .281 | n/a |
| | C2 | 96 | -0.61 | 0.91 | | (df=195) | | |
| BAZ T2 | E2 | 101 | 0.27 | 1.11 | 0.12 | 0.72 | .475 | n/a |
| | C2 | 96 | 0.15 | 1.20 | | (df=195) | | |

Table 4.18 indicates that BF%, triceps skinfold and sum of skinfolds showed statistical significant differences between E2 and C2 for post-intervention results ($p<.05$ $d>0.20$) with C2 reflecting the larger scores compared to E2.

**Table 4.19: Inferential statistics: Comparison between E2 and C2 schools in respect of all variables assessed for pre-to-post-intervention differences (D2-1)**

| Variable | School | n | Mean | S.D. | Diff. | t | p | Cohen's d |
|---|---|---|---|---|---|---|---|---|
| Height D2-1 (cm) | E2 | 101 | 2.70 | 2.34 | -0.38 | -1.40 | .164 | n/a |
| | C2 | 96 | 3.08 | 1.28 | | (df=195) | | |
| Weight D2-1 (kg) | E2 | 101 | 2.49 | 1.79 | 0.10 | 0.47 | .642 | n/a |
| | C2 | 96 | 2.39 | 1.32 | | (df=195) | | |
| BMI D2-1 ($kg/m^2$) | E2 | 101 | 0.67 | 1.09 | 0.16 | 1.28 | .203 | n/a |
| | C2 | 96 | 0.51 | 0.62 | | (df=195) | | |
| Body Fat% D2-1 (%) | E2 | 101 | 0.02 | 2.78 | -0.99 | -2.32 | **.021** | **0.33** |
| | C2 | 96 | 1.00 | 3.17 | | (df=195) | | **Small** |
| Triceps D2-1 (mm) | E2 | 101 | 0.43 | 2.27 | -0.02 | -0.05 | .958 | n/a |
| | C2 | 96 | 0.45 | 2.60 | | (df=195) | | |
| Subscapular D2-1 (mm) | E2 | 101 | -0.28 | 2.14 | -1.61 | -4.77 | **<.0005** | **0.68** |
| | C2 | 96 | 1.32 | 2.57 | | (df=195) | | **Medium** |
| Sum Skinfolds D2-1 (mm) | E2 | 101 | 0.14 | 3.85 | -1.62 | -2.63 | **.009** | **0.38** |
| | C2 | 96 | 1.77 | 4.77 | | (df=195) | | **Small** |
| WAZ D2-1 | E2 | 44 | 0.08 | 0.29 | 0.05 | 0.86 | .393 | n/a |
| | C2 | 36 | 0.03 | 0.25 | | (df=78) | | |
| HAZ D2-1 | E2 | 101 | -0.11 | 0.37 | -0.05 | -1.27 | .207 | n/a |
| | C2 | 96 | -0.05 | 0.18 | | (df=195) | | |
| BAZ D2-1 | E2 | 101 | 0.13 | 0.50 | 0.06 | 1.04 | .300 | n/a |
| | C2 | 96 | 0.07 | 0.28 | | (df=195) | | |

When comparing E2 and C2 in terms of T2 minus T1 mean differences for each of the variables measured as depicted in Table 4.19, it can be seen that four of the ten measured variables showed both statistical and practically significant differences ($p<.05$; $d>0.20$). These differences were in terms of BF% and subscapular skinfold and sum of skinfolds, with C2 revealing larger increases for all variables.

#### 4.3.1.3 *Inferential statistics for comparing schools: Health Education and Nutrition intervention (E3) versus no Health Education and Nutrition intervention (C3)*

Tables 4.20 to 4.23 show inferential statistics that reflect the comparison of two schools (E3 and C3) for pre-intervention (T1), post-intervention (T2), and pre-to-post-intervention differences (D2-1).

**Table 4.20: Inferential statistics: Comparison between E3 and C3 schools in respect of all variables assessed at pre-intervention (T1)**

| Variable | School | n | Mean | S.D. | Diff. | t | p | Cohen's d |
|---|---|---|---|---|---|---|---|---|
| Age T1 (years) | E3 | 87 | 10.12 | 0.87 | 0.17 | 1.60 | .110 | n/a |
| | C3 | 147 | 9.95 | 0.75 | | (df=232) | | |
| Height T1 (cm) | E3 | 87 | 134.57 | 7.81 | 0.55 | 0.56 | .574 | n/a |
| | C3 | 147 | 134.02 | 6.93 | | (df=232) | | |
| Weight T1 (kg) | E3 | 87 | 33.18 | 10.10 | 1.88 | 1.61 | .108 | n/a |
| | C3 | 147 | 31.30 | 7.62 | | (df=232) | | |
| BMI T1 (kg/m$^2$) | E3 | 87 | 18.07 | 3.86 | 0.78 | 1.64 | .102 | n/a |
| | C3 | 147 | 17.29 | 3.26 | | (df=232) | | |
| Body Fat% T1 (%) | E3 | 87 | 17.37 | 7.54 | 1.11 | 1.15 | .251 | n/a |
| | C3 | 147 | 16.25 | 6.94 | | (df=232) | | |
| Triceps T1 (mm) | E3 | 87 | 11.51 | 4.91 | 0.35 | 0.54 | .592 | n/a |
| | C3 | 147 | 11.16 | 4.78 | | (df=232) | | |
| Subscapular T1 (mm) | E3 | 87 | 8.44 | 5.41 | 1.13 | 1.78 | .076 | n/a |
| | C3 | 147 | 7.31 | 4.21 | | (df=232) | | |
| Sum Skinfolds T1 (mm) | E3 | 87 | 19.95 | 9.93 | 1.48 | 1.20 | .232 | n/a |
| | C3 | 147 | 18.47 | 8.64 | | (df=232) | | |
| WAZ T1 | E3 | 46 | -0.06 | 1.18 | 0.03 | 0.13 | .896 | n/a |
| | C3 | 91 | -0.09 | 1.25 | | (df=135) | | |
| HAZ T1 | E3 | 87 | -0.66 | 1.07 | -0.07 | -0.48 | .634 | n/a |
| | C3 | 147 | -0.60 | 0.99 | | (df=232) | | |
| BAZ T1 | E3 | 87 | 0.37 | 1.30 | 0.24 | 1.46 | .147 | n/a |
| | C3 | 147 | 0.13 | 1.20 | | (df=232) | | |

Table 4.20 reflects that no significant differences were observed between E3 and C3 for all variables at T1.

**Table 4.21: Inferential statistics: Comparison of age distribution among E3 and C3 schools at pre-intervention (T1)**

| School | Age Category T1 | | | | | |
|---|---|---|---|---|---|---|
| | 8 – 9 years | | 10 – 11 years | | Total | |
| E3 | 44 | 51% | 43 | 49% | 87 | 100% |
| C3 | 87 | 59% | 60 | 41% | 147 | 100% |
| Total | 131 | 56% | 103 | 44% | 234 | 100% |
| $Chi^2$(df = 1, n = 234) = 1.64; p = .200 | | | | | | |

The $Chi^2$ test reflected in Table 4.21 was performed to compare the frequency distributions of age for the experimental and control schools and no statistical difference was found between the two schools.

**Table 4.22: Inferential statistics: Comparison between E3 and C3 schools in respect of all variables assessed at post-intervention (T2)**

| Variable | School | n | Mean | S.D. | Diff. | t | p | Cohen's d |
|---|---|---|---|---|---|---|---|---|
| Height T2 (cm) | E3 | 87 | 137.91 | 8.15 | 0.80 | 0.78 | .436 | n/a |
| | C3 | 147 | 137.11 | 7.23 | | (df=232) | | |
| Weight T2 (kg) | E3 | 87 | 36.85 | 11.47 | 2.85 | 2.18 | **.031** | **0.29** |
| | C3 | 147 | 34.00 | 8.45 | | (df=232) | | **Small** |
| BMI T2 ($kg/m^2$) | E3 | 87 | 19.09 | 4.19 | 1.15 | 2.24 | **.026** | **0.30** |
| | C3 | 147 | 17.94 | 3.54 | | (df=232) | | **Small** |
| Body Fat% T2 (%) | E3 | 87 | 20.36 | 10.61 | 2.30 | 1.67 | .096 | n/a |
| | C3 | 147 | 18.06 | 9.91 | | (df=232) | | |
| Triceps T2 (mm) | E3 | 87 | 13.62 | 6.92 | 1.29 | 1.37 | .171 | n/a |
| | C3 | 147 | 12.33 | 6.99 | | (df=232) | | |
| Subscapular T2 (mm) | E3 | 87 | 10.38 | 8.47 | 1.46 | 1.39 | .165 | n/a |
| | C3 | 147 | 8.92 | 7.27 | | (df=232) | | |
| Sum Skinfolds T2 | E3 | 87 | 24.00 | 15.03 | 2.75 | 1.42 | .156 | n/a |
| | C3 | 147 | 21.25 | 13.86 | | (df=232) | | |
| WAZ T2 | E3 | 23 | 0.30 | 1.33 | 0.27 | 0.76 | .452 | n/a |
| | C3 | 45 | 0.03 | 1.41 | | (df=66) | | |
| HAZ T2 | E3 | 87 | -0.67 | 1.09 | 0.00 | 0.02 | .982 | n/a |
| | C3 | 147 | -0.67 | 0.99 | | (df=232) | | |
| BAZ T2 | E3 | 87 | 0.62 | 1.24 | 0.37 | 2.28 | **.023** | **0.31** |
| | C3 | 147 | 0.25 | 1.20 | | (df=232) | | **Small** |

Table 4.22 demonstrates that the relevant schools, E3 and C3, showed statistical significant differences ($p<.05$; $d>0.20$) in terms of weight and BMI in T2, with all revealing small practical significance. The experimental group displayed larger mean values than the control group. BAZ also yielded a statistical and practically significant difference between E3 and C3, again with E3 revealing the larger value.

**Table 4.23: Inferential statistics: Comparison between E3 and C3 schools in respect of all variables assessed for pre-to-post-intervention differences (D2-1)**

| Variable | School | n | Mean | S.D. | Diff. | t | p | Cohen's d |
|---|---|---|---|---|---|---|---|---|
| Height D2-1 (cm) | E3 | 87 | 3.34 | 1.06 | 0.25 | 1.43 | .155 | n/a |
| | C3 | 147 | 3.09 | 1.39 | | (df=232) | | |
| Weight D2-1 (kg) | E3 | 87 | 3.67 | 2.02 | 0.97 | 3.93 | **<.0005** | **0.53** |
| | C3 | 147 | 2.70 | 1.70 | | (df=232) | | **Medium** |
| BMI D2-1 (kg/m²) | E3 | 87 | 1.03 | 0.84 | 0.37 | 3.14 | **.002** | **0.42** |
| | C3 | 147 | 0.65 | 0.91 | | (df=232) | | **Small** |
| Body Fat% D2-1 | E3 | 87 | 2.99 | 5.86 | 1.18 | 1.71 | .088 | n/a |
| | C3 | 147 | 1.81 | 4.61 | | (df=232) | | |
| Triceps D2-1 (mm) | E3 | 87 | 2.11 | 4.05 | 0.94 | 1.80 | .073 | n/a |
| | C3 | 147 | 1.17 | 3.76 | | (df=232) | | |
| Subscapular D2-1 (mm) | E3 | 87 | 1.94 | 4.95 | 0.33 | 0.53 | .596 | n/a |
| | C3 | 147 | 1.61 | 4.33 | | (df=232) | | |
| Sum Skinfolds D2-1 (mm) | E3 | 87 | 4.05 | 8.73 | 1.27 | 1.19 | .234 | n/a |
| | C3 | 147 | 2.78 | 7.33 | | (df=232) | | |
| WAZ D2-1 | E3 | 23 | 0.21 | 0.24 | 0.10 | 1.46 | .148 | n/a |
| | C3 | 45 | 0.11 | 0.27 | | (df=66) | | |
| HAZ D2-1 | E3 | 87 | -0.01 | 0.15 | 0.07 | 2.79 | **.006** | **0.38** |
| | C3 | 147 | -0.07 | 0.20 | | (df=232) | | **Small** |
| BAZ D2-1 | E3 | 87 | 0.25 | 0.30 | 0.13 | 2.92 | **.004** | **0.40** |
| | C3 | 147 | 0.12 | 0.35 | | (df=232) | | **Small** |

When comparing E3 and C3 in terms of T2 minus T1 mean differences for each of the variables measured as depicted in Table 4.23, it can be observed that five of all the variables showed both a statistical and practically significant difference ($p<.05$; $d>0.20$). These differences were in terms of weight and BMI, with E3 revealing larger mean differences between T2 and T1 for weight and BMI. Additionally, HAZ and BAZ also reflected significant differences in this regard ($p<.05$; $d>0.20$), with E3 having the larger mean difference compared to C3. WAZ showed no significant differences.

#### 4.3.1.4 *Inferential statistics for comparing schools: PA, Health Education and Nutrition intervention (E4) versus no PA, Health Education and Nutrition intervention (C4)*

Tables 4.24 to 4.27 demonstrate inferential statistics comparing two schools, E4 (experimental school) and C4 (control school) for pre-intervention (T1), post-intervention (T2), and pre-to-post-intervention differences (D2-1) respectively.

**Table 4.24: Inferential statistics: Comparison between E4 and C4 schools in respect of all variables assessed at pre-intervention (T1)**

| Variable | School | n | Mean | S.D. | Diff. | t | p | Cohen's d |
|---|---|---|---|---|---|---|---|---|
| Age T1 (years) | E4 | 168 | 10.39 | 0.73 | 0.27 | 2.65 | **.009** | **0.36** |
| | C4 | 82 | 10.12 | 0.80 | | (df=248) | | **Small** |
| Height T1 (cm) | E4 | 168 | 131.58 | 6.99 | 0.67 | 0.71 | .479 | n/a |
| | C4 | 82 | 130.91 | 7.14 | | (df=248) | | |
| Weight T1 (kg) | E4 | 168 | 28.45 | 5.92 | 1.43 | 1.80 | .072 | n/a |
| | C4 | 82 | 27.03 | 5.78 | | (df=248) | | |
| BMI T1 ($kg/m^2$) | E4 | 168 | 16.30 | 2.26 | 0.65 | 2.21 | **.028** | **0.30** |
| | C4 | 82 | 15.65 | 2.06 | | (df=248) | | **Small** |
| Body Fat% T1 | E4 | 168 | 14.39 | 5.41 | 1.43 | 1.96 | .051 | n/a |
| | C4 | 82 | 12.96 | 5.40 | | (df=248) | | |
| Triceps T1 (mm) | E4 | 168 | 9.33 | 3.34 | 1.39 | 3.21 | **.002** | **0.43** |
| | C4 | 82 | 7.94 | 2.93 | | (df=248) | | **Small** |
| Subscapular T1 (mm) | E4 | 168 | 6.75 | 3.46 | 0.12 | 0.27 | .788 | n/a |
| | C4 | 82 | 6.62 | 3.33 | | (df=248) | | |
| Sum Skinfolds T1 (mm) | E4 | 168 | 16.07 | 6.51 | 1.51 | 1.77 | .079 | n/a |
| | C4 | 82 | 14.56 | 6.05 | | (df=248) | | |
| WAZ T1 | E4 | 56 | -0.76 | 1.31 | 0.36 | 1.49 | .139 | n/a |
| | C4 | 42 | -1.12 | 0.97 | | (df=96) | | |
| HAZ T1 | E4 | 168 | -1.35 | 1.05 | -0.11 | -0.80 | .424 | n/a |
| | C4 | 82 | -1.24 | 0.97 | | (df=248) | | |
| BAZ T1 | E4 | 168 | -0.42 | 1.15 | 0.30 | 1.94 | .053 | n/a |
| | C4 | 82 | -0.72 | 1.09 | | (df=248) | | |

Table 4.24 indicates that a small but significant difference between the experimental and control schools was observed for age, BMI and triceps skinfold ($p<.05$; $d>0.20$). E4 had the larger mean values for all these variables.

**Table 4.25: Inferential statistics: Comparison of frequency distribution of age for E4 and C4 schools at pre-intervention (T1)**

| School | Age Category T1 | | | | | |
|---|---|---|---|---|---|---|
| | 8 – 9 years | | 10 – 11 years | | Total | |
| E4 | 53 | 32% | 115 | 68% | 168 | 100% |
| C4 | 40 | 49% | 42 | 51% | 82 | 100% |
| Total | 93 | 37% | 157 | 63% | 250 | 100% |
| $Chi^2$(df = 1, n = 250) = 7.00; p = .008; V = 0.17 Small | | | | | | |

The $Chi^2$ test reflected in Table 4.25 was performed to compare the frequency distributions of age for the experimental and control schools and a statistical difference was found ($p<.05$, $V>0.1$) between the two schools. Two thirds of the participants in E4 fell in the older age group versus only half of the participants in C4 being in the same age category.

**Table 4.26: Inferential statistics: Comparison between E4 and C4 schools in respect of all variables assessed at post-intervention (T2)**

| Variable | School | n | Mean | S.D. | Diff. | t | p | Cohen's d |
|---|---|---|---|---|---|---|---|---|
| Height T2 (cm) | E4 | 168 | 133.98 | 7.35 | -0.80 | -0.73 | .465 | n/a |
| | C4 | 82 | 134.78 | 9.40 | | (df=248) | | |
| Weight T2 (kg) | E4 | 168 | 31.40 | 6.78 | 1.96 | 2.16 | **.032** | **0.29** |
| | C4 | 82 | 29.43 | 6.63 | | (df=248) | | **Small** |
| BMI T2 (kg/m$^2$) | E4 | 168 | 17.35 | 2.58 | 1.23 | 3.65 | **<.0005** | **0.49** |
| | C4 | 82 | 16.11 | 2.36 | | (df=248) | | **Small** |
| Body Fat% T2 | E4 | 168 | 14.21 | 5.82 | 0.78 | 0.99 | .321 | n/a |
| | C4 | 82 | 13.43 | 5.77 | | (df=248) | | |
| Triceps T2 (mm) | E4 | 168 | 9.21 | 3.74 | 0.34 | 0.68 | .497 | n/a |
| | C4 | 82 | 8.86 | 3.76 | | (df=248) | | |
| Subscapular T2 (mm) | E4 | 168 | 6.75 | 3.46 | 0.49 | 1.05 | .293 | n/a |
| | C4 | 82 | 6.27 | 3.36 | | (df=248) | | |
| Sum Skinfolds T2 (mm) | E4 | 168 | 15.96 | 6.93 | 0.83 | 0.89 | .375 | n/a |
| | C4 | 82 | 15.13 | 6.93 | | (df=248) | | |
| WAZ T2 | E4 | 17 | -0.01 | 1.52 | 0.69 | 1.62 | .115 | n/a |
| | C4 | 19 | -0.70 | 1.03 | | (df=34) | | |
| HAZ T2 | E4 | 168 | -1.51 | 1.09 | -0.30 | -1.96 | .052 | n/a |
| | C4 | 82 | -1.20 | 1.28 | | (df=248) | | |
| BAZ T2 | E4 | 168 | -0.08 | 1.12 | 0.60 | 3.76 | **<.0005** | **0.51** |
| | C4 | 82 | -0.68 | 1.30 | | (df=248) | | **Medium** |

Table 4.26 indicates that there was a small but significant difference between E4 and C4 with regards to weight and BMI ($p<.05$; $d>0.20$), with E4 revealing larger mean values. In T2, BAZ also yielded a significant difference between E4 and C4 ($p<.05$; $d>0.20$). Again, school E4 had a larger mean value compared to C4.

**Table 4.27: Inferential statistics: Comparison between E4 and C4 schools in respect of all variables assessed for pre-to-post-intervention differences (D2-1)**

| Variable | School | n | Mean | S.D. | Diff. | t | p | Cohen's d |
|---|---|---|---|---|---|---|---|---|
| Height D2-1 (cm) | E4 | 168 | 2.40 | 1.16 | -1.47 | -3.11 | **.002** | **0.42** |
| | C4 | 82 | 3.87 | 5.91 | | (df=248) | | **Small** |
| Weight D2-1 (kg) | E4 | 168 | 2.94 | 1.56 | 0.53 | 2.65 | **.009** | **0.36** |
| | C4 | 82 | 2.41 | 1.36 | | (df=248) | | **Small** |
| BMI D2-1 ($kg/m^2$) | E4 | 168 | 1.04 | 0.74 | 0.58 | 4.98 | **<.0005** | **0.67** |
| | C4 | 82 | 0.46 | 1.09 | | (df=248) | | **Medium** |
| Body Fat% D2-1 | E4 | 168 | -0.18 | 3.37 | -0.65 | -1.50 | .134 | n/a |
| | C4 | 82 | 0.47 | 2.87 | | (df=248) | | |
| Triceps D2-1 (mm) | E4 | 168 | -0.12 | 2.37 | -1.05 | -3.40 | **.001** | **0.46** |
| | C4 | 82 | 0.93 | 2.09 | | (df=248) | | **Small** |
| Subscapular D2-1 (mm) | E4 | 168 | 0.01 | 3.00 | 0.36 | 0.98 | .328 | n/a |
| | C4 | 82 | -0.36 | 2.10 | | (df=248) | | |
| Sum Skinfolds D2-1 (mm) | E4 | 168 | -0.11 | 5.09 | -0.68 | -1.08 | .282 | n/a |
| | C4 | 82 | 0.57 | 3.78 | | (df=248) | | |
| WAZ D2-1 | E4 | 17 | 0.24 | 0.22 | 0.18 | 2.52 | **.017** | **0.84** |
| | C4 | 19 | 0.06 | 0.20 | | (df=34) | | **Large** |
| HAZ D2-1 | E4 | 168 | -0.16 | 0.16 | -0.19 | -2.80 | **.005** | **0.38** |
| | C4 | 82 | 0.04 | 0.86 | | (df=248) | | **Small** |
| BAZ D2-1 | E4 | 168 | 0.34 | 0.29 | 0.30 | 4.17 | **<.0005** | **0.56** |
| | C4 | 82 | 0.04 | 0.85 | | (df=248) | | **Medium** |

Table 4.27 indicates that all the variables showed significantly different pre-to-post intervention scores ($p<.05$; $d>0.20$), with the exception of BF%, subscapular skinfold and sum of skinfolds. E4 had larger increases in mean differences in terms of weight, BMI, WAZ and BAZ, whereas C4 showed increased mean difference for height, triceps skinfold, sum of skinfolds and HAZ.

### 4.3.2 Inferential statistics comparing experimental and control schools per intervention among children in respect of the variables underweight; stunting; and thinness, normal weight and obesity

#### *4.3.2.1 Inferential statistics for comparing schools: E1 versus C1 in terms of the following variables: underweight; stunting; and thinness, normal weight and obesity*

Tables 4.28 and 4.29 show inferential statistics comparing two schools, the experimental school receiving PA intervention only (E1) and its control school (C1) in respect of the variables underweight; stunting; and thinness, normal weight and obesity; in children for pre-intervention (T1) and post-intervention (T2), respectively.

**Table 4.28: Inferential statistics: Comparison between E1 and C1 schools in respect of variables underweight; stunting; and thinness, normal weight and obesity; among children at pre-intervention (T1)**

| **Underweight** | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| School | No | | Yes | | Total | | | |
| E1 | 58 | 98% | 1 | 2% | 59 | 100% | | |
| C1 | 91 | 99% | 1 | 1% | 92 | 100% | | |
| Total | 149 | 99% | 2 | 1% | 151 | 100% | | |
| Chi²(df = 1, n = 151) = 0.10; p = .750 | | | | | | | | |
| **Stunting** | | | | | | | | |
| School | No | | Yes | | Total | | | |
| E1 | 84 | 98% | 2 | 2% | 86 | 100% | | |
| C1 | 112 | 100% | 0 | 0% | 112 | 100% | | |
| Total | 196 | 99% | 2 | 1% | 198 | 100% | | |
| Chi²(df = 1, n = 198) = 2.63; p = .105 | | | | | | | | |
| **Thin Normal Obese** | | | | | | | | |
| School | Thin | | Normal | | Obese | | Total | |
| E1 | 1 | 1% | 76 | 88% | 9 | 10% | 86 | 100% |
| C1 | 1 | 1% | 106 | 95% | 5 | 4% | 112 | 100% |
| Total | 2 | 1% | 182 | 92% | 14 | 7% | 198 | 100% |
| Chi²(df = 2, n = 198) = 2.72; p = .257 | | | | | | | | |

Table 4.28 reflects results for the Chi$^2$ test performed to test for the difference in frequency distribution between E1 and C1 schools in terms of nutritional status. The statistical test yielded no significant differences for underweight; stunting; and

thinness, normal weight and obesity between the two schools. The distribution of underweight was the same at both schools, while for stunting school C1 revealed no such prevalence among their children. Majority of the children were in the normal weight category, followed by obesity. Thinness was the same in both schools, with 1% prevalence.

**Table 4.29: Inferential statistics: Comparison between E1 and C1 schools in respect of underweight; stunting; and thinness, normal weight and obesity among children at post-intervention (T2)**

| **Underweight** | | | | | | |
|---|---|---|---|---|---|---|
| School | No | | Yes | | Total | |
| E1 | 33 | 94% | 2 | 6% | 35 | 100% |
| C1 | 66 | 100% | 0 | 0% | 66 | 100% |
| Total | 99 | 98% | 2 | 2% | 101 | 100% |
| $Chi^2(df = 1, n = 101) = 3.85; p = .050; V = 0.20$ Small | | | | | | |
| **Stunting** | | | | | | |
| School | No | | Yes | | Total | |
| E1 | 81 | 94% | 5 | 6% | 86 | 100% |
| C1 | 112 | 100% | 0 | 0% | 112 | 100% |
| Total | 193 | 97% | 5 | 3% | 198 | 100% |
| $Chi^2(df = 1, n = 198) = 6.68; p = .010; V = 0.18$ Small | | | | | | |

| **Thin Normal Obese** | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| School | Thin | | Normal | | Obese | | Total | |
| E1 | 2 | 2% | 76 | 88% | 8 | 9% | 86 | 100% |
| C1 | 1 | 1% | 104 | 93% | 7 | 6% | 112 | 100% |
| Total | 3 | 2% | 180 | 91% | 15 | 8% | 198 | 100% |
| $Chi^2(df = 2, n = 198) = 1.36; p = .505$ | | | | | | | | |

Table 4.29 shows that in T2, there were significant differences found between E1 and C1 for underweight and stunting ($p<.05$, $V>0.1$). The experimental school presented more underweight and stunting in children, compared to the control school which had no underweight and stunting prevalence. No significant difference was observed in terms of thinness, normal weight and obesity in children when comparing E1 and C1.

#### 4.3.2.2 *Inferential statistics for comparing schools: PA and Health Education intervention (E2) versus no PA and Health Education intervention (C2) in terms of underweight; stunting; and thinness, normal weight and obesity among children*

Tables 4.30 and 4.31 illustrate inferential statistics comparing two schools (E2 and C2) in respect of underweight; stunting; and thinness, normal weight and obesity among children for pre-intervention (T1) and post-intervention (T2) respectively.

**Table 4.30: Inferential statistics: Comparison between E2 and C2 schools in respect of underweight; stunting; and thinness, normal weight and obesity in children at pre-intervention (T1)**

| **Underweight** | | | | | | |
|---|---|---|---|---|---|---|
| School | No | | Yes | | Total | |
| E2 | 75 | 96% | 3 | 4% | 78 | 100% |
| C2 | 68 | 94% | 4 | 6% | 72 | 100% |
| Total | 143 | 95% | 7 | 5% | 150 | 100% |
| Chi$^2$(df = 1, n = 150) = 0.25; p = .620 | | | | | | |

| **Stunting** | | | | | | |
|---|---|---|---|---|---|---|
| School | No | | Yes | | Total | |
| E2 | 92 | 91% | 9 | 9% | 101 | 100% |
| C2 | 90 | 94% | 6 | 6% | 96 | 100% |
| Total | 182 | 92% | 15 | 8% | 197 | 100% |
| Chi$^2$(df = 1, n = 197) = 0.50; p = .482 | | | | | | |

| **Thin Normal Obese** | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| School | Thin | | Normal | | Obese | | Total | |
| E2 | 2 | 2% | 92 | 91% | 7 | 7% | 101 | 100% |
| C2 | 4 | 4% | 86 | 90% | 6 | 6% | 96 | 100% |
| Total | 6 | 3% | 178 | 90% | 13 | 7% | 197 | 100% |
| Chi$^2$(df = 2, n = 197) = 0.82; p = .664 | | | | | | | | |

The Chi$^2$ test results in Table 4.30 showed no significant differences between the experimental and control schools for underweight; stunting; and thinness, normal weight and obesity in children. Underweight was seen more in the control school, whereas stunting was more prevalent in the experimental school. Majority of the children fell in the normal weight category, with school E2 having more obese children compared to C2 that had more children in the thinness category, however none of these differences were significant.

**Table 4.31: Inferential statistics: Comparison between E2 and C2 schools in respect of underweight; stunting; and thinness, normal weight and obesity in children at post-intervention (T2)**

| **Underweight** | | | | | | |
|---|---|---|---|---|---|---|
| School | No | | Yes | | Total | |
| E2 | 46 | 100% | 0 | 0% | 46 | 100% |
| C2 | 35 | 97% | 1 | 3% | 36 | 100% |
| Total | 81 | 99% | 1 | 1% | 82 | 100% |
| $Chi^2(df = 1, n = 82) = 1.29; p = .255$ | | | | | | |
| **Stunting** | | | | | | |
| School | No | | Yes | | Total | |
| E2 | 91 | 90% | 10 | 10% | 101 | 100% |
| C2 | 88 | 92% | 8 | 8% | 96 | 100% |
| Total | 179 | 91% | 18 | 9% | 197 | 100% |
| $Chi^2(df = 1, n = 197) = 0.15; p = .703$ | | | | | | |

| **Thin Normal Obese** | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| School | Thin | | Normal | | Obese | | Total | |
| E2 | 0 | 0% | 91 | 90% | 10 | 10% | 101 | 100% |
| C2 | 4 | 4% | 87 | 91% | 5 | 5% | 96 | 100% |
| Total | 4 | 2% | 178 | 90% | 15 | 8% | 197 | 100% |
| $Chi^2(df = 2, n = 197) = 5.63; p = .060$ | | | | | | | | |

In Table 4.31, $Chi^2$ results revealed no significant differences between E2 and C2 schools for underweight; stunting; and thinness, normal weight and obesity in children.

#### *4.3.2.3 Inferential statistics for comparing schools: Health Education and Nutrition intervention (E3) versus no Health Education and Nutrition intervention (C3) in terms of underweight; stunting; and thinness, normal weight and obesity among children*

Tables 4.32 and 4.33, show inferential statistics that reflect the comparison of pre-intervention (T1) and post-intervention (T2) for both experimental and control schools in respect of underweight; stunting; and thinness, normal weight and obesity among children.

**Table 4.32: Inferential statistics: Comparison between E3 and C3 schools in respect of underweight; stunting; and thinness, normal weight and obesity in children at pre-intervention (T1)**

| **Underweight** | | | | | | |
|---|---|---|---|---|---|---|
| School | No | | Yes | | Total | |
| E3 | 45 | 98% | 1 | 2% | 46 | 100% |
| C3 | 68 | 94% | 4 | 6% | 72 | 100% |
| Total | 113 | 96% | 5 | 4% | 118 | 100% |
| $Chi^2$(df = 1, n = 118) = 0.79; p = .374 | | | | | | |
| **Stunting** | | | | | | |
| School | No | | Yes | | Total | |
| E3 | 79 | 91% | 8 | 9% | 87 | 100% |
| C3 | 90 | 94% | 6 | 6% | 96 | 100% |
| Total | 169 | 92% | 14 | 8% | 183 | 100% |
| $Chi^2$(df = 1, n = 183) = 0.56; p = .454 | | | | | | |

| **Thin Normal Obese** | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| School | Thin | | Normal | | Obese | | Total | |
| E3 | 3 | 3% | 75 | 86% | 9 | 10% | 87 | 100% |
| C3 | 1 | 1% | 139 | 95% | 7 | 5% | 147 | 100% |
| Total | 4 | 2% | 214 | 91% | 16 | 7% | 234 | 100% |
| $Chi^2$(df = 2, n = 234) = 5.36; p = .069 | | | | | | | | |

Table 4.32 shows the $Chi^2$ test results comparing the frequency distributions of E3 and C3 schools in respect of underweight; stunting; and thinness, normal weight and obesity in T1. No significant differences were found between E3 and C3 schools in respect of the relevant variables assessed.

**Table 4.33: Inferential statistics: Comparison between E3 and C3 schools in respect of underweight; stunting; and thinness, normal weight and obesity among children at post-intervention (T2)**

| **Underweight** | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| School | No | | Yes | | | Total | | |
| E3 | 22 | 96% | 1 | 4% | | 23 | 100% | |
| C3 | 35 | 97% | 1 | 3% | | 36 | 100% | |
| Total | 57 | 97% | 2 | 3% | | 59 | 100% | |
| Chi²(df = 1, n = 59) = 0.11; p = .745 | | | | | | | | |
| **Stunting** | | | | | | | | |
| School | No | | Yes | | | Total | | |
| E3 | 78 | 90% | 9 | 10% | | 87 | 100% | |
| C3 | 88 | 92% | 8 | 8% | | 96 | 100% | |
| Total | 166 | 91% | 17 | 9% | | 183 | 100% | |
| Chi²(df = 1, n = 183) = 0.22; p = .640 | | | | | | | | |
| **Thin Normal Obese** | | | | | | | | |
| School | Thin | | Normal | | Obese | | Total | |
| E3 | 0 | 0% | 73 | 84% | 14 | 16% | 87 | 100% |
| C3 | 0 | 0% | 139 | 95% | 8 | 5% | 147 | 100% |
| Total | 0 | 0% | 212 | 91% | 22 | 9% | 234 | 100% |
| Chi²(df = 1, n = 234) = 7.28; p = .007; V = 0.18 Small | | | | | | | | |

Table 4.33 shows no significant differences between the experimental and control schools in respect of underweight and stunting in children post-intervention. However, a significant difference was seen in the distribution of thinness, normal weight and obesity among children (p<.05, V>0.1) from the relevant two schools. Majority of the children from both schools had normal weight and there was no thinness observed at either school. The experimental school had a higher frequency of obesity among children post-intervention.

#### *4.3.2.4 Inferential statistics for comparing schools: PA, Health Education and Nutrition intervention (E4) versus no PA, Health Education and Nutrition intervention (C4) in terms of underweight; stunting; and thinness, normal weight and obesity in children*

Tables 4.34 and 4.35 demonstrate inferential statistics comparing two schools, E4 (experimental school) and C4 (control school) in respect of underweight; stunting; and thinness, normal weight and obesity among children for pre-intervention (T1) and post-intervention (T2), respectively.

**Table 4.34: Inferential statistics: Comparison between E4 and C4 schools in respect of underweight; stunting; and thinness, normal weight and obesity in children at pre-intervention (T1)**

| **Underweight** | | | | | | |
|---|---|---|---|---|---|---|
| School | No | | Yes | | Total | |
| E4 | 45 | 80% | 11 | 20% | 56 | 100% |
| C4 | 34 | 81% | 8 | 19% | 42 | 100% |
| Total | 79 | 81% | 19 | 19% | 98 | 100% |
| $Chi^2(df = 1, n = 98) = 0.01; p = .941$ | | | | | | |
| **Stunting** | | | | | | |
| School | No | | Yes | | Total | |
| E4 | 128 | 76% | 40 | 24% | 168 | 100% |
| C4 | 66 | 80% | 16 | 20% | 82 | 100% |
| Total | 194 | 78% | 56 | 22% | 250 | 100% |
| $Chi^2(df = 1, n = 250) = 0.59; p = .444$ | | | | | | |

| **Thin Normal Obese** | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| School | Thin | | Normal | | Obese | | Total | |
| E4 | 12 | 7% | 152 | 90% | 4 | 2% | 168 | 100% |
| C4 | 10 | 12% | 71 | 87% | 1 | 1% | 82 | 100% |
| Total | 22 | 9% | 223 | 89% | 5 | 2% | 250 | 100% |
| $Chi^2(df = 2, n = 250) = 2.06; p = .356$ | | | | | | | | |

Table 4.34 shows there were no significant differences observed between the experimental and control schools for underweight; stunting; or thinness, normal weight and obesity among children at pre-intervention assessment.

**Table 4.35: Inferential statistics: Comparison between E4 and C4 schools in respect of underweight; stunting; and thinness, normal weight and obesity among children at post-intervention (T2)**

| **Underweight** | | | | | | |
|---|---|---|---|---|---|---|
| School | No | | Yes | | Total | |
| E4 | 16 | 94% | 1 | 6% | 17 | 100% |
| C4 | 17 | 89% | 2 | 11% | 19 | 100% |
| Total | 33 | 92% | 3 | 8% | 36 | 100% |
| $Chi^2(df = 1, n = 36) = 0.25; p = .615$ | | | | | | |

| Stunting | | | | | | |
|---|---|---|---|---|---|---|
| School | No | | Yes | | Total | |
| E4 | 117 | 70% | 51 | 30% | 168 | 100% |
| C4 | 63 | 77% | 19 | 23% | 82 | 100% |
| Total | 180 | 72% | 70 | 28% | 250 | 100% |
| Chi²(df = 1, n = 250) = 1.41; p = .235 | | | | | | |

| Thin Normal Obese | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| School | Thin | | Normal | | Obese | | Total | |
| E4 | 8 | 5% | 151 | 90% | 9 | 5% | 168 | 100% |
| C4 | 10 | 12% | 71 | 87% | 1 | 1% | 82 | 100% |
| Total | 18 | 7% | 222 | 89% | 10 | 4% | 250 | 100% |
| Chi²(df = 2, n = 250) = 6.65; p = .036; V = 0.16 Small | | | | | | | | |

Table 4.35 shows that a significant difference was found in respect of thinness, normal weight and obesity among children ($p<.05$, $V>0.1$) from two schools, E4 and C4, but no significant differences were found for underweight and stunting. More thinness in children was found in the control school and obesity was more prevalent in the experimental school.

### 4.3.3 Univariate ANOVA and ANCOVA results for overall comparison of exposure versus non-exposure to each of the three intervention components in respect of anthropometric measurements

This sub-section describes the univariate ANOVA and ANCOVA results comparing the effect of exposure versus non-exposure to each of the three intervention components (PA, Health Education and Nutrition) on the relevant anthropometric measurements irrespective of whether combined or not with another intervention component. The results are presented according to pre- and post-intervention assessments as well as pre-to post-intervention differences (D2-1). ANOVAs were conducted for the pre-intervention assessments and ANCOVAs were conducted for the post-interventions and pre-to post-intervention differences with the relevant pre-intervention assessments being the covariates.

Table 4.36 reflects univariate ANOVA results comparing the effect of exposure vs non-exposure to each of the three intervention components on the mean value of the relevant anthropometric measurement at T1.

**Table 4.36: Univariate ANOVA results: Pre-intervention (T1) comparison of exposure versus non-exposure to each of the three intervention components in respect of mean anthropometric measurements**

| Effect | F-value (df=1; 875) | p | Cohen's d | Mean Values | |
|---|---|---|---|---|---|
| **Weight (kg)** | | | | | |
| Intercept | 10694.28 | <.0005 | 4.05 | | |
| Intervention: | | | | No | Yes |
| PA | 0.90 | .344 | n/a | 30.70 | 29.98 |
| Health Ed. | 0.00 | .962 | n/a | 30.64 | 30.07 |
| Nutrition | 0.06 | .807 | n/a | 30.55 | 30.07 |
| **Height (cm)** | | | | | |
| Intercept | 236077.00 | <.0005 | 18.93 | | |
| Intervention: | | | | No | Yes |
| PA | 0.70 | .411 | n/a | 133.37 | 132.50 |
| Health Ed. | 0.60 | .443 | n/a | 133.37 | 132.50 |
| Nutrition | 0.10 | .822 | n/a | 133.19 | 132.60 |
| **BMI (kg/m$^2$)** | | | | | |
| Intercept | 20661.31 | <.0005 | 5.62 | | |
| Intervention: | | | | No | Yes |
| PA | 0.71 | .401 | n/a | 17.11 | 16.91 |
| Health Ed. | 0.13 | .715 | n/a | 17.09 | 16.95 |
| Nutrition | 0.35 | .554 | n/a | 17.08 | 16.90 |
| **Body Fat%** | | | | | |
| Intercept | 3477.11 | <.0005 | 2.31 | | |
| Intervention: | | | | No | Yes |
| PA | 0.91 | .340 | n/a | 15.97 | 15.94 |
| Health Ed. | 1.05 | .306 | n/a | 16.26 | 15.52 |
| Nutrition | 0.06 | .801 | n/a | 16.19 | 15.41 |
| **Triceps (mm)** | | | | | |
| Intercept | 3405.04 | <.0005 | 2.28 | | |
| Intervention: | | | | No | Yes |
| PA | 0.12 | .725 | n/a | 10.59 | 10.25 |
| Health Ed. | 2.22 | .137 | n/a | 10.74 | 10.04 |
| Nutrition | 0.08 | .777 | n/a | 10.61 | 10.07 |

| Effect | F-value (df=1; 875) | p | Cohen's d | Mean Values | |
|---|---|---|---|---|---|
| **Subscapular (mm)** | | | | | |
| Intercept | 1747.34 | <.0005 | 1.64 | | |
| Intervention: | | | | No | Yes |
| PA | 2.20 | .138 | n/a | 7.54 | 7.79 |
| Health Ed. | 0.54 | .464 | n/a | 7.76 | 7.47 |
| Nutrition | 0.26 | .608 | n/a | 7.77 | 7.32 |
| **Sum Skinfolds (mm)** | | | | | |
| Intercept | 2699.97 | <.0005 | 2.03 | | |
| Intervention: | | | | No | Yes |
| PA | 0.92 | .338 | n/a | 18.13 | 18.05 |
| Health Ed. | 1.32 | .250 | n/a | 18.50 | 17.51 |
| Nutrition | 0.02 | .902 | n/a | 18.39 | 17.40 |

Table 4.36 indicates that none of the mean anthropometric values differed significantly between those who were to receive either of the three interventions and those who were not.

Table 4.37 depicts ANCOVA results comparing the effect of exposure versus non-exposure to each of the three intervention components on the relevant mean anthropometric measurements in T2.

**Table 4.37: Univariate ANCOVA results: Post-intervention (T2) comparison of exposure versus non-exposure to each of the three intervention components in respect of the mean anthropometric measurements**

| Effect | F-value (df=1; 874) | p | Cohen's d | Mean Values | |
|---|---|---|---|---|---|
| **Weight (kg)** | | | | | |
| Intercept | 0.61 | .433 | n/a | | |
| Weight T1 | 25744.09 | <.0005 | n/a | | |
| Intervention: | | | | No | Yes |
| PA | 2.48 | .115 | n/a | 33.50 | 32.62 |
| Health Ed. | 0.09 | .760 | n/a | 33.20 | 33.06 |
| Nutrition | 0.08 | .775 | n/a | 33.10 | 33.25 |
| **Height (cm)** | | | | | |
| Intercept | 0.31 | .578 | n/a | | |
| Height T1 | 8587.05 | <.0005 | n/a | | |
| Intervention: | | | | No | Yes |
| PA | 9.82 | .002 | 0.22 | 136.74 | 135.13 |
| Health Ed. | 0.07 | .797 | n/a | 136.69 | 135.21 |
| Nutrition | 0.51 | .476 | n/a | 136.40 | 135.32 |
| **BMI (kg/m$^2$)** | | | | | |
| Intercept | 0.30 | .584 | n/a | | |
| BMI T1 | 11165.79 | <.0005 | n/a | | |
| Intervention: | | | | No | Yes |
| PA | 1.07 | .302 | n/a | 17.76 | 17.69 |
| Health Ed. | 2.89 | .089 | n/a | 17.63 | 17.88 |
| Nutrition | 10.35 | .001 | 0.09 | 17.64 | 17.94 |
| **Body Fat%** | | | | | |
| Intercept | 0.56 | .455 | n/a | | |
| Body Fat% T1 | 2880.11 | <.0005 | n/a | | |
| Intervention: | | | | No | Yes |
| PA | 59.01 | <.0005 | 0.27 | 18.06 | 15.74 |
| Health Ed. | 2.56 | .110 | n/a | 17.77 | 16.17 |
| Nutrition | 0.00 | .947 | n/a | 17.46 | 16.31 |

| Effect | F-value (df=1; 874) | p | Cohen's d | Mean Values | |
|---|---|---|---|---|---|
| **Triceps (mm)** | | | | | |
| Intercept | 0.00 | .953 | n/a | | |
| Triceps T1 | 2177.14 | <.0005 | n/a | | |
| Intervention: | | | | No | Yes |
| PA | 37.92 | <.0005 | 0.30 | 12.08 | 10.35 |
| Health Ed. | 3.21 | .073 | n/a | 11.90 | 10.62 |
| Nutrition | 0.96 | .327 | n/a | 11.66 | 10.71 |
| **Subscapular (mm)** | | | | | |
| Intercept | 0.07 | .793 | n/a | | |
| Subscapular T1 | 1636.03 | <.0005 | n/a | | |
| Intervention: | | | | No | Yes |
| PA | 46.92 | <.0005 | 0.25 | 9.06 | 7.49 |
| Health Ed. | 1.15 | .284 | n/a | 8.81 | 7.86 |
| Nutrition | 0.26 | .608 | n/a | 8.61 | 7.99 |
| **Sum Skinfolds (mm)** | | | | | |
| Intercept | 1.68 | .195 | n/a | | |
| Sum Skinfolds T1 | 2176.00 | <.0005 | n/a | | |
| Intervention: | | | | No | Yes |
| PA | 50.62 | <.0005 | 0.28 | 21.14 | 17.84 |
| Health Ed. | 2.50 | .114 | n/a | 20.71 | 18.48 |
| Nutrition | 0.03 | .857 | n/a | 20.26 | 18.70 |

Table 4.37 shows a significant difference in the mean values of children participating in the PA intervention component in respect of BF%, triceps, subscapular and sum of skinfolds (p<.05 d>0.20) at post-intervention when compared to those who did not participate in PA. Those children who did not participate in the PA intervention had significantly larger BF%, triceps, subscapular and sum of skinfolds scores than those who participated in the PA intervention component.

Table 4.38 depicts ANCOVA results comparing the effect of exposure versus non-exposure to each of the three intervention components on the mean values of the relevant anthropometric measurements, looking at the pre-to-post intervention differences (D2-1).

**Table 4.38: Univariate ANCOVA results: Pre-to-post-intervention difference comparisons between exposure versus non-exposure to each of the three intervention components in respect of mean anthropometric measurements**

| Effect | F-value (df=1; 878) | p | Cohen's d | Mean Values | |
|---|---|---|---|---|---|
| **Weight (kg)** | | | | | |
| Intercept | 0.61 | .433 | n/a | | |
| Weight T1 | 208.22 | <.0005 | n/a | | |
| Intervention: | | | | No | Yes |
| PA | 12.65 | <.0005 | 0.09 | 2.79 | 2.64 |
| Health Ed. | 3.77 | .053 | n/a | 2.56 | 2.99 |
| Nutrition | 8.43 | .004 | 0.38 | 2.55 | 3.19 |
| **Height (cm)** | | | | | |
| Intercept | 0.31 | .578 | n/a | | |
| Height T1 | 2.17 | .141 | n/a | | |
| Intervention: | | | | No | Yes |
| PA | 9.82 | .002 | 0.33 | 3.38 | 2.63 |
| Health Ed. | 0.07 | .797 | n/a | 3.32 | 2.71 |
| Nutrition | 0.51 | .476 | n/a | 3.22 | 2.72 |
| **BMI ((kg/m$^2$)** | | | | | |
| Intercept | 0.30 | .584 | n/a | | |
| BMI T1 | 16.95 | <.0005 | n/a | | |
| Intervention: | | | | No | Yes |
| PA | 1.07 | .302 | n/a | 0.65 | 0.78 |
| Health Ed. | 2.89 | .089 | n/a | 0.54 | 0.93 |
| Nutrition | 10.35 | .001 | 0.53 | 0.56 | 1.04 |
| **Body Fat%** | | | | | |
| Intercept | 7.27 | .007 | 0.27 | | |
| Body Fat% T1 | 0.06 | .806 | n/a | | |
| Intervention: | | | | No | Yes |
| PA | 42.07 | <.0005 | 0.49 | 1.43 | -0.03 |
| Health Ed. | 0.56 | .456 | n/a | 1.06 | 0.52 |
| Nutrition | 0.52 | .472 | n/a | 0.87 | 0.76 |

| Effect | F-value (df=1; 878) | p | Cohen's d | Mean Values | |
|---|---|---|---|---|---|
| **Triceps (mm)** | | | | | |
| Intercept | 0.00 | .953 | n/a | | |
| Triceps T1 | 10.29 | .001 | n/a | | |
| Intervention: | | | | No | Yes |
| PA | 37.92 | <.0005 | 0.44 | 1.49 | 0.10 |
| Health Ed. | 3.21 | .073 | n/a | 1.16 | 0.58 |
| Nutrition | 0.96 | .327 | n/a | 1.04 | 0.64 |
| **Subscapular (mm)** | | | | | |
| Intercept | 0.07 | .793 | n/a | | |
| Subscapular T1 | 8.77 | .003 | n/a | | |
| Intervention: | | | | No | Yes |
| PA | 46.92 | <.0005 | 0.49 | 1.52 | -0.30 |
| Health Ed. | 1.15 | .284 | n/a | 1.05 | 0.40 |
| Nutrition | 0.26 | .608 | n/a | 0.83 | 0.66 |
| **Sum Skinfolds (mm)** | | | | | |
| Intercept | 1.68 | .195 | n/a | | |
| Sum Skinfolds T1 | 22.93 | <.0005 | n/a | | |
| Intervention: | | | | No | Yes |
| PA | 50.62 | <.0005 | 0.51 | 3.01 | -0.21 |
| Health Ed. | 2.50 | .114 | n/a | 2.21 | 0.98 |
| Nutrition | 0.03 | .857 | n/a | 1.88 | 1.31 |

Table 4.38 reflects that those children who participated in the PA intervention had a significantly smaller increase in height in comparison to those with non-exposure.

The PA intervention resulted in a negative change in the individual skinfold measurements as well as BF% pre- to post-intervention while those who were not exposed to PA presented with an increase in the latter variables. The differences reflected regarding skinfold measurements and BF% were significant ($p<.05$ $d>0.20$). Exposure to the PA and nutrition interventions had significant differences registered in terms of the exposed children's weight. Those children who did not participate in the PA intervention had significantly larger weight scores than those who did participate in PA, whereas children that received the nutrition intervention showed significantly larger increases in mean weight and BMI values ($p<.05$ $d>0.20$) in comparison to those who did not receive the relevant intervention.

### 4.3.4 ANOVA and ANCOVA results for overall comparison of exposure versus non-exposure to each of the three intervention components in respect of WAZ, HAZ and BAZ

Tables 4.39 reflects ANOVA, while Tables 4.40 and 4.41 depict ANCOVA results comparing the mean WAZ, HAZ and BAZ in respect of each of the three intervention components applied at T1 and T2 and for the differences between T1 and T2 (D2-1) respectively. These comparisons are made between exposure versus non-exposure to each of the three intervention components either on its own or in combination with the other two.

**Table 4.39: Univariate ANOVA results: Pre-intervention (T1) comparison of exposure versus non-exposure to each of the three intervention components in respect of mean WAZ, HAZ and BAZ**

| Effect | F-value | p | Cohen's d | Mean Values | |
|---|---|---|---|---|---|
| **WAZ (df=1; 532)** | | | | | |
| Intercept | 15.17 | <.0005 | 0.17 | | |
| Intervention: | | | | No | Yes |
| PA | 0.04 | .840 | n/a | -0.18 | -0.25 |
| Health Ed. | 0.40 | .529 | n/a | -0.13 | -0.35 |
| Nutrition | 1.00 | .317 | n/a | -0.15 | -0.44 |
| **HAZ (df=1; 875)** | | | | | |
| Intercept | 459.71 | <.0005 | 0.70 | | |
| Intervention: | | | | No | Yes |
| PA | 3.50 | .062 | n/a | -0.63 | -0.92 |
| Health Ed. | 0.37 | .543 | n/a | -0.59 | -0.98 |
| Nutrition | 17.40 | <.0005 | 0.50 | -0.60 | -1.11 |
| **BAZ (df=1; 875)** | | | | | |
| Intercept | 1.24 | .266 | n/a | | |
| Intervention: | | | | No | Yes |
| PA | 1.33 | .250 | n/a | 0.06 | -0.06 |
| Health Ed. | 1.19 | .276 | n/a | 0.07 | -0.07 |
| Nutrition | 5.08 | .024 | 0.19 | 0.08 | -0.15 |

The results in Table 4.39 show a significantly lower HAZ value prior to exposure (T1) for those children who were subsequently exposed to the nutrition intervention. WAZ and BAZ showed no significant differences between the relevant groups at T1.

**Table 4.40: Univariate ANCOVA results: Post-intervention (T2) comparison of exposure versus non-exposure to each of the three intervention components in respect of mean WAZ, HAZ and BAZ**

| Effect | F-value | p | Cohen's d | Mean Values | |
|---|---|---|---|---|---|
| **WAZ (df=1; 280)** | | | | | |
| Intercept | 14.62 | <.0005 | 0.03 | | |
| WAZ T1 | 4588.71 | <.0005 | n/a | | |
| Intervention: | | | | No | Yes |
| PA | 6.75 | .010 | 0.13 | 0.09 | -0.07 |
| Health Ed. | 4.35 | .038 | 0.03 | 0.05 | 0.01 |
| Nutrition | 1.10 | .295 | n/a | 0.02 | 0.17 |
| **HAZ (df=1; 874)** | | | | | |
| Intercept | 30.51 | <.0005 | 0.73 | | |
| HAZ T1 | 8170.46 | <.0005 | n/a | | |
| Intervention: | | | | No | Yes |
| PA | 11.08 | .001 | 0.35 | -0.66 | -1.04 |
| Health Ed. | 0.06 | .812 | n/a | -0.62 | -1.09 |
| Nutrition | 0.82 | .365 | n/a | -0.65 | -1.22 |
| **BAZ (df=1; 874)** | | | | | |
| Intercept | 117.53 | <.0005 | 0.13 | | |
| BAZ T1 | 5944.85 | <.0005 | n/a | | |
| Intervention: | | | | No | Yes |
| PA | 0.16 | .693 | n/a | 0.17 | 0.14 |
| Health Ed. | 1.72 | .190 | n/a | 0.14 | 0.19 |
| Nutrition | 8.90 | .003 | 0.00 | 0.16 | 0.16 |

Table 4.40 shows a significant difference for HAZ between exposure to PA intervention component and non-exposure. There were no observed differences between exposure versus non-exposure to the three intervention components in respect of WAZ and BAZ at post-intervention assessment (T2).

**Table 4.41: Univariate ANCOVA results: Comparison of exposure versus non-exposure to each of the three intervention components in respect of mean WAZ, HAZ and BAZ pre-to-post-intervention differences (D2-1)**

| Effect | F-value | p | Cohen's d | Mean Values | |
|---|---|---|---|---|---|
| **WAZ (df=1; 280)** | | | | | |
| Intercept | 14.62 | <.0005 | 0.24 | | |
| WAZ T1 | 1.93 | .165 | n/a | | |
| Intervention: | | | | No | Yes |
| PA | 6.75 | .010 | 0.16 | 0.09 | 0.04 |
| Health Ed. | 4.35 | .038 | 0.34 | 0.04 | 0.15 |
| Nutrition | 1.10 | .295 | n/a | 0.05 | 0.22 |
| **HAZ (df=1; 874)** | | | | | |
| Intercept | 30.51 | <.0005 | 0.19 | | |
| HAZ T1 | 1.08 | .299 | n/a | | |
| Intervention: | | | | No | Yes |
| PA | 11.08 | .001 | 0.30 | -0.02 | -0.12 |
| Health Ed. | 0.06 | .812 | n/a | -0.04 | -0.11 |
| Nutrition | 0.82 | .365 | n/a | -0.05 | -0.11 |
| **BAZ (df=1; 874)** | | | | | |
| Intercept | 117.53 | <.0005 | 0.32 | | |
| BAZ T1 | 27.02 | <.0005 | n/a | | |
| Intervention: | | | | No | Yes |
| PA | 0.16 | .693 | n/a | 0.11 | 0.20 |
| Health Ed. | 1.72 | .190 | n/a | 0.07 | 0.26 |
| Nutrition | 8.90 | .003 | 0.52 | 0.08 | 0.31 |

Table 4.41 indicates that WAZ, HAZ and BAZ showed significant results in respect of Health Education, PA and nutrition intervention components, respectively. Those participants who were exposed to Health Education presented with significantly larger ($p<.05$ $d>0.20$) mean increases in pre- to post-intervention differences for WAZ scores than those who were not. Furthermore, those participants who were exposed to PA showed a significantly larger ($p<.05$ $d>0.20$) mean decrease in HAZ score pre-to-post intervention comparison than those who did not have this exposure. Lastly, children exposed to the nutrition intervention showed significantly larger mean increase in terms of BAZ scores, compared to those children not exposed to the intervention.

### 4.3.5 Inferential statistics comparing exposure and non-exposure to each of the three intervention components in respect of the following variables: underweight; stunting; and thinness, normal weight and obesity

Tables 4.42 and 4.43 show inferential statistics comparing the PA intervention versus no PA intervention in terms of nutritional status variables such as underweight; stunting; and thinness, normal weight and obesity; for pre-intervention (T1) and post-intervention (T2) assessments respectively.

**Table 4.42: Inferential statistics for comparing exposure versus non-exposure to the PA intervention component at pre-intervention (T1) in respect of the distribution of variables depicting nutritional status**

| **Underweight** | | | | | | |
|---|---|---|---|---|---|---|
| PA | No | | Yes | | Total | |
| No | 326 | 95% | 17 | 5% | 343 | 100% |
| Yes | 178 | 92% | 15 | 8% | 193 | 100% |
| Total | 504 | 94% | 32 | 6% | 536 | 100% |
| $Chi^2(df = 1, n = 536) = 1.74; p = .187$ | | | | | | |
| **Stunting** | | | | | | |
| PA | No | | Yes | | Total | |
| No | 482 | 92% | 42 | 8% | 524 | 100% |
| Yes | 304 | 86% | 51 | 14% | 355 | 100% |
| Total | 786 | 89% | 93 | 11% | 879 | 100% |
| $Chi^2(df = 1, n = 879) = 9.02; p = .003; V = 0.10$ Small | | | | | | |

| **Thin Normal Obese** | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| PA | Thin | | Normal | | Obese | | Total | |
| No | 19 | 4% | 477 | 91% | 28 | 5% | 524 | 100% |
| Yes | 15 | 4% | 320 | 90% | 20 | 6% | 355 | 100% |
| Total | 34 | 4% | 797 | 91% | 48 | 5% | 879 | 100% |
| $Chi^2(df = 2, n = 879) = 0.25; p = .884$ | | | | | | | | |

Table 4.42 shows that in T1 the distribution was statistically different for stunting among participants destined to receiving the PA intervention component compared to those not destined to receiving the PA intervention component ($p<.05$, $V>0.1$). Participants to be exposed to the PA intervention component showed the significantly higher prevalence of stunting (14% versus 8%).

**Table 4.43: Inferential statistics for comparing exposure versus non-exposure to the PA intervention component at post-intervention (T2) in respect of the distribution of variables depicting nutritional status**

| **Underweight** | | | | | | |
|---|---|---|---|---|---|---|
| PA | No | | Yes | | Total | |
| No | 183 | 97% | 6 | 3% | 189 | 100% |
| Yes | 95 | 97% | 3 | 3% | 98 | 100% |
| Total | 278 | 97% | 9 | 3% | 287 | 100% |
| $Chi^2(df = 1, n = 287) = 0.00; p = .958$ | | | | | | |

| **Stunting** | | | | | | |
|---|---|---|---|---|---|---|
| PA | No | | Yes | | Total | |
| No | 473 | 90% | 51 | 10% | 524 | 100% |
| Yes | 289 | 81% | 66 | 19% | 355 | 100% |
| Total | 762 | 87% | 117 | 13% | 879 | 100% |
| $Chi^2(df = 1, n = 879) = 14.39; p < .0005; V = 0.13$ Small | | | | | | |

| **Thin Normal Obese** | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| PA | Thin | | Normal | | Obese | | Total | |
| No | 15 | 3% | 474 | 90% | 35 | 7% | 524 | 100% |
| Yes | 10 | 3% | 318 | 90% | 27 | 8% | 355 | 100% |
| Total | 25 | 3% | 792 | 90% | 62 | 7% | 879 | 100% |
| $Chi^2(df = 2, n = 879) = 0.28; p = .871$ | | | | | | | | |

In table 4.43 it can be observed that a significant difference was seen in the distribution of stunting among participants who had exposure to the PA intervention component compared to those with no such PA exposure ($p<.05$, $V>0.1$). The group with PA exposure showed a higher prevalence of stunting than the non-exposure group in T2.

Tables 4.44 and 4.45 show inferential statistics comparing exposure versus no-exposure to the Health Education intervention component in terms of the following variables: underweight; stunting; and thinness, normal weight and obesity; for pre-intervention (T1) and post-intervention (T2) assessments respectively.

**Table 4.44: Inferential statistics for comparing exposure versus non-exposure to the Health Education intervention component at pre-intervention (T1) in respect of the distribution of variables depicting nutritional status**

| **Underweight** | | | | | | |
|---|---|---|---|---|---|---|
| Health Ed. | No | | Yes | | Total | |
| No | 339 | 95% | 17 | 5% | 356 | 100% |
| Yes | 165 | 92% | 15 | 8% | 180 | 100% |
| Total | 504 | 94% | 32 | 6% | 536 | 100% |
| Chi²(df = 1, n = 536) = 2.70; p = .101 | | | | | | |
| **Stunting** | | | | | | |
| Health Ed. | No | | Yes | | Total | |
| No | 487 | 93% | 36 | 7% | 523 | 100% |
| Yes | 299 | 84% | 57 | 16% | 356 | 100% |
| Total | 786 | 89% | 93 | 11% | 879 | 100% |
| Chi²(df = 1, n = 879) = 18.65; p < .0005; V = 0.15 Small | | | | | | |

| **Thin Normal Obese** | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Health Ed. | Thin | | Normal | | Obese | | Total | |
| No | 17 | 3% | 478 | 91% | 28 | 5% | 523 | 100% |
| Yes | 17 | 5% | 319 | 90% | 20 | 6% | 356 | 100% |
| Total | 34 | 4% | 797 | 91% | 48 | 5% | 879 | 100% |
| Chi²(df = 2, n = 879) = 1.38; p = .503 | | | | | | | | |

Table 4.44 reflects a significant difference for stunting among participants destined to be exposed to the health education intervention component (p<.05, V>0.1) compared to the destined non-exposure group, with children from the latter group showing less prevalence of stunting compared to the relevant intervention group.

**Table 4.45: Inferential statistics for comparing exposure versus non-exposure to the Health Education intervention component at post-intervention (T2) in respect of the distribution of variables depicting nutritional status**

| **Underweight** | | | | | | |
|---|---|---|---|---|---|---|
| Health Ed. | No | | Yes | | Total | |
| No | 194 | 97% | 7 | 3% | 201 | 100% |
| Yes | 84 | 98% | 2 | 2% | 86 | 100% |
| Total | 278 | 97% | 9 | 3% | 287 | 100% |
| Chi²(df = 1, n = 287) = 0.27; p = .606 | | | | | | |
| **Stunting** | | | | | | |
| Health Ed. | No | | Yes | | Total | |
| No | 476 | 91% | 47 | 9% | 523 | 100% |
| Yes | 286 | 80% | 70 | 20% | 356 | 100% |
| Total | 762 | 87% | 117 | 13% | 879 | 100% |
| Chi²(df = 1, n = 879) = 20.92; p < .0005; V = 0.15 Small | | | | | | |

| **Thin Normal Obese** | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Health Ed. | Thin | | Normal | | Obese | | Total | |
| No | 17 | 3% | 477 | 91% | 29 | 6% | 523 | 100% |
| Yes | 8 | 2% | 315 | 88% | 33 | 9% | 356 | 100% |
| Total | 25 | 3% | 792 | 90% | 62 | 7% | 879 | 100% |
| Chi²(df = 2, n = 879) = 5.09; p = .078 | | | | | | | | |

The same tendency depicted in T1 was seen in T2, with Table 4.45 only showing a significant difference between the health education component exposure and non-exposure group for stunting (p<.05, V>0.1), with the non-exposure group showing less prevalence of stunting.

Tables 4.46 and 4.47 show inferential statistics comparing exposure versus non-exposure to the Nutrition intervention component in terms of the following variables: underweight; stunting, and thinness, normal weight and obesity; at pre-intervention (T1) and post-intervention (T2) assessments respectively.

**Table 4.46: Inferential statistics for comparing exposure versus non-exposure to the Nutrition intervention component at pre-intervention (T1) in respect of the distribution of variables depicting nutritional status**

| **Underweight** | | | | | | |
|---|---|---|---|---|---|---|
| Nutrition | No | | Yes | | Total | |
| No | 414 | 95% | 20 | 5% | 434 | 100% |
| Yes | 90 | 88% | 12 | 12% | 102 | 100% |
| Total | 504 | 94% | 32 | 6% | 536 | 100% |
| $Chi^2$(df = 1, n = 536) = 7.53; p = .006; V = 0.12 Small | | | | | | |
| **Stunting** | | | | | | |
| Nutrition | No | | Yes | | Total | |
| No | 579 | 93% | 45 | 7% | 624 | 100% |
| Yes | 207 | 81% | 48 | 19% | 255 | 100% |
| Total | 786 | 89% | 93 | 11% | 879 | 100% |
| $Chi^2$(df = 1, n = 879) = 25.80; p < .0005; V = 0.17 Small | | | | | | |

| **Thin Normal Obese** | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Nutrition | Thin | | Normal | | Obese | | Total | |
| No | 19 | 3% | 570 | 91% | 35 | 6% | 624 | 100% |
| Yes | 15 | 6% | 227 | 89% | 13 | 5% | 255 | 100% |
| Total | 34 | 4% | 797 | 91% | 48 | 5% | 879 | 100% |
| $Chi^2$(df = 2, n = 879) = 3.96; p = .138 | | | | | | | | |

Table 4.46 shows significant differences between the group destined for nutrition exposure and the group not destined for such exposure in terms of the distribution of underweight and stunting among participants (p<.05, V>0.1). The prevalence of underweight and stunting among participants was higher in the group destined for nutrition exposure compared to the group not destined for nutrition exposure.

**Table 4.47: Inferential statistics for comparing exposure versus non-exposure to the Nutrition intervention component at post-intervention (T2) in respect of the distribution of variables depicting nutritional status**

| **Underweight** | | | | | | |
|---|---|---|---|---|---|---|
| Nutrition | No | | Yes | | Total | |
| No | 240 | 97% | 7 | 3% | 247 | 100% |
| Yes | 38 | 95% | 2 | 5% | 40 | 100% |
| Total | 278 | 97% | 9 | 3% | 287 | 100% |
| Chi$^2$(df = 1, n = 287) = 0.53; p = .466 | | | | | | |
| **Stunting** | | | | | | |
| Nutrition | No | | Yes | | Total | |
| No | 567 | 91% | 57 | 9% | 624 | 100% |
| Yes | 195 | 76% | 60 | 24% | 255 | 100% |
| Total | 762 | 87% | 117 | 13% | 879 | 100% |
| Chi$^2$(df = 1, n = 879) = 32.51; p < .0005; V = 0.19 Small | | | | | | |

| **Thin Normal Obese** | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Nutrition | Thin | | Normal | | Obese | | Total | |
| No | 17 | 3% | 568 | 91% | 39 | 6% | 624 | 100% |
| Yes | 8 | 3% | 224 | 88% | 23 | 9% | 255 | 100% |
| Total | 25 | 3% | 792 | 90% | 62 | 7% | 879 | 100% |
| Chi$^2$(df = 2, n = 879) = 2.28; p = .320 | | | | | | | | |

Table 4.47 reflects a significant difference for stunting among participants in the nutrition exposed group ($p<.05$, $V>0.1$) compared to the non-nutrition exposed group. The group receiving the nutrition intervention showed higher prevalence of stunting than the non-nutrition exposed group.

The next chapter provides an interpretation and discussion of the results reflected above before drawing conclusions and offering recommendations for future research.

# CHAPTER 5

# DISCUSSION, CONCLUSION, LIMITATIONS AND RECOMMENDATIONS

## 5.1 INTRODUCTION

The aim of this study was to determine the effect of various combinations of school-based interventions on the body composition of grade 4 children from lower socio-economic communities in Port Elizabeth.

The results obtained for the measured variables in the present study were reflected in Chapter 4. Descriptive statistics were used to describe the participants under investigation and inferential statistics were reflected in accordance with the aims and objectives of the study. This chapter commences with a section comparing the entire sample in terms of variables measured at pre, post and pre- to post-intervention differences. The section that follows provides an interpretation and possible explanations for the results provided for the pair-wise comparison of schools. Literature is used to provide explanations for significant and non-significant results of each of the intervention components for children exposed, in comparison to those not exposed to the interventions. Ultimately, a summary of results is provided, indicating the extent to which the study achieved its aim, and a final conclusion is offered. This chapter is completed by an overview of the limitations and strengths of the study, followed by recommendations for future research.

## 5.2 DESCRIPTION OF PARTICIPANT DEMOGRAPHICS AND MEASURED VARIABLES

On analysing the study participants, it was seen that the majority of the children were in the 8-9 year-old category (59%) (Table 4.1) and in terms of gender, there was an even distribution of boys and girls (50% respectively) (Table 4.2). The majority of the participants were Black Africans (62%) residing in the Township areas of Port Elizabeth (Table 4.3).

Table 4.10 reflects that the mean age of all participants during pre-testing (T1) was 9.94 ± 0.80 years, with children from school C1 as the youngest (9.49 ± 0.76 years) and children from E4 as the oldest (10.39 ± 0.73 years) (Appendix 10). The average height of the sample group was 133.02 ± 7.03 cm (Table 4.10). Participants from the Northern area schools had a lower average height (131.90 cm) (Appendix 10) compared to participants from area schools who were taller, with an average height of 134.17 cm (Appendix 10). Average weight was recorded as 30.41 ± 7.51 kg. The heaviest participants were from a Township school (E3) with a mean weight of 33.18 ± 10.10 kg with the lowest mean weight being recorded at 27.03 ± 5.78 kg from a Northern area school (C4) (Appendix 10).

The average BMI of all participants was 17.03 ± 3.03 kg/m$^2$ (Table 4.10) and this is similar to the provincial average BMI of 17.1 kg/m$^2$ and 17.7 kg/m$^2$ for boys and girls respectively (Shisana *et al.*, 2014:206). The highest BMI score was again from a school (E3), with a mean value of 18.07 ± 3.86 kg/m$^2$ and the lowest score recorded from a Northern area school (C4) was a mean BMI of 15.65 ± 2.06 kg/m$^2$ (Appendix 10). BF% (Table 4.10) was 15.96 ± 6.91% on average. The highest mean value was 19.11 ± 9.08% at school E1 (Township school) and the lowest score was again from school C4, with a mean score of 12.96 ± 5.40%.

At post-test (T2), the mean age was 10.56 ± 0.80 years (Table 4.10). Pre-testing commenced in February 2015 and post-intervention was conducted in September 2015 and this explains the increase in mean age from pre- to post-test of 0.62 ± 0.02 years, as some children had a birthday after the pre-test period. The average height and weight of the entire sample group increased post-intervention to 136.09 ± 7.52cm and 33.14 ± 8.40 kg respectively (Table 4.10). The BMI and BF% also increased to 17.73 ± 3.27 kg/m$^2$ and 17.12 ± 8.57% for the sample group. The following pre- to post-intervention differences were found for height (3.07 ± 2.31cm), weight (2.73 ± 1.73 kg) BF% (1.16 ± 4.29%) and BMI (0.70 ± 0.92 kg/m$^2$) (Table 4.10).

When analysing the nutritional status (WAZ, HAZ and BAZ) (Tables 4.4 to 4.8) of the entire group from pre- to post-intervention, it is evident that the prevalence of underweight (6% to 3%) children and thinness (4% to 3%) decreased. In contrast, stunting (11% to 13%) and obesity (5% to 7%) increased. A study conducted in two districts in the Eastern Cape (n = 1390) evaluated the impact of NSNP and TBF breakfast programmes and reported a prevalence of stunting (10.6%), underweight (2.5%) and obesity (3.5%) in their study participants (Graham *et al.*, 2015:26). The prevalence of malnutrition in this study is therefore higher than that reported by Graham *et al.* (2015:26).

Township schools, in general, had the tallest and heaviest children, compared to Northern area schools that had the shortest and lightest children on average. Northern area children, on average, had a higher prevalence of underweight, stunting and thinness when compare to Township children who displayed a prevalence of overnutrition, as reflected in Figures 5.1 and 5.2 below. These results corroborate those found in the SAHANES-1, with Coloured children displaying significantly more stunting and underweight compared to Black African children (Shisana *et al.*, 2014:207). In contrast, Armstrong *et al.* (2011:838) found in their study that significantly more Black African children were stunted in comparison to Coloured children. The reason for these conflicting results could be attributed to the fact Armstrong *et al.* (2011:838) used datasets from two cross-sectional studies, the South African National Primary Schools' Anthropometry Survey (Jinabhai *et al.*, 2003:360) and the Discovery Vitality Health of the Nation Study (Armstrong, Lambert, Sharwood & Lambert, 2006:440). Their study sample included Black African, mixed ancestry and White children from rural and urban areas, whereas the current study sample consisted of a homogenous lower socio-economic group of urban Black African and Coloured children. Armstrong *et al.* (2011:838) calculated the prevalence of stunting and obesity according to the National Centre for Health Statistics and the Obesity Task Force reference data, with the current study utilising WHO references.

Figures 5.1 and 5.2 compare the nutritional status (underweight, stunting and obesity) between baseline (T1) and post ten-week intervention (T2) for individual schools.

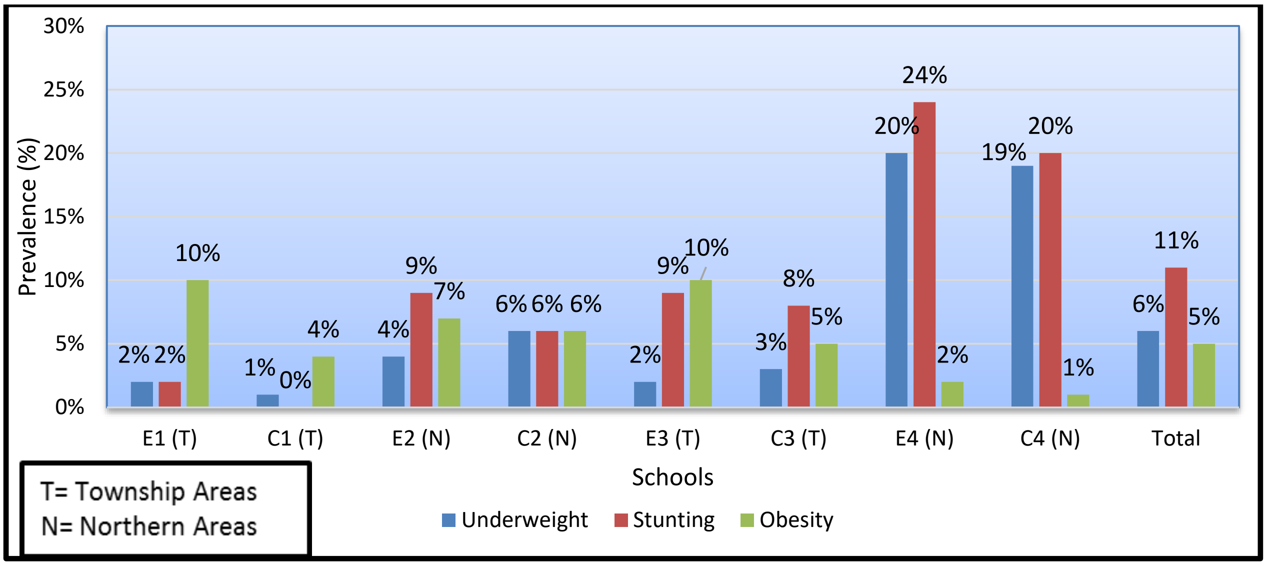


**Figure 5.1: Nutritional status of the entire sample in T1**

Figure 5.1 illustrates that children from the Northern areas had a higher percentage of children in the underweight and stunting category, especially schools E4 (20% and 24%) and C4 (19% and 20%) respectively. Children from Township areas reflected more evidence of obesity, especially schools E1 (10%) and E3 (10%).

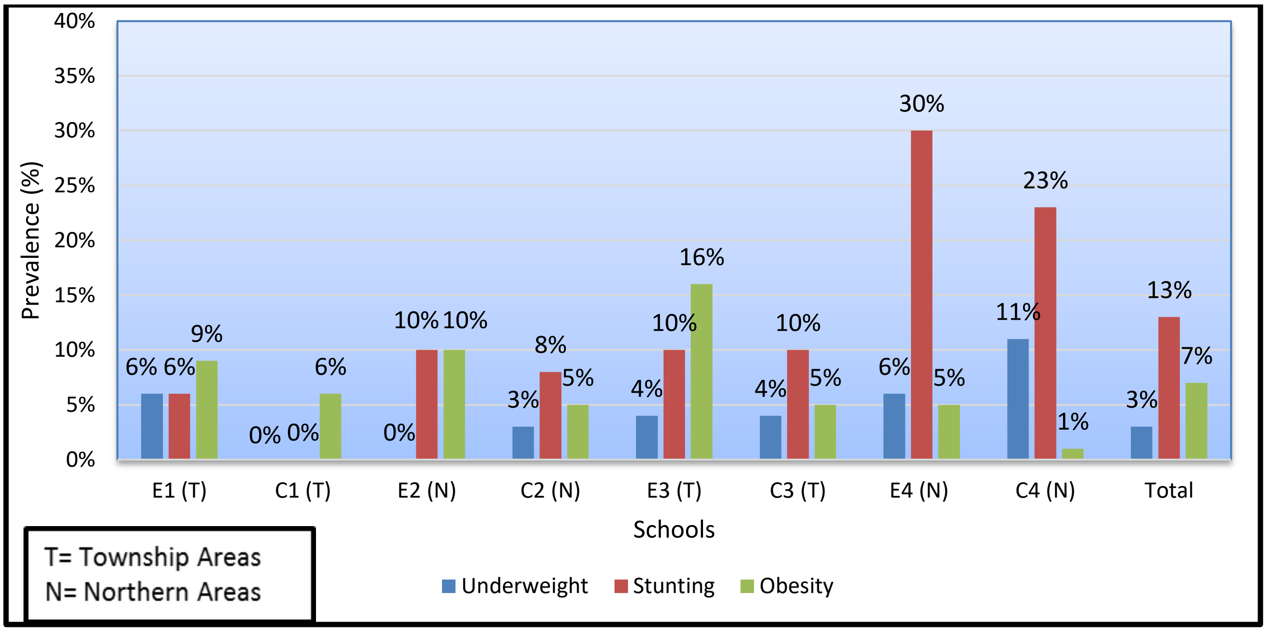


**Figure 5.2: Nutritional status of the entire sample in T2**

In Figure 5.2 it is evident that the prevalence of under-nourishment had increased slightly at three Township schools (E1, E3 and C3) and decreased at schools E4 and C4, which were initially high in T1. Although the prevalence of under-nourishment had decreased at Northern area schools, C4 still had the highest percentage of children in the underweight category (11%). The prevalence of stunting increased in all schools, with the exception of school C1 that stayed the same (0%). Northern area schools E4 and C4 had the highest prevalence of stunting (30% and 23% respectively) post-intervention. The prevalence of obesity increased at schools C1, E2, E3 and E4, with E3 having the highest prevalence (16%) post-intervention.

## 5.3 COMPARISON BETWEEN SCHOOLS E1 AND C1 IN RESPECT OF PA INTERVENTION IMPACT

Schools E1 and C1 were both Township schools with a similar geographical area and socio-economic status. E1 was an experimental school participating in the PA only intervention and C1 was the control school. The majority of the children from both schools were in the 8-9 years age category, with 81% of the children from C1 falling into this category. At pre-testing, children from E1 were significantly ($p = .004$; $d = 0.42$) older than children from C1. Table 4.12 in Chapter 4 reflects these values.

Before the experimental school participated in the ten-week intervention, pre-test measurements were obtained to assess body composition. Results indicated that only age and BF% displayed significant differences between the two schools for pre-test results, with E1 having higher BF% scores (19.11 ± 9.08%) compared to C1 (15.82 ± 6.48%). The two schools did not show any significant differences for BMI, WAZ, HAZ and BAZ. As mentioned in Chapter 4, section 4.2.2, WAZ was used to identify underweight, HAZ was used to distinguish between the incidence of stunting and non-stunting, and BAZ was used as an indicator to distinguish between thinness, normal weight and obesity.

When examining the post-test results illustrated in Table 4.14, there were no significant differences between the experimental and control school. The reason BF% showed no significant difference post-intervention, although there was significance at pre-testing, is because school C1 increased BF% scores while E1 decreased. Studies that implemented PA interventions have seen an improvement in body composition of the experimental group and have attributed this improvement to increased time spent being active during PE classes (Sallis *et al.*, 1997:1331; Kriemler *et al.*, 2010:c790; Monyeki *et al.*, 2012:245).

The results obtained for this study, as depicted in Table 4.15, indicate that the experimental school (E1) differed significantly ($p < .05$; $d > 0.2$) from the control school in respect of pre- to post-intervention differences for BF% ($p < .0005$; $d = 0.96$), WAZ ($p = .022$; $d = 0.49$) and HAZ ($p = .02$; $d > 0.45$). A discussion of the possible reasons for these results is presented in the section below.

BF% decreased in the experimental school (-0.47 ± 4.05%), while it increased in the control school (3.84 ± 4.78%), resulting in a significant difference. Similar results were reported in a study by Monyeki *et al.* (2012:245), where the experimental group decreased and the control group significantly increased BF% scores after a ten-month PA intervention. The BF% results seen at the experimental school indicate that there is an association between PA and BF%. Children participated in more PA through participating in PE classes twice a week and in-class PA breaks every day. Treuth, Hou, Young and Maynard (2005:1609) hold that participating in light PA was associated with a reduction in fat mass and percentage fat in their study population.

The significant differences seen in WAZ and HAZ scores reflected a mean increase in these z-scores for age among the control schools. The level of underweight and stunting improved at the control school but did not improve at the experimental school. Table 4.15 indicates that school C1 increased height ($p < .0005$; $d = 0.52$) and weight ($p = .016$; $d = 0.35$) significantly more than school E1, and this could explain the improved values for WAZ and HAZ scores at C1. The increase in height at the control school could be due to the age differences between the two schools, with school C1 initially having significantly more children in the younger age category. At post-intervention, children from the control school could possibly have been in the initiation of an adolescent growth spurt, where the velocity curve begins to accelerate, which is between nine and ten years of age (Malina, Bouchard & Bar-Or, 2004:61). Children from the experimental school who were initially older and showed less of an increase in height, could possibly have been beyond this stage.

Chi-Square ($Chi^2$) tests were performed to test for the difference in frequency distributions in terms of nutritional status for schools E1 and C1. There were no significant differences observed in T1 (Table 4.28), as both schools indicated similar distributions in nutritional status. Table 4.29 indicates a significant difference in the distribution of underweight ($p = .050$; $V = 0.20$) and stunting ($p = .010$; $V = 0.18$) at post-intervention. School E1 indicated a significantly higher percentage in terms of the distribution of underweight and stunted children, while school C1 indicated a decrease. The distribution of stunting reported for school E1 (6%) was lower than the prevalence reported in the SANHANES-1 (15.4%), but the prevalence of underweight was similar, 6% in the current study and 5.8% in the national survey (Shisana *et al.*, 2014:207)

## 5.4 COMPARISON BETWEEN SCHOOLS E2 AND C2 IN RESPECT OF THE PA AND HEALTH AND HYGIENE EDUCATION INTERVENTION IMPACT

At pre-testing there were no significant ($p > .05$) differences between E2 and C2 as illustrated in Table 4.16. It can be concluded that the experimental and control schools were comparable in terms of all body composition variables assessed prior to the ten-week intervention programme. Both schools were from the Northern areas and had a mixture of Black African and Coloured children attending the school. Socio-economic conditions and the geographic location of the schools were similar, and the schools were found to be comparable in terms of body composition.

Findings for post-test and pre- to post-intervention differences between schools E2 and C2 are illustrated in Tables 4.18 and 4.19. The results indicated that BF% was the only variable that showed a significant difference ($p = .050$; $d = 0.28$). When examining the pre- to post-intervention mean differences, it is evident that the two schools differed in terms of BF%, with school E2 indicating significantly lower results compared to school C2. Both schools increased BF% scores but the experimental school increased less (0.02 ± 2.78%) compared to the control school (1.00 ± 3.17%). Participating in the PA intervention could have influenced the results of the experimental school.

The BMI, WAZ, HAZ and BAZ scores indicated non-significant differences between the two schools. This indicates that the experimental and control schools were relatively similar post-intervention in terms of these nutritional indicators. $Chi^2$ test results also indicated no significant differences between the two schools in terms of the distribution of underweight, stunting, thinness, normal weight and obesity in the children (Tables 4.30 and 4.31).

## 5.5 COMPARISON BETWEEN SCHOOLS E3 AND C3 IN RESPECT OF THE HEALTH AND HYGIENE EDUCATION AND NUTRITION INTERVENTION IMPACT

Findings illustrated in Table 4.20 indicate that none of the tested variables displayed significantly different ($p > .05$) pre-intervention results. It can be concluded that the experimental and control schools were equivalent in terms of all body composition variables assessed prior to implementing the intervention programme.

Post-intervention results, as illustrated in Table 4.22, indicate that two variables were significantly ($p < .05$; $d > 0.2$) different between E3 and C3, namely: BMI ($p = .026$; $d = 0.30$) and BAZ ($p = .023$; $d = 0.31$). School E3 participated in the health and hygiene education and nutrition intervention and as part of the nutrition intervention children consumed a supplement every day for ten-weeks. Post-intervention results indicated that BMI presented a value of 19.09 ± 4.19 kg/m$^2$ for the experimental school in comparison to the 17.94 ± 3.54 kg/m$^2$ for the control school. The same tendency was observed for BAZ scores, where E3 with a BAZ score of 0.62 ± 1.24 differed significantly from the 0.25 ± 1.20 score of C3.

Pre- to post-intervention mean differences between the two schools revealed statistically significant results, with the experimental school showing significantly larger increases, 1.03 ± 0.84 versus 0.65 ± 0.91 kg/m$^2$ for BMI ($p = .002$; $d = 0.42$) and 0.25 ± 0.30 versus 0.12 ± 0.35 for BAZ ($p = .004$; $d = 0.40$) scores, and significantly lower HAZ scores ($p = .006$; $d = 0.38$) for C3 (-0.07 ± 0.20) than E3 (-0.01 ± 0.15) (Table 4.23). The reasons for the increase in BMI and BAZ scores at the experimental school is possibly twofold, namely: consumption of a nutritional supplement and limited opportunity for PA participation.

For the nutrition intervention, the study project provided a RUSF supplement that children had to consume daily. This is a possible explanation for the increase in BMI and BAZ at the experimental school. In a community-based intervention study by Steenkamp, Lategan and Raubenheimer (2015:325), for children aged 12 to 60 months, the implementation of a RUSF supplement for 6 weeks resulted in a 0 to 25% recovery rate in children with moderate to acute malnutrition. However, the WAZ, HAZ and BAZ improvements were only noticed immediately after the intervention was administered and not with continued use (Steenkamp *et al.*, 2015:325). The latter results nevertheless indicate that supplementation has beneficial effects on children's nutritional status, even though the participants in the study by Steenkamp *et al.* (2015:325) were younger than the participants in the present study. The BMI value recorded for school E3 was 19.09 kg/m$^2$ and this is higher than the average BMI values of 17.7 kg/m$^2$ for children living in the Eastern Cape aged 0-14 years (Shisana *et al.*, 2014:206). These BMI values of the children in the experimental school are alarming, as high BMI in children is associated with obesity in adulthood.

Shrimpton, Victora, de Onis, Lima, Blössner and Clugston (2001:e77) hold that nutritional interventions in lower socio-economic communities have beneficial effects for individuals at risk of stunting, but may prove problematic for those at risk of obesity. This may be the case in the current study, as there was a 3.67kg mean weight increase at school E3 post-intervention, which was significantly ($p < .0005$; $d = 0.53$) higher than at school C3 (2.70kg). A review in the Lancet revealed that school-based interventions with feeding programmes reported increases in weight gains but inconclusive results for height gain. They advised caution with these interventions as they may lead to obesity (Bhutta, Das, Rizvi, Gaffey, Walker, Horton, Webb, Lartey *et al.*, 2013:465). The current study's results also showed a lack of improvement in the children's HAZ score, but both BMI and BAZ scores increased post-intervention. Interventions implemented in low- to middle-income countries undergoing a nutritional transition should consider finding a balance between supplementation and feeding programmes and PA promotion in order to avoid an increase in BMI without energy expenditure (Armstrong *et al.*, 2011:839).

In South Africa, there is a challenge of schoolchildren not being exposed to adequate PE, thus limiting the benefits of PA (Van Deventer, 2009:140). This is due to a number of reasons, a number of which are: a lack of resources and facilities; under-qualified teachers and limited time allocated for PE (Van Deventer, 2009:141, 2011:834-35). Schools participating in this study were faced with the same challenges as other schools in disadvantaged communities. PE was not prioritized and was not part of a normal school day. A study conducted in Sau Paulo, Brazil, found that low energy expenditure may be a risk factor for weight gain in susceptible children and this may explain the increase in weight as a risk for obesity in shantytown girls in their study

(Hoffman, Sawaya, Coward, Wright, Martins, de Nascimento, Tucker & Roberts, 2000:1030). In South Africa, authors found an association between PA (weekdays and weekends) and BMI, BF% and fat mass (Mamabolo, Kruger, Lennox, Monyeki, Pienaar, Underhay & Czlapka-Matyasik, 2007:1053), suggesting that there are beneficial effects from being active, as PA results in fat mass reduction (Mamabolo *et al.*, 2007:1053). The increase in BMI and BAZ scores seen in the present study could also be associated with low activity levels.

$Chi^2$ results in Table 4.33 revealed a significant difference in the distribution of obesity, with E3 presenting a higher percentage of obese children than C3 after the intervention. This intervention was considered to have a negative effect, as the distribution of obese children increased significantly ($p = .007$; $V = 0.18$) at the experimental school. The distribution of obese children at school E3 (16%) was higher than the Eastern Cape prevalence reported in the SAHANES-1 (7.1%) and the national prevalence in the HAKSA 2014 report (10%) (Shisana *et al.*, 2014:206; Draper, Basset, De Villiers, Lambert & Group, 2014:S101). These results show that caution must be taken when implementing nutrition interventions as they may lead to an increase in body weight, leading to obesity.

## 5.6 COMPARISON BETWEEN SCHOOLS E4 AND C4 IN RESPECT OF THE PA, HEALTH AND HYGIENE EDUCATION AND NUTRITION INTERVENTION IMPACT

Schools E4 and C4 were both Northern area schools, E4 was an experimental school participating in all three intervention components and C4 was the control school. At pre-testing, children from C4 were the shortest and lightest and had the lowest BMI and BF% of all the participating schoolchildren. The experimental school had the majority of the older children (68%) who were the oldest of all the participants. At pre-testing, children from school C4 were significantly ($p < .05$; $d > 0.2$) younger than children from E4 (Table 4.24).

Prior to the ten-week intervention, pre-test results indicated that only age ($p = .009$; $d = 0.36$) and BMI ($p = .028$; $d = 0.30$) indicated significant differences between the two schools, with E4 having higher BMI score (16.30 ± 2.26) than C4 (15.65 ± 2.06). The two schools did not show any significant differences for BF%, WAZ, HAZ and BAZ (Table 4.24).

When looking at post-intervention results, as illustrated in Table 4.26, there were significant differences between the experiment and control school in terms of BMI and BAZ scores. The results indicate that school E4 had significantly higher ($p < .0005$; $d = 0.49$) BMI values (17.35 ± 2.58 kg/$m^2$) than C4 (16.11 ± 2.36 kg/$m^2$) and E4 also presented with higher BAZ scores (-0.08 ± 1.12) than C4 (-0.68 ± 1.30) ($p < .0005$; $d = 0.51$).

The results obtained for this study as depicted in Table 4.27, indicate that the experimental school differed significantly ($p < .05$; $d > 0.2$) from the control school in post-intervention mean differences in respect of BMI, ($p < .0005$; $d = 0.67$), WAZ and ($p = .017$; $d = 0.84$), HAZ ($p = .005$; $p = 0.38$) and BAZ ($p < .0005$; $d = 0.56$). BMI (1.04 ± 0.74 versus 0.46 ± 1.09 kg/$m^2$), WAZ (0.24 ± 0.22 versus 0.06 ± 0.20) and BAZ scores (0.34 ± 0.29 versus 0.04 ± 0.85) of the experimental school increased significantly compared to the control school, that is, school E4's children gained significantly more weight (2.94 ± 1.56 versus 2.41 ± 1.36 kg). For HAZ scores, the control school improved their level of stunting (0.04 ± 086), while the experimental school reflected a decreased value (-0.16 ± 0.16). A discussion of the possible reasons for these results is provided in the following section.

In terms of BMI, both schools increased their scores, but the experimental school increased more than the control school. Specifically, in the case of the experimental school, children displayed increased BMI, WAZ and BAZ, with lower HAZ scores. $Chi^2$ results also indicated an increase in the distribution of obese children at school E4 post-intervention (Table 4.35). The increase in the distribution of obese children was significantly higher ($p = .036$; $V = 0.16$) than that reported for children at school C4. The increase in BMI, WAZ and BAZ scores at the experimental school could be attributed to the significant increase in weight ($p = .009$; $d = 0.36$) compared to the control school.

The improvement in HAZ scores at the control school could be due to the significant increase in height ($p = .002$; $d = 0.42$) compared to the experimental school. The results of HAZ scores at the control school must be interpreted with caution, as the control school had significantly younger children initially who may have been experiencing the onset of an adolescent growth spurt (Malina *et al.*, 2004:61).

Steyn, Nel, Tichelaar, Prinsloo, Dhansay, Oelofse and Benadé (1994:12) hold that due to urbanization, people from poor communities tend to experience the co-existence of under- and overnutrition. If interventions are not put in place, increased weight with a short stature persists as children grow into adolescents. In a study conducted in the North-West Province involving 10- to 15-year old children, results indicated that girls displaying stunted growth tend to accumulate more fat in the abdominal area during adolescence, indicating the co-existence of overweight and stunting (Mukuddem-Petersen & Kruger, 2004:850). Popkin *et al.* (1996:3014) proposed that this association could be a result of slowed growth and changes in hormonal responses, coupled with an inadequate dietary intake.

If the trend of increased BMI with the existence of a low height-for-age z-score continues in children from the experimental group, this may have far reaching effects in adulthood. This possibility emphasizes the need for early implementation of school-based PA and nutrition interventions, as stunting is associated with adult obesity (Popkin *et al.*, 1996:3014).

## 5.7 COMPARISON OF THE OVERALL EFFECT OF EACH OF THE THREE INTERVENTION COMPONENTS

Results illustrated in Table 4.36 confirm that no significant ($p > .05$) differences were evident for BMI and BF% at pre-testing when comparing exposure versus non-exposure to each of the three intervention components. It can be concluded that the participants exposed versus those not exposed to the interventions were the same in terms of body composition variables assessed prior to intervention implementation. However, there was a significant difference in terms of HAZ scores in children who were subsequently exposed versus those not exposed to the nutrition intervention ($p < .0005$; $d = 0.50$), with children exposed to the intervention having a lower HAZ score at pre-testing (Table 4.39).

Table 4.37 reflects post-intervention results and indicates that only BF% showed significant results ($p < .0005$; $d = 0.27$) in favour of children exposed to the PA intervention who had a decrease in BF%, when compared to those not exposed, showing a significant increase. There was a significantly lower HAZ score for children exposed to the PA intervention versus those not exposed ($p = .001$; $d = 0.35$), with children exposed to the intervention exhibiting lower HAZ scores after the intervention (Table 4.40).

Tables 4.38 and 4.41 display the results of children exposed versus those not exposed to each of the three intervention components. Results for pre- to post-intervention mean differences are discussed below with possible reasons for the reported results.

BF% ($p < .0005$; $d = 0.49$) and HAZ ($p = .001$; $d = 0.30$) reflected significant differences from pre- to post-intervention differences between children exposed versus those not exposed to the PA intervention. Table 4.38 indicated improvements in the BF% of children exposed to the PA intervention as their BF% scores decreased significantly (-0.03%) compared to an increase (1.43%) in children not exposed to the PA intervention (Figure 5.3). Table 4.41 indicates that children exposed to the PA intervention reflected significantly lower HAZ scores (-0.12), compared to children not exposed to the intervention (-0.02), indicating a decreased height-for-age value (Figure 5.4). The BF% results are congruent with results found in a South African PA intervention study, where the control group showed a significant increase in BF% while the experimental group had a decrease in BF% (Monyeki *et al.*, 2012:245).

Figures 5.3 and 5.4 below illustrate the significant decrease in BF% and HAZ scores for children exposed to the PA intervention

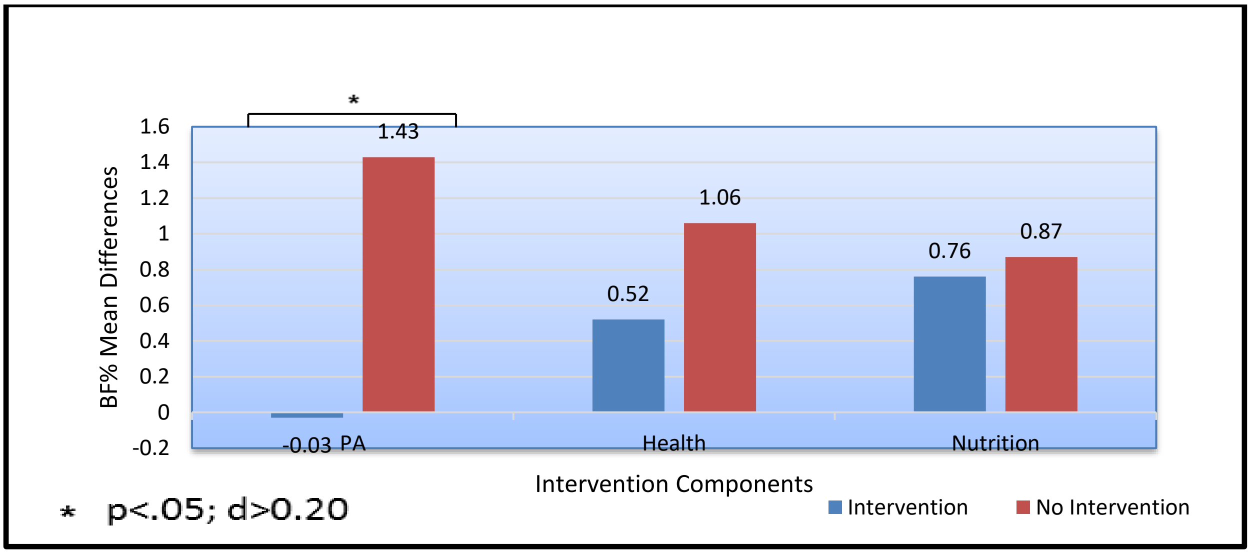


**Figure 5.3:** **Impact of the individual intervention components on the pre- to post-intervention BF% mean differences**

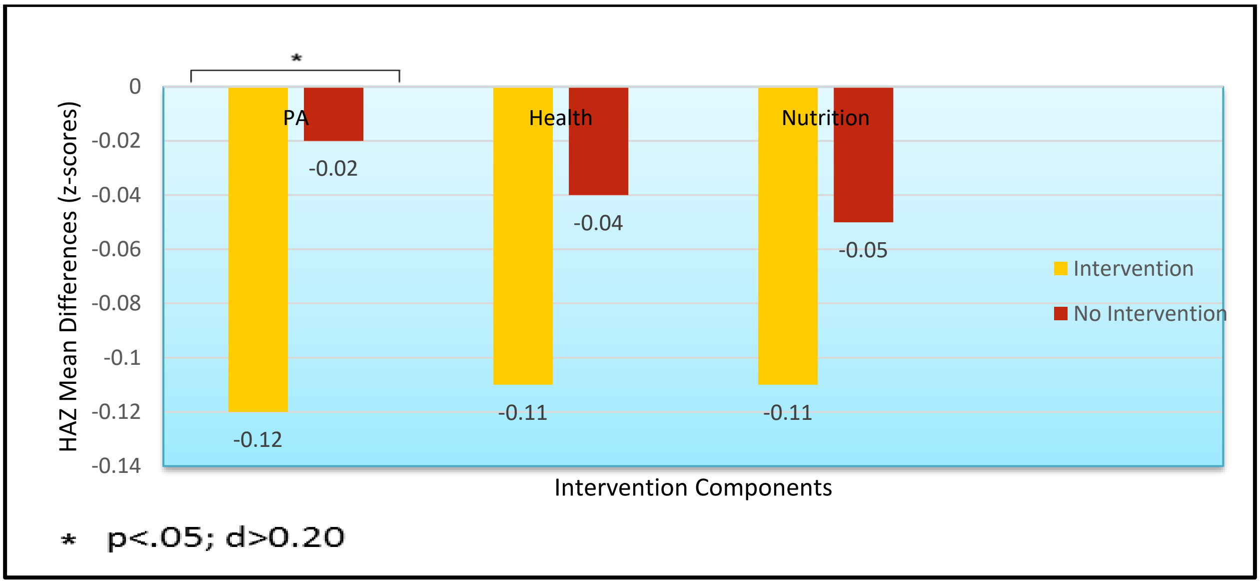


**Figure 5.4:** **Impact of the individual intervention components on the pre- to post-intervention HAZ score mean differences**

Figures 5.3 and 5.4 indicate that children exposed to the PA intervention reflected significant decreases in BF% and HAZ scores, compared to the other two intervention components that showed non-significant differences.

The low HAZ scores in children exposed to the PA intervention in the current study can be ascribed to the significantly lower height increase ($p = .002$; $d = 0.33$) for children exposed to the PA intervention, in comparison to those not exposed (2.63 versus 3.38 z-scores). It should be noted that the PA intervention resulted in a significant reduction in BF%, but the intervention seemed to have had a negative impact on children's HAZ scores, indicating a high frequency of children with a low height-for-age. Previous research (Mamabolo *et al.*, 2007:1054) proposed that school-based interventions should be planned with consideration to a balance between PA and dietary intake, owing to the fact that excessive energy expenditure during PA may inhibit growth in children coming from lower socio-economic communities. Energy expenditure with the lack of proper nutrition could be explored as a contributing factor for the results. It should be noted that energy expenditure was not assessed and this could be seen as a limitation of the study and a suggestion for further research in this area.

Popkin *et al.* (1996:3013) investigated the relationship between the stunting and overweight status in children aged 3 to 6 and 7 to 9 years in four countries, including South African Black and Coloured children. Results indicated that the prevalence of stunted children was 28.5%, overweight 7.5%, overweight in stunted children 13.1% and overweight in non-stunted children 5.1%. In a more recent study by Armstrong *et al.* (2011:838), which looked at trends in the prevalence of stunting, overweight and obesity among South African children (aged 8-11years) from 1994 to 2004, findings indicated changes in children's nutritional status. The prevalence of stunting decreased, while overweight increased from 1994 to 2004. There were significantly ($p < .001$) fewer overweight and obese children classified as stunted in comparison with non-overweight and non-obese children (Armstrong *et al.*, 2011:838). It must be noted that the latter study included older children, used data over a ten-year period and included Black African, White and mixed ancestry children (Armstrong *et al.*, 2011:837). From these two studies it is clear that stunting and overweight can co-exist in young children, however, this has not been reported in the current study as stunted and non-stunted children were not compared. The present study found an association between a decrease in BF% and participation in the PA intervention.

In cases where children have low HAZ values, nutritional interventions with a feeding programme, supplementation or nutrition education are implemented to facilitate an increase in child growth. This is due to the fact that low HAZ (stunting) results from, among other things, undernourishment during infancy and early childhood, with growth faltering beginning around three months and continuing until three years of age

(Shrimpton *et al.*, 2001:e77). A debate exists as to whether catch up growth is likely to occur in older stunted children and in a study by Walker *et al.* (1996:3023), results revealed that catch up growth is possible following stunting in early childhood, even when children remain in poor communities. However, long term benefits may not necessarily be achieved if supplementation interventions begin after the age of one. Other authors have recommended that nutritional interventions should focus on children around the age of three, as it is difficult for children to fully recover from stunting when they are older than three years of age (Shrimpton *et al.*, 2001:e77).

BMI and BAZ displayed significant ($p < .05$; $d > 0.2$) pre- to post-intervention mean differences in children exposed to the nutrition intervention. Table 4.38 indicates that children exposed to the nutrition intervention significantly ($p = .001$; $d = 0.53$) increased BMI (1.04 $kg/m^2$) compared to children not exposed to the intervention (0.56 $kg/m^2$) (Figure 5.5). Table 4.41 also reflected a significant ($p = .003$; $d = 0.52$) increase in BAZ scores in children exposed to the nutrition intervention compared to those not exposed to this intervention (Figure 5.6). The increase in BMI and BAZ scores can be attributed to the significantly ($p = .004$; $d = 0.38$) larger increase in weight in children exposed to the nutrition intervention than those not exposed to this intervention (3.19kg and 2.55kg) respectively. From previous research, a nutrition intervention using supplementation was reported to improve WAZ, HAZ and BAZ, but this was in younger children (Steenkamp *et al.*, 2015:325). Although the intervention was in younger children, it can be noted that nutrition interventions influence body weight, and hence, body composition and nutritional status. From these results it can be deduced that implementing nutrition interventions, with supplementation but without a PA intervention, can pose a problem if it is not aimed at specific populations. There needs to be a balance to avoid providing nutrition interventions to children at risk of becoming overweight or obese (Shrimpton *et al.*, 2001:e77). Alternatively, if such interventions are implemented, interventions promoting regular PA and healthy eating habits must be introduced to prevent an increase in overweight and obesity in children (Armstrong *et al.*, 2011:839).

Figures 5.5 and 5.6 below illustrate the significant increase in BMI and BAZ scores for children exposed to the nutrition intervention.

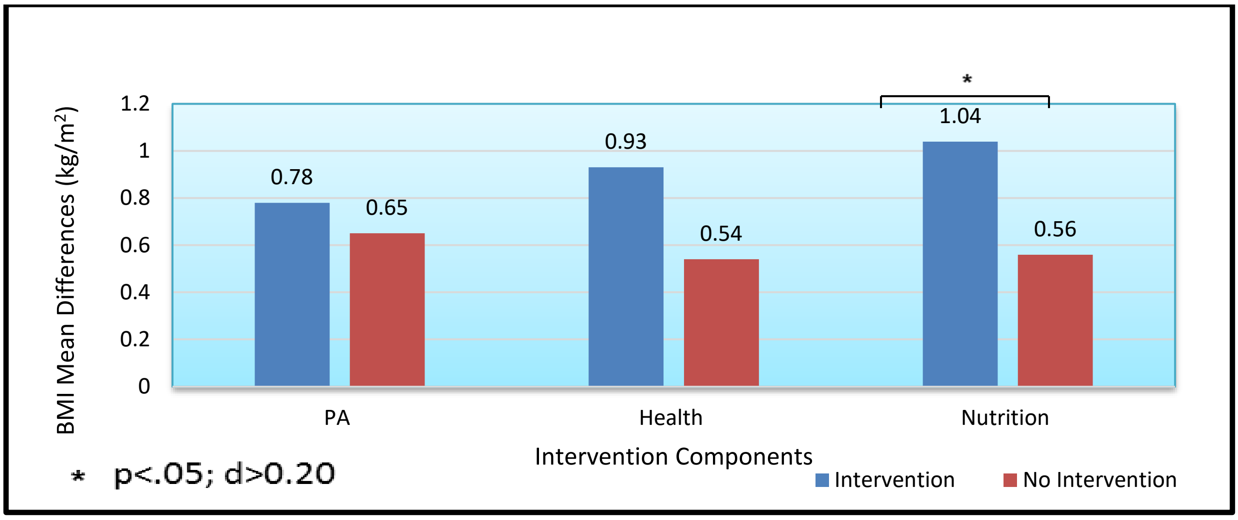


**Figure 5.5:** **Impact of the individual intervention components on the pre- to post-intervention BMI mean differences**

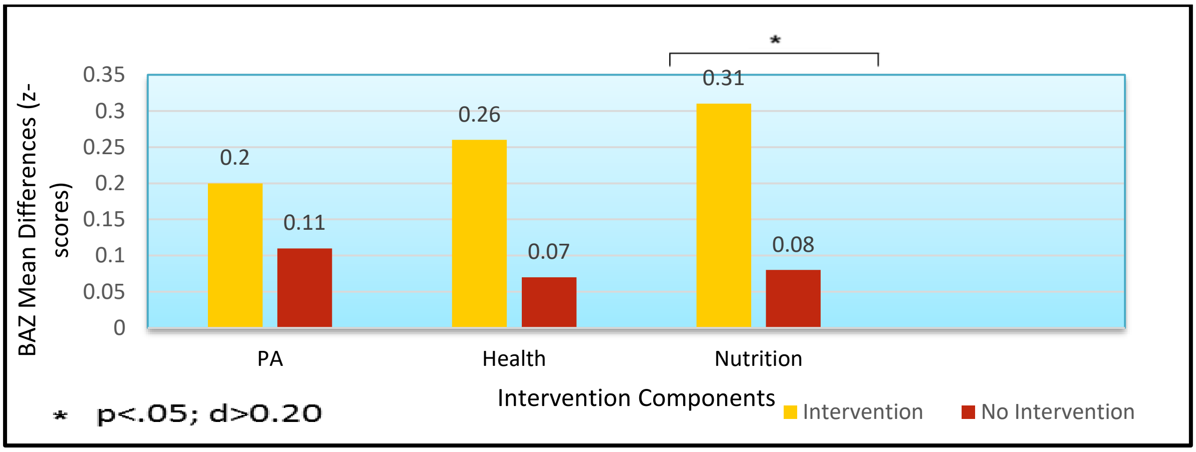


**Figure 5.6:** **Impact of the individual intervention components on the pre- to post-intervention BAZ score mean differences**

Figures 5.5 and 5.6 reflect that the nutrition intervention resulted in significant increases in BMI and BAZ, compared to the other two intervention components.

WAZ scores indicated a significant ($p = .038$; $d = 0.34$) improvement in children exposed to the health and hygiene education intervention, as their level of underweight improved compared to those not exposed to the intervention (Figure 5.7). Health and hygiene education intervention entailed education about infections, how to prevent them and the importance of washing one's hands to prevent the spread of germs. Some of the study areas, especially the Northern areas, were characterized by unhygienic living conditions, with poor sanitation and litter (Müller *et al.*, 2016:496). The reason for the improved underweight status (indicated by WAZ scores), in children participating in the health and hygiene education intervention can be attributed to the hand washing and the increase in education and awareness about germs and infections. From Figure 5.2 it is clear that the two schools that had a high prevalence of underweight, one of which participated in the health and hygiene education intervention, reflected a decrease post-intervention.

The Figure 5.7 below illustrates the significant increase in WAZ scores for children exposed to the nutrition intervention.

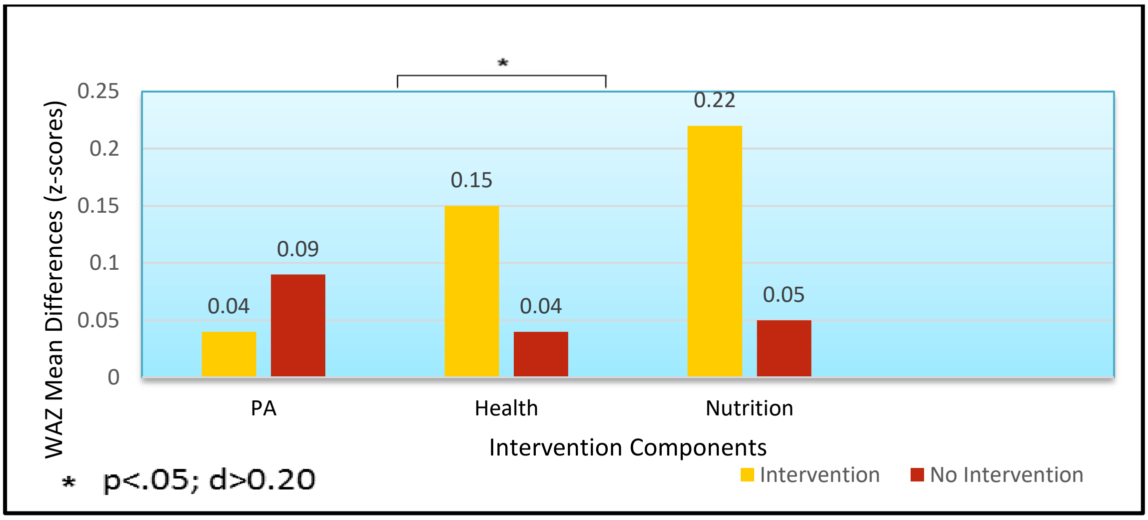


**Figure 5.7: Impact of the individual intervention components on the pre- to post-intervention WAZ score mean differences**

The health and hygiene education intervention, as depicted in Figure 5.7, reflected a significantly higher WAZ score increase than the other two intervention components.

## 5.8 SUMMARY OF FINDINGS

This section presented a detailed discussion and interpretation of the results, using literature to support the significant results obtained where relevant. The following section provides a summary of the findings of the study, indicating the extent to which the five research objectives were met. Summary findings are listed with relevance to each objective that was set for the study.

The effect of the PA intervention (E1 versus C1):

- The experimental school (E1) revealed a significantly ($p < .05$; $d > 0.2$) larger reduction in BF% compared to the control school (C1) for post-intervention mean differences. This decrease in BF% was possible due to the PA intervention.

- The control school significantly ($p < .05$; $d > 0.2$) improved WAZ and HAZ scores in comparison to the experimental school. These results can be ascribed to the significantly ($p < .05$; $d > 0.2$) high increases seen in height and weight at school C1, which could account for the increased WAZ and HAZ scores that were identified.
- The $Chi^2$ test confirmed results for WAZ and HAZ scores and indicated significant ($p < .05$; $d > 0.2$) differences in the distribution of underweight and stunting in children post-intervention. The control school had a significantly ($p < .05$; $d > 0.2$) lower incidence of children who were underweight and stunted, while school E1 showed an increased incidence.

The effect of the PA and health and hygiene education intervention (E2 versus C2):

- Pre- to post-intervention mean differences were in favour of the experimental school, revealing a significantly ($p < .05$; $d > 0.2$) lower increase in BF% than at the control school. The decrease in BF% could be due to the PA intervention, as participating in PA has been associated with a reduction in fat mass.

The effect of the health and hygiene education and nutrition intervention (E3 versus C3):

- Pre- to post-intervention differences were revealed for BMI, HAZ and BAZ scores, with school E3 indicating significantly ($p < .05$; $d > 0.2$) larger increases for BMI and BAZ scores, with a lower increase in HAZ scores compared to school C3.
- The increase in BMI and BAZ scores at the experimental school can be attributed to the children having undergone the nutrition intervention, probably due to the supplement received, which has been confirmed by previous studies to increase children’s body composition and nutritional status.
- This outcome was also confirmed by the $Chi^2$ test results, which indicated that the incidence of obese children from the experimental school significantly ($p < .05$; $d > 0.2$) increased compared to the control school.

The effect of the PA, health and hygiene education and nutrition intervention (E4 versus C4):

- The experimental and control schools reported significant ($p < .05$; $d > 0.2$) results for pre- to post-intervention differences for four variables, namely: BMI, WAZ, HAZ and BAZ.
- The experimental school significantly increased BMI and BAZ, while HAZ scores were significantly lower than those recorded for the control school.
- $Chi^2$ test results reflected significant ($p < .05$; $d > 0.2$) increases in the frequency of obese children at school E4 compared to school C4, confirming the increase in BMI and BAZ scores.
- This increase in BMI and BAZ is possibly due to the nutrition intervention. When looking at findings from the other paired comparisons (E1 versus C1), it seems that the nutrition intervention superseded the PA intervention effect, as children in the experimental group increased BMI and BAZ, displaying no significant reduction in BF% due to the PA intervention.
- The experimental school improved in respect of WAZ scores. The children's weight-for-age z-score increased, indicating a reduction in the level of underweight. This could be attributed to the hand washing performed in the health and hygiene education intervention, coupled with an increase in weight due to the daily supplement.

The effect of individual intervention components on body composition:

- When comparing the overall effect of each of the intervention components individually for pre- to post-intervention mean differences, the results seem to confirm the preceding findings of the paired comparisons.
- The PA intervention resulted in significantly ($p < .05$; $d > 0.2$) lower BF% and significantly lower HAZ scores. It can therefore be deduced that the PA intervention significantly decreased BF% but it is important to note that the intervention had a negative effect on growth, as depicted by HAZ scores, indicating a higher frequency of children with lowered height-for-age z-scores.

- The nutrition intervention resulted in significantly ($p < .05$; $d > 0.2$) higher BMI and BAZ scores ascribed to increased weight that was possibly due to the nutrition intervention, consisting of a daily supplement.
- The health and hygiene education intervention significantly ($p < .05$; $d > 0.2$) increased WAZ scores. Children exposed to this intervention improved their level of underweight, compared to those not exposed to the intervention and these results are possibly due to hand washing and awareness of germs and infection at schools that had high levels of malnutrition and that received the intervention.

## 5.9 CONCLUSION

The results of the study provide an insight into the body composition and nutritional status of Grade 4 children from eight primary schools from disadvantaged communities in Port Elizabeth. Results indicate that Coloured children from the Northern areas were affected more by conditions of undernutrition, in comparison to Black Township children who were affected more by conditions of overnutrition.

The study reported a significant decrease in the BF% of children exposed to the PA intervention and this result is supported by other findings, which indicated that PA is associated with a reduction in fat mass. The nutrition intervention resulted in a significant increase in children's BMI and BAZ scores, while the health and hygiene intervention indicated significantly positive WAZ scores in children participating in that intervention. From the study findings, it can be speculated that low PA participation combined with a nutritional supplement can contribute towards children increasing BMI and BAZ scores. The decrease in BF% in children participating in the PA intervention highlights the importance of regular participation in PA to reduce fat mass and encourage favourable body composition in children.

## 5.10 LIMITATIONS

Despite all the efforts made to conduct the study as well as possible, there were limitations that could have affected the study's outcomes.

- The intervention period was relatively short, lasting for ten weeks. This was because the study schedule had to consider school holidays, mid-term assessments and end-of-term examinations pertinent to the schools.
- Results of the study did not identify causality, but rather identified association. The study could not confirm that the intervention caused the changes indicated by the findings, as there are factors that could not be accounted for. These include factors such as other interventions at the school, the children's dietary habits and activities during break-times and after school.
- Some children were absent during follow-up testing, mainly due to them changing schools, being absent on the day of testing as well as on catch-up testing days and some had incomplete data.
- The study only included children that had complete anthropometric and body composition measurements. Children with missing height, weight and skinfold measurements were excluded, as these variables were used to analyse children's body composition and nutritional status.
- The general compliance of the children in the PA intervention is unknown, especially with the known challenges related to the implementation of PE in disadvantaged schools due to marginalization of PE in the curriculum, inadequate facilities and under-qualified teachers. Despite these limitations, significant effects were found for BF% in those exposed to the PA intervention.

## 5.11 STRENGTHS OF THE STUDY

- The sample size of the study was large, with the overall study testing 1009 children and the current study reporting on 879 children.
- The study included two ethnic groups and found associations between ethnicity and various body composition and nutritional indicators.
- The socio-economic status of the participants was low and homogenous, and this is a group that needs more research as they are mostly affected by conditions associated with poverty and low-income, such as over- and undernutrition.

## 5.12 RECOMMENDATIONS

The study has not controlled for the wide range of factors that affect under- and overnutrition. There could be biological and environmental factors that were not measured and accounted for. An expanded research project with more measured variables is required in order to confirm the study's findings. Future research should also consider investigating the effect of the following:

- Implementing longer PA and nutrition interventions and measuring the effects on children's body composition.
- PA and nutrition interventions on boys compared to girls' body composition.
- The food sold at school tuck shops and vendors around the school and how this affects children's body composition and nutritional status.
- Differentiated nutrition interventions on children that are stunted in comparison to non-stunted children.
- PA school interventions implemented in accordance with the daily recommended PA (60 minutes) for children. These could be achieved through PE lessons, activity during break-time and after school extramural activities.

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## LIST OF APPENDICES

## APPENDIX 1: INFORMED CONSENT FORM

### INFORMED CONSENT FORM

| **PROJECT TITLE: The effect of school-based physical activity interventions on the Body Composition of grade 4 children from lower socioeconomic communities in the Nelson Mandela Bay Municipality, Port Elizabeth** |
|---|

### 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 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 individual has not been forced into giving consent, and the 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 and explained 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 received a copy of this written informed consent form and an additional letter of information that I keep myself.

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:

------------------------------------ **Thank you very much for your invested time!** -------------------------------
**If you have any questions about the study, please feel free to contact:**
**Siphesihle Nqweniso – 072 229 6293**

## APPENDIX 2: ASSENT FORM

**ASSENT FORM TEMPLATE FOR CHILD PARTICIPANTS**

| |
|---|
| **TITLE: The effect of school-based physical activity interventions on the Body Composition of grade 4 children from lower socioeconomic communities in the Nelson Mandela Bay Municipality, Port Elizabeth** |

**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 your height and weight changes after taking part in the programme. We will take your height and weight measurements and skinfold measurements on your arm and upper back. None of these measurements will be painful. 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 a slight pinch from the skinfold calipers. However, before the measurement is taken we will show how the skinfold caliper works, using your finger to show that the process will not hurt.

**Benefits of participating in the study (Can anything good happen to me?)**

You will be able to see how you have grown (become taller and stronger) after taking part in the programme.

**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.

**Contact information (Who can I talk to about the study?)**

You can contact Siphesihle Nqweniso on 072 229 6293, 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

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

________________________ ____________________

Signature of Child Date

## APPENDIX 3: PA INTERVENTION

PA Lesson

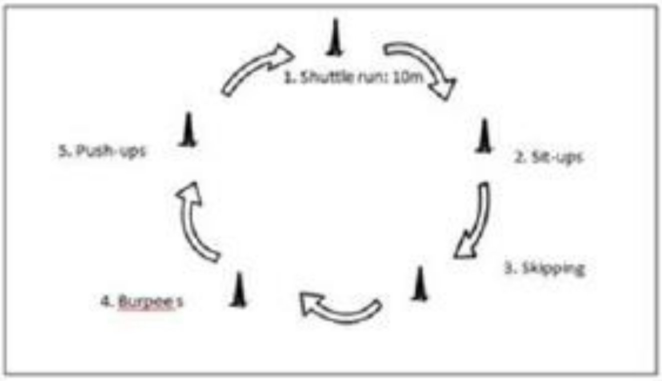
| LESSON NO : 9 | EQUIPMENT |
|---|---|
| **Lesson focus:**<br>Cardiovascular endurance, agility, strength, flexibility | **35 Cones** |
| | **10 Hula Hoops** |
| | **35 Tennis Balls** |
| | **25 Skipping Ropes** |
| | **1 Whistle** |

| ACTIVITY |
|---|
| **Introduction (5min-10Min)**<br>**Stuck in the Mud**<br>You will need an area big enough to run around in<br>The game is played as follows:<br>One person (per 10 competitors) is "on" and they need to go around touching other people. Once touched, they become "stuck" in the mud, need to spread their legs and can only move once a friend who is not stuck in the mud crawls through their legs to get them "unstuck". The game is over once all the people are stuck in the mud and cannot be rescued by their friends.<br>With larger groups, try running 2 games at once |
| **Fitness Component (10min-15min)**<br><br>**Fitness exercise circuit:**<br>Class divided into 5 groups, each group at an exercise station. Each exercise is demonstrated beforehand. They spend one minute at each station, before rotating to the next station |
| **Modified Invasion Game (10min-15min)**<br><br>**Hand soccer**<br>The game is similar to soccer, except that the ball may only be played by hand. A goal is scored when it passes through two beacons. The ball may not be caught, but must be struck with the hand. If the ball is hit into the air, it must be caught and placed on the ground. The game then continues normally. The ball may not be played with two hands. 5-a-side, have 2 or 3 games going at a time.<br>*Equipment 1 tennis ball per game, beacons to mark a field and 4 cones for goals.*<br>Use the bands to demarcate the teams. |
| **Cool Down Stretch (5min-10min)**<br><br>**Stretching 1** – 8 Figure, Straddle, Long Seat, and Arm Stretch.<br>Reflection: Ask children what they enjoyed, what they learnt …..while stretching and cooling down |

**ACTIVITY**

**Fitness Component (10min-15min)**

**Fitness exercise circuit:**




**Modified Invasion Game (10min-15min)**

**Hand Soccer**

**Cool Down Stretch (5min-10min)**

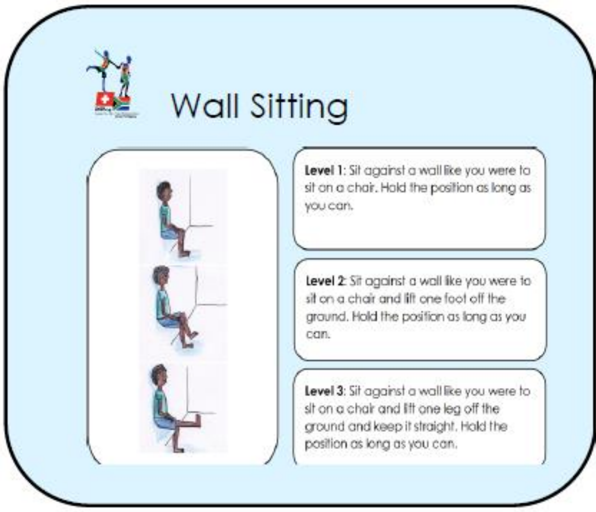
8 Figure

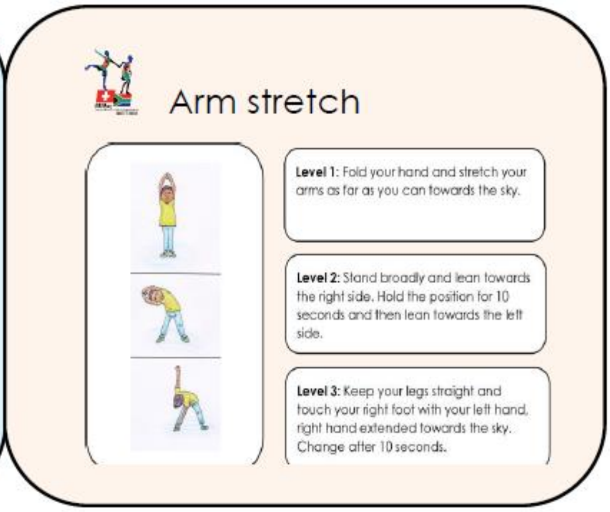
Straddle

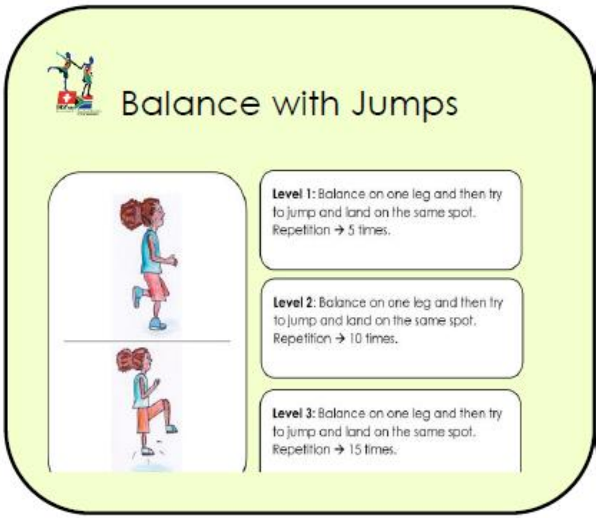
Long Seat

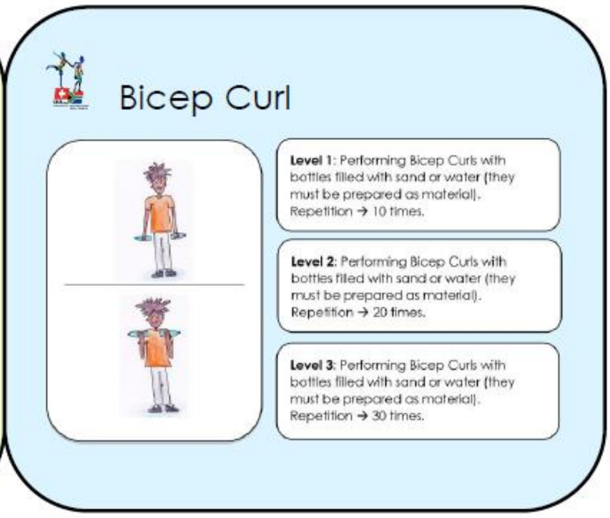
Arm Stretch

In-Class PA break exercises



Example of playground structures

## APPENDIX 4: HEALTH AND HYGIENE EDUCATION INTERVENTION

<u>Handwashing Poster</u>

**Little Toilet Experts (Task to do in class: Classify your school toilet**

| | School toilet | |
|---|---|---|
| Number of toilet seats in the toilet | | |
| This is a<br>- flush toilet inside or attached to the house<br>- flush toilet outside the house<br>- improved latrine<br>- unimproved latrine<br>- There is no latrine or toilet available in this house: shared latrine is used<br>- There is no latrine or toilet available in this house: open defecation is practiced | | |
| | **YES** | **NO** |
| Is the latrine/toilet fully working? | | |
| Are there any signs of damage? | | |
| Are surfaces of walls and floors smooth and easy to clean? | | |
| Is a garbage bin present? | | |
| Are there any leaks from the toilet bowel or pipes? | | |
| Is there a comfortable temperature in the toilet room? | | |
| For flush toilets: Does the toilet bowl flush easily? | | |
| Is there any peeling paint or flaking plaster? | | |
| Is the roof leaking? | | |
| Does the light work properly? | | |
| Are the walls clean? | | |
| Is the floor clean? | | |

**APPENDIX 5: NUTRITION INTERVENTION**

Example of nutrition lesson

Version from 19/01/2016

**Fruit and vegetables: Eat plenty every day!**

At each meal, fill half of the plate with fruit and vegetables.

Fruit and vegetables:

- boost **energy**;
- strengthen your **immune system** and keep you healthy;
- have **fibre** for digestion, keeping you fuller for longer.


Choose red, orange, as well as green vegetables!

Like a robot…

Red: **anti-oxidants** protect your body e.g. **tomatoes**

Orange: **vitamin A** protects your **eyes** e.g. **sweet potato, carrots**

Green: **iron** gives **energy** and helps your **brain to concentrate** and learn e.g. **leafy vegetables like spinach**

## APPENDIX 6: APPROVAL FROM NMMU RESEARCH ETHICS COMMITTEE

Nelson Mandela Metropolitan University

*for tomorrow*

• PO Box 77000 • Nelson Mandela Metropolitan University
• Port Elizabeth • 6031 • South Africa • www.nmmu.ac.za

**Vice-Chairperson: Research Ethics Committee (Human)**
Tel: +27 (0)41 504-2235

**Ref: [H14-HEA-HMS-002/Approval]**

**Contact person: Mrs U Spies**

4 July 2014

Prof R du Randt
Faculty of Health Sciences
School of Lifestyle Sciences
Building 125 - Room - 0111
South Campus

Dear Prof Du Randt

**IMPACT OF DISEASE BURDEN ON SCHOOL CHILDREN'S PHYSICAL FITNESS AND PSYCHOSOCIAL HEALTH IN PORT ELIZABETH, SOUTH AFRICA AND EFFECTS OF SETTING SPECIFIC INTERVENTIONS**

PRP: Prof R Du Randt
PI: Prof Dr U Pühse

Your above-entitled application for ethics approval served at Research Ethics Committee (Human).

We take pleasure in informing you that the application was approved by the Committee.

The ethics clearance reference number is **H14-HEA-HMS-002** and is valid for three years. Please inform the REC-H, via your faculty representative, if any changes (particularly in the methodology) occur during this time. An annual affirmation to the effect that the protocols in use are still those for which approval was granted, will be required from you. You will be reminded timeously of this responsibility, and will receive the necessary documentation well in advance of any deadline.

We wish you well with the project. Please inform your co-investigators of the outcome, and convey our best wishes.

Yours sincerely

CB Cilliers

**Prof CB Cilliers**
**Chairperson: Research Ethics Committee (Human)**

cc: Department of Research Capacity Development
Faculty Officer: Health Sciences

## APPENDIX 7: APPROVAL FROM THE DEPARTMENT OF HEALTH

**Eastern Cape Department of Health**

| | | | |
|---|---|---|---|
| Enquiries: | Zonwabele Merile | Tel No: | 040 608 0830 |
| Date: | 07th November 2014 | Fax No: | 043 642 1409 |
| e-mail address: | zonwabele.merile@impilo.ecprov.gov.za | | |

Dear Prof Rosa du Randt 0866114682

**Re: Impact of disease burden on school children's physical fitness and psychosocial health in Port Elizabeth, South Africa and effects of setting specific interventions**

The Department of Health would like to inform you that your application for conducting a research on the abovementioned topic has been approved based on the following conditions:

1. During your study, you will follow the submitted protocol with ethical approval and can only deviate from it after having a written approval from the Department of Health in writing.
2. You are advised to ensure, observe and respect the rights and culture of your research participants and maintain confidentiality of their identities and shall remove or not collect any information which can be used to link the participants.
3. The Department of Health expects you to provide a progress on your study every 3 months (from date you received this letter) in writing.
4. At the end of your study, you will be expected to send a full written report with your findings and implementable recommendations to the Epidemiological Research & Surveillance Management. You may be invited to the department to come and present your research findings with your implementable recommendations.
5. Your results on the Eastern Cape will not be presented anywhere unless you have shared them with the Department of Health as indicated above.

Your compliance in this regard will be highly appreciated.

**DEPUTY DIRECTOR: EPIDEMIOLOGICAL RESEARCH & SURVEILLANCE MANAGEMENT**

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## APPENDIX 8: APPROVAL FROM THE DEPARTMENT OF EDUCATION

Province of the
**EASTERN CAPE**
EDUCATION

**STRATEGIC PLANNING POLICY RESEARCH AND SECRETARIAT SERVICES**
Steve Vukile Tshwete Complex • Zone 6 • Zwelitsha • Eastern Cape
Private Bag X0032 • Bhisho • 5605 • REPUBLIC OF SOUTH AFRICA
Tel: +27 (0)40 608 4773/4035/4537 • Fax: +27 (0)40 608 4574 • Website: www.ecdoe.gov.za

Enquiries: B Pamla Email: babalwa.pamla@edu.ecprov.gov.za **Date: 13 August 2014**

Professor R du Randt

Department of Human Movement Science

Nelson Mandela Metropolitan University

P.O. Box 77000

**Port Elizabeth**

**6031**

Dear Prof Du Randt

**PERMISSION TO UNDERTAKE AN INDEPENDENT STUDY BY INSTITUTIONS OF HIGHER LEARNING: IMPACT OF DISEASE BURDEN AND SETTING SPECIFIC INTERVENTIONS ON SCHOOL CHILDREN'S CARDIO-RESPIRATORY PHYSICAL FITNESS AND PSYCHOSOCIAL HEALTH IN PORT ELIZABETH, SOUTH AFRICA**

1. Thank you for your application to conduct research.

2. Your application to conduct the above mentioned research in 50 Primary Schools under the jurisdiction of Port Elizabeth District of the Eastern Cape Department of Education (ECDoE) is hereby approved on condition that:

   a. there will be no financial implications for the Department;

   b. institutions and respondents must not be identifiable in any way from the results of the investigation;

   c. you present a copy of the written approval letter of the Eastern Cape Department of Education (ECDoE) to the Cluster and District Directors before any research is undertaken at any institutions within that particular district;

   d. you will make all the arrangements concerning your research;

   e. the research may not be conducted during official contact time, as educators' programmes should not be interrupted;

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building blocks for growth

*Ikamva eliqaqambileyo!*

f. should you wish to extend the period of research after approval has been granted, an application to do this must be directed to Chief Director: Strategic Management Monitoring and Evaluation;

g. the research may not be conducted during the fourth school term, except in cases where a special well motivated request is received;

h. your research will be limited to those schools or institutions for which approval has been granted, should changes be effected written permission must be obtained from the Chief Director: Strategic Management Monitoring and Evaluation;

i. you present the Department with a copy of your final paper/report/dissertation/thesis free of charge in hard copy and electronic format. This must be accompanied by a separate synopsis (maximum 2 – 3 typed pages) of the most important findings and recommendations if it does not already contain a synopsis.

j. you present the findings to the Research Committee and/or Senior Management of the Department when and/or where necessary.

k. you are requested to provide the above to the Chief Director: Strategic Management Monitoring and Evaluation upon completion of your research.

l. you comply with all the requirements as completed in the Terms and Conditions to conduct Research in the ECDoE document duly completed by you.

m. you comply with your ethical undertaking (commitment form).

n. You submit on a six monthly basis, from the date of permission of the research, concise reports to the Chief Director: Strategic Management Monitoring and Evaluation.

3. The Department reserves a right to withdraw the permission should there not be compliance to the approval letter and contract signed in the Terms and Conditions to conduct Research in the ECDoE.

4. The Department will publish the completed Research on its website.

5. The Department wishes you well in your undertaking. You can contact the Chief Director, Mr. GF Mac Master on the numbers indicated in the letterhead or email greg.macmaster@edu.ecprov.gov.za should you need any assistance.

**GF MAC MASTER**
**CHIEF DIRECTOR: STRATEGIC MANAGEMENT MONITORING AND EVALUATION**

**FOR SUPERINTENDENT-GENERAL: EDUCATION**

## APPENDIX 9: DATA COLLECTION SHEET

| PARTICIPANT EVALUATION FORM | | | |
|---|---|---|---|
| **BIOGRAPHICAL INFORMATION** | | | |
| ID | ☐ ☐ ☐ ☐ ☐ | TEST DATE | (dd / mm) : _____/_____/ 2015 |
| NAME | | SURNAME | |
| BIRTHDAY | (dd / mm / yyyy): _____/_____/20____ | | |

| PHYSICAL FITNESS COMPONENTS | | | |
|---|---|---|---|
| **ANTHROPOMETRY** | | | |
| HEIGHT *(cm)* | | WEIGHT (kg) | |
| SKINFOLDS *(mm)* | ***TRIAL 1*** | ***TRIAL 2*** | ***TRIAL 3*** |
| TRICEPS | | | |
| SUBSCAPULAR | | | |

| PHYSICAL FITNESS TESTS | | | | | | |
|---|---|---|---|---|---|---|
| | | | | ***TRIAL 1*** | ***TRIAL 2*** | |
| **Station 1** | *Flexibility* | Sit & Reach *(cm)* | | | | |
| | | | *CIRCLE DOMINANT HAND* | ***TRIAL 1*** | ***TRIAL 2*** | ***TRIAL 3*** |
| **Station 2** | *Upper body strength* | Grip strength *(kg)* | Right hand | | | |
| | | | Left hand | | | |
| | | | | ***TRIAL 1*** | ***TRIAL 2*** | |
| **Station 3** | *Lower body strength* | Standing Broad Jump *(cm)* | | | | |
| **Station 4** | *Coordination & speed* | Jump Sideward | | | | |
| **Station 5** | *Cardiorespiratory fitness* | 20m Shuttle Run Test (20m SRT) | | Start Number | | |
| | | | | Laps | | |

**APPENDIX 10: TABLE 4.48**

| | E1 (n = 86) | | C1 (n = 112) | | E2 (n = 101) | | C2 (n = 96) | | E3 (n =87) | | C3 (n = 147) | | E4 (n = 168) | | C4 (n = 82) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Mean | S.D. | Mean | S.D. | Mean | S.D. | Mean | S.D. | Mean | S.D. | Mean | S.D. | Mean | S.D. | Mean | S.D. |
| Age Dec T1 | 9.82 | 0.82 | 9.49 | 0.76 | 9.67 | 0.64 | 9.74 | 0.66 | 10.12 | 0.87 | 9.95 | 0.75 | 10.39 | 0.73 | 10.12 | 0.80 |
| Height T1 | 134.60 | 7.07 | 133.48 | 6.07 | 132.24 | 7.52 | 133.25 | 5.99 | 134.57 | 7.81 | 134.02 | 6.93 | 131.58 | 6.99 | 130.91 | 7.14 |
| Weight T1 | 32.85 | 9.52 | 30.91 | 6.10 | 30.08 | 7.05 | 30.44 | 6.54 | 33.18 | 10.10 | 31.30 | 7.62 | 28.45 | 5.92 | 27.03 | 5.78 |
| BMI T1 | 17.93 | 3.88 | 17.29 | 2.81 | 17.05 | 2.67 | 17.02 | 2.75 | 18.07 | 3.86 | 17.29 | 3.26 | 16.30 | 2.26 | 15.65 | 2.06 |
| Body Fat% T1 | 19.11 | 9.08 | 15.82 | 6.48 | 15.81 | 6.73 | 17.05 | 6.73 | 17.37 | 7.54 | 16.25 | 6.94 | 14.39 | 5.41 | 12.96 | 5.40 |
| Age Dec T2 | 10.43 | 0.82 | 10.13 | 0.76 | 10.28 | 0.64 | 10.35 | 0.66 | 10.72 | 0.87 | 10.59 | 0.75 | 11.01 | 0.73 | 10.77 | 0.80 |
| Height T2 | 137.58 | 7.57 | 137.15 | 6.42 | 134.93 | 7.19 | 136.32 | 6.32 | 137.91 | 8.15 | 137.11 | 7.23 | 133.98 | 7.35 | 134.78 | 9.40 |
| Weight T2 | 35.08 | 10.18 | 33.79 | 7.13 | 32.57 | 7.84 | 32.83 | 7.27 | 36.85 | 11.47 | 34.00 | 8.45 | 31.40 | 6.78 | 29.43 | 6.63 |
| BMI T2 | 18.32 | 3.96 | 17.88 | 3.08 | 17.72 | 2.93 | 17.53 | 2.94 | 19.09 | 4.19 | 17.94 | 3.54 | 17.35 | 2.58 | 16.11 | 2.36 |
| Body Fat% T2 | 18.64 | 7.54 | 19.66 | 9.63 | 15.83 | 7.29 | 18.05 | 8.49 | 20.36 | 10.61 | 18.06 | 9.91 | 14.21 | 5.82 | 13.43 | 5.77 |
| Height D2-1 | 2.98 | 1.33 | 3.68 | 1.33 | 2.70 | 2.34 | 3.08 | 1.28 | 3.34 | 1.06 | 3.09 | 1.39 | 2.40 | 1.16 | 3.87 | 5.91 |
| Weight D2-1 | 2.23 | 1.95 | 2.88 | 1.79 | 2.49 | 1.79 | 2.39 | 1.32 | 3.67 | 2.02 | 2.70 | 1.70 | 2.94 | 1.56 | 2.41 | 1.36 |
| BMI D2-1 | 0.40 | 1.03 | 0.60 | 0.84 | 0.67 | 1.09 | 0.51 | 0.62 | 1.03 | 0.84 | 0.65 | 0.91 | 1.04 | 0.74 | 0.46 | 1.09 |
| Body Fat% D2-1 | -0.47 | 4.05 | 3.84 | 4.78 | 0.02 | 2.78 | 1.00 | 3.17 | 2.99 | 5.86 | 1.81 | 4.61 | -0.18 | 3.37 | 0.47 | 2.87 |

Descriptive statistics for individual schools in respect of age and anthropometric variables