NELSON MANDELA UNIVERSITY

Effect of a Physical Activity Intervention on the Physical Fitness of Primary Schoolchildren in Disadvantaged Communities in Port Elizabeth

Submitted in fulfilment of the requirements for the degree

Master of Human Movement Science to be awarded at the Nelson Mandela University

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Declaration

A dissertation submitted in fulfilment of the requirements for the degree Master of Human Movement Science, in the Department of Human Movement Science, Faculty of Health Sciences, at the Nelson Mandela University.

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Dedication

Dedicated to my father, who taught me to think…

Barend Daniel (Ben) Joubert
21 January 1958 – 5 June 2011

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Table of Contents

List of Tables

List of Equations

List of Figures

List of Abbreviations

Abbreviation	Definitions
°C	Celsius
1RM	one repetition maximum
AAHPER	American Association for Health, Physical Education and Recreation
AAHPERD	American Alliance for Health, Physical Education, and Recreation and Dance
B	boys
BAZ	BMI-for-age z-scores
BMI	body mass index
C2005	Curriculum 2005
CAPS	Curriculum and Assessment Policy Statement
CG	Control Group
CI	confidence intervals
cm	centimetres
CP 1 or 2	Control Phase 1 or 2
DASH	Disease, Activity and Schoolchildren's Health
DSBG	Department für Sport, Bewegung und Gesundheit
DXA	Dual-Energy X-ray Absorptiometry
EBRBs	energy balance-related behaviours
FET	Further Education and Training
g	gram
G	girls
HAKSA	Healthy Active Kids report card South Africa
HAZ	height-for-age z-scores
HDI	human development index
ICH - GCP	International Conference on Harmonisation - Good Clinical Practice
IG	Intervention Group
IP 1 or 2	Intervention Phase 1 or 2
IQ	Intelligence Quotient
ISAK	International Society for the Advancement of Kinanthropometry
ISRCTN	International Standard Registered Clinical / Social Study Number
IUHPE	International Union of Health Promotion and Education
kcal	kilocalorie
kg	kilograms
kJ	kilojoule
$km.h^{-1}$	kilometres per hour
M	mean
m	metres
max	maximum
Mdn	median
METs	metabolic equivalent

Abbreviation	Definitions
min	minimum
ml	millilitre
$ml.kg^{-1}.min^{-1}$	millilitres per kilogram per minute
mm	millimetres
MVPA	moderate-to-vigorous intensity physical activity
n	sample size
NRF	National Research Foundation
OBE	Outcomes Based Education
PACER	Progressive Aerobic Cardiovascular Endurance Run
R-NCS	Revised National Curriculum Statement
ROM	range of motion
RSD	relative standard deviation
SD	standard deviation
sec	seconds
SEE	standard error of estimates
SEM	standard error of mean
SNSF	Swiss National Science Foundation
SSAJRP	Swiss South African Joint Research Programme
STH	soil transmitted helminth
Swiss TPH	Swiss Tropical and Public Health Institute
T 1 or 2 or 3	Testing Phase 1 or 2 or 3
UNESCO	United Nations Educational Scientific and Cultural Organization
$\dot{V}O_2$max	maximal oxygen uptake
WAZ	weight-for-age z-scores

Abstract

Background: Physical activity is an essential component of a healthy lifestyle, and schools are ideal settings for promoting activity and wellness. Only half of South African children meet global activity recommendations and overweightness and obesity remain a growing challenge. Disadvantaged communities are at even greater risk, as environmental- and socioeconomic challenges further influence children's health and activity levels.

Aim and Objectives: This study investigated the effect of a physical activity intervention on the following health-related physical fitness parameters of primary schoolchildren: cardiorespiratory fitness, upper- and lower body strength, lower body flexibility, and body composition. More specifically the objectives were to describe and compare the intervention and control groups, at baseline, mid- and post intervention.

Methodology: A cluster randomised controlled trial determined the effect of the intervention. Testing was phased in three cross sectional surveys, baseline, mid and post-intervention. The study sample consisted of 157 children, aged 8-12 years, from two primary schools in the township of Motherwell, Port Elizabeth. The physical activity intervention consisted of two intervention periods, each 10-weeks in duration, and included physical education lessons, move-to-music dance classes, in-class physical activity breaks, and physical activity 'homework'. Furthermore, a low-cost physical activity-friendly school environment was created with play structures, painted games, and the upgrade of sporting facilities and equipment.

Results: The intervention was shown to have significant positive effects on the number of laps ran ($p < 0.05$), indicating cardiorespiratory fitness, and handgrip strength ($p < 0.001$), an indicator of upper body musculature strength. No significant effects were found for lower body musculature strength ($p > 0.05$), lower body flexibility ($p > 0.05$) or body mass index ($p > 0.05$).

Conclusion: Schoolchildren's level of health-related physical fitness should be regularly assessed, and effective interventions should be implemented and monitored to ensure that children meet recommended activity and fitness standards. Physical education in South African schools is currently compromised, with children having low levels of in-school activity and high levels of sedentary behaviour. The majority of physical activity and health-related physical fitness measures are poor, with even lower scores for girls and children from lower socioeconomic areas. Interventions are thus essential and should focus on extended durations and higher activity intensities in order to achieve health enhancing benefits.

Keywords: Physical fitness; physical activity; school-based intervention; primary schoolchildren; disadvantaged communities

Chapter 1 : Problem Identification

1.1. Introduction

This study investigates the effect of a school-based physical activity intervention on the physical fitness of primary schoolchildren from disadvantaged communities in Port Elizabeth, in the Eastern Cape Province of South Africa. The following chapter serves as an introduction and contextualises the study by providing the necessary background, as well as the scope and significance of the study. Thereafter, the research aim and objectives are described and important concepts within the study are explained.

1.2. Contextualisation

This section provides an overview of several key elements in this study. The importance of physical activity for schoolchildren in light of globally low activity levels and associated health dangers are considered. The ways in which physical activity contributes to physical fitness are also discussed. Finally, the challenges that lower socio-economic settings pose for the promotion of physical activity and fitness for children are highlighted.

Humanity is currently spending more time indoors than ever before. This can be linked to advances in technology which have led to new forms of entertainment, changing demands in job markets, and different modes of non-active transportation, among other factors. Accordingly, children are becoming increasingly inactive and consequently are at risk for a multitude of factors linked to hypokinetic diseases (Hoeger & Hoeger 2011: 18-22). Overweight and obesity, for example, have reached epidemic proportions with an alarming 340 million children between the ages of 5-19 being classified as either overweight or obese in 2016 (World Health Organization, 2018a). Furthermore, in 2018, the physical activity levels of South African children were assigned a C grade in the Healthy Active Kids South Africa Report Card 2018, indicating that only about half of South Africa's children are currently meeting global activity recommendations (Uys, Bassett, Draper, Micklesfield, Monyeki, de Villiers & Lambert, 2018).

Although the development of this situation is somewhat understandable given humanity's drastic lifestyle change in recent history, inactivity and the results thereof have the potential of contributing to a myriad of health problems. These include cardiovascular diseases, such as myocardial infarctions, high blood pressure and cerebrovascular accidents, as well as metabolic diseases, including diabetes, of which more than 1.8 million cases were recorded in South Africa in 2017, to name just a few (International Diabetic Federation, 2018).

Such risk factors demonstrate the importance of encouraging and incentivising physical activity in children from a young age. Moreover, contemporary studies confirm that physical activity leads to improvements in the physical-, psychological- and cognitive development of children. Physical health benefits range from improving body composition, aerobic fitness and skeletal health, to reducing cardiovascular disease risk and metabolic risk health markers as well as certain types of cancer (Sallis, Prochaska & Taylor, 2000). Psychological health outcomes have further been positively linked to participation in regular physical activity. These parameters range from a reduction in stress, anxiety and depression symptoms, to the improvement of self-esteem and social development and behaviours (Strong, Malina, Blimkie, Daniels, Dishman, Gutin, Hergenroeder, Must, Nixon, Pivarnik, Rowland, Trost & Trudeau, 2005). Recent research has further revealed that children's cognitive functioning relates positively to physical activity interventions, a single bout of physical activity, as well as physical fitness (Donnelly, Hillman, Castelli, Etnier, Lee, Tomporowski, Lambourne & Szabo-Reed, 2016).

Thus, it is vital that children remain active, even as our changing world is increasingly encouraging more sedentary activities. Although this is clear to even a casual observer, achieving this goal is not as simple. Several pursuits have the potential of increasing children's physical activity and fitness levels; among them are active play and active transport, informal games, physical education classes and school sports which foster team spirit and camaraderie.

However, for a large part of the South African population, it remains a major challenge to access such activities, facilities and equipment. This is linked to lower socio-economic conditions and related factors. Many children in disadvantaged communities are unable to spend sufficient active time outside due to safety concerns or unavailable infrastructure. As such, schools have the potential of serving as ideal settings for the promotion of physical activity and a healthy lifestyle, especially in disadvantaged communities (Walter, 2011). Children spend a significant portion of their waking hours at school, and schools offer unique opportunities for active group activities and team sports. However, many South African schools, particularly those in disadvantaged communities, are confronted with limited access to resources, qualified teachers, activity equipment and safe environments appropriate for childhood physical activity. Given the already established low levels of physical activity among children, the dangers associated with this and the additional challenges which schools in disadvantaged communities face, it becomes evident that the need to address the situation is paramount. This is true, not only for the benefit of the children themselves and the health advantages they stand to gain from regular participation in physical activity, but also because lifelong activity patterns are frequently established during childhood (Kobel, Wartha, Wirt, Dreyhaupt, Lämmle, Friedemann, Kelso, Kutzner, Hermeling & Steinacker, 2017). This therefore means that today's children are effectively likely to carry such established behaviours throughout their lives and pass them on to the next generation. This further serves to highlight the importance of early intervention.

1.3. Research Aim, Question and Objectives

The primary aim of the study is to investigate the effects of a school-based physical activity intervention on the physical fitness of primary school children.

The research question the study plans to answer reads: Does a school-based physical activity intervention increase the physical fitness, namely, the body composition, the cardiorespiratory fitness, the upper- and lower body strength, and the lower body flexibility of primary school children in Port Elizabeth?

In order to achieve the primary aim and answer the research question, the following three objectives were addressed:

1. To compare the performance of children in the intervention group, with that of children in the control group, across three testing phases, for the physical fitness components assessed.
2. To explore, describe and compare the performance of children in the intervention group, across three testing phases, for the physical fitness components assessed.

3. To explore, describe and compare the performance of children in the control group, across three testing phases, for the physical fitness components assessed.

The scope of the study follows, where a brief overview of the project is provided.

1.4. Scope of the Study

This study falls under the auspices of a larger, three-year research project entitled: "The impact of disease burden and setting-specific interventions on schoolchildren's cardiorespiratory, physical fitness and psychosocial health in Port Elizabeth, South Africa". In the current study, this larger project is referred to as 'the DASH project', an acronym for 'Disease, Activity and Schoolchildren's Health'. The study was funded by the Swiss South African Joint Research Programme (SSAJRP), a collaboration between the South African National Research Foundation (NRF) and the Swiss National Science Foundation (SNSF).

The present study investigates the effect of a school-based physical activity intervention on the body composition and physical fitness of primary schoolchildren in disadvantaged communities. The study employed a quantitative approach and used a cluster randomised controlled trial research design. Three testing phases, between 2015 and 2016, consisting of baseline testing and two post-intervention testing phases, were used to gather the data. The participants of the study consisted of 157 primary schoolchildren, 65 children in the intervention group and 92 children in the control group, from two primary schools in a lower socioeconomic township area, outside Port Elizabeth, in the Eastern Cape Province of South Africa.

Body composition was assessed with estimated body fat percentage, through two skinfolds sites and body mass index (BMI), and indicators of nutritional status, including weight-for-age, height-for-age and BMI-for-age z-scores. Physical fitness was determined by selected tests from the Eurofit testing battery and included: cardiorespiratory fitness assessment, with the 20-metre multistage shuttle run test, static upper body muscular strength, measured with a handheld dynamometer, lower body strength and power, with standing broad jump, and lower body flexibility, assessed with the sit-and-reach test.

Two intervention phases, each consisting of 10-weeks, were scheduled between the first and the second, and the second and the third testing phase. The physical activity intervention consisted of two 40-minute Physical Education classes per week, one 45-minute move-to-music mass dance class per week, three to four in-class physical activity breaks during the day, of one-to-two minutes in duration, physical activity 'homework' performed by the learners after school hours, and lastly, the creation of a low-cost physical activity-friendly school environment by implementing physical play structures, painting colourful games on the school terrain and upgrading sporting facilities.

To aid in interpretation, data analysis incorporated descriptive statistics, including central tendency (mean and median) and quartiles, standard deviation, standard error of mean, relative standard deviation and percentage values. Furthermore, inferential statistics, using a series of multiple regression analysis with indicator variables and stepwise elimination, was used to determine the intervention effect.

The proceeding section provides a brief overview of key terms used within the study, and definitions of physical activity and exercise, health- and skill-related physical fitness and Physical Education are provided.

1.5. Concept Clarification

The words ‘physical activity’ and ‘exercise’ are often used interchangeably, but they do refer to different concepts. Additionally, physical fitness can refer to either health-related or skill-related components. It is therefore fitting that the study starts by defining these key concepts, to aid in further understanding and interpretation. This section provides a brief definition for physical activity, exercise, health- and skill-related physical fitness, as well as Physical Education. Further clarification and examples of these concepts can be found in Chapter 2: Literature Review, section 2.2.1.

Physical activity: According to Caspersen, Powell & Christenson (1985), physical activity is defined as any bodily movement produced by skeletal muscles that results in energy expenditure. The amount of energy expenditure associated with physical activity is determined by the amount of muscle mass producing movement, as well as the intensity, duration and frequency of muscle contractions (Caspersen *et al.*, 1985).

Exercise: On the other hand, exercise refers to a type of physical activity, involving bodily movements produced by skeletal muscles and also results in energy expenditure. Exercise is often performed to improve or maintain components of health, or physical fitness. Exercise activities are also usually planned, structured and require repetitive body movements (Hoeger & Hoeger, 2011: 7). Furthermore, exercise positively correlates to physical fitness, as the intensity, duration and frequency of movement increases (Caspersen *et al.*, 1985).

Physical fitness: Often defined as a set of attributes an individual has or can achieve, physical fitness can be divided into health-related and skill-related components (Caspersen et al., 1985). Individuals are physically fit when they can safely and effectively meet both the ordinary, and the unusual demands of daily life, without being overly fatigued (Hoeger & Hoeger, 2011: 7-9). The components of health-related physical fitness are cardiorespiratory fitness, musculature strength, endurance and flexibility as well as body composition. Skill-related physical fitness, the second division of physical fitness identified above, consists of six components (Riebe et al. 2017: 49), and includes agility, coordination, balance, power, reaction time and speed.

Physical Education: In this study, Physical Education refers to the school subject aimed at promoting childhood health, through the promotion of physical activity, exercise and fitness, as well as healthy eating habits. In South Africa this is no longer a stand-alone school subject, but instead forms part of the learning area known as Life Skills (within the Foundation and Intermediate Phases, from Grades one to six) or Life Orientation (within the Senior and Further Education and Training Phases, from Grades seven to 12). The evolution and current implementation of Physical Education, which is discussed fully in Chapter 2, poses additional challenges for promoting physical activity in children and necessitates the implementation of interventions, such as the intervention being investigated in this study.

In summary then, the main difference between physical activity and exercise lies in the fact that exercise is performed explicitly with the goal of improving or maintaining components of health or physical fitness while physical activity refers to any movement resulting in energy expenditure. Furthermore, physical fitness is a set of attributes an individual has or can achieve and involves both health related and skill related components. Physical Education refers to the school subject, aimed at promoting childhood health.

1.6. Significance of the Study

The study is significant for several reasons. Firstly, it must be recognised that there is a distinct lack of intervention research in low-to-middle income countries. As a result, attempts at generalisations of research conducted in developed countries, yield little benefits, as there are vast differences in populations and daily experiences, as well as challenges encountered at grassroots level in low-to-middle income countries. Furthermore, there is a paucity of children's physical fitness data in South Africa. The publication of the Healthy Active Kids Report Card of South Africa indicates insufficient data since the first publication in 2014 (Draper, Basset, Villiers & Lambert, 2014; Draper, Tomaz, Bassett, Burnett, Christie, Cozett, Milander, Krog, Monyeki, Naidoo, Naidoo, Prioreschi, Walter, Watson & Lambert, 2018; Uys, Bassett, Draper, Micklesfield, Monyeki, de Villiers & Lambert, 2016). Among South African research available, the majority of recent studies were conducted in either the Western Cape or the KwaZulu Natal Province. Therefore, this study conducted in the Eastern Cape is important. It provides insights into childhood physical fitness levels, in a province of South Africa that has been repeatedly identified as having severe socioeconomic problems, including exceptionally high crime rates and of the lowest school pass rates, among others. Thus, on all these levels the current study provides insights into an area where data has been lacking.

Furthermore, as has already been mentioned, global physical activity levels are declining, especially in children, consequently physical fitness levels are also decreasing. Research such as this study emphasises the importance of physical activity and has the potential of serving as a catalyst to encourage schools to implement improved Physical Education programs and additional physical activity interventions.

Finally, policy makers, including the Department of Education and the Department of Health, can use research, particularly research from the larger DASH study of which the present study forms part, to implement health interventions in governmental school structures aimed at improving learners' health and activity levels.

1.7. Conclusion

This first chapter provided background to the study and justified the need for research investigating physical activity in light of current global trends. Specifically, the gap in available literature illustrated the need for research concerning a physical activity intervention in a primary school setting, located in a lower socioeconomic area, in a low-to-middle income country. The following chapter builds on these findings by providing a review of literature, investigating the benefits of physical activity and physical fitness, childhood activity recommendations, and current global physical activity levels. Furthermore, Physical Education in the South African context is investigated, along with the challenges disadvantage community settings face. The last section of Chapter 2 provides background on school-based activity interventions, particularly the factors found to be successful and the components utilised in this study. Lastly, empirical research, published on health promoting school-based interventions and the corresponding effects on health-related physical fitness parameters in children, is provided.

Chapter 2 : Literature Review

2.1. Introduction

This study investigates the effect of a school-based, physical activity intervention on physical fitness- and body composition measures of primary schoolchildren in disadvantaged communities. The following chapter reviews literature concerning the importance of physical activity and physical fitness for schoolchildren, investigates the historical development of physical education in the South African context and provides background on physical activity- and health promoting school-based interventions.

2.2. Physical Activity and Physical Fitness

The terms physical activity, exercise and physical fitness are often used interchangeably. They do, however describe different concepts. Therefore, it is vital to ensure that these terms are understood accurately prior to commencing the discussion. The following section defines physical activity, exercise and physical fitness, as they are understood in the context of this study and provides practical examples of each.

2.2.1 Defining Physical Activity and Physical Fitness

According to Caspersen, Powell & Christenson (1985), physical activity is defined as any bodily movement produced by skeletal muscles that results in energy expenditure. Energy expenditure is measured in kilojoules (kJ) or kilocalories (kcal), where one kcal is equivalent to 4.184 kJ. A kcal can be described as a unit of energy, with one kcal equal to the amount of heat required to raise the temperature of one kilogram (kg) of water by one degree Celsius (°C) (Hoeger & Hoeger 2011: 67). The amount of energy expenditure associated with physical activity is determined by the amount of muscle mass producing movement, as well as the intensity, duration and frequency of muscle contractions (Caspersen *et al.*, 1985).

Physical activity can be categorised according to intensity, which refers to rate at which activity is being performed (World Health Organization, 2014). Not all people experience the same intensity level when performing any given physical activity. The intensity level experienced depends on the individual's previous exercise experience and fitness level. Metabolic equivalents (METs) are used to express intensity of physical activity, with one MET equivalent to a caloric consumption of 1 kcal per kg bodyweight per hour or the oxygen consumption of 3.5 millilitres (ml) per kg bodyweight per minute (min). This is the energy requirement for a resting metabolism, for example, while sitting quietly in a chair (Jette, Sidney & Blumchent, 1990). METs are a useful and standardised way of describing the absolute intensity of a range of physical activities.

Activities are classified into the following categories: (Ainsworth, Haskell, Herrmann, Meckes, Bassett, Tudor-Locke, Greer, Vezina, Whitt-Glover & Leon, 2011)

- Sedentary behaviour (1.0 – 1.5 METs), including sitting quietly in a chair;
- Light intensity activity (1.6 – 2.9 METs), such as driving a car;
- Moderate intensity activity (3 – 5.9 METs), for example aerobic dancing and riding a bicycle at 10 kilometres per hour ($km.h^{-1}$); and lastly,

- Vigorous intensity activity (> 6 METs), including activities such as jogging at 9 km.h^{-1} and rope skipping at 66 skips per minute.

Exercise, on the other hand, refers to a type of physical activity involving bodily movements produced by skeletal muscles, resulting in energy expenditure and performed to improve or maintain components of health or physical fitness. Exercise activities are also usually planned, structured and require repetitive body movements (Hoeger & Hoeger 2011: 7). Furthermore, exercise correlates positively to physical fitness as the intensity, duration and frequency of movement increases (Caspersen *et al.*, 1985).

Physical fitness can be understood as a set of attributes an individual has or can achieve. This can be divided into health-related and skill-related components of physical fitness (Caspersen *et al.*, 1985). Individuals are physically fit when they can safely and effectively meet both the ordinary, and the unusual demands of daily life, without being overly fatigued, and still have energy left to pursue leisure and recreational activities (Hoeger & Hoeger 2016: 8).

The components of health-related physical fitness are listed below. Health-related physical fitness also has a strong relationship to overall health and wellness, and is associated with lower prevalence of chronic disease (Riebe, Ehrman, Liguori & Magal 2017: 49).

1. **Cardiorespiratory fitness:** Also referred to as cardiovascular endurance or aerobic fitness, refers to the ability of the cardiovascular (circulatory) and respiratory systems to meet the body's demands of providing fuel and eliminating by-products, during sustained physical activity (Caspersen *et al.*, 1985). Distance running is an example of an activity that requires cardiorespiratory fitness.
2. **Musculature strength:** Which can be defined as the maximum amount of force a muscle or group of muscles can generate (Powers & Howley 2014: 179-183). Musculature strength is often expressed as one repetition maximum (1 RM) and is the maximum amount of load that can be lifted, with good form, through a full range of motion. Activities such as lifting a heavy load or pushing a heavy box, require musculature strength.
3. **Musculature endurance:** Often plainly known as endurance, refers to the ability of a muscle or group of muscles to contract repeatedly against a submaximal force without fatigue (Corbin, McConnell, Le Masurier, Corbin & Farrar 2014: 19-20). Performing a number of abdominal crunches is an example of abdominal musculature endurance.
4. **Musculature flexibility:** Refers to the achievable range of motion (ROM) at a joint or group of joints (Hoeger & Hoeger 2016: 8-9). Range of motion can be improved by stretching. Regular stretching of the hamstring muscles for instance will allow a normal range at the hip joint.
5. **Body composition:** Consists of the relative amount of fat mass and fat free mass in the musculature, bones and other vital organs and tissues (Caspersen *et al.*, 1985). Body composition is often assessed through body fat (Corbin et al. 2014: 19-21). Body fat can be classified into essential and non-essential body fat. Essential body fat is needed to allow certain body functions, such as temperature regulation, shock absorption and the regulation of essential nutrients, including vitamins A, D, E and K (Welk, Corbin, Welk & Corbin 2015: 276-278). Males should have no less than 5 % essential body fat and females

no less than 10 %. Any fat that is above the essential body fat percentage, is classified as non-essential body fat. A healthy range of non-essential body fat for males is 10 – 20 %, while it is 17 – 28 % for females (Welk *et al.* 2015: 276-278). A body fat percentage above the healthy range can lead to increased health risks.

Skill-related physical fitness, the second division of physical fitness identified above, consists of six components (Riebe *et al.* 2017: 49), and includes the following:

1. **Agility:** Relates to the ability to change the direction of the entire body in space, with speed and accuracy (Caspersen *et al.*, 1985). Agility is important in sports such as soccer, where rapid changes in direction is required, while body control is maintained (Hoeger & Hoeger 2016: 8).
2. **Coordination:** Refers to the ability to coordinate the nervous- and muscular systems, enabling the body to perform motor tasks smoothly and accurately. This is achieved by using the senses, particularly sight and hearing, along with body parts (Caspersen *et al.*, 1985). Activities that require hand-eye or foot-eye movements, such as golf and soccer involve coordination (Hoeger & Hoeger 2016: 9).
3. **Balance:** The ability to maintain equilibrium while standing or moving, is required in sports such as gymnastics (Corbin *et al.* 2014: 29-30).
4. **Power:** The ability to produce maximum force in the shortest time, involves two components, speed and force. Possessing power allows an individual to produce explosive movement required for jumping, used in basketball and shotput for example (Hoeger & Hoeger 2016: 9).
5. **Reaction time:** Refers to the amount of time required to move once a need to act has been recognised (Corbin, Le Masurier & McConnell 2014: 21-22). Good reaction times are important in sports such as swimming and track athletics.
6. **Speed:** The ability to propel the body, or part of the body, rapidly from one point to another (Hoeger & Hoeger 2016: 10). Activities that require speed include sprinting in athletics as well as soccer and basketball.

In summary, although the terms physical activity and exercise are often used interchangeably, these terms in fact refer to different concepts. Furthermore, physical fitness is a broad term that can be divided into health-related and skill-related components. This study is concerned with the component of health-related physical fitness, which includes cardiorespiratory fitness, musculature strength, -endurance and -flexibility, as well as body composition. The skill-related components of physical fitness consist of agility, coordination, balance, power, reaction time and speed.

The following section investigates the benefits of physical activity and health-related physical fitness, with specific reference to schoolchildren.

2.2.2 Benefits of Physical Activity and Physical Fitness

Research on physical activity participation, physical fitness status and health has provided undisputable evidence that activity leads to improvements in the physical-, psychological- and cognitive development of children. This section aims to highlight several of the benefits achieved when children participate in regular physical activity and possess high levels of physical fitness.

2.2.2.1. Physical Health Benefits of Regular Physical Activity

Current literature increasingly demonstrates that physical activity has beneficial effects across several physical health outcomes (Penedo & Dahn, 2005). These benefits range from improving body composition, aerobic fitness and skeletal health, to reducing cardiovascular disease risk and metabolic risk health markers as well as certain types of cancer (Sallis *et al.*, 2000).

Globally, overweightness and obesity has reached epidemic proportions. More than 1.9 billion adults, 340 million children between the ages of 5-19 years and 41 million children younger than 5 years, were classified as either overweight or obese in 2016 (World Health Organization, 2018a). Specifically childhood obesity appears to be on the rise in both developed and developing countries, for both genders, and across all ethnic and socioeconomic groups, with some of the largest increases observed in the lowest socioeconomic areas worldwide (Yildirim, Van Stralen, Chinapaw, Brug, Van Mechelen, Twisk & Te Velde, 2011).

Although obesity is a complex and multi-dimensional problem, physical activity can assist with weight reduction, weight loss maintenance and improvement of body composition. Energy balance-related behaviours (EBRBs), including physical activity-, sedentary- and dietary behaviours, result in weight status, including weight gain and weight control (Verjans-Janssen, Van De Kolk, Van Kann, Kremers & Gerards, 2018). An increase in physical activity leads to an automatic decrease in sedentary time, which can result in a negative energy balance, if more energy is used than consumed. Overweightness and obesity are also tracked from childhood into adulthood. This emphasises the importance of promoting healthy EBRBs, including regular physical activity participation, during childhood (Brug, van Stralen, Te Velde, Chinapaw, De Bourdeaudhuij, Lien, Bere, Maskini, Singh, Maes, Moreno, Jan, Kovacs, Lobstein & Manios, 2012). Moreover, regular physical activity participation has the benefit of maintaining or improving physical fitness (Sallis *et al.*, 2000). Physical fitness, in turn, has various positive effects on bodily functions. Particularly an improvement in cardiorespiratory fitness, positively affects various vital body organs and systems, including the cardiovascular system (heart, arteries, veins, capillaries, as well as the blood) and the respiratory system (the lungs) (Reilly, Secher, Snell, Williams & Williams 2005: 111-114). Additional physical fitness benefits, within both the health- and skill related physical fitness domains, include the development of fundamental movement skills[1] and physical competencies, for example: strength, endurance, balance and speed. These skills and competencies build the foundation for physical activity participation later in life and promote a lifelong active lifestyle (Bailey, 2006).

Physical activity, and particularly weight-bearing activities, also has an effect on the skeletal system. When participating in regular weight-bearing activities, the skeletal system is placed under the same mechanical strain as the musculature system and responds similarly. The skeletal system therefore increases in strength, through increased bone mineral content. However, this increase in strength only occurs at the site where mechanical strain is applied (Malina, 2001). Bone mineral density refers to the mineral density that is established during childhood, through physical activity and nutritional intake. This largely determines the bone mineral density during adulthood, since the lifetime peak bone mass is obtained during the adolescent years (Malina, 2001). Thus, children who participate in

[1] Movement patterns that involve various body parts and provide a basis of physical literacy, which refers to the motivation, confidence, physical competence, knowledge, and understanding to value and taking responsibility for engagement in physical activities for life (International Physical Literacy Association, 2017).

regular weight-bearing physical activities from an early age, benefit from stronger bones, with a higher bone mineral content, than children who do not.

Physical activity, specifically vigorous intensity activities, further positively affects a range of cardiovascular and metabolic health risk markers, improving blood pressure, blood lipid levels and blood glucose regulation (Janssen & LeBlanc, 2010; Loprinzi, 2015; Lucas-De La Cruz, Martínez-Vizcaíno, García-Prieto, Arias-Palencia, Diez-Fernandez, Milla-Tobarra & Notario-Pacheco, 2018). Non-communicable diseases, particularly those cardiovascular and metabolic in nature, are on the rise. Recent reports suggest that they are responsible for the deaths of 41 million people each year, which amounts to 71 % of all death globally (World Health Organization, 2018b). Since academic evidence suggests that the development of certain non-communicable diseases can start in childhood, children who participate in regular physical activity, especially vigorous intensity activity, would have a decreased cardiovascular- and metabolic risk, and therefore be less prone to developing non-communicable diseases later in life (Vicente & Moreira, 2018).

A literature review by Sallis *et al.*, (2000), identified at least modest positive effects in youth on health outcomes, including body composition, physical fitness and cardiovascular and metabolic health risk markers. These findings serve to emphasise the fact that regular physical activity participation provides great physical benefits to children. These benefits are not only enjoyed during childhood but carry through into adulthood and can aid in promoting lifelong physical activity participation. The following section briefly considers the concept of psychological wellness and notes some psychological benefits physical activity participation can provide for children.

2.2.2.2. Psychological Benefits of Regular Physical Activity

Psychological wellness refers to a state in which an individual realises their own ability, can cope with everyday stressors in life, can perform tasks productively and contribute to their surrounding community. This forms an integral part of health and wellbeing (World Health Organization, 2018c). Psychological health outcomes have been positively linked to participation in regular physical activity. Within school settings it has also been linked to Physical Education and sports participation. These psychological parameters range from a reduction of stress, anxiety and depression symptoms, to the improvement of self-esteem, social development and behaviours which can further contribute to a pro-school attitude (Strong *et al.*, 2005).

Regular sports participation specifically, has been linked to the reduction of symptoms of depression and anxiety (Eime, Young, Harvey, Charity & Payne, 2013). Although the underlying mechanisms responsible are not fully understood, it is hypothesized that social support within sporting activities contribute to these positive psychological health outcomes (Bailey, 2006). Interestingly, the influence of physical activity on depression symptoms, varied in accordance with the intensity of the activity. Moderate intensity physical activity has proven to be responsible for larger positive effects than vigorous intensity activity (Janssen & LeBlanc, 2010).

Strong evidence has linked physical activity participation to improvements in self-esteem, self-concept and self-efficacy (Eime *et al.*, 2013). Self-esteem and self-concept have also been identified as important predictors of other behaviours, ranging from improvement in academic performance to reduction in antisocial or criminal behaviour. Indeed, self-concept has been described as one of the variables with the ‘highest payoff’ in physical activity research (Calfas & Taylor, 1994).

Lastly, Bailey (2006) reports that appropriately structured and presented physical activity in school settings can make a contribution to the development of a pro-school attitude. The relationship between physical activity, education and sport can therefore affect the general attitude towards school. An increase in the availability of activities within the school's context, can also result in the school experience becoming more attractive (Bailey, 2006).

The link between physical activity and cognitive performance is a domain of particular importance in school-aged children. The following section briefly describes the cognitive improvements that have been connected with regular physical activity participation.

2.2.2.3. Cognitive Health Benefits of Regular Physical Activity

Cognitive functioning, defined by Donnelly *et al.,* (2016) as a set of mental processes that contribute to perception, memory, intellect and action, is hypothesized to underlie academic performance (Donnelly *et al.*, 2016). Recent research has revealed that children's cognitive functioning relates positively to physical activity interventions, a single bout of physical activity, as well as physical fitness (Donnelly *et al.*, 2016). Moreover, physical activity, especially activities that are aerobic in nature, greatly benefit children with learning disabilities, who struggle to meet mathematics and reading standards (Fedewa & Ahn, 2011).

Bailey (2006) suggests that physical activity improves cognitive performance by increasing blood flow to the brain and thus increasing mental alertness. Furthermore, physiological brain changes associated with physical activity include structural integrity and myelination of the genu of the corpus callosum[2] and increased white matter microstructures, resulting in faster neural conduction between the right and left brain hemispheres (Chaddock-Heyman, Erickson, Kienzler, Drollette, Raine, Kao, Bensken, Weisshappel, Castelli, Hillman & Kramer, 2018).

Children living in lower socioeconomic areas face a multitude of challenges that hinder their academic performance. These challenges include insufficient hygiene, as, for example, a lack of clean water and inadequate sanitation. Such conditions increase the risk of helminth infections (Speich, Croll, Fürst, Utzinger & Keiser, 2016). Helminth infections, in turn, result in growth retardation, anaemia, cognitive impairments and decreased academic performance (Utzinger, Becker, Knopp, Blum, Neumayr, Keiser & Hatz, 2012). Furthermore, high absenteeism rates from school are often the norm in lower socioeconomic areas. This is due to limited access to healthcare, resulting in extensive travel when healthcare is required. Drug- and alcohol abuse or gang related activities also interfere with children's performance at school as well as their ability to complete homework assignments or regularly attend school. These issues result in reduced academic exposure, and consequently, lower academic performance (Zulu, Urbani, van der Merwe & van der Walt, 2004). The high prevalence of stunting[3] within lower socioeconomic areas further contributes to poor cognitive development and low intelligence quotient (IQ) (Anthony, King & Austin, 2011). The combination of these factors decreases

[2] Genu of the corpus callosum refers to the anterior end, near the frontal lobes, of the corpus collosum. The corpus collosum has been found to play a role in attention, memory and cognitive processing speed (Chaddock-Heyman *et al.*, 2018).

[3] Stunting, also referred to as growth retardation, defined as when a child fails to reach linear growth for their age. Factors that can contribute to stunting include: long term food deprivation, poor quality of food, repeated infectious diseases or low socioeconomic status (de Onis *et al.*, 2007).

children's ability to process information, concentrate and focus on academic tasks (Gall, Adams, Joubert, Ludyga, Müller, Nqweniso, Pühse, du Randt, Seelig, Smith, Steinmann, Utzinger, Walter & Gerber, 2018). Research increasingly suggests that physical activity has the potential to improve not only children's physical health, but also their cognitive functioning. This includes executive functioning, attention and academic performance (Ludyga, Gerber, Brand, Holsboer-Trachsler & Pühse, 2016).

The cognitive domain is especially important within the school context, even more so in lower socioeconomic areas, since they face unique challenges above and beyond those common to the school environment. It is well established that healthier children have the ability to learn more effectively. Educators and scientists are increasingly coming to recognise the important interaction between physical and cognitive health (Castelli, Centeio, Hwang, Barcelona, Glowacki, Calvert & Nicksic, 2014).

This section provided a brief overview of the physical, psychological and cognitive benefits which are likely to result from children's regular participation in physical activity. Not only is the body of literature that explains and supports the positive results of children's participation in regular physical activity growing, but physical inactivity has also been identified as the 4th leading cause of mortality globally. In many cases, sustained inactivity can also lead to disability and severe reduction of quality of life (Bailey, 2006). The following section explains the current global physical activity recommendations for school-aged children.

2.2.3 Childhood Physical Activity Recommendations

Current scientific evidence concludes that physical activity provides fundamental health benefits for children and is necessary for normal growth and development (Centers for Disease Control and Prevention, 2013). Global physical activity recommendations for school-aged children therefore stipulate that children, between the ages of 5 – 17 years, should be active for a minimum of 60 minutes per day (World Health Organization, 2015). This recommendation is relevant for all children, irrespective of gender, race, ethnicity or income level. Activity should comprise of moderate-to-vigorous intensity physical activity (MVPA), and is prescribed to improve cardiorespiratory fitness, muscle and bone health, weight management, as well as cardiovascular and metabolic health risk biomarkers (Centers for Disease Control and Prevention, 2018). Due to physical activity following a dose-response relationship, exceeding 60 minutes of moderate-to-vigorous intensity physical activity will lead to additional health benefits (World Health Organization, 2010).

It is recommended that most of the prescribed physical activity should be aerobic in nature, with muscle- and bone strengthening activities, such as running and jumping, included at least three times a week (World Health Organization, 2010). Furthermore, the physical activity time per day can be accumulated in shorter bouts and does not necessarily have to be completed in a continues 60-minute period. The concept of accumulation refers to meeting the daily physical activity goal, with four x 15 minute activity bouts for example, adding up to 60 minutes per day (World Health Organization, 2015). The recommended physical activity can be accumulated in various ways, including: playing physical games, sporting activities, active transportation, doing chores around the house, recreational activities, Physical Education classes at school, as well as planned exercise (World Health Organization, 2011).

Since, as the above discussion illustrates, physical activity is of the utmost importance in maintaining and promoting health and wellness in children, it is vital that physical activity, fitness and health parameters are regularly assessed. The following section investigates levels of physical activity and fitness in children both globally and nationally.

2.2.4 Global Levels of Physical Activity in Children

Despite childhood physical activity being an essential component of health and wellbeing, global activity levels are decreasing. This trend adversely affects the physical, mental, social and cognitive domains of children. This section aims to provide an overview of current global physical activity levels in children.

The largest global organisation investigating physical activity patterns in children is the Healthy Active Kids Global Alliance. The Alliance is a non-profit organisation comprised of researchers and health professionals working together to advance physical activity in children from around the world. The Alliance was established in 2014, following the world's first global summit on the physical activity of children held in Toronto, Canada. The Alliance has since released 'report cards' on physical activity for children and youth in different countries. These report cards follow standardised development processes to grade a variety of physical activity indicators, biennially. See Table 2.1, where the standardised grading used within the report cards is explained.

Table 2.1: Healthy Active Kids Report Card standardised grading

Adapted from the Healthy Active Kids Global Matrix 1.0., 2.0. and 3.0 (2014; 2016; 2018)

A	Succeeding with a large majority of children and youth	81 % to 100 %
B	Succeeding with well over half of children and youth	61 % to 80 %
C	Succeeding with about half of children and youth	41 % to 60 %
D	Succeeding with less than half but some children and youth	21 % to 40 %
F	Succeeding with very few children and youth	0 % to 20 %
Incomplete (INC)	Inconclusive due to insufficient data available	

With the number of countries involved in releasing report cards increasing with each publication, global comparisons can be made more successfully. Currently, 10 common physical activity indicators are compared. The physical activity indicators assessed that are of importance to this study are summarised in Table 2.2.

Table 2.2: Physical activity indicators assessed by the Healthy Active Kids Global Alliance

Adapted from the Healthy Active Kids Global Matrix 1.0., 2.0. and 3.0 (2014; 2016; 2018)

Physical Activity Indicator	Definition	Benchmark
Overall physical activity	Any bodily movement produced by skeletal muscles that requires energy expenditure.	% of children who meet the global recommendations on physical activity for health, at least 60 minutes of daily moderate- to vigorous-intensity physical activity.
Physical fitness	Characteristics that permit a good performance of a given physical task in a specified physical, social, and psychological environment.	% of children who meet criterion-referenced age and sex standards for muscular strength, muscular endurance and flexibility.
School	Any policies, organizational factors (infrastructure, accountability for policy implementation) or student factors (physical activity options based on age, gender or ethnicity) in the school environment that can influence the physical activity opportunities and participation.	% of schools with active school policies (daily Physical Education, daily physical activity, recess, "everyone plays" approach, outdoor time), and physical activity opportunities, excluding Physical Education. % of schools where the majority (≥ 80%) of students are taught by a Physical Education specialist, offered the mandated amount of Physical Education. % of schools with students who have regular access to facilities and equipment that support physical activity (outdoor playgrounds, sporting fields, multi-purpose space for physical activity, equipment in good condition).
Sedentary behaviour	Any waking behaviour characterized by an energy expenditure ≤ 1.5 METs, while in a sitting, reclining or lying posture.	% of children and youth who meet the Canadian sedentary behaviour guidelines (5- to 17-year-olds: no more than two hours of screen time per day).

The latest global activity findings were released at the Movement to Move conference in Adelaide, Australia in November 2018. Referred to as the Global Matrix 3.0, findings were provided for physical activity indicators of 49 countries, across 6 continents. A total of 517 experts and researchers were involved in the process. This comprises the largest global publication of childhood physical activity levels to date (Healthy Active Kids Global Matrix 3.0., 2018). The findings of key physical activity indicators, since the first report by the Healthy Active Kids Global Alliance, for selected countries from around the world, are summarised below in Table 2.3.

Table 2.3: Healthy Active Kids Global Alliance report card gradings for key physical activity indicators from around the world

Adapted from the Healthy Active Kids Global Matrix 1.0., 2.0. and 3.0 (2014; 2016; 2018)

Africa	**South Africa**			**Botswana**			**Nigeria**			**Zimbabwe**		
	2014	2016	2018	2014	2016	2018	2014	2016	2018	2014	2016	2018
Overall physical activity	D	C	C			INC	C	C	C		C +	C +
Sedentary behaviour	F	F	INC			B -	F	F	B -		B	B
Physical fitness	INC	INC	INC			INC	INC	INC	INC		INC	INC
School	D	D	D -			C -	INC	C -	C -		D	C

Australasia	**Australia**			**New Zealand**		
	2014	2016	2018	2014	2016	2018
Overall physical activity	D -	D -	D -	B	B -	D -
Sedentary behaviour	D -	D -	D -	C	C	D
Physical fitness	INC	INC	D +	INC	INC	INC
School	B -	B -	B +	B -	C +	B -

Europe	**England**			**Germany**			**Finland**		
	2014	2016	2018	2014	2016	2018	2014	2016	2018
Overall physical activity	D +	D -	C -			D -	D	D	D
Sedentary behaviour	INC	INC	D +			D -	D	D	D -
Physical fitness	INC	INC	C -			INC	INC	INC	C
School	A -	B +	B +			B +	B	B	A

Americas	**Brazil**			**Mexico**			**USA**			**Canada**		
	2014	2016	2018	2014	2016	2018	2014	2016	2018	2014	2016	2018
Overall physical activity		C -	D	C +	C	D +	D -	D -	D -	D -	D -	D +
Sedentary behaviour		D +	D -	D	D	D -	D	D -	D	F	F	D +
Physical fitness		INC	D	INC	INC	INC	INC	INC	C -	INC	INC	D
School		INC	C	D	D -	D +	C -	D +	D -	C +	B	B -

Asia	**China**			**India**			**Japan**		
	2014	2016	2018	2014	2016	2018	2014	2016	2018
Overall physical activity		F	F		C -	D		INC	INC
Sedentary behaviour		F	F		C	C -		C	C -
Physical fitness		INC	D		INC	F		INC	A
School		B +	D +		INC	INC		B	B +

As evident in Table 2.3, low levels of physical activity and high levels of sedentary behaviour are observed among children and youth worldwide. The average global grade for physical activity in 2018 was measured as a D grade, with only 21 % to 40 % of children achieving the recommended 60 minutes of MVPA daily. 75 % of the countries measured obtained failing grades, ranging from a D to an F grade.

The overall assessment of physical activity levels obtained an average D grade. Furthermore, a significant negative correlation between a high human development index (HDI)[4] and overall physical activity grades were found. The global average grade for 2018 remained the same as the global assessment conducted in 2016, emphasising the importance of strong and continuous efforts to increase childhood physical activity levels. Although South African children measured a C grade for 2018, one score higher than the global average, no improvement were found from 2016.

Childhood sedentary behaviour obtained a global average D + grade, with low grades positively correlating to all physical activity indicators assessed. Sedentary behaviour improved from a D grade in 2016, to a D + grade in 2018, with South Africa measuring severely lower than the global average, at an F grade for both 2014 and 2016. Sedentary behaviour assessments were not possible during 2018 due to insufficient data availability.

The physical fitness parameter obtained a global average C - score, but caution is necessary when interpreting this result, as 27 countries, including South Africa, had incomplete results. Significant positive correlates with country public health expenditure and negative correlations with Gini[5] and gender inequality indices were measured. Due to the large number of countries with incomplete measure of physical fitness, global measures during 2016 were not possible. Furthermore, the fact that South Africa has been unable to provide a childhood physical fitness grade from the start of the global assessments in 2014 is of particular significance. This emphasises the importance of research investigating childhood physical fitness levels in South Africa. This research study aims to make a contribution towards filling this evident gap.

Lastly, the school environment obtained an average C grade, with higher HDI countries obtaining higher grades. South Africa, obtaining a D - grade, was graded amongst the lowest in the world. Additionally, positive correlations between grade and HDI and negative correlations between grade and Gini and gender inequality were found. The global school environment remained at a C grade from 2016 to 2018 and decreased from a D grade to a D - in South Africa during the same time. This once again serves to highlight the importance of school-based interventions that promote physical activity in children. This research study aims to investigate this area specifically, in further detail.

The latest global physical activity report, examining childhood physical activity indicators emphasizes the fact that the majority of children are not achieving global, health promoting physical activity recommendations. It is apparent that in recent years children spend too much time in front of screens and have alarmingly low levels of physical fitness. Future research should focus on further developing standardised global surveillance systems of physical activity and related indicators among children in

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[4] Human Development Index (HDI) is a summary measure of average achievement in key dimensions of human development, including a long and healthy life, being knowledgeable and having a decent standard of living. It was created to emphasize that people and their capabilities should be the ultimate criteria for assessing the development of a country, and not economic growth alone (United Nations Development Programme, 2018).

[5] The Gini index (Gini coefficient / Gini ratio) is a measure of statistical distribution, used to gauge economic inequality, measuring income distribution or wealth distribution among a population. Ranging from 0 (0%) representing perfect equality to 1 (100%) representing perfect inequality (Kenton, 2018).

order to fill current gaps, especially in low- and middle- income countries (Healthy Active Kids Global Matrix 3.0., 2018).

2.2.5 Measuring Health-Related Physical Fitness in the Field

Various methods exist whereby health-related physical fitness can be assessed. Measurements are often classified into methods most suited within a laboratory setting, in a clinical context, or methods most useful when testing in the field. The techniques described below vary with respect to accuracy, practicality and budgetary constraints. Availability of trained personnel, population specifics and available testing time were all taken into consideration when deciding on the most suitable methods to use for the current study.

The following section provides details concerning several measuring techniques and attempts to justify the choice of assessments used in this study. Within the subsequent explanation, measuring techniques are grouped according to the components of body composition- and physical fitness assessment.

2.2.5.1. Body Composition Assessment

Many techniques have been developed to assess body composition, the majority of which focus on the amount of fat free mass compared to the amount of fat mass or body fat percentage. The different techniques each have a standard error of estimate (SEE)[6].This refers to a measure of accuracy of the prediction made through regression equations of that specific technique (Hoeger & Hoeger 2011: 114-120). Each technique may therefore provide slightly different results, which emphasizes the importance of using the same technique pre- and post-test, allowing comparable results. Furthermore, body composition assessment is particularly challenging in children, due to the large height, weight and body composition changes children undergo during puberty.

The importance of determining body composition lies in the fact that abnormal fat free- or fat mass, whether above or below the normal value, can cause serious health problems. In children it is a particular concern when fat free- and fat mass fall below normal ranges since this results in underweight, stunting and wasting.[7] On the other hand, fat mass above normal ranges can be equally dangerous, as overweight and obesity[8] occurs in such cases. This leads to the further health problems already discussed above.

This section aims to provide an overview of the possible assessment methods that can be used to determine body composition. They include dual-energy x-ray absorptiometry, hydrostatic or underwater weighing, air displacement, bioelectrical impedance analysis, circumference measurements, skinfold thickness and body mass index (BMI).

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[6] An individual's body fat percentage measuring at 18 % with a SEE of ± 3.00, means that the actual body fat percentage can range from 15 % to 21 % (Hoeger & Hoeger, 2011).

[7] Underweight (low weight-for-age), stunting (low height-for-age) and wasting (low weight-for-height), classified by the World Health Organization's growth reference curves as less than 2 standard deviations below the median (de Onis *et al.*, 2007).

[8] Overweight and obesity (high body mass index-for-age), classified by the World Health Organization's growth reference curves as greater than 1 and greater than 2 standard deviations above the median, respectively (de Onis *et al.*, 2007).

Dual-energy x-ray absorptiometry (DXA) refers to a radiographic technique where a very low dose of x-ray energy is used to measure total body fat, fat distribution patterns and bone mineral density (Hoeger & Hoeger 2016: 41-50). DXA is often referred to as the criterion measure and is used to validate other body composition assessments, as it provides whole-body measurement of body fatness and has a SEE of ± 1.8 % (Hoeger & Hoeger 2011: 114-120; Welk *et al.* 2015: 278-280). Due to the large expense of the DXA machine, the associated operational expenses and the time taken for a single assessment (approximately 30 minutes), this technique is primarily used in a medical laboratory setting.

Hydrostatic or underwater weighing is a technique that compares a person's weight to their weight underwater (Hoeger & Hoeger 2011: 114-120). Due to fat mass being more buoyant than non-fat mass, comparing these two weights can determine a person's body fat percentage. This technique requires a considerable amount of time, technique, equipment and space, and is mostly used in physiology laboratories. The SEE for hydrostatic weighting is ± 2.5 % (Hoeger & Hoeger 2011: 114-120). Disadvantages of using this technique include the time taken for each assessment (approximately 30 minutes), the fact that residual lung volume[9] must be measured before testing, as well as the inability to test individuals with aquaphobia[10].

Air displacement plethysmography is a technique that requires an individual to sit in a small chamber. Pressure sensors are then used to determine the amount of air displaced by the person and therefore their body volume. This technique uses the same principle as underwater weighing, to calculate body density and body fat percentage (Welk *et al.*, 2015: 278-280). With a SEE of approximately ± 2.2 %, the air displacement technique has been found to overestimate body fat percentage in thinner participants and underestimate body fat percentage in heavier participants, when compared with the DXA technique (Hoeger & Hoeger 2011: 114-120).

Bioelectrical impedance analysis refers to a technique where sensors are applied to the skin and a weak electrical current is run through the body (Hoeger & Hoeger 2011: 114-120). The electrical resistance is measured during this process. As fat tissue is a less efficient conductor of electrical current than fat free tissue, this measurement is then used to estimate body fat, fat free mass and body water. The SEE of bioelectrical impedance can be up to ± 10 %, as hydration status and body temperature influence the results (Hoeger & Hoeger 2011: 114-120). Furthermore, the same equation used to estimate body composition cannot be used by everyone, and valid and accurate equations specific for the population, including specifics on age, gender and ethnicity, are required.

Circumference measures are used to determine body composition and specifically disease risk, through the waist- and hip circumference. The ratio between the two measures are calculated and can be used to determine where fat is stored, either abdominally or in the trunk region. This is important as location of fat storage affects risk of disease, more so than the total amount of fat present within the body (Hoeger & Hoeger, 2011: 120-126). Android obesity, where fat storage occurs abdominally, places an individual at nearly double the disease risk, compared to gynoid obesity, where fat storage occurs primarily around the thighs and hips (Hoeger & Hoeger, 2016: 46-50).

[9] Residual lung volume refers to the amount of air left in the lungs following a complete, forceful exhalation (Hoeger & Hoeger, 2011)

[10] Aquaphobia, the fear of water, refers to a persistent and abnormal amount of fear and anxiety that prevents an individual from getting close to water. Not to be confused with hydrophobia, a late symptom of rabies in humans (Legg & Lindberg, 2018).

Circumference measures are easily performed by trained personnel and this is a fast and inexpensive method to measure many participants. Furthermore, circumference measures have a SEE of approximately ± 4 %, making it a valid assessment of body composition (Hoeger & Hoeger, 2011: 120-126).

Skinfold measurements are a practical method of assessing body composition. They are done most frequently to estimate percentage body fat (Hoeger & Hoeger, 2016: 44-46). A skinfold refers to two thicknesses of skin along with the amount of fat that lies subcutaneously. This is based on the principle that half the body's adipose tissue lies directly beneath the skin. Measuring skinfold thickness of various sites around the body allows one to estimate body fatness, by applying population specific equations. Skinfold measurements are reliable when done by trained personnel, as well as being relatively fast, inexpensive and easy to perform (Welk *et al.*, 2015: 278-280). Furthermore, skinfold measurements have a low SEE value of ± 3.5 % (Hoeger & Hoeger, 2011:115-116).

Body mass index (BMI), refers to an index incorporating height and weight into estimating critical fat values at which risk of disease increases (Hoeger & Hoeger, 2016: 45-50). BMI is calculated by dividing weight in kilograms (kg) by square height in metres (m). Due to its simplicity and consistency across populations, BMI is used almost exclusively to determine health risks and mortality rates associated with excessive body weight. BMI is a useful tool for screening the general population but does however fail to differentiate between lean body mass and fat mass, as well as fat distribution, and caution should therefore be applied when assessing athletes with large muscle mass.

The following section elaborates on the start of physical fitness assessment in children and various available methods of assessing physical fitness currently.

2.2.5.2. Physical Fitness Assessment

As has already been explained, it is vital that physical fitness is both monitored and encouraged from an early age. Several methods of monitoring and assessing physical fitness in school-aged children have been developed. There are, in fact, more than 300 fitness tests currently available. As such, choosing the most suitable fitness test in any given situation depends on a number of factors including, among others, the main focus of the assessment or study and various field or research constraints. This section provides a brief explanation of some of the main methods and accounts for the use of various aspects of the Eurofit testing battery during this study.

According to Mood, Jackson & Morrow (2007), five important events have most likely influence the measurement of physical fitness and physical activity in the past 50 years, and will continue to influence these measures in the 21st century. These factors are:

1. The first important event influencing physical fitness testing was the start of physical fitness interest in school-aged children by a report published in 1954 Research Quarterly, entitled: Minimal Muscular Fitness Tests in School Children (Kraus & Hirschland, 1954).

Part of the interest of the physical fitness report published can be attributed to the fact that it was published close to the end of World War 2 and the ongoing Cold War. The report highlighted significant differences between the fitness of American and European youth, based on a battery of 6 muscular strength and flexibility items. American youth scored far below European youth, which led to the importance of fitness testing in youth and corresponding interventions to increase fitness parameters, especially in America. The report further led to the establishment of the American President's Council on Physical Youth Fitness, who further investigated national youth fitness levels, and the creation of the American Association for Health, Physical Education and Recreation (AAHPER) Youth Fitness Test (Hunsicker & Reiff, 1976).

2. The second event influencing physical fitness testing was the 'health-related fitness' concept introduction and its differentiation from performance-based youth fitness testing.

In 1973, the terms 'motor ability' and 'physical fitness' were differentiated and defined by Prof A.S. Jackson and Prof A.E. Coleman. Motor ability, referring to performance fitness within today's context, encompassing running speed, running agility and jumping ability, and were assessed separate of physical fitness, referred to as health-related physical fitness today, and encompassing musculature strength and endurance of the upper body, abdominal area, and cardiorespiratory fitness. This definition led to the establishment of American Alliance for Health, Physical Education, and Recreation and Dance (AAHPERD) Health-Related Physical Fitness Test. A technical manual for the health-related tests, providing background, justification, and rationale for the test battery and individual items were thereafter published in 1985 (Pate, 1985).

3. The third event influencing physical fitness testing was the publication of three national fitness studies within America during 1985 to 1987. These publications include the National Children and Youth Fitness Study (Ross & Gilbert, 1985), and it's follow-up report (Ross & Gilbert, 1987), as well as the President's Council on Physical Fitness and Sports publication (Reif, Dixon, Jacoby, Ye, Spain & Hunsicker, 1985).

Shortly after these reports were published, the Council of Europe Committee for the Development of Sport published the manual entitled: *Eurofit: European Tests for Physical Fitness*, a test battery designed to assess physical fitness in school-aged children (Council of Europe Committee for the Development of Sport, 1988), as the need to identify or develop means of accurately assessing physical fitness in European children became more and more apparent.

The Council of Europe Committee for the Development of Sport set out the Eurofit testing battery to be simple and practical, cost effective and based on relevant and proven ways to assess physical fitness components. Furthermore, the tests were designed so they could be carried out by a Physical Educator, in either a class or laboratory-type setting. The tests were designed to be suitable for any child participating in normal Physical Education lessons and the test battery was set up so that a class can be tested in reasonable time. Moreover, Eurofit provided testers with immediate standardised data, that could be used longitudinally to detect status, changes and trends.

The Eurofit testing battery incorporated structural factors, including height, weight and body fat, functional factors, including cardio-respiratory fitness, both static and dynamic muscle strength, flexibility and running- and segmented speed, and lastly factors of coordination – totalling 9 fitness tests.

The process of selecting tests to establish a European fitness test battery were based on several important criteria (Council of Europe Committee for the Development of Sport, 1988). These factors include:

a. Each test's internal validity had to have been established by means of factor analysis, in order to select independent parameters.

b. Each included test's external validity should be demonstrated, to be an effective descriptor of levels of fitness in normal populations and to differentiate between varying groups.

c. The reliability and objectivity of each test should be high, tested through test-retest procedures and comparing scores given by different test administrators.

d. Lastly, the tests needed to be sustainable for survey purposes in large scale projects, so tests needed to be practical and applicable in school or club settings. Easier tests were therefore preferred to more sophisticated tests, provided that this did not undermine the criteria of validity, reliability and objectivity.

The Eurofit testing battery has since its first publication been revised, and a second edition was released in 1993.

4. The fourth event influencing physical fitness testing was the change of evaluation perspectives, with the move from norm-referenced to criterion-referenced evaluation of youth physical fitness.

During early fitness testing, norm-referenced evaluation was typically used to assess test scores. Norm-referenced criteria refers to a learner's performance that is compared to the performance of scores of his / her peers. The problem with norm-referenced criteria is that no information is provided on whether a learner met, exceeded or fell short of specific performance criteria. Theoretically, changes in the normative values could be used to track changes in fitness levels, but the interpretation of the norm-referenced criteria does not provide information about the health risks of associated test performance scores, for example (Mood *et al.*, 2007). Criterion-referenced standards on the other hand, can help one identify physical fitness levels associated with reduced health risk. The development of the standard is independent of the percent of the population that achieve the standard and does not fluctuate due to changes in the population's performance. The FITNESSGRAM®, developed by the Cooper Institute in 1988, was one of the first physical fitness tests that made use of criterion-referenced evaluation procedures (Mood *et al.*, 2007). Thereafter, more and more evaluations started using criterion-referenced standards to assess performance in physical fitness evaluations.

5. The fifth and last event influencing physical fitness testing is the growing interest in measuring physical activity, rather than assessing physical fitness.

The assessment of physical activity is becoming increasingly popular, which can be seen as the 'process by which one becomes physically fit' compared to the assessment of physical fitness, seen as the 'product of being physically active'. Two processes are available to assess physical activity, indirect assessment and direct assessment. Indirect physical activity assessment can comprise of subjective self-report survey techniques, detailed physical activity diaries or questionnaires, or simple single response physical activity questions. Direct or objective physical activity assessments involve technological apparatuses such as pedometers, heart rate monitors and accelerometers. Regardless of whether direct or indirect methods of physical activity assessment is use, physical activity measurement metrics usually consists of the following: the number of steps taken per day; calories or energy expenditure, METs or minutes spent in activity categories, including light-, moderate-, vigorous-, or moderate-to-vigorous physical activity.

Based on the significant events discussed, influencing not only the start of physical fitness assessment, but physical activity and physical fitness assessments nowadays, the physical fitness tests discussed are summarised in Table 2.4. Physical fitness parameters and corresponding tests used for assessment are listed to contrast and compare parameters and assessment methods.

Table 2.4: Physical fitness test batteries and corresponding test

Adapted from (Council of Europe Committee for the Development of Sport, 1988; Hunsicker & Reiff, 1976; Mood *et al.*, 2007; Pate, 1985)

	American Association for Health, Physical Education and Recreation Youth Fitness Test (1976)	**American Alliance for Health, Physical Education, and Recreation and Dance Health-Related Physical Fitness Test (1985)**	**Eurofit: European Tests for Physical Fitness (1988)**	**FITNESSGRAM® (1988)**
Aerobic capacity	Shuttle run / 600-yard Run	Mile run / Nine-minute run	Endurance shuttle run / Bike ergometer test	PACER[11] / Mile run / Walk test
Body composition		Sum of triceps and subscapular skinfolds and percentage body fat	Height; Weight; Skinfolds and percentage body fat	Skinfolds / Body mass index
Abdominal strength and endurance	Sit-ups	Sit-ups	Sit-ups	Curl-ups
Upper body strength and endurance	Flexed arm hang / Pull-ups		Handgrip; Bent-arm hang	Push-ups / Modified pull-ups; Pull-ups / Flexed arm hang
Trunk extensor strength and endurance				Trunk lift
Lower body strength and power	Long jump		Standing long jump	

[11] PACER, an acronym for Progressive Aerobic Cardiovascular Endurance Run

	American Association for Health, Physical Education and Recreation Youth Fitness Test (1976)	American Alliance for Health, Physical Education, and Recreation and Dance Health-Related Physical Fitness Test (1985)	Eurofit: European Tests for Physical Fitness (1988)	FITNESSGRAM® (1988)
Flexibility		Sit-and-reach	Sit-and-reach	Back saver sit-and-reach; Shoulder stretch
Running speed and agility	50-yard Dash		Shuttle run	
Speed of limb movement			Plate tapping	
Balance			Flamingo balance	

For the purposes of this study, taking into consideration the study population, availability of trained personnel, budgetary constraints and the physical activity intervention employed, selected tests from the Eurofit testing battery was most suited to evaluate the physical fitness of the study's participants. Body composition was assessed with BMI, age and gender specific BMI (BMI-for-age z-scores (BAZ)), and body fat percentage, using two-site skinfold measures, the triceps and subscapular skinfolds. Physical fitness, determined by cardiorespiratory fitness, through the 20 m multistage shuttle run test, upper body static strength, through maximum handgrip strength, lower body explosive power, through the standing broad jump and lower body flexibility with the sit-and-reach assessment, were further utilised.

The following section investigates Physical Education in the South African context, with special focus on the historical events resulting in today's Life Skills or Life Orientation, which encompass Physical Education. Moreover, the following section provides background on disadvantaged settings and their unique challenges, related to the school and its immediate area, teachers within these schools and the schools' learners.

2.3. Physical Education in South African Schools

The end of the Apartheid Era heralded significant and far-reaching changes within the South African society. This is particularly evident in the education system and specifically the school curriculum. This section discusses the evolution of Physical Education as a school subject in the South African context both during, and after the Apartheid Era. Additionally, this section illustrates the lasting negative consequences of Apartheid Era educational policies with reference to Physical Education, which are still evident in disadvantaged communities where a lack of access to acceptable Physical Education is evident. Thereby, the discussion aims to demonstrate some of the reasons for the necessity of physical activity interventions within South African schools at present.

2.3.1 The Historical Context of School-Based Physical Education

Physical Education in South Africa has been on the receiving end of curriculum reform with far-reaching consequences. Prior to 1994, the National Department of Education of the National Party Government controlled education. Physical Education was a stand-alone subject taught to boys and girls separately (Stroebel, Hay & Bloemhoff, 2016). The syllabi differed, with the programme for boys mainly focused on sporting activities, while it consisted of both sport and independent activities for girls. Although it was a compulsory subject from Grade 1 to 12, with two Physical Education periods a week allocated for all grades, many schools either did not implement it as such or started phasing it out due to staff-related limitations or a shortage of equipment and facilities (Stroebel *et al.*, 2016). Moreover, Physical Education did not enjoy the prestige attributed to examinable school subjects. Many educators failed to fully grasp its importance and began allocating less time on the timetable to Physical Education in favour of 'more important subjects'.

Physical Education was taught as an official subject predominantly in White schools, with only a few Indian, Coloured and Black schools offering the subject. Former White schools also then began the process of phasing out Physical Education as a school subject (van der Merwe, 1999). Although some schools retained Physical Education as a stand-alone subject for some time, others began implementing movement programmes presented by specialists from the private sector. Consequently, a vast number of learners were subsequently excluded from physical activities during and after school hours due to the financial implications of private programmes, particularly as schools were expected to become less racially segregated in the Post-Apartheid Era. The result was that Physical Education teachers increasingly lost interest in the subject and children were often left to simply play games without much regard for their physical development or fitness levels (van der Merwe, 1999).

The gradual decline in interest on the part of Physical Education teachers can be partly attributed to the significant changes that occurred in teacher training following the end of the Apartheid Era. Prior to 1994 more than 120 national teacher training colleges provided specialised teacher training for Physical Education teachers (van der Merwe, 1999). However, following the post-Apartheid educational reforms and particularly since the turn of the century, such colleges were gradually phased out or combined with other higher education institutions. Physical Education as a teaching subject within teacher training was subsequently under pressure in the broader higher education environment (Stroebel *et al.*, 2016). Moreover, it has been argued that teaching Physical Education came to be regarded as a temporary duty among teachers, changing from year to year. This resulted in a situation where no teachers truly took ownership of the subject. Consequently, teachers increasingly began to dislike presenting the subject and it was no longer regarded as an important, specialised skill (Stroebel *et al.*, 2016).

Following the inauguration of the first democratic government, the South African Schools Act was established in 1996 (Republic of South Africa, 1996). The act (Act 84 of 1996, which was accented to in November 1996 and took effect as of January 1997) set out laws for the governance and funding of schools and recognised that new national systems for schools were needed to redress past injustices. This resulted in the beginning of earnest curriculum reform. The philosophy of Outcomes Based Education (OBE) formed the vehicle for educational transformation across the education systems in South Africa (Ramrathan, 2015). Some of the major changes that were implemented with the OBE curriculum included a learner centred teaching approach that identified the competencies learners needed to understand and demonstrate. Learner centred education replaced teacher led classrooms and allowed learners to participate actively and consistently in the learning process. The roles and responsibilities of teachers also changed as they were primarily expected to facilitate and mediate learner participation as opposed to completely taking charge (Botha, 2002). Furthermore, the Learning Area Committee stipulated seven focus areas for Physical Education. These were: a healthy body, mind and spirit; personal wellbeing; a healthy lifestyle; motor skills; physical activity; safety; and fitness.

Thus, the importance of physical activity was recognised and understood in theory. Nevertheless, the availability of school funds and perceptions concerning the importance of Physical Education and school sport largely determined both the place of Physical Education in the curriculum as well as the quality of these programmes. As funds supplied by the government only provided salaries for teachers and few additional expenditures, schools had to rely primarily on donations and fund-raisers to supplement these programmes (Lion-Cachet, 1997).

The first attempt at the practical implementation of the OBE teaching philosophy was made in 1997 and termed Curriculum 2005 (C2005) (Stroebel *et al.*, 2016). Under the new system Physical Education was further reduced to a learning outcome of a new learning area titled, Life Orientation. Life Orientation was an amalgamation of non-examinable subjects including religious studies, career guidance and Physical Education, among others. However, strong critique against C2005 was voiced from several stakeholders. This included teachers who felt ill qualified to teach C2005 due to a lack of effective teacher training strategies in place. Teachers additionally found school infrastructure unable to adequately support C2005, and regarded assessment methods difficult and problematic (Ramrathan, 2015). Therefore, a review process was commissioned by the Department of Education in 2000.

Meanwhile in schools, 'subjects' were replaced with 'learning areas' within C2005. Life Orientation was one of the learning areas that were incorporated into all phases and were compulsory for all Grade R to Grade 12 learners, although only one period per week was dedicated to it. A general negative attitude regarding Life Orientation persisted among both teachers and learners as it remained challenging to assess and was consequently often neglected in favour of other more traditional subjects, such as mathematics and the sciences (Stroebel *et al.*, 2016). Children increasingly perceived Life Orientation as insignificant as well. Such sentiments in turn negatively impacted both attitudes towards, and participation in Physical Education.

The outcome of the C2005 review commissioned in 2000, by the Department of Education, led to a revision of C2005, termed Revised National Curriculum Statement (R-NCS), which was introduced in 2004 (Pudi, 2006). Life Orientation continued to face major challenges, with learners remaining reluctant to participate and the public increasingly perceiving the subject as a waste of time and money, although all stakeholders still appeared to recognise the value of physical activity for children (Stroebel *et al.*, 2016).

Further revisions of the curriculum followed in 2009, resulting in the Curriculum and Assessment Policy Statements (CAPS) for each subject. CAPS was implemented from the beginning of 2011 and was established up to Grade 12 by 2012. This system is still in use today (van Deventer, 2011). A Ministerial Project Committee developed CAPS for each subject with the aim of improving R-NCS (Stroebel *et al.*, 2016). The study areas known as Life Skills (in the Foundation- and Intermediate Phases), and Life Orientation (in the Senior- and Further Education and Training (FET) Phases) were aimed at guiding and preparing learners for life and its possibilities, including equipping learners for meaningful and successful living in a rapidly changing and transforming society.

In the Foundation Phase (Grade 1 to 3), six hours were allocated to Life Skills per week, of which two hours were allocated to Physical Education and movement. In the Intermediate Phase (Grade 4 to 6), four hours per week were spent on Life Skills. The Physical Education outcome is assigned 60-minutes of this time, which converts roughly into two periods per week. Within the Intermediate Phase, Physical Education targets the development of learners' physical wellbeing and knowledge of movement and safety. The aim is for learners to develop motor skills through engagement and participate in a variety of physical activities (Department of Basic Education: Republic of South Africa, 2011). Lastly, for the Senior Phase (Grade 7 to 9) and the FET Phase (Grade 10 to 12), two hours of Life Orientation were allocated per week, with Physical Education also scheduled for 60-minutes per week.

Despite much reform which sounds promising in theory, Life Skills and Life Orientation within the CAPS curriculum faces many challenges and is still seen as a low status subject (Stroebel *et al.*, 2016). The low status is partly attributed to the subject's non-examination status, resulting in learners viewing the subject as unnecessary and irrelevant (Jacobs, 2011). Furthermore, studies have indicated that the subject does not accomplish its aim, mainly due to major problems in the practical implementation thereof (Christiaans & Roux, 2006; Prinsloo, 2007). The situation is further exacerbated by insufficient training provided to Life Skills teachers. This lack of training negatively affects the quality of Physical Education especially (Krishna & Jairam, 2013). A study reporting on the status of Physical Education in four South African provinces, concluded that 51 % of teachers in the Foundation Phase, and 49 % of teachers in the Intermediate Phase were not qualified to teach Physical Education (van Deventer, 2011).

Thus, in summary, it is evident that Life Skills and Life Orientation still faces many challenges and has to date been unable to reach its objectives, among them physical activity and fitness promotion in children. Despite continued well-intentioned reform the school curriculum continues to fail in providing children with the necessary physical activity to sustain a healthy lifestyle and promote healthy physical activity behaviours in later life. This trend seems to be continuing as the Minister of Basic Education, Angie Motshekga, announced after three years of deliberation, that History will replace Life Orientation, including Physical Education, as one of the fundamental subjects in the FET Phase, and will be incrementally introduced into the curriculum from 2023 onward (Parker, 2018). The failure of adequate Physical Education provision within the school curriculum remains most keenly felt in underprivileged communities, where the burden of major past inequalities still exists. This situation leads to children becoming both increasingly inactive and unaware of the importance of physical activity. Educational reform alone has proved unequal to the task of remedying this situation. Therefore, the current state of affairs necessitates the implementation of physical activity interventions like the intervention employed in this study.

2.3.2 Physical Education Implementation Challenges in Disadvantaged Settings

Nevertheless, the current situation concerning the implementation and promotion of physical activity in South African schools continues to be shaped by far more than historical factors and ongoing challenges regarding curriculum reform. This section explores the further strain that disadvantaged settings place on physical activity in schools. This strain specifically relates to township areas and includes challenges regarding the school setting itself, the teachers and the school learners.

The present study was conducted in the township of Motherwell in the Nelson Mandela Bay Municipality, in the Eastern Province of South Africa. A township refers to an underdeveloped and segregated urban area that was reserved for non-Whites, including Black Africans, Coloureds and Indians, during the Apartheid Era (South Africa 1997). Previous Apartheid policies resulted in an uneven distribution of ethnic groups across socioeconomic strata within the South African population. To date, the Nelson Mandela Bay Municipality remains the most racially segregated city in South Africa (Statistics South Africa, 2016). It is therefore not surprising that the ethnic population of Motherwell township comprises of 99.2 % Black Africans (Statistics South Africa, 2011). Most townships were developed on the periphery of towns and cities due to segregated living laws under Apartheid. At present, such areas still lack basic services such as clean water, electricity and sewerage and road infrastructure. This naturally negatively affects the quality of life among residents (Pettman 2015). In these respects, Motherwell township is no different. The township occupies an area of 25.86 km^2, located North East of Port Elizabeth, and accommodates a population of 140,351 people living in 38,919 households (Statistics South Africa, 2011). Further challenges that are common within township areas, including the township of Motherwell, are poverty, overcrowding, violence and high unemployment rates. These socioeconomic problems directly influence school settings and heavily impact the teaching and learning environment, to the detriment of children's education (Zulu *et al.*, 2004). The school settings themselves, as well as the circumstances surrounding teachers and learners within disadvantage communities will subsequently be discussed in further detail as a means of highlighting some of these challenges.

2.3.2.1. Challenges Related to School Settings

School settings within disadvantaged communities experience unique challenges affecting teaching and learning and physical education in numerous ways. These challenges include:

1. Limited resources such as physical education equipment, sporting facilities and lack of funds;
2. Unstable management and governance structures and unsupportive administration, which contribute to the marginalisation of physical education including limited teaching time; and
3. Large class sizes within schools located in disadvantaged communities.

Township areas remained largely underdeveloped following the end of the Apartheid Era. This lack of development continues to have a negative effect on, among other things, sport and recreation, resulting in limited community programmes and facilities. Therefore, the local community from necessity relies on schools and local government to provide the necessary resources for sport and recreation, to allow children to meet daily activity recommendations (Walter, 2011). Schools however are not indemnified from the challenges faced within the disadvantaged communities in which they are located. In an investigation of the challenges which historic disadvantaged schools within the Western Cape face, de Waal & Bardill (2004), concluded that the following factors contributed to the compromised delivery of quality physical education and its effective implementation in school settings. Teachers routinely lack appropriate and sufficient instructional resources and equipment, drastically limiting the range of physical education content that can be taught. The available equipment is usually either unable to accommodate the large class sizes or broken. What's more, some schools simply have no equipment whatsoever due to financial constraints. A study conducted by McCaughtry, Barnard, Martin, Shen & Kulinna (2006) reported the following comment from a physical education teacher:

"You can't blame these kids for getting bored with the same things day after day. It's no wonder they start slapping each other upside the head. It's [misbehaviour] not really their fault. When you have to wait so long for your turn that you sit down, how can you blame them?" (McCaughtry *et al.*, 2006)

Teachers in similar environments have attempted to resolve this issue by seeking donations specifically for sporting equipment, purchasing equipment themselves or fashioning equipment using recycled materials (Barnard & McCaughtry, 2007).

Schools located in disadvantaged communities also usually lack adequate sporting facilities (Barney & Deutsch, 2009; Ishwarlal, van Deventer, Rajput & Deventer, 2010). In many cases such facilities are either completely absent or in a state of total disrepair. This leads to learners being discouraged from sports participation and extramural sports programmes only being available at irregular intervals (Mchunu & Le Roux, 2010). Facility related limitations can range from the absence of an undercover area for physical education lessons, resulting in lessons being dependant on favourable weather conditions, to the lack of an outside area of sufficient size to accommodate the number of learners, or the available terrain being unfit for use, due to conditions that can lead to injury, such as the presence of broken glass or other potentially harmful objects (de Waal & Bardill, 2004).

The prevalence of violence remains a nation-wide problem in South Africa, particularly in lower income areas. This issue inevitably spills into the education sector and negatively effects the teaching and learning environment. In terms of physical activity it limits the practical possibilities for outdoor activity and raises the actual stress levels among both teachers and learners (Zulu *et al.*, 2004). Crime, theft on school property, and vandalism within township area schools further hinder schools' best efforts to provide adequate facilities and equipment to aid in physical education teaching (de Waal & Bardill, 2004). In the KwaZulu Natal Province, for example, up to 75 % of a sample of learners indicated that they felt school is not a safe setting, 76 % indicated that they have witnessed a physical attack on a fellow learner and 38 % witnessed an attack on a teacher (Zulu *et al.*, 2004). Given such statistics, it is not surprising that teachers in similar settings reported spending up to 50 % of class time teaching conflict resolution, self-control, and cooperation and eliminating bullying (McCaughtry *et al.*, 2006). These facts indicate that underprivileged settings remain vulnerable to violence and children in these settings are likely to experience the effects of this in numerous ways.

Violence also has a profound impact on teachers within such settings and their relationship with the children they teach. The following quote illustrates the emotional turmoil such circumstances can cause for teachers.

"Kids just shouldn't have to deal with this, you know? Children are supposed to be innocent… They shouldn't have to worry about getting gang raped on the way home from school or beaten for their jacket." [Nearly in tears] *"I can't imagine the kinds of abuse these kids endure. Even at home, you know, your house should be your safe zone, but for many of these kids, it's not, they get more abuse at home than anywhere else."* (McCaughtry *et al.*, 2006)

Moreover, de Waal & Bardill (2004) explain that the absence of supportive administration and stability in management and governance structures, often found in schools located in disadvantaged settings, severely affects teaching and learning and the value placed on physical education. Physical education instructional time is regularly limited due to the marginalisation of physical education on the school's timetable, in favour of prioritising 'more important', examinable subjects (Ishwarlal *et al.*, 2010). A study examining teachers' attitudes and perspectives of physical education also revealed that parents often do not consider physical education to be as important as other academic subjects. Parents even felt that if their children are involved in physical education lessons during school time, their academic grades could be negatively affected (Barney & Deutsch, 2009). Further lack of adequate support from the government, such as the Learning Area advisory services, severely hinders proper physical education teaching and the empowerment of teachers to deal with the difficulties they encounter.

Most schools within disadvantaged areas further lacks adequate funding as the majority of parents are unable to pay school fees and most of the monetary allocation from the government is used for salaries and municipal services (de Waal & Bardill, 2004). Insufficient funding contributes to a lack of further training and development for teachers as well as inadequate equipment, facilities and infrastructure, such as the minimum number of classrooms necessary to accommodate registered learners. Lack of sufficient classroom space further contributes to overcrowding and large class sizes. This hinders both the realistic abilities of teachers to tend to all learners under their care and the learning process in its entirety drastically (Ishwarlal *et al.*, 2010). Jessop & Penny (1998) investigated teachers' voice and vision in South African primary schools and reported on a teacher making the following comment:

> *"As I've told you, we are still teaching with 60, 70 [children per class] …. But even here at this moment, we simply just teach, using the choral teaching method, because we can't pay individual attention."* (Jessop & Penny, 1998)

Further negative consequences of large class sizes include class management problems, disciplinary issues and weaker learners failing to get sufficient attention to allow them to make progress (de Waal & Bardill, 2004). The following section elaborates on challenges related to teachers, who teach in disadvantage settings, with special focus on the teaching of physical education.

2.3.2.2. Challenges Related to Teachers

The challenges of schooling in disadvantaged communities are not limited to the settings themselves. Teachers in these schools present further difficulties as they are often also members of the community. physical education challenges surrounding teachers include:

1. Contribution to the low status physical education classes possess;
2. Lack of adequate physical education training and qualification;
3. Lack of motivation and commitment to teaching physical education; and
4. Severe staff shortages.

Although teachers' attitudes and perspectives surrounding physical education seem positive, and teachers express that they regard physical education participation to be important for children's growth and development, their actions are often not in line with such rhetoric (Barney & Deutsch, 2009). In practice, teachers were found to allocate more time to subjects such as mathematics, the sciences and languages. Due to the low status of physical education, it often becomes the first subject to be either entirely replaced or at least shortened with regard to time allocation.

Teachers from schools located in disadvantage communities, do not have access to as many resources or training courses as those of teachers in more favourable environments. This affects physical education teaching as teachers are often not adequately trained to conduct physical education. In the South African context, teachers have been found to lack the ability to integrate physical education into other study areas within the Life Skills / Life Orientation subject area, which includes personal and social wellbeing and creative arts (Ishwarlal *et al.*, 2010). Furthermore, following the extensive post-Apartheid curriculum reform discussed above, scepticism exists as to whether sufficient ongoing training, professional development and support are being provided for teachers by the National Department of Education and other teacher training institutions (Pudi, 2006). Historically disadvantaged Black and Coloured schools within the Western Cape, for example felt compromised in delivering quality physical education due to insufficient training and teacher development (de Waal & Bardill, 2004). These findings have been corroborated by Ishwarlal & van Deventer (2010) who found that teachers often lack the necessary confidence and enthusiasm when it comes to teaching physical education. Teachers further considered themselves unable to teach as they had not been trained for the realities of disadvantaged school settings. This highlights the importance of preparing future physical education teachers for the realities faced in disadvantaged settings rather than assuming that the teaching and learning process will take place in an equipped and functional environment (Barnard & McCaughtry, 2007).

A study conducted in the rural midlands of KwaZulu Natal, found that most teachers, both new and experienced, lack adequate general preparation and pedagogical skills, as well as motivation and professional commitment to teaching. This further results in a decline in job satisfaction and morale (Jessop & Penny, 1998). This might be due to the majority of teachers selecting the profession of teaching based on salary, status, the desire to urbanise and the attainment of qualifications. In fact, only a quarter of teachers interviewed reported that teaching was their first career choice (Jessop & Penny, 1998).

Lastly, a major challenge confronted by these teachers is severe staff shortages. This can be partly attributed to financial constraints within schools located in disadvantaged settings. Violence within these settings further lead to a low teacher retention rate as well as problems with commitment, accountability and rules that lead to frequent teacher absenteeism (de Waal & Bardill, 2004). Available teachers are thus overloaded, and learner-teacher ratios are high, making physical education facilitation extremely difficult. Moreover, a study evaluating a large sample of South African educators working in public schools concluded that the combination of difficulties experienced by teachers in disadvantaged communities lead to considerably higher stress levels when compared with teachers facing a less challenging work environment. Teachers in disadvantaged communities are consequently more at risk for stress-related physical illnesses, such as hypertension, heart disease, stomach ulcers, mental distress, and tobacco and alcohol misuse (Peltzer, Shisana, Zuma, van Wyk & Zungu-Dirwayi, 2009). These stress-related physical illnesses further complicate the teaching of physical education, especially the practical components thereof. A teacher in a similar setting reported:

> *"I just don't know how much longer I can be in this. You know, sometimes I get so upset and I think to myself, I don't know if I can go back tomorrow"* (McCaughtry *et al.*, 2006).

To summarise, difficulties surrounding teachers in the attempt at the successful teaching of physical education in disadvantaged communities include the low status of the subject, lack of qualified teachers and ongoing teacher training, lack of motivation and commitment from teachers and severe staff shortages. The following section investigates the challenges confronting the learners themselves within disadvantaged settings.

2.3.2.3. Challenges Related to Schoolchildren

The diverse challenges surrounding learners attending schools located in disadvantaged communities can be divided into the following areas:

1. The diverse set of learners and learning abilities found in a single classroom; and
2. The effects of the surrounding community's socioeconomic problems on learners, resulting in problems at school related to discipline and violence.

Teachers teaching in disadvantage schools settings within South Africa, as well as similar urban settings, found it difficult to provide positive, safe and culturally rich physical education for a diverse and complex group of learners (Barnard & McCaughtry, 2007; de Waal & Bardill, 2004). The diversities among learners include varying academic levels, evident in significant reading ability differences between learners in the same grade, as well as differences in practical physical abilities, which naturally effect physical education at school. These differences are due to major health-related physical fitness and motor proficiency disparities between learners in the same grade, which are especially evident in disadvantaged communities (de Waal & Bardill, 2004). The 2016 Healthy Active Kids South Africa (HAKSA) report card found that primary school learners' health-related physical fitness measured fair to poor, with even lower scores for learners from lower income communities. More than half of primary-school children assessed proved to be below average in object control skills, such as throwing, kicking and catching (Uys *et al.*, 2016). This emphasizes the difficulty teachers experience with physical education instruction, as some learners are unable to perform at the level indicated in the curriculum. This results in teachers having to accommodate varying degrees of skill levels within each class and learners remaining unable to meet curriculum demand.

A final barrier frequently found in disadvantaged communities is discipline-related problems in learners and the lack of commitment towards schoolwork. This lack of commitment involves far more than mere laziness or an unwillingness to learn. Learners in disadvantaged communities lack the necessary parental support and encouragement regarding their education. Learners are routinely left to their own devices as parents display an indifferent attitude towards the entire education endeavour (de Waal & Bardill, 2004). Parents or guardians are often unemployed and abject poverty prevails. In such circumstances the efforts of the entire family may become directed towards a daily struggle for survival. As unemployment and poverty persists, learners may in frustration join peer groups in perpetrating crimes and violence (Zulu *et al.*, 2004). Consequently, parental unemployment hampers the education of the learners and schools within townships present with low learner pass rates, high absenteeism and high drop-out rates due to pregnancy, drug- and alcohol abuse or gang related activities (Zulu *et al.*, 2004).

It is evident that schools located in disadvantaged communities face a myriad of challenges that shape how physical education is taught. These encompass the setting within which their schooling takes place, the attitudes of and avenues available to their teachers as well as personal difficulties among the learners themselves. As can be expected, the lack of adequate physical education and sporting opportunities within school settings negatively affects the physical activity participation of learners from disadvantaged communities. Given that children from these communities present with the lowest physical activity levels and have fewer opportunities to be active within their community and school setting, they are at high risk for all the dangers of an inactive lifestyle, both in relation to their personal health and development as well as their social and emotional wellbeing. This demonstrates the need to support schools and teachers in providing adequate physical education and offer increasing opportunities for in-school physical activity participation (McVeigh, Norris & De Wet, 2004).

2.4. School-Based Physical Activity Interventions

Schools have the potential to serve as ideal settings for the promotion of physical activity and a healthy lifestyle, especially in disadvantaged communities (Walter, 2011). Children spend a significant portion, at least a third of their waking time, at school (Ip, Ho, Louie, Chung, Cheung, Lee, Hui, Ho, Ho, Wong & Jiang, 2017). Furthermore, most health behaviours develop during childhood, and therefore interventions to promote a healthy lifestyle must start early, even as early as kindergarten (Kobel *et al.*, 2017). This is important as risk factors are already present in young children and most health behaviours develop at an early age and are then carried into youth and adulthood. In township areas, kindergartens are often informal, and with more than 70% of these facilities in South Africa functioning below recommended standards, the earliest structured schooling where interventions can be implemented, are in primary schools (Johnson, 2017).

This section sets out to review literature surrounding school-based health promotion and physical activity interventions. The section starts with factors that affect health promoting interventions, followed by school-based physical activity promotion components, and concludes with research studies demonstrating physical activity effects on body composition and physical fitness measures, in the form of an empirical evidence table.

2.4.1. Factors Affecting School-Based Interventions Promoting Health

The International Union of Health Promotion and Education (IUHPE) produced a set of guidelines for promoting health in schools by defining basic principles and components, through a process of discussions with both health and education professionals from around the world, and drawing on the best research and available evidence of good practice (International Union for Health Promotion and Education, 2008). The published report is titled: Promoting Health in Schools, from Evidence to Action, and focuses on the concept of 'Health Promoting Schools', also referred to as 'Comprehensive School Health' or 'Coordinated School Health'. The Health Promoting Schools concept refers to a whole-school approach to enhance health and educational outcomes in children, through learning and teaching experiences at school (International Union for Health Promotion and Education, 2009).

The Health Promoting Schools concept, has been found to be successful when incorporating the following six components:

1. **Healthy school policies:** Referring to clearly defined documents and accepted practices that promote health and wellbeing in the school setting.
2. **The school's physical environment:** Including buildings, grounds, equipment and facilities, as well as spaces provided that encourage children to be physically active.
3. **The school's social environment:** Here, quality of the relationships amongst and between staff and students come into play. The school's social environment is also influenced by parents' relationships and the community wherein the school is located.
4. **Individual health skills and action competencies:** Which refers to the school curriculum and associated activities that provide age-related knowledge, understanding, skills, and

experiences to children, which empowers them to act to improve their own health and wellbeing.

5. **Community links:** Allowing links between schools, students' families, key local community groups and leaders. Consultation and participation with these stakeholders enhance health promotion at school and provide school staff and students with support for their actions.

6. **Health services:** That can be either local or regional, which focuses on a school-based approach to promote health through direct services.

Research has found that health outcomes, and in relation, education and learning, improved if schools used the Health Promoting Schools concept in addressing health related problems in the education context (Stewart-Brown, 2006). Furthermore, multifaceted approaches have been found to be more effective in achieving these health and educational outcomes, compared to classroom-only or single-focus intervention approaches (Mukamana & Johri, 2016). The majority of physical activity promotion research, has however, been conducted within middle- to high income countries, and a paucity of research exists within lower income countries, such as South Africa (Heath, Parra, Sarmiento, Andersen, Owen, Goenka, Montes, Brownson, Alkandari, Bauman, Blair, Bull, Craig, Ekelund, Guthold, Hallal, Haskell, Inoue, Kahlmeier, Katzmarzyk, Kohl, Lambert, Lee, Leetongin, Lobelo, Loos, Marcus, Martin, Pratt, Puska, Ogilvie, Reis, Sallis & Wells, 2012).

The justification for each of the intervention components used within this study is further elaborated on in the following section. Furthermore, detailed descriptions of each intervention component can be found in Chapter 3: Research Methodology, in section 3.5. Physical Activity Intervention.

2.4.2. Components of Physical Activity Interventions

An article published in the Lancet in 2012, focusing solely on physical activity interventions and investigating evidence-based effective interventions from around the world, found that school-based interventions that encompass the following strategies are effective in promoting physical activity, these include: physical education classes, classroom activities, after-school sports, active transport and the creation of environments at school that promote activity (Heath *et al.*, 2012). Each of these effective intervention components are discussed in the following section.

2.4.2.1. Physical Education Lessons

The United Nations Educational Scientific and Cultural Organization (UNESCO) Charter of Physical Education and Sport (UNESCO, 1978) stipulate the following:

> *"Every human being has a fundamental right of access to physical education and sport, which are essential for the full development of his / her personality. The freedom to develop physical, intellectual and moral powers through physical education and sport must be guaranteed both within the educational system and in other aspects of social life."*

A key outcome of physical education is to provide an active environment for learners that is supportive and facilitates the skills, knowledge and attitude necessary to pursue an active and healthy lifestyle beyond the school environment (Batia, 2013). As emphasized by the UNESCO Charter, physical education is an essential component within the school context to provide learners with a holistic education. Furthermore, physical education lessons are possibly one of the most effective ways to promote physical activity within the school context, and have further benefits, including physical fitness outcomes, motor skills development and the reduction of cardiovascular disease risk markers (Heath *et al.*, 2012).

Within most school curricula, including the current CAPS curriculum in South Africa, physical education is already present and forms part of the compulsory subject set, with fixed times allocated on the timetable. The effectiveness of the practical delivery of physical education, however, becomes questionable as lower resourced areas specifically, face unique challenges as already discussed. The physical education present in the school curriculum can however be enhanced by increasing the number or the duration of the lessons, ideally to five sessions of 45 min per week as Heath *et al.* (2012) recommends. Furthermore, the quality of these lessons can be increased through capacity building and staff training, as well as provision of sporting equipment. Further adjustments can also be made to the content, to make it more appealing to the specific target population (Heath *et al.*, 2012). A study conducted in eight high schools, for example, found that giving learners a choice in respect to the physical education content significantly increased their participation and therefore their activity levels during class, compared to a control group that was not given the same choice (Batia, 2013).

2.4.2.2. In-Class Physical Activity Promotion

Another successful strategy for promoting activity within the school environment, is incorporating physical activity within the classroom. Classroom physical activity can be incorporated using integrated activity lessons, where specific academic learning areas are combined with physical activity, or with in-class physical activity breaks (Orlowski, Lorson, Lyon & Minoughan, 2013). An example of integrated activity lessons is where learners are asked to solve mathematical problems by giving the answer with the correct number of star jumps (2 times 3 is 6 star jumps) (de Greeff, Hartman, Mullender-Wijnsma, Bosker, Doolaard & Visscher, 2016). In-class physical activity breaks, on the other hand, are usually short in duration, lasting anything from one to five minutes, and can be performed at the beginning of a class or midway through. The main aim of these breaks is to energise and refocus the learners' attention, and furthermore, to promote activity (Orlowski *et al.*, 2013).

A study conducted in 2016 in the United States of America, investigating the effectiveness of in-class physical activity breaks, found that the activity breaks did not interfere with classroom instruction time and teachers continued to use the activity breaks after the study concluded, due to the positive outcomes experienced by the teachers (Phillips, Meister, Johns, Bears & Hamm, 2016). Moreover, the learners reported that the activity breaks were fun, helped them feel more physically fit, and made them more excited about school in general.

2.4.2.3. School Sports

Within lower socioeconomic areas in South Africa, a paucity of sports and recreation facilities exists, and schools are therefore the primary site allowing children to participate in team sports (Walter, 2011). Nevertheless, school sports are on the decline, with the Healthy Active Kids Report Card downgrading the school context and school sports from a D grade in 2014 and 2016 to a D - grade in 2018, with less than 21 - 40 % of children being provided with adequate facilities, equipment, instruction and opportunities to partake in school sports. Schools and the government alike, should place more emphasis on the delivery of school sports since sports participation provides a magnitude of benefits to growing children, far more than just physical benefits, as emphasised by the UNESCO Charter of Physical Education and Sport (UNESCO, 1978).

2.4.2.4. Extracurricular Physical Activities

Extracurricular or after-school physical activities refer to a range of activities taking place outside school hours, with the aim of increasing physical activity in children. Active transportation, additional physical education or sports lessons, fitness games or dancing are all initiatives that can be used to increase activity outside school hours.

Contemporary research has revealed that children and youth, particularly those from disadvantaged communities, want to engage with physical activities that are fun, safe, age-appropriate and culturally relevant (Beaulac, Bouchard & Kristjansson, 2010). South African culture is deeply rooted in music and dance, inspired by everything from wedding ceremonies and rituals, the traditional Zulu warrior dance, protests and battles, to mine workers' gumboot dancing, and the famous Madiba Jive. As such, it is not surprising that majority of South Africans enjoy dancing (South Africa Tourism, 2004). Dance interventions has further proved to be a cost effective way to increase moderate-to-vigorous intensity physical activity in children from lower socioeconomic settings (Romero, 2012). Moreover, research has demonstrated that different forms of dance can be a relevant and fun activity for diverse groups of young people (Beaulac, Olavarria & Kristjansson, 2010).

2.4.2.5. School Environments Promoting Physical Activity

An unsupportive physical environment that has insufficient places for safe and active leisure and play, has been identified as one of the key elements that prevent young people in disadvantaged communities from participating in physical activity (Beaulac *et al.*, 2010). It is therefore evident that a key element of improving physical activity, particularly in school settings, is providing children with an environment that encourages active play. A physical-activity friendly school environment has also been associated with a lower risk of obesity in children, in a large study investigating 208 280 children between the ages of 6 - 18 years, in 438 schools (Ip *et al.*, 2017).

2.4.3. Empirical Research on School-Based Interventions Improving Health-Related Physical Fitness

This section investigates research published on health promoting school-based interventions, with a special focus on physical activity promotion, and the corresponding effects on health-related physical fitness parameters in children, measured with the Eurofit testing battery. The studies are presented in reverse chronological order and were published between 1998 and 2016.

Table 2.5: Empirical evidence table summarising school-based physical activity interventions and the effects on health-related physical fitness

No.	Authors, Title and Journal	Area and Country	Intervention	Study Design	Participants	Outcomes	Results and Findings
1	(de Greeff, Hartman, Mullender-Wijnsma, Bosker, Doolaard & Visscher 2016) **Effect of physically active academic lessons on body mass index and physical fitness in primary school children** Journal of School Health 2016 86 346-352	Northern part of Netherlands, Europe	School- and classroom-based intervention focusing on integrating physical activity into the routine academic lessons (mathematics, spelling, reading). The physical exercises were moderate to vigorous intensity and easy to perform. Physical education expert conducted the intervention which as employed 3 x week; 30 minutes for 22 weeks.	2-year Cluster-randomized controlled trial Intervention duration: 22 weeks	Primary schools n=12 2nd and 3rd Grade 376 Children, girls n=215; boys n=161 Intervention age 8.0 years ± 0.7 years; Control age 8.2 years ± 0.8 years Intervention group 6 classes n=181; Control group 6 classes n=195	1. Anthropometry: • Height, weight, BMI 2. Physical fitness via Eurofit testing battery, including: • Speed and coordination: 10 × 5 m shuttle run • Cardiorespiratory fitness: 20 m endurance shuttle run • Explosive lower body strength: Standing broad jump • Muscle endurance: 30 sec Sit-ups • Static handgrip strength: Handheld dynamometer	1. Anthropometry: • A significant effect on the BMI of 3rd grade children were found. • The BMI of the intervention group did not change significantly, whereas a significant increase was found in the control group during the intervention period. 2. Physical fitness: • No significant effects were found on any physical fitness measure tested.

No.	Authors, Title and Journal	Area and Country	Intervention	Study Design	Participants	Outcomes	Results and Findings
2	(Uys, Draper, Hendricks, de Villiers, Fourie, Steyn & Lambert, 2016) **Impact of a South African school-based intervention, HealthKick, on fitness correlates** American Journal of Health Behaviour 2016 40 (1) 55-66	Western Cape Province, South Africa	HealthKick Intervention: A whole-school health promotion program developed for primary schools in low-income areas. Focusing on healthy eating and physical activity promotion by creating a school environment which is supportive of a healthy lifestyle. 'Low-touch' or limited contact intervention. HealthKick toolkit was developed and delivered to schools, including • Educator's manual • Curriculum manual • Resource box • Physical activity resource bin Intervention focused on: • School food and nutrition • School physical activity and sport • Staff health - chronic disease and diabetes awareness	2-year Cluster-randomized controlled trial Study duration: 2009-2011	Urban and rural primary schools n=16, Intervention schools n=8, Control schools n=8 4th Grade Intervention group n=532; Control group n=556 Socioeconomic status: Low (Quintile 1-3)	1. Anthropometry: • Height, weight, BMI 2. Physical fitness via Eurofit testing battery, including: • Flexibility: Sit-and-reach test • Explosive lower body strength: Standing broad jump • Trunk strength: Sit ups • Speed and agility: 10 × 5 m shuttle run 3. Questionnaire: • General attitude towards physical activity, physical activity knowledge, social support, self-efficacy, perceived barriers, and enjoyment	1. Anthropometry: • No significant differences between the intervention and control groups post-intervention. 2. Physical fitness via Eurofit testing battery, including: • Flexibility: No significant differences between the intervention and control groups post-intervention. • Explosive lower body strength: No significant differences between the intervention and control groups post-intervention. • Trunk strength: Significant increase in both intervention and control groups. • Speed and agility: No significant differences between the intervention and control groups post-intervention. 3. Questionnaire: • Increased in children's physical activity-related knowledge and self-efficacy.

No.	Authors, Title and Journal	Area and Country	Intervention	Study Design	Participants	Outcomes	Results and Findings
3	(Andrade, Lachat, Ochoa-Aviles, Verstraeten, Huybregts, Roberfroid, Andrade, Camp, Rojas, Donoso, Cardon &Kolsteren 2014) **A school-based intervention improves physical fitness in Ecuadorian adolescents: a cluster-randomized controlled trial** International Journal of Behavioral Nutrition and Physical Activity 2014 11 153 -170	Urban areas of Cuenca, 3rd largest city in Ecuador, South America	Intervention developed using results of qualitative (focus groups) and quantitative (physical fitness assessment) needs assessment through children, parents and school staff. Intervention included an individual and environmental component tailored to the local context and resources. 1. Physical activity intervention objectives: • Decrease daily screen time (1–2 hours/day) • Increase daily physical activity levels to reach 60 min/day • School offers more opportunities for being active 2. Individual strategy included delivery of educational package organised at classroom level 3. The physical activity environmental strategy • Workshops with parents • Organisation of social events at school such as an interactive session with famous young athletes • Environmental modification, including a walking trail	Pair-matched cluster (school) randomized controlled trial Intervention duration: October 2009 to June 2012 – 28 months	School pairs n=10; Schools in total n=20 8th and 9th grade Total sample n=1440; girls 63.2%; boys 36.8% Intervention group n=700; 48.6 %, Control group n=740; 51.4%.	1. Anthropometry: • Height, weight, BMI and BMIz 2. Physical fitness, including: • Cardiorespiratory fitness: 20 m shuttle run test • Static upper body strength: Handgrip dynamometer • Lower body strength: Vertical jump • Upper body endurance: Bent arm hang • Abdominal endurance: Sit-up test • Speed: 10 × 5 m shuttle run and plate tapping • Flexibility: Sit-and-reach • Balance: Flamingo balance test 3. Objectively assessed physical activity: • Accelerometers (type GT-256 and GT1M Actigraph) 4. Questionnaires: • Students' and teachers' satisfaction of the intervention (7-point Likert scale) • Screen time was assessed using a validated self-reported questionnaire • Socio-economic status according to the Integrated Social Indicator System for Ecuador	1. Anthropometry: • No significant effect for BMI or BMIz between the intervention and control group post-intervention. 2. Physical fitness, including: • Cardiorespiratory fitness: No significant effect. • Static upper body strength: No significant effect. • Lower body strength: Significant increase in intervention group. • Upper body endurance: No significant effect. • Abdominal endurance: No significant effect. • Speed: Significant increase in intervention group. • Flexibility: No significant effect. • Balance: Significant increase in control group. 3. Objectively assessed physical activity: • Total physical activity level decreased in the intervention group and control group with both groups showing a similar increase in sedentary time. • Children meeting activity recommendation decreased significantly less in the intervention group. 4. Questionnaires: • Screen time questionnaire: children with > 3 h of screen time during the weekend increased in 13% of intervention schools.

No.	Authors, Title and Journal	Area and Country	Intervention	Study Design	Participants	Outcomes	Results and Findings
4	(Eather, Morgan & Lubans, 2013) **Improving the fitness and physical activity levels of primary school children: Results of the Fit-4-Fun group randomized controlled trial** Preventive Medicine 2013 56 12-19	Hunter Region, New South Wales, Australia	Fit-4-Fun intervention: Conducted by research team who is trained physical educators. 1. 8-week health promoting school (HPS) programme curriculum (60 min per week), theory and practical based lessons 2. 8-week home activity program (3 × 20 min per week) 3. 8-week daily break-time activity program (2 x per school day)	Randomised controlled trial design Baseline assessment: April 2011 Immediate post-intervention assessment: June 2011 Follow-up assessment: December 2011 Duration: 6 months	Primary schools n=4 5^{th} and 6^{th} Grade Total sample n=226 children, 52.2 % girls and 47.8 % boys 10.7 years ± 0.6 years Intervention group n=118; Control group n=108	1. Anthropometry: • Height, weight, BMI and BMIz 2. Physical fitness, including: • Cardiorespiratory fitness: 20 m shuttle run test • Flexibility: Sit-and-reach (back saver) • Explosive lower body strength: Standing broad jump • Abdominal muscle strength: 7-stage sit-up • Basketball throw • Push-up test 3. Objectively assessed physical activity: • Yamax SW700 pedometers for 7 days (at least 3 consecutive days and 1 weekend day) 4. Questionnaires: • Demographics (age, sex, language spoken at home, country of birth) • Evaluation questionnaires were administered to determine students' and teachers' satisfaction of the various program components and participation in extra-curricular and break-time activities (7-point Likert scale)	1. Anthropometry: • Significant improvements for BMI and BMIz. 2. Physical fitness: • 20 m shuttle run test: Significant improvement. • Sit-and-reach (back saver): Significant improvement. • 7-stage sit-up: Significant improvement. • Standing broad jump: No significant improvement. • Basketball throw: No significant improvement. • Push-up test: No significant improvement. 3. Objectively assessed physical activity: • Significant improvement. 4. Questionnaires: • Older students less likely to participate in break-time activities. • High to very high overall satisfaction rates for the Fit-4-Fun program. • Students reported difficulties with parent and family involvement in the home program.

No.	Authors, Title and Journal	Area and Country	Intervention	Study Design	Participants	Outcomes	Results and Findings
5	(Naidoo & Coopoo, 2012) **The impact of a primary school physical activity intervention in KwaZulu-Natal, South Africa** African Journal for Physical, Health Education, Recreation and Dance (AJPHERD) 2012 18 (1) 75-85.	Urban and rural regions of KwaZulu-Natal Province, South Africa	Nutrition and Physical Activity (NAP) intervention: Incorporated within school lessons, during breaks and after school, with minimal external support. 1. Workshops training educators to lead intervention activities, provided with activities and allowed to choose activities. 2. Classroom-based physical activity for one-minute prior to each lesson. 3. Equipment for sports and games provided to encourage physical activity during lunch breaks. 4. School policy changes where school staff and learners were encouraged to engage in policy change efforts, such as developing a school PA policy.	Pre-test – Post-test design Duration of intervention: 18 months	Primary schools n=6: Urban n=1 Peri-urban n=2 Rural n=3 5 Intervention schools (n=277 children) 1 Control school (n=150 children) 6th Grade 427 Children; Girls n=123; Boys n=147 9-16 years 94 % ethnic Black 83% Zulu, 12 % Xhosa, 6 % English Socioeconomic status: Low to middle income	Quantitative Assessment 1. Anthropometry: • Height, weight, BMI 2. Physical fitness via Eurofit testing battery, including: • Speed and coordination: 10 x 5 m shuttle run test • Flexibility: Sit-and-reach • Explosive lower body strength: Standing broad jump • Muscle endurance: 30 sec Sit-ups 3. Questionnaires: • Subjective physical activity • Subjective nutrition Qualitative Assessment 1. Focus groups: • 5 principals and 14 educators were interviewed pre-intervention, during the intervention (follow-up visits) and post-intervention 2. Observations: • Learners observed during lunch breaks for physical activity and sports participation	Quantitative Assessment 1. Anthropometry: • No significant effects. 2. Physical fitness: • Shuttle run test: No significant increase. • Sit and reach: Significant increase, both intervention and control group. • Standing broad jump: Significant increase, both intervention and control group. • 30 sec Sit-ups: Significant increase, intervention and control group. Qualitative Assessment 1. Focus groups: • Classroom-based physical activity increased activity by 19-37 min per day. 2. Observations: • Significantly higher sports participation. • Increased participation in soccer, dancing and netball. • Decrease in swimming, gymnastics and athletics. • Increased participation in physical education.

No.	Authors, Title and Journal	Area and Country	Intervention	Study Design	Participants	Outcomes	Results and Findings
6	(Naidoo, Coopoo, Lambert & Draper, 2009) **Impact of a primary school-based nutrition and physical activity intervention on learners in KwaZulu-Natal, South Africa: A pilot study** South African Journal of Sports Medicine 2009 21 (1) 7-12	KwaZulu-Natal Province, South Africa	Nutrition and Physical Activity (NAP) intervention: • Introduce various methods of physical activity and healthy nutritional habits within the school's existing curriculum. • Classroom-based intervention materials were developed to provide a cost-effective and sustainable intervention. Educators were trained to lead intervention activities with minimal external support.	Prospective empirical pilot study with an intervention and pre-test – post-test, no control group Intervention duration: 6 months	Primary schools n=4 6th Grade Educators n=10; Learners n=256 Socio-economic status: Low- to middle income	Quantitative 1. Anthropometry: • Height, weight, BMI and BMIz 2. Physical fitness via Eurofit testing battery, including: • Flexibility: Sit-and-reach test • Muscular endurance: 30 sec sit-ups • Explosive power: Standing long jump 3. Questionnaires • Knowledge, attitudes and practices of learners towards physical activity and basic nutrition. • Self-report physical activity and school sport participation. Qualitative 1. Observations of physical activity and sports participation 2. Semi-structured interviews	Quantitative 1. Anthropometry: • No significant improvements. 2. Physical fitness via Eurofit testing battery, including: • Flexibility: No significant improvements. • Muscular endurance: Significant increase in number of sit-ups completed. • Explosive power: No significant improvements. 3. Questionnaires • Physical activity participation at club or team level increased significantly pre- and post-intervention, as well as average number of sports participated in during physical education / life orientation lessons and a general increase in after-school activities. Qualitative • Physical activity among learners ranged from 45 to 215 minutes per week of moderate to vigorous physical activity during school hours. • Semi-structured interviews revealed healthier food and drink options at selected school tuck-shops.

No.	Authors, Title and Journal	Area and Country	Intervention	Study Design	Participants	Outcomes	Results and Findings
7	(Verstraete, Cardon, De Clercq & De Bourdeaudhuij, 2007) **A comprehensive physical activity promotion programme at elementary school: The effects on physical activity, physical fitness and psychosocial correlates of physical activity** Public Health Nutrition 2006 10 (5) 477-484	East Flanders, Belgium, Europe	SPARK intervention: 1. Health-related physical education programme, including physical education lessons plans for teachers. 2. Classroom-based health education lessons, 6 lessons conducted by researchers and self-management teaching skills (goal-setting, time-planning, problem-solving and self-talk). 3. Extracurricular physical activity promotion programme during recess periods. 4. Once a week after-school activity lessons conducted by an external teacher. 5. Homework to promote activity after school. 6. Sports and games equipment provided to promote more physical activity.	Pre-test – Post-test design Pre-test: September to October 2002 Post-test: April to June 2004 Duration of intervention: Two school years	Elementary schools n=16 Interventions schools n=8; Control schools n=8 4^{th} and 5^{th} Grade Total sample n=764 Children; Girls n=391 Boys n=373 9.7 ± 0.7 years	1. Anthropometry: • Height, weight • Sum of 5 skinfolds (biceps, triceps, subscapular, suprailiac and calf) 2. Physical fitness via Eurofit testing battery, including: • Cardiorespiratory endurance: 20 m shuttle run • Flexibility: Sit-and-reach • Explosive lower body strength: Standing broad jump • Static upper body strength: Handgrip • General balance: Flamingo balance test • Speed of limb movement: Plate tapping • Trunk strength and abdominal endurance: Sit-ups • Functional strength and arm and shoulder endurance: Bent arm hang • Speed and coordination: 10 x 5m shuttle run 3. Objective physical activity assessment: Accelerometers 4. Questionnaires: • Leisure time physical activity • Psychosocial correlates of physical activity • General attitude towards activity, social support, self- efficacy, perceived barriers and benefit	1. Anthropometry: • Height significantly lower in intervention school. • Sum of skinfolds significantly lower in intervention school. 2. Physical fitness: • No significant effects in any physical fitness tests. 3. Objective physical activity assessment: accelerometers • Higher MVPA in intervention schools. • Smaller decrease in moderate and MVPA from baseline in intervention schools. • Increase in total physical activity engagement from baseline. 4. Questionnaire • Increase leisure time moderate intensity physical activity in intervention group.

No.	Authors, Title and Journal	Area and Country	Intervention	Study Design	Participants	Outcomes	Results and Findings
8	(Manios, Kafatos & Mamalakis, 1998) **The effects of a health education intervention initiated at first grade over a 3-year period: physical activity and fitness indices** Health Education Research 1998 13 (4) 593-606	Iraklio, Rethimno and Chania, Greece, South-Eastern Europe	Culturally adapted 'Know Your Body' school health promotion programme by the American Health Foundation. • Multicomponent workbooks covering dietary information, physical activity and fitness, and also dental health hygiene and accident prevention were produced for grades 1–3. • Teaching aids, produced by the researchers, in the form of teaching manuals, audio-taped stories, posters and workbooks were also provided. • Classroom modules were designed to develop behavioural capability, expectations and self-efficacy for healthful eating, physical activity and fitness. • Practical aspects were delivered in the playground where fitness (rather than motor) -oriented exercise sessions took place. • Parental meetings and information sessions.	Pre-test – post-test design Intervention duration: 3-years	Total schools n=40, Urban n=17; Rural n=23 Intervention schools n=24, Urban n=10 Rural n=14 Children n=538 Control schools n=16, Urban n=7 Rural n=9 Children n=424 Total sample: Girls n=453; Boys n=509	1. Health knowledge • 13 Multiple choice questions, focusing on diet, food products and physical activity 2. Anthropometry: • Skinfolds • BMI 3. Physical activity • Parents were asked to report their children's physical activities during two consecutive weekday afternoons and 1 day of the weekend. 4. Physical fitness via Eurofit testing battery, including: • Cardiorespiratory endurance: 20 m shuttle run • Flexibility: Sit-and-reach • Explosive lower body strength: Standing broad jump • Static upper body strength: Handgrip • Trunk strength and abdominal endurance: Max sit-ups in 30 sec 5. Parental data • Questionnaire investigating knowledge of, attitudes to and beliefs on health matters	1. Health knowledge 2. Anthropometry: • Intervention group significant improvement compared to the control group for BMI and suprailiac skinfolds. • No significant effects for biceps, triceps or subscapular skinfold. 3. Physical activity • Significant increases in the amount of time spent in MVPA out of school for both the control and the intervention group, however significantly higher in the intervention group. 4. Physical fitness via Eurofit testing battery: • Significant improvements in physical fitness for both the control and the intervention group. • Cardiorespiratory endurance: Intervention group significant improvement compared to the control group. • Flexibility: Intervention group significant improvement compared to the control group. • Explosive lower body strength: Intervention group significant improvement compared to the control group. • Static upper body strength: No significant effects. • Trunk strength and abdominal endurance: Intervention group significant improvement compared to the control group. 5. Parental data • Increased significantly for both the control and the intervention group.

The studies examined used different school-based interventions, looking solely at the physical activity components, and focused on decreasing sedentary behaviours and promoting activity. A variety of strategies were employed to achieve these goals, ranging from classroom focused interventions which were incorporated into lessons, breaktime interventions, as well as interventions focusing on extracurricular physical activity promotion at school, in the form of sports promotion and active transportation. Some interventions involved theory components, teaching the importance of physical activity to both learners and their parents, with the help of activity workbooks. The delivery method of these interventions varied, and some interventions were provided by the class teachers with supplemented material and training workshops, while others were conducted by external physical education specialists.

In relation to the settings, the studies were conducted in a variety of countries, including countries in Europe and South America, and in Australia and South Africa. The South African studies were conducted in the provinces of KwaZulu Natal Province and the Western Cape. The studies were also conducted in areas of various socioeconomic levels. Furthermore, although all the participants were school-aged, the empirical table includes children from 2nd to 9th grade, aged 8 to 15 years.

Lastly, different study designs were employed and included true randomisation, cluster randomisation which is often used within school-based research, as grades and classes present in natural occurring clusters, and pre-test – post-test study designs, with and without the use of a control group.

The empirical evidence table summarises school-based physical activity interventions and their effects on health-related physical fitness, measured through various tests from the Eurofit testing battery. From the table it is evident that body composition and physical fitness improvements are difficult to obtain, and improvements achieved through school-based interventions were marginal and small. Further discussions on the empirical evidence presented and comparisons between the empirical research and the present study, can be found in Chapter 5, titled: Discussion, Conclusion, Limitations and Recommendations.

2.5. Conclusion

In summary then, this chapter has reviewed literature concerning three main topics: physical activity and physical fitness in children, physical education, specifically in the South African context, and school-based physical activity interventions.

The chapter starts by providing definitions of key concepts, including physical activity, exercise, and health- and skill-related physical fitness. Thereafter, the physical, psychological and cognitive benefits that are the result of regular physical activity are explored in greater detail. The section continues with physical activity guidelines for children, set at 60 minutes of moderate-to-vigorous intensity physical activity per day and highlights current global physical activity levels, which clearly indicate that children across the globe are not meeting the recommended minimum activity requirements for healthy development. The field measurement of health-related physical activity is then explained, providing justification for the present study's use of the Eurofit testing battery.

It is evident that physical education in South Africa has undergone major curriculum reform, minimizing its status in the curriculum. The second section of this chapter was concerned with the historical context surrounding curriculum reform, with special reference to its effects on physical education. Disadvantaged settings, such as the setting wherein this study was conducted, results in many unique challenges, especially surrounding the physical school setting and location. physical education implementation in these settings is detrimentally affected by the challenges that the settings themselves present. This includes challenges faced by the school itself, as well as teachers and learners within these settings.

The final section of this chapter discussed factors affecting school-based physical activity interventions. Components within these interventions found to be successful, were examined, and worldwide empirical research demonstrating activity's effects on physical fitness, were presented.

The following chapter, Chapter 3, provides a detailed explanation of the research methodology used within the present study. The research design is explained, followed by a description of the participants and sampling technique used, as well as the measuring instruments and techniques utilised in obtaining the data. Furthermore, the data analysis and interpretation are explained as well as the ethical consideration the study took into account.

Chapter 3 : Research Methodology

3.1. Introduction

This study falls under the auspices of a larger three-year longitudinal research project entitled “The impact of disease burden and setting-specific interventions on schoolchildren’s cardiorespiratory, physical fitness and psychosocial health in Port Elizabeth, South Africa”. This larger project is known as ‘the DASH project’, which is an acronym for ‘Disease, Activity and Schoolchildren’s Health’.

This chapter reflects detailed descriptions of the research design and methodology used to collect and analyse the study’s data. The research design and methodology were chosen to ensure reproducible and valid results, thereby increasing the accuracy of the conclusions that could be drawn. This chapter commences with an explanation of the research design and how the study’s participants were sampled. This is followed by specifics of the physical activity intervention that was employed. A description of how the data was collected, including the instrumentation and techniques used, and details of how the data was analysed and interpreted follows. Due to the vulnerability of children in disadvantaged communities, great care was taken to ensure that the study was conducted in accordance with the appropriate ethical standards. The chapter concludes with a description of the ethical considerations that applied to this study.

3.2. Research Design

Research design refers to the logical structure that guides the study to address the study aim and answer the research questions (Salkind 2010: 1252-1258). The kind of research questions to be answered therefore determines the specific research design. As mentioned in Chapter 1, section 1.3, the study’s research question reads, “Does a school-based physical activity intervention improve the body composition and physical fitness, namely: cardiorespiratory fitness, strength and flexibility of primary schoolchildren from disadvantaged communities?”. A quantitative research approach was employed to address the study’s research question, aim and objectives.

The DASH project, including the present study, employed three testing phases (between 2015 and 2016), consisting of baseline testing and two post-intervention testing phases. Preparatory work for the study started in 2014, with dissemination of results taking place in 2017. The timeline of the study, showing the testing and intervention phases, is shown in Table 3.1.

Table 3.1: Research study timeline showing the timeframes for the intervention and testing phases of the DASH project and the present study

Date		**Intervention Group**	**Control Group**
February	2015	Baseline Testing **T1**	
July to September	2015	Intervention Phase 1 **IP 1**	Control Phase 1 **CP 1**
October	2015	1st Post-Intervention Testing **T2**	
February to April	2016	Intervention Phase 2 **IP 2**	Control Phase 2 **CP 2**
April to May	2016	2nd Post-Intervention Testing **T3**	

Both the larger DASH project and the present study follow a cluster randomised controlled trial design. Figure 3.1 was adapted from the University of Wisconsin and the University of Oxford (Ebling Library 2017; Centre of Evidence-Based Medicine, University of Oxford, 2018) and indicates where randomised controlled trials fall within the evidence hierarchy. Cluster controlled trials have groups or clusters of individuals, rather than individuals themselves, that are randomised (Puffer, Torgerson & Watson, 2005). In the education setting clusters occur naturally in grades and schools, and individual randomisation is practically impossible.

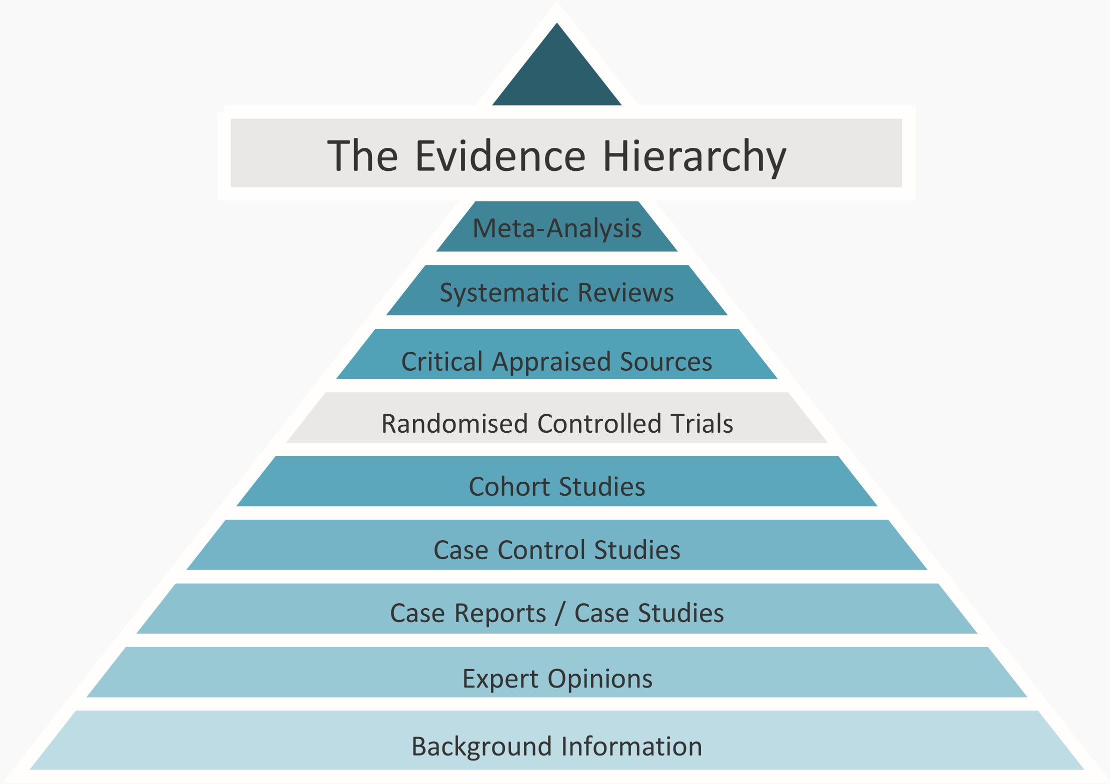

Figure 3.1: The evidence hierarchy

3.3. Participants and Sampling Methods

The study sample for the DASH project consisted of 1009 Grade 4 primary schoolchildren (girls n = 501; boys n = 508), age 8 to 12 years, from eight public primary schools. These schools are located in historically Black African, known as township areas, and Coloured areas, also referred to as Northern areas, around Port Elizabeth, in the Eastern Cape province of South Africa. Previous apartheid policies resulted in an uneven distribution of ethnic groups across socioeconomic strata within South Africa, where lower socioeconomic areas contained mainly Black individuals and higher socioeconomic areas have mostly White individuals. The Nelson Mandela Bay area remain the most racially segregated city in South Africa (Statistics South Africa, 2016).

Figure 3.2, illustrates the social tapestry of Nelson Mandela Bay, and the geographic location of the eight DASH project schools. This study's sample consists of Intervention School 1 and Control School 1 only, located in the township of Motherwell.

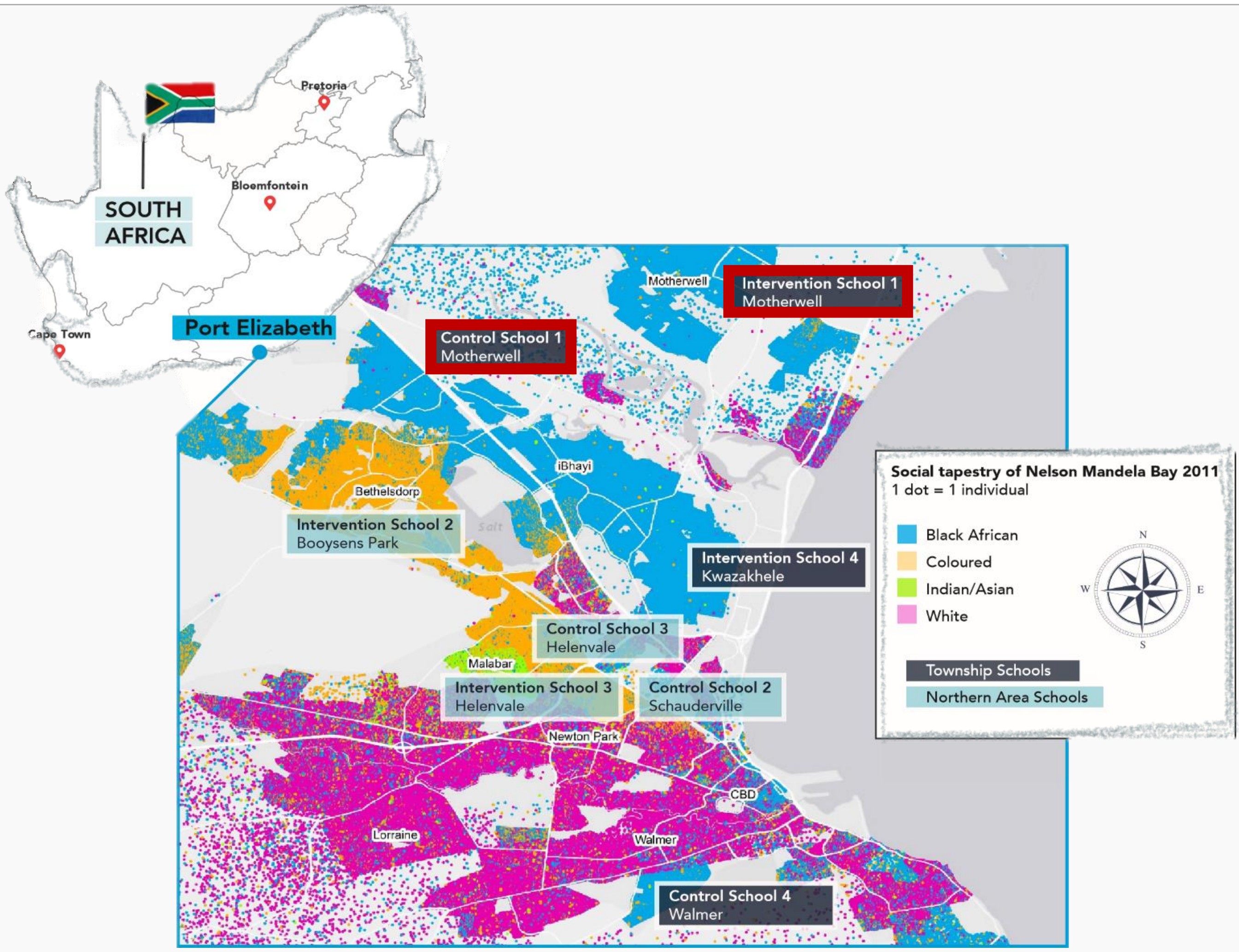

Figure 3.2: Ethnic composition and geographic location of the eight DASH project schools within the Nelson Mandela Bay area

Adapted from Statistics South Africa (2016) and the DASH project protocol (Yap, Müller, Walter, Seelig, Gerber, Steinmann, Damons, Smith, Gall, Bänninger, Hager, Htun, Steenkamp, Gresse, Probst-Hensch, Utzinger, Du Randt & Pühse, 2015).

All the schools selected for the DASH project were classified as quintile-three. The quintile system categorises all South African public schools for the main purpose of allocating financial resources (van Wyk, 2015). The scale starts at quintile one, with the poorest of public schools, and ends at quintile five, categorised as the least poor schools. These rankings are determined nationally according to the poverty level of the community surrounding the school, as well as certain infrastructural factors. Quintiles one to three are non-fee paying schools, whilst quintile four and five schools charge school fees (South Africa National Treasury, 2017). Quintile-three are the lowest quintile-ranked schools found within the Nelson Mandela Bay area, according to the Eastern Cape Department of Education (2015).

As mentioned, participants from two schools (out of the eight schools in the larger DASH project) formed part of the present study. One school served as the intervention group, and participated in the physical activity intervention, and the other school served as the control group. The larger DASH project focused on four interventions, namely: physical activity, health and hygiene education, a nutrition intervention and anthelmintic pharmaceutical treatment[12] where needed. Anthelminthic pharmaceutical treatment was provided to the intervention and the control groups, based on the guidelines provided by the World Health Organization (World Health Organization, 2018d). To ensure that test results were not influenced by interventions other than physical activity, to best address the research aim and answer the research questions of the current study, schools involved in the health and hygiene education and nutrition intervention packages were not selected to partake in this study. Grade 4 learners were specifically selected, as the DASH project was longitudinal in nature. Furthermore, the DASH project interventions had complemented the National Curriculum and Assessment Policy Statement (CAPS) (Department of Basic Education: Republic of South Africa, 2011) to be accepted by the Department of Education. Using learners from the same phase (Intermediate Phase from Grades 4 to 6) throughout the length of the study thus ensured that subject content and weekly time allocations stayed standard throughout the study.

3.3.1. Sampling Strategy

The strategy used to gather participants for the larger DASH project, involved initially identifying the 103 quintile-three primary schools in Port Elizabeth that were situated in disadvantaged communities and historically Black and Coloured areas. The research project information was delivered to each of these schools by hand, as many did not have access to communication media such as email and internet or facsimile lines. Interested principals, Grade 4 teachers and school governing body members were invited to an information session in October 2014 where the research project details were discussed. Written responses to attend the information sessions were received from 25 interested schools, and a total of 15 schools were represented on the day. Eight primary schools were chosen thereafter based on geographic location and whether the schools each had at least 100 Grade 4 learners. The eight schools were match-paired and randomly assigned to the intervention or control condition. The match-pair technique is used as an alternative to random sampling to minimise the threats to internal validity[13] (Thomas, Silverman & Nelson, 2015: 352-355). Further information sessions were subsequently held with the principal and teachers at each school, as well as parents, guardians or caregivers and the schoolchildren themselves to provide information about the study. The objectives, procedures and potential benefits and risks of participating in the study were explained, questions were answered, and the learners were encouraged to participate in the study.

Parents or guardians had to have completed an informed consent form that allowed learners to partake in the study. The informed consent form explained the study as well as provided the researchers' contact details. Provision was also made for illiterate individuals to provide a thumb print serving as a signature, although all the parents or guardians of the learners partaking in the study, were literate. See Appendix D for all the DASH project informed consent forms. Furthermore, learners also had to have provided oral assent to partake. All the forms were translated from English into

[12] Anthelmintic pharmaceutical treatment refers to medicine that kill helminths, worm-like parasites such as flukes, roundworms and tapeworms. Anthelmintic pharmaceuticals include: mebendazole (Vermox) and albendazole (Albenza) (World Health Organization, 2018d).

[13] Internal validity refers to the accuracy of statements made about the causal relationship between the independent variable and the dependent variable (Salkind, 2010: 619-622).

Xhosa, predominantly spoken in township schools, and Afrikaans, predominantly spoken in Northern area schools.

Schoolchildren were included in the study if they met the following inclusion criteria:

a. Willing to participate in the study and provided oral assent;
b. Grade 4 learner between the ages of 8 and 12 years;
c. Completed informed consent form from parent or guardian;
d. Not participating in any other clinical trials during the study period; and
e. Not suffering from any condition that prevents participation in the physical fitness assessment, as determined by a registered medical nurse.

3.3.2. Final Study Sample

The final sample for this study consisted of 157 primary schoolchildren (girls: 84; boys: 73), aged 8 to 12 years at baseline testing phase (9.11 ± 0.88). This comprised of 65 learners (girls: 37; boys: 28) in the intervention group and 92 learners (girls: 47; boys: 45) in the control group. Figure 3.3 provides a flow diagram of the study sample from the first to the third testing phase.

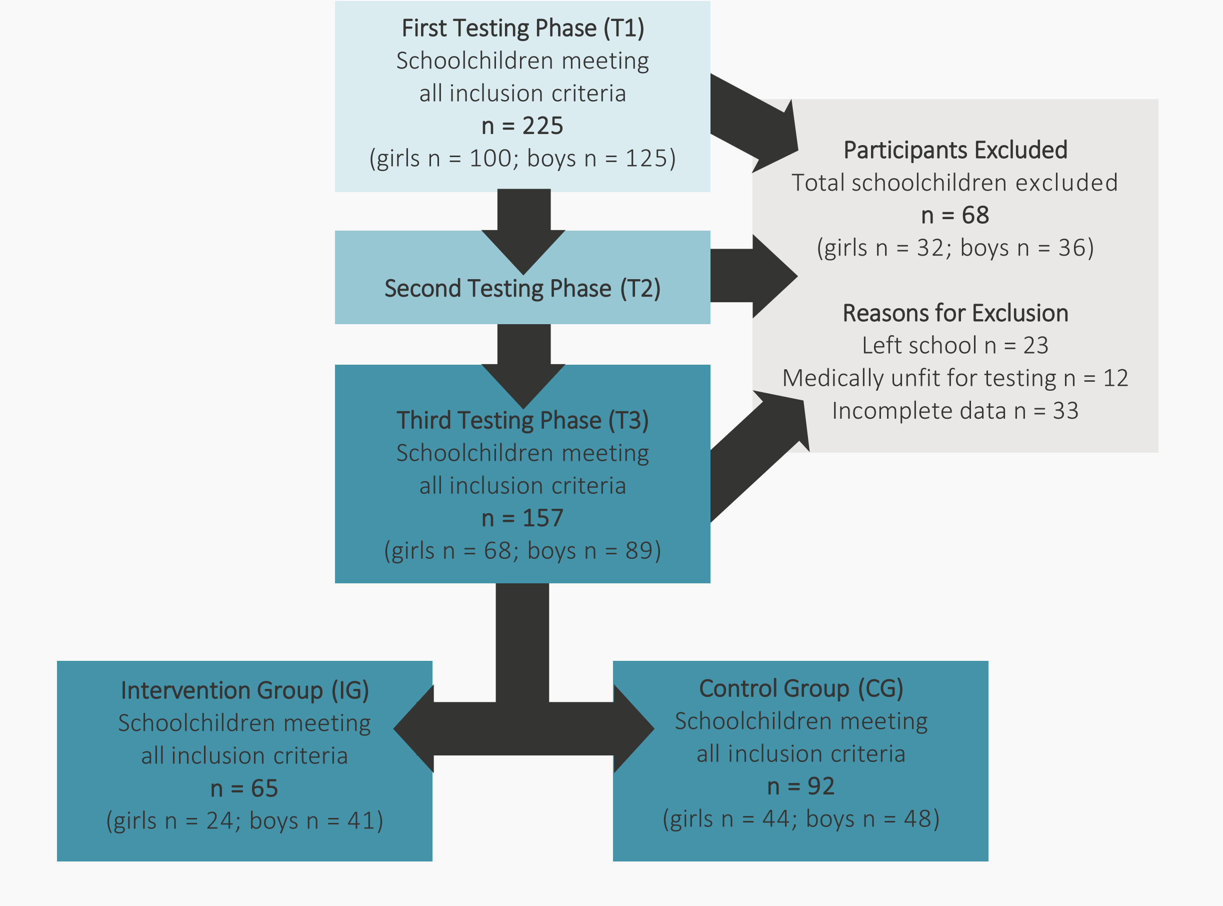

Figure 3.3: Diagram showing the study sample flow

Of the 68 participants excluded, 23 left school and 33 had missing data due to no consent from a parent or guardian or no verbal assent from the participant. Furthermore, missing data was attributed to absenteeism, on either day one or day two of testing, as well as on the ‘catch-up’ testing day. A total of 12 learners were also deemed medically unfit to partake in maximal exercise testing, by a registered medical nurse. Symptoms resulting in exclusion ranged from bilateral crepitation or wheezing respiratory sounds, enlarged tonsils and swollen glands, hypertension and tachycardia. Each medically excluded participant was referred to the nearest clinic for further treatment.

3.4. Intervention and Control Group Allocation

The larger DASH project described in section 3.2, involved eight schools, four of these schools participated in various school-based interventions and were match-paired with four control schools. The match-pairing of schools was based on geographic location, level of helminthic infections and the ethnic composition of the schools. This allowed for fairer comparison between experimental and control schools given that several confounding variables could be accounted for, which may not necessarily be possible in a true randomised experimental study design. Table 3.2 shows the intervention and control groups and how the interventions were combined for each intervention school. Schools 1 and 2 formed part of the present study.

Table 3.2: Allocation of intervention and control groups in the DASH project, with a focus on school 1 and 2, which forms part of the present study

Intervention Group		Control Group		Geographical Location
School 1 **IG 1**	Physical activity Pharmaceutical treatment	School 2 **CG 1**	Pharmaceutical treatment	Township area
School 3 **IG 2**	Physical activity Health and hygiene education Pharmaceutical treatment	School 4 **CG 2**	Pharmaceutical treatment	Northern area
School 5 **IG 3**	Physical activity Health and hygiene education Nutrition intervention Pharmaceutical treatment	School 6 **CG 3**	Pharmaceutical treatment	Northern area
School 7 **IG 4**	Health and hygiene education Nutrition intervention Pharmaceutical treatment	School 8 **CG 4**	Pharmaceutical treatment	Township area

After the third testing phase of the project was completed, all the interventions, including the physical activity, the health and hygiene education as well as the nutrition intervention equipment and material, were provided to all the schools. Anthelminthic pharmaceutical treatment was provided immediately, as needed, to both the intervention and control schools, based on the World Health Organization's preventative chemotherapy recommendations (World Health Organization, 2017).

3.5. Physical Activity Intervention

The study investigated the effect of two 10-week, school-based physical activity interventions on primary schoolchildren's body composition and physical fitness. The first 10-week intervention was conducted during July to September 2015, after the baseline testing. The second 10-week intervention was conducted during February to April 2016, after the first follow-up testing. See Table 3.1 in section 3.2 for the research study timeline.

The physical activity intervention was designed by the DASH project research team (of which the researcher formed part of) and consisted of physical education lessons, move-to-music dance lessons, activity breaks during class, physical activity 'homework' and the creation of a physical activity-friendly environment at schools. The DASH project research team collaborated with local students, teachers, and health professionals in designing the intervention.

The physical activity intervention was designed in accordance with the national Curriculum Assessment Policy Statement (CAPS) of the Life Skills subject for Intermediate Phase, Grade 4 to 6 (Department of Basic Education: Republic of South Africa, 2011). The CAPS documents represent a policy statement for learning and teaching in South African schools and include Grades R to 12.

The aim of the Life Skills module is the holistic development of the learner through the equipment of knowledge, skills and values that can assist them to achieve their full physical, intellectual, personal, emotional and social potential. The Life Skills subject contain three components: physical education, Creative Arts and Personal and Social Wellbeing. Four hours are allocated per week for the subject, with an hour dedicated to physical education, and an hour and a half for both Creative Arts and Personal and Social Wellbeing. The DASH intervention aligned with the physical education and the Creative Arts components of the curriculum.

Workshops were conducted prior to the implementation of the intervention, with the teachers responsible for teaching the Life Skills subject. The workshops were presented by experienced physical education teachers and Human Movement Science master degree students from the Nelson Mandela University. During the workshops the importance of childhood physical activity and daily activity recommendations were explained. Pedagogical approaches in physical education were discussed, along with the theoretical background of the lessons. Furthermore, practical implementation of the lessons was demonstrated and later practiced by the teachers themselves. General class management concepts and techniques were also shared. The workshops concluded with a feedback session to ensure all questions and concerns from the teachers' side were addressed.

Teachers were given a resource package at the workshop, containing everything required to conduct the physical activity intervention. The resource package contained various manuals explaining physical activity lessons, including physical education lesson plans for Grade 4 and 5, physical activity cards and exercise posters, as well as small equipment needed for the implementation of the lessons. As mentioned, after the third testing phase was completed, all the interventions' equipment and material, were provided to all the schools. Anthelminthic pharmaceutical treatment was provided immediately, as needed, to both the intervention and control schools.

The following sections explain the different aspects of the physical activity intervention in more detail.

3.5.1. Physical Education Lessons

The physical education lessons that were created for the DASH physical activity intervention, complimented the physical education section in the Life Skills subject, for intermediate phase, Grade 4 to 6, in the CAPS curriculum.

The main aim of the physical education section is the development of learners' physical wellbeing and knowledge of movement and safety. Ultimately, this will result in learners being physically fit, mentally alert, emotionally balanced and socially well adjusted (Department of Basic Education: Republic of South Africa, 2011). Furthermore, emphasis in this section is placed on the importance of a physically active lifestyle and how it is achieved.

Aligning with the CAPS time frame provided for physical education, two 40-minute physical education lessons per week were conducted as part of the DASH physical activity intervention. The lesson plans were designed in accordance to the physical education outline in Table 3.3 The first intervention was conducted when the study sample was in Grade 4, and the second intervention when they were in Grade 5.

Table 3.3: Overview of topics covered in the Grade 4 and 5 physical education section of the Life Skill subject
(Department of Basic Education: Republic of South Africa, 2011)

Grade 4	Grade 5
Different ways to locomote, rotate, elevate and balance, using various parts of the body with control	Movement sequences that require consistency and control in smooth and continues combinations
A variety of modified invasion games	A variety of target games
Rhythmic movements with focus on posture	Rhythmic movements and steps with attention to posture and style
Basic field and track athletics or swimming activities	A variety of field and track athletics or swimming activities
Safety measures	Safety measures

Due to the fact that none of the teachers who taught the Life Skills learning area were specifically trained in physical education, a 'teacher coach' was assigned to assist teachers for one of the two physical education lessons per week. The teacher coaches were postgraduate students with a Human Movement Science degree, based at the Nelson Mandela University. The teacher coach visited the school once a week and systematically mentored the Life Skills teacher in lesson conduction. The Grade 4's (for example) might be divided into three classes, Grade 4a, 4b and 4c at the intervention school at the start of the intervention, with each class doing physical education separately. When the teacher coach visited the school, the lesson with Grade 4a (for instance) would be conducted by the teacher coach with the Life Skills teacher observing. The lesson with Grade 4b, would then be conducted by the teacher coach with the assistance of the Life Skills teacher. The last physical education lesson, with the Grade 4c class, would be conducted by the Life Skills teacher alone, with the teacher coach observing. Thus, with each class the Life Skills teacher's role incrementally increased until she was in full control of the class. The second physical education lesson per week, for each class, would then be conducted entirely by the Life Skills teacher, without the teacher coach being present.

Physical education lesson plans were created and given to the teachers at the workshop, as explained earlier. Appendix C contains examples of the DASH Project Physical Activity Intervention material, with section i. and ii. specifically containing examples of the Grade 4 and Grade 5 physical education lessons.

3.5.2. Move-to-Music Dance Classes

The move-to-music dance lessons formed part of the Creative Arts section of the CAPS Life Skills subject. Creative Arts encompass a range of forms including dance, drama, music and visual arts. The purpose of this section is to develop the learners as creative, imaginative individuals that appreciate the arts. A safe and supportive environment is created where learners can explore, experience and express their thoughts, ideas and concepts in an atmosphere of openness and acceptance (Department of Basic Education: Republic of South Africa, 2011).

CAPS allow for one-and-a-half hours of Creative Arts per week for the Intermediate Phase. Therefore, a 45-minute mass dance class was conducted once a week at the intervention school, for the duration of the intervention phases. In Table 3.4, the outline of lessons and the overview of topics covered in the Creative Arts curriculum is presented.

Table 3.4: Overview of topics covered in the Grade 4 and 5 Creative Arts section of the Life Skill subject
(Department of Basic Education: Republic of South Africa, 2011)

Grade 4	Grade 5
Physical warm-up including: • Active relaxation • Travelling movements and freezing • Body part isolations • Floor work • Neutral posture and character postures • Jumps with soft landings	Physical warm-up including: • Rolling up and down spine • Arm swings, knee bends and rises • Cool downs
Game exploring: • Active relaxation • Rhythm and music • Creativity • Direction • Call and response • Concentration and focus • Sensory awareness • Trust and listening	Game exploring as in Grade 4, including: • Spatial and group awareness • Body percussion (in unison, canon and /or call and response)

The move-to-music dance classes were conducted by dancers and cheerleaders from Nelson Mandela University. The classes included exercises to music, with modern dance moves and rhythmic, aerobic activities. Each class started with a warm-up and concluded with a cool down and stretching section. Two to three instructors would conduct each mass dance class, to ensure the entire grade, consisting of 3 classes, could be accommodated at once.

Refer to Appendix C, Figure C.2 that displays the move-to-music mass dance setting.

3.5.3. In-Class Physical Activity Breaks

Teachers were encouraged to perform in-class physical activity breaks, of one to two-minutes in duration, three to four times throughout the school day. Teachers were provided with physical activity cards (see Appendix C, section iii.), illustrating various activities and exercises to be implemented in class. The goal of the activity breaks was to improve concentration and focus and to help with attention, memory and cognition.

3.5.4. Physical Activity Homework

Physical activity cards were also provided with the DASH Project Physical Activity Intervention materials (see Appendix C, section iii.). The cards displayed activities and exercises that are easy to perform and fun to do. Teachers were encouraged to utilise the activity cards to provide ideas for physical activity 'homework'. These activities were designed to be performed at the learners' homes with minimal or no equipment. The teachers selected activities daily and demonstrated and explained these in class and encouraged the learners to perform these at home.

3.5.5. Physical Activity-Friendly School Environment

A low-cost intervention, with the aim of creating an environment that promotes more physical activity at school, was created at the intervention school. Schools situated in disadvantaged communities often do not have sufficient resources to create an environment conducive to free play. Refer to Appendix C, Figure C.3, that illustrates the school terrain before the physical activity-friendly environment was created.

Physical activity was encouraged through the implementation of physical play structures and stations (jungle gyms, balance beams, monkey bars, tyre stations and over- and under bars), illustrated in Appendix C, Figure C.4. Various colourful painted games on the school terrain were also created, in an attempt to improve physical activity levels and brighten the school environment (Appendix C, Figure C.5). Furthermore, school sport was also encouraged by upgrading facilities (painting netball courts and fixing soccer goal posts) and providing small equipment to facilitate practices, including balls, bibs, whistles and cones (see, Appendix C, Figure C.1).

3.6. Measuring Instruments and Techniques

Health-related physical fitness parameters were measured over three testing phases, namely baseline testing (T1), followed by two post-intervention testing phases (T2 and T3). Table 3.1 shows the research study timeline and the intervention and testing phases. The anthropometric and physical fitness components that were measured to determine the effect of the physical activity intervention are summarised in Table 3.5.

Table 3.5: Anthropometric and physical fitness components assessed

Component	Assessment Used
Anthropometric Measures	
Body composition	Body Mass Index (BMI) (body mass and stature)
	Estimated body fat percentage (sum of triceps and subscapular skinfolds)
Indicators of nutritional status	Weight-for-age z-scores (WAZ) Height-for-age z-scores (HAZ) BMI-for-age z-scores (BAZ)
Physical Fitness Measures	
Cardiorespiratory fitness	20-metre multistage shuttle run
Upper body muscular strength	Grip strength (handheld dynamometer)
Lower body muscular strength[14]	Standing broad jump
Lower body flexibility	Sit-and-reach

[14] Also referred to as lower body musculature power or explosive power.

The following sub-sections elaborate on each of the components that were measured. The different tests that were used are described, as well as the instruments and techniques that were used to obtain the data.

3.6.1. Anthropometric Measurements

Anthropometry refers to the science that deals with measuring the size, mass and proportions of the human body. The anthropometric measures included body mass, stature and triceps, and subscapular skinfolds. From these anthropometric measures, body mass index and estimated body fat percentage were calculated. Furthermore, indicators of nutritional status, WAZ, HAZ and BAZ, were also calculated to assess learners' growth. All the anthropometric measures were based on standards of the International Society for the Advancement of Kinanthropometry (ISAK) (Norton, Olds & Australian Sports Commission 2007: 25-76). Detailed explanations of each anthropometric measure and the variables that were calculated are provided below.

3.6.1.1. Body Mass

Purpose: Measure body mass of participant, and along with stature, determine estimated body composition through BMI calculation.

Equipment: An electronic digital scale, Scalemaster microelectronic platform T7E (Optima Electronics; George, South Africa), was used to measure body mass. Refer to Figure 3.4 displaying the equipment and procedure.

Set Up: The scale was calibrated before use in each testing phase and was accurate to the nearest 100 gram (g). The scale was placed on a flat and level surface. It was ensured that the reading was zero (0.00 kg) before each measurement was taken.

Method: Each participant was asked to remove shoes and jerseys or jackets to allow weighing with minimal clothing. The participant stood in the centre of the scale and was asked to displace mass evenly over both feet, while standing upright and looking straight ahead. Minimal movement was ensured before the measurement was recorded.

Unit of Measure: Body mass was measured in kilograms (kg), to the nearest 0.1 kg.

Number of Trials: One measurement was taken.

Scoring: The body mass measure was used to calculate the BMI, along with stature, as well as WAZ.

Validity and Reliability: Face validity was accepted. Reliability was accepted due to the measurements being taken by qualified personnel, using appropriate, calibrated equipment.

Reference of Measure: *Anthropometrica: A Textbook of Body Measurement for Sports and Health Education* (Norton *et al.*, 2007: 29-38).

Figure 3.4: Body mass measurement equipment and procedure

3.6.1.2. Stature

Purpose: Measure stature of participant and determine estimated body composition through calculating BMI along with body mass.

Equipment: Seca portable stadiometer, model 213 (Surgical SA; Johannesburg, South Africa) was used to measure stature. Refer to

Figure 3.5 displaying the equipment and procedure.

Set Up: The stadiometer was assembled on a flat, level surface.

Method: The participant was asked to remove his or her shoes and stand with his or her thoracic spine, gluteus and the back of the heels against the stadiometer. The participant was instructed to stand in an erect position with the feet together.

The head was placed in the Frankfort plane, where the upper margin of the external auditory canal lines up horizontally with the lower margin of the orbit. The headboard was lowered to the vertex of the head and gentle pressure was applied to compress hair. The measurement was taken at the end of an inhalation.

Unit of Measure: Stature was measured in centimetres (cm), to the nearest 0.1 cm.

Number of Trials: One measurement was taken.

Scoring: The stature measure was used to calculate BMI, along with body mass, as well as HAZ.

Validity and Reliability: Face validity was accepted. Reliability was accepted due to the measurements being taken by qualified personnel, using appropriate, calibrated equipment.

Reference of Measure: *Anthropometrica: A Textbook of Body Measurement for Sports and Health Education* (Norton *et al.*, 2007: 29-35).

Figure 3.5: Stature measurement equipment and procedure

3.6.1.3. Body Mass Index

Purpose: Body mass index (BMI) is calculated to estimate body composition and used as an indicator of body fatness. Body Mass Index is an inexpensive and easy measure to categorise body mass in relation to stature, that might lead to increased health risks.

Variables: Body mass and stature measurement are required to calculate BMI.

Calculation: To calculate BMI, the body mass in kilograms is divided by the square of stature in metres (m).

$$\text{BMI} = \text{Body Mass (kg)} \div \text{Stature (m)}^2$$

Unit of Measure: BMI is measured in $kg.m^{-2}$.

Classification: For children aged 5-19 years, BMI is age- and gender-specific and classification criteria are referred to as BAZ. Section 3.6.1.6, show the full BAZ scoring and classification.

Reference of Measure: *Anthropometrica: A Textbook of Body Measurement for Sports and Health Education* (Norton *et al.*, 2007: 365-371).

3.6.1.4. Triceps and Subscapular Skinfold Measurement

Purpose: Skinfolds are measured to estimate body fat percentage of each participant.

Equipment: To obtain a skinfold landmark, a dermographic pen and a flexible, non-extensible steel tape was required, calibrated in cm with millimetre (mm) gradation to measure prescribed distances from bony landmarks. To obtain the skinfold measurement, a Harpenden skinfold caliper was used, with a compression of 10 g per mm^2 and calibrated to 80 mm in 0.2 mm increments.

Refer to Figure 3.6 displays the equipment (flexible streel tape and skinfold caliper), landmarks and procedure used.

Set Up: Private locations, separating girls and boys, were used to measure skinfolds. Before the measurement was taken, the caliper was shown to the learner and his or her finger clamped to show that the measurement would not hurt. The learners stood erect with the arms relaxed at the side while the landmarks were located, and the measurements taken.

Method: A dermographic pen was used to mark the skin on the designated landmarks and a double fold of skin, with the underlying subcutaneous adipose tissue, was raised on the right side of the body, with the measurer's index finger and thumb. The grip was maintained and the skinfold caliper was placed perpendicular to the skinfold and mid-fingernail length deep. The full force of the caliper was released by removing the finger from the caliper trigger and the measurement taken after two seconds (sec), to allow compressibility of the adipose tissue.

Triceps skinfold

The triceps skinfold site was located by marking the mid-acromiale-radiale landmark through palpation of the acromiale and radiale. The vertical triceps fold, parallel to the upper arm, was taken at the mid-acromiale-radiale site over the most posterior aspect of the right triceps.

Subscapular skinfold

The skinfold was located by marking the under-most tip of the inferior angle of the scapula. A 2 cm lateral and obliquely downward mark was made at a 45° angle, aligning with the natural lines of the skin. The diagonal fold was raised and measured.

Unit of Measure: Skinfold measurements were taken in mm to the nearest 0.1 mm.

Number of Trials: Three skinfold measurements of the triceps and subscapular were taken and averaged to obtain the final triceps and subscapular measures, respectively. Triceps and subscapular measures were taken one after the other to ensure that the compressibility of subcutaneous tissue did not influence the result. Measures that differed more than ± 5% from the previous measure were repeated.

Scoring: Triceps and subscapular skinfold measures were used to estimate body fat percentage. The calculation used to obtain body fat percentage from the skinfold measures, is given in 3.6.1.5.

Validity and Reliability: Face validity was accepted. Reliability was accepted due to the measurements being taken by qualified personnel, using appropriate, calibrated equipment.

Reference of Measure: *Anthropometrica: A Textbook of Body Measurement for Sports and Health Education* (Norton *et al.*, 2007: 44-47).

Figure 3.6: Triceps and subscapular measurement equipment and procedure

3.6.1.5. Estimated Body Fat Percentage

Purpose: Estimated body fat percentages is used to categorise body fat that indicates increased health risks.

Variables: The sum of the triceps and subscapular skinfolds is used to calculate estimated body fat percentage.

Calculation: If the sum of the triceps and subscapular skinfolds was ≤ 35 mm, the following formula was used:

Girls: 1.33 (triceps + subscapular) - 0.013 (triceps + subscapular)^2 – 2.5
Boys: 1.21 (triceps + subscapular) - 0.008 (triceps + subscapular)^2 – 3.2

If the sum of the triceps and subscapular skinfolds was > 35 mm, the following formula was used:

Girls: 0.546 (triceps + subscapular) + 9.7
Boys: 0.783 (triceps + subscapular) + 1.6

Unit of Measure: Estimated body fat is a percentage.

Reference of Measure: Skinfold Equations for Estimation of Body Fatness in Children and Youth (Slaughter, Lohman, Boileau, Horswill, Stillman, Van Loan & Bemben, 1988).

3.6.1.6. Indicators of Nutritional Status

Purpose: Children's growth and general nutritional status can be assessed by using anthropometric measures, body mass and stature measures, and applying standardised age- and gender-specific growth references to calculate WAZ, HAZ and BAZ.

Variables: To calculate WAZ, HAZ and BAZ indicators, body mass and stature measures were required.

Equipment: Calculations were completed on the World Health Organization's AnthroPlus Software for Personal Computers: Software for Assessing Growth of the World's Children and Adolescents (Department of Nutrition; Geneva, Switzerland) (World Health Organization, 2009).

Calculation: Indicators were calculated by using the following formula:

z-score = observed value – mean value of the reference population ÷ standard deviation (SD) value of reference population

Unit of Measure: The indicators were expressed as a number of SD or z-scores above or below a reference mean value.

Classification: The following classifications were used for indicators of nutritional status:

Table 3.6: Classification of indicators of nutritional status

Weight-for-age z-scores (WAZ)	
Only until age of 10 years	
< -2 SD to -3 SD	Underweight
< -3 SD	Severely Underweight

Height-for-age z-scores (HAZ)	
< -2 SD to -3 SD	Stunted
< -3 SD	Severely Stunted

Body-mass-index-for-age z-scores (BAZ)	
> 2 SD	Obese
> 1 SD to <= 2 SD	Overweight
-2 SD to 1 SD	Normal
< -2 SD to -3 SD	Thin
< -3 SD	Severely Thin

Reference of Measure: 2006 World Health Organization Growth Standards (de Onis, Onyango, Borghi, Siyam, Nishida & Siekmann, 2007).

3.6.2. Physical Fitness Measurements

For the purpose of this study, physical fitness measures were assessed and included estimated cardiorespiratory fitness, upper body muscular strength, lower body muscular strength and lower body flexibility. All of these variables were adapted from the *Eurofit: European Tests of Physical Fitness Manual* (Council of Europe Committee for the Development of Sport, 1993). Detailed explanations of each fitness measure and variable that was calculated follow below.

3.6.2.1. Cardiorespiratory Fitness

Purpose: The multistage 20-metre shuttle run test was performed to estimate the participant's cardiorespiratory fitness in terms of maximal oxygen uptake ($\dot{V}O_2$max).

Equipment: To perform the multistage shuttle run test, the following equipment was required:

- Measuring rope;
- Coloured cones;
- Score counting sheet;
- Shuttle run audio guide and speaker;
- Numbered bibs; and
- A pace runner.

Set Up: An 80 m measuring rope was used to mark a 20 m by 20 m square, on a flat running surface. Coloured cones were used to mark the start and the 20 m mark. The audio system was placed within listening distance of the runners. The score counting sheet, showing the number of laps completed, was placed to the side of the field so that it could easily be seen by the assistants counting the completed laps. Each participant wore a numbered bib.

Method: Before the shuttle run test started, the participants were given a chance to familiarise themselves with the audio system by completing two 20 m shuttle runs. Once the two trials were completed, the participants ran in groups of ten back and forth between the 20 m marked cones, following the pre-set sound signals. A pace runner ran with the learners to assist them in keeping time with the audio guide and to provide motivation to continue running. Such encouragement to continue running is allowed by the protocol. The running speed of the pre-recorded audio guide started at 8 kilometres per hour (km.h^{-1}) and gradually increased every minute by 0.5 km.h^{-1}. Refer to

Figure 3.7 for the display of the procedure.

The test was terminated if the participant stopped due to exhaustion or failed to follow the pace for two consecutive intervals, i.e. not reaching the 20 m mark for two consecutive intervals.

Number of Trials: One maximum run attempt was allowed, which included two 20 m trial runs before the test started.

Scoring: The number of full laps was recorded, as shown on the lap score counting sheet, when the test was terminated for each participant.

Variables: To calculate estimated cardiorespiratory fitness in terms of $\dot{V}O_2$max, the final speed in km.h^{-1} and the participant's age, in years, was required.

Calculation: The following equation was used to calculate estimated cardiorespiratory fitness in terms of $\dot{V}O_2$max:

Estimated $\dot{V}O_2$max = 31.025 + 3.238 x speed (km.h^{-1}) – 3.248 x age (years) + 0.1536 x age (years) x speed (km.h^{-1})

Unit of Measure: For the multistage 20 m shuttle run test, only full completed laps that were run were counted, and converted to a speed value in km.h^{-1}.

Estimated maximal oxygen uptake ($\dot{V}O_2$max) was calculated in millilitres of oxygen per minute per kilogram of body mass (ml.min^{-1}.kg^{-1}).

Validity and Reliability: Validity in children can be predicted from the maximal aerobic shuttle running speed and age, with 0.71 correlation and a standard error of the estimate of 5.9 ml.min^{-1}.kg^{-1} or 12.1%.

The 20 m shuttle run test was found to be reliable in children (r = 0.89), with no significant differences (P > 0.05) between the test and retests.

Reference of Measure: The Multistage 20-metre Shuttle Run Test for Aerobic Fitness (Léger, Mercier, Gadoury & Lambert, 1988).

Figure 3.7: 20-metre multistage shuttle run measurement procedure
Bottom most picture showing the pace runner, the male running in the centre.

3.6.2.2. Upper Body Musculature Strength

Purpose: Grip strength was measured with a handheld dynamometer to estimate upper body strength.

Equipment: A Saehan hydraulic handheld dynamometer (MSD Europe BVBA; Tisselt, Belgium) and a stopwatch, to ensure that a 30 sec rest interval between repeated measures with the same hand, were implemented to measure upper body strength. Refer to

Figure 3.8 displaying the equipment and procedure.

Set Up: Each participant had their dominant hand noted and dominant hand span measured, from the tip of the thumb to the tip of the little finger. The dynamometer was adjusted accordingly to ensure that maximum force could be applied. Furthermore, before each measurement, the tester ensured that the dynamometer dial was on 0.00 kg before initiating the next trial.

Method: In a seated position, each participant was instructed to maintain the measured hand's elbow at 90°, without squeezing the elbow against the body. Each participant was instructed to grip the dynamometer as hard as possible, while verbal encouragement was given.

Scoring: The value was read off the dynamometer after approximately two secs of maximal force being applied. For the final result, the dominant hand maximum grip strength was used, regardless of the highest measure obtained.

Number of Trials: Three trials each were measured alternately with the dominant and the non-dominant hand, and the highest score for each hand was used as the final result. A 30 sec rest period between each repeated measure of the same hand as well as between hands was given, as this test requires maximum effort.

Unit of Measure: Grip strength was measured in kg, to the nearest 0.1 kg.

Validity and Reliability: Face validity was accepted. Reliability was accepted due to the measurements being taken by qualified personnel, using appropriate, calibrated equipment.

Reference of Measure: *EUROFIT European Tests of Physical Fitness* (Council of Europe Committee for the Development of Sport, 1993).

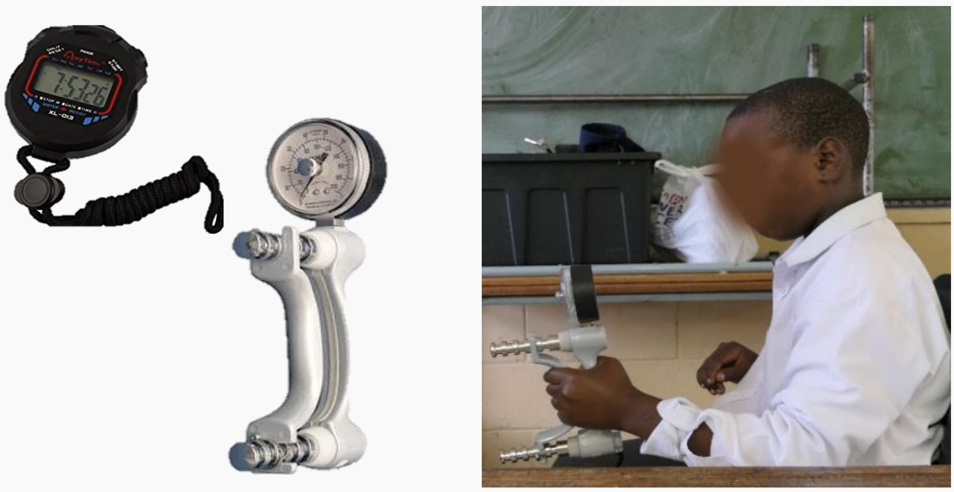

Figure 3.8: Upper body muscular strength measurement equipment and procedure

3.6.2.3. Lower Body Musculature Strength

Purpose: The standing broad jump test was used to estimate lower body musculature strength and explosive power.

Equipment: To perform the standing broad jump test, the following equipment was required:

- Black spray paint to mark a starting line;
- A measuring tape to measure the distance jumped; and
- A tent peg, T-stick and 90° triangle to aid in measuring distance.

Set Up: A straight starting line was marked with black spray paint on a level surface and a tape measure was positioned with the 0 cm mark at the starting line. A tent peg was used to secure the 0 cm mark of the measuring tape. A T-stick and 90° triangle were used to ensure that a straight measuring line, without error of parallax could be measured.

Method: Each participant was instructed to stand naturally with the feet positioned apart, with the toes touching the starting line. Furthermore, the participant was encouraged to bend the knees and use a swinging motion with the arms (counter movement jump technique) to aid in jumping forward as far as possible. The participant had to land in a standing position, with feet together and with unlocked knees. Refer to Figure 3.9 for a display of the equipment and procedure used.

Scoring: The furthest distance jumped were measured with the measuring tape. The T-stick and 90° triangle were used to ensure a straight measuring distance from the starting line to the participant's heel, closest to the starting line.

Number of Trials: For the standing broad jump test, two trials were completed, and the highest value was used for the final result. One practice trial was given before the test started.

Unit of Measure: Standing broad jump distance was measured in m to the nearest 1 cm.

Validity and Reliability: Face validity was accepted. Reliability was accepted due to the measurement often being used in test batteries and being conducted by qualified personnel, using appropriate equipment.

Reference of Measure: *EUROFIT European Tests of Physical Fitness* (Council of Europe Committee for the Development of Sport, 1993).

Figure 3.9: Lower body muscular strength measurement equipment and procedure

3.6.2.4. Lower Body Flexibility

Purpose: The sit-and-reach test was used to determine lower body flexibility, specifically around the hip joint, involving the hamstrings and lower back musculature.

Equipment: A sit-and-reach box (40 cm by 40 cm with an extra overhang of 26 cm) was required. A measuring ruler was mounted on the box, from the start of the overhang to the end of the box. An exercise mat was also used to sit on.

Set Up: The sit-and-reach box was placed on an exercise mat. The one end of the mat and the back of the box was placed against a wall.

Method: The participants were instructed to remove shoes and to sit on the exercise mat, the feet flat against the inside of the box and the overhang towards the participant. The participants had to place their hands over each other and reach forward as far as possible, along the measuring ruler, during an exhalation. Straight knees needed to be maintained throughout the movement. Refer to Figure 3.10 for a display of the equipment and procedure used.

Scoring: While the participant reached forward, the tester placed his / her hand on the participant's knees to ensure that their legs remained straight throughout the movement. The tester recorded the furthest distance the participants reached with their middle fingers, along the attached ruler.

Number of Trials: Two sit-and-reach trials were measured, and the furthest distance was regarded as the final result.

Unit of Measure: Sit-and-reach distance was recorded in cm to the nearest 0.1 cm.

Validity and Reliability: Face validity was accepted. Reliability was accepted due to the measurements being taken by qualified personnel, using appropriate, calibrated equipment.

Reference of Measure: *EUROFIT European Tests of Physical Fitness* (Council of Europe Committee for the Development of Sport, 1993).

Figure 3.10: Lower body flexibility measurement equipment and procedure

3.7. Data Collection

During data collection, research assistants from the Nelson Mandela University were used. Biokineticist post-graduate students were used as main test administrators, as they possess the knowledge and experience to successfully perform the required tests. Undergraduate Human Movement Science students were used to ensure well-organised data collection, and assisted by fetching participants, setting-up testing stations and scribing while the measurements were taken. Workshops were held with all research assistants to ensure consistency in testing procedures and efficient data collection.

As mentioned, data was collected at three testing phases, baseline testing (T1) and two post-intervention testing phases (T2 and T3) to assess the effect of the physical activity intervention. Table 3.1 in section 3.2 shows the testing and intervention phases. All the data collection phases consisted of the same tests and screenings and contained the following:

1. A clinical examination by a registered medical nurse to identify any health problems and subsequent exclusion from the physical fitness assessment (Appendix B).
2. Body composition measurements including body mass and stature, and triceps and subscapular skinfold measurements (Appendix B).
3. A physical fitness assessment, consisting of cardiorespiratory fitness, upper- and lower muscular strength and lower body flexibility (Appendix B).

4. Other measures conducted on the same participants and which formed part of the larger DASH project and not the current study, included: Soil-Transmitted Helminth (STH)[15] infection screening of participants' stool samples using the Kato-Katz thick smear technique[16]; Selective Attention with the d2 Test for Attention; and various psychosocial health assessment questionnaires. For more information on these assessments, refer to the protocol article published (Yap *et al.*, 2015).

All data collection was conducted at the respective schools during school hours to ensure as little disruption to the school setting as possible. During each of the testing phases, data were collected over a three-day period for each school. The first testing day encompassed all the health screening components, including the clinical examination, body composition measurements, STH screenings and psychosocial health assessments. The second testing day consisted of all the physical fitness measurements. The third testing day served as a buffer, allowing for catch-up testing of any missed assessments from the first two days, or assessment of any participants who may have been absent. Refer to Figure 3.11 showing the layout of the tests per testing day.

[15] Soil-transmitted helminths refer to the intestinal worms infecting humans, that are transmitted through contaminated soil (World Health Organization, 2018d).

[16] Kato-Katz thick smear technique is a laboratory method for preparing human stool samples prior to searching for parasite eggs (Microbe Online, 2016).

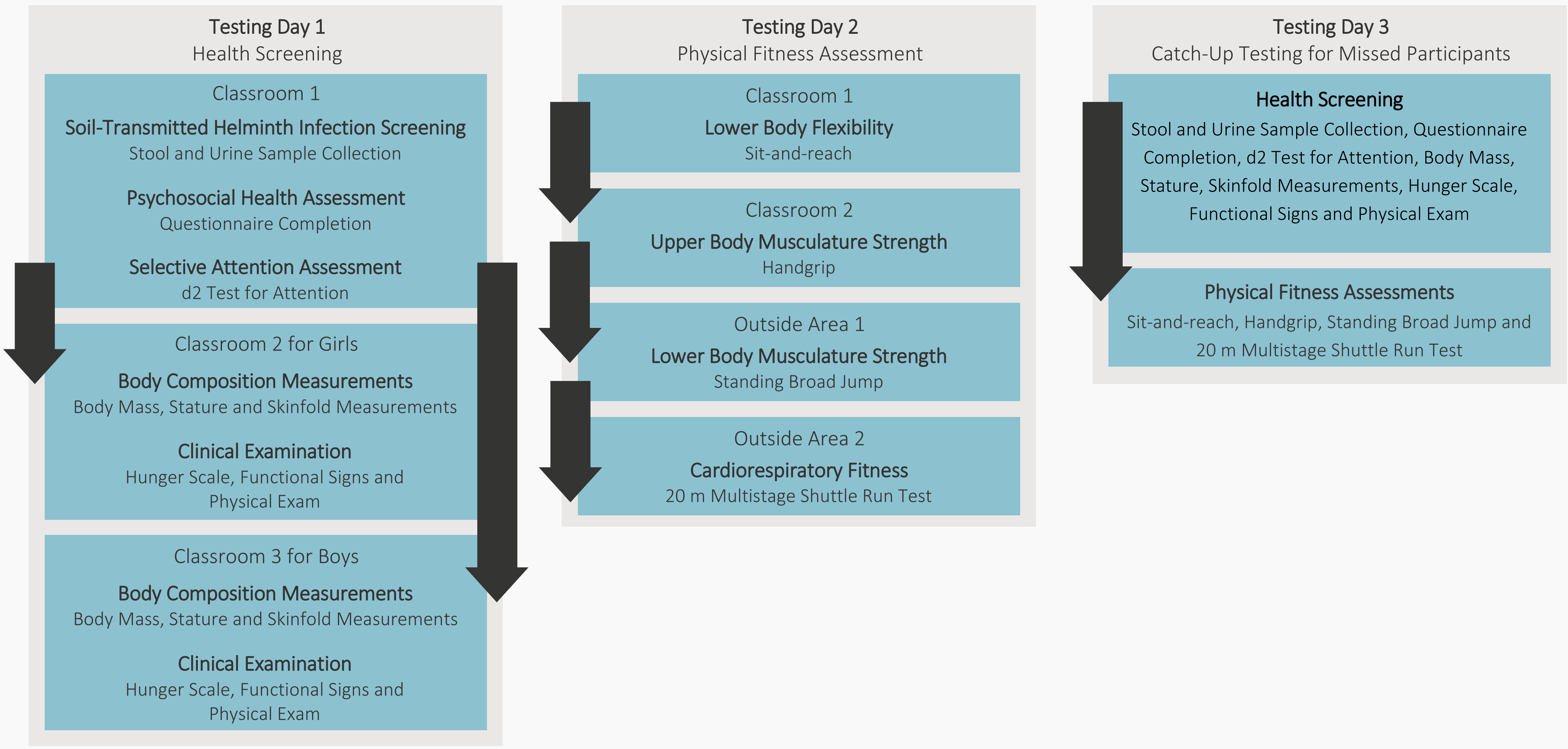

Figure 3.11: Graphic representation of test layout and flow for each testing day

3.8. Data Analysis and Interpretation

Quantitative data was collected from all three testing phases to assess the effect of the physical activity intervention. A statistician affiliated with the Nelson Mandela University assisted with the analyses and interpretation of the data. All the statistics were performed with Statistica version 13.3 for Windows (Dell Software Inc; Texas, United States of America) and Microsoft Excel 2016 for Windows (Microsoft Office; Washington, United States of America).

To ensure that data was correctly captured from the data collection sheets, EpiData 3.1 software (EpiData Association; Odense, Denmark) was used for double entry[17] and validation.

Data that is normally distributed is an important requirement for many statistical techniques. Therefore, before statistical analyses commenced, data distributions were analysed and where non-normal distributions were identified, Box Cox and Log transformations were applied to normalise these distributions.

Statistical techniques used to analyse the collected data included the following descriptive and inferential statistics.

Descriptive statistics were calculated for the entire sample, as well as the intervention and control group separately, and included:

1. Central tendency, including means (M) and medians (Mdn); and
2. Quartiles, standard deviations (SD), standard error of mean (SEM), relative standard deviation (RSD) and percentages (%) for categorical values[18].

Inferential statistics was used to determine whether the effects of the physical activity intervention were statistically significant. A series of multiple regression analysis using indicator variables[19] was used for categorical variables. Stepwise elimination was used to arrive at a final model.

Independent variables included:

1. Testing phase;
2. Age;
3. Gender;
4. Body mass; and
5. Stature.

To aid in interpretation, 95% confidence intervals (CI) are presented. Values highlighted in red text depict statistical significance, which was set at $p < 0.05$[20] across all analyses. Lastly, the mean and standard deviation is presented in brackets.

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[17] Double entry refers to a technique where the same data is captured twice, by two different people, to ensure that the correct data is captured from a written form to an electronic database. Double entry is the gold standard to transfer paper-based data to an electronic format (Paulsen, Overgaard & Lauritsen, 2012).

[18] Categorical variables refer to variables made up of categories, e.g. gender referring to girls and boys (Field, 2016: 377-380).

[19] An indicator variable refers to an artificial dichotomous variable used as an independent variable in regression, indicating either the presence or the absence of a characteristic, e.g. intervention group = 1, control group = 0.

[20] The p-value refer to the probability at which you are prepared to believe a hypothesis (Field, 2016: 339-341)

3.9. Ethical Considerations

Researchers have two basic categories of ethical responsibility, firstly to the participants in the research study, whether human or non-human, and secondly to the discipline of science, which refers to accurate and honest reporting of research and subsequent findings (de Vos, Strydom, Fouche & Delport, 2005: 56). Research ethics focuses on the researcher's responsibility to be honest and respectful to all individuals who are in any way affected by the research study (Gravetter & Forzano, 2011: 108). Due to the especially vulnerable sample in this study, namely primary schoolchildren from disadvantaged communities, great care was taken to ensure the highest ethical standards throughout the research process.

Before the DASH research study commenced, ethics approval for the study was sought from the Ethical Committee Northwest and Central Switzerland in Basel, Switzerland. This was obtained on 1 August 2014 (Appendix D, section i.). Furthermore, ethical approval was sought in Port Elizabeth, South Africa, from the following organisations:

a. The Nelson Mandela University Research Ethics Committee (Human), whose approval was obtained on 4 July 2014 for the larger DASH project (Appendix D, section ii.);
b. The Nelson Mandela University Research Ethics Committee (Human), whose approval was obtained on 29 April 2016 for this research study (Appendix D, section iii.);
c. The Eastern Cape Department of Education, which granted permission on 13 August 2014 (Appendix D, section iv.); and
d. The Eastern Cape Department of Health, which gave permission on 7 November 2014 (Appendix D, section v.).

Furthermore, the following ethical principles were also addressed throughout the research process to ensure that the research was conducted in an ethical manner:

1. **Avoidance of harm:** Due to the vulnerability of the participating children, it was of the utmost importance to ensure that they were not exposed to any harm, as suggested by de Vos *et al*. (2005: 58), whether this was physical, emotional, social or any other form of harm.

2. **Informed consent:** All participants had the right to informed consent (de Vos *et al*. 2005: 59). The parent or guardian of each participant was provided with an information sheet in either English, Xhosa or Afrikaans, providing details pertaining to the research study. Each participant's parent or legal guardian provided written consent that allowed his or her child to participate in the study. Each child also gave verbal assent to participate. It was emphasised that participation was completely voluntary and, therefore, that withdrawal from the study could occur at any time without any explanation, consequences or further obligation. Appendix A contains all the study consent forms in English.

3. **Privacy, anonymity and confidentiality:** This principle deals with the right of the participant to decide when, where, to whom, and to what extent the findings of the research study would be revealed (de Vos *et al*. 2005: 61). Great care was taken to ensure each participant's anonymity by coding his or her identity as well as the primary schools that were used for the research study. Only the core research team had access to the un-coded information, and anybody else that had access to the data (statisticians for example), only had access to coded information.

4. **Competence of the researchers:** The researchers conducting the study are ethically obligated to make sure that they are competent and possess the required skills to undertake the research project (de Vos *et al.*, 2005: 63). It is also their responsibility to ensure that the study was conducted in an ethical manner from start to completion. The principal investigators of the study, both from Switzerland and South Africa, had well-established and sound research experience.

5. **Release and publication of results:** This principle deals with the dissemination of the results and findings of the study (de Vos *et al.*, 2005: 65). The research team focused on not only making the results of the study public on scientific platforms in the form of journal articles, but also to the school setting, informing principals, teachers, learners and parents, of the study outcomes. Schools were provided with the study outcomes in the form of a symposium that was held at the Nelson Mandela University in October 2017.

6. **Research Policies for Human Participants:** The study was conducted in accordance with several research ethic policies, including: the Declaration of Helsinki (World Medical Association, 2013), International Conference on Harmonisation – Good Clinical Practice (ICH – GCP) (ICH Expert Working Group, 1996) as well as the Nelson Mandela University's Policy on Research Ethics for human participants.

Furthermore, the control group of the study will serve as waiting-list control,

Lastly, to ensure transparency and to improve research awareness for clinicians, researchers, patients and the public, the DASH project was registered under the International Standard Registered Clinical Trial Number (ISRCTN) registry. The ISRCTN registry is a primary clinical trial registry recognised by the World Health Organization and the International Committee of Medical Journal Editors. The DASH project unique identifier is ISRCTN68411960, and the study was registered on 1 October 2014.

3.10. Conclusion

In summary, this chapter described the research methods and procedures that was used to conduct the study. The study followed a cluster randomised controlled trial design to establish the effect of a school-based physical activity intervention on schoolchildren's body composition, (body mass index and estimated body fat percentage) and physical fitness (cardiorespiratory fitness, upper- and lower body musculature strength and flexibility) in disadvantaged communities in Port Elizabeth.

The following chapter, Chapter 4, contains the results of the study that were obtained following the methods and procedures described in Chapter 3.

Chapter 4 : Study Results

4.1. Introduction

This study set out to determine the effect of a school-based physical activity intervention on the body composition and physical fitness of primary schoolchildren in disadvantaged communities. This chapter presents the results of the study and addresses the research objectives described in Chapter 1, section 1.3.

The chapter commences with information on the demographic profile of the participants, including gender, ethnicity and age distributions. This is followed by descriptive and inferential statistics for each measured body composition- and physical fitness parameter, across the three testing phases.

4.2. Demographic Profile of Participants

The study sample consisted of 157 participants. This comprised of 65 participants in the intervention group and 92 participants in the control group.

4.2.1. Gender and Ethnicity

The entire study's gender distribution is displayed in Figure 4.1. The study sample involved more girls than boys overall, as well as for both the intervention and control groups.

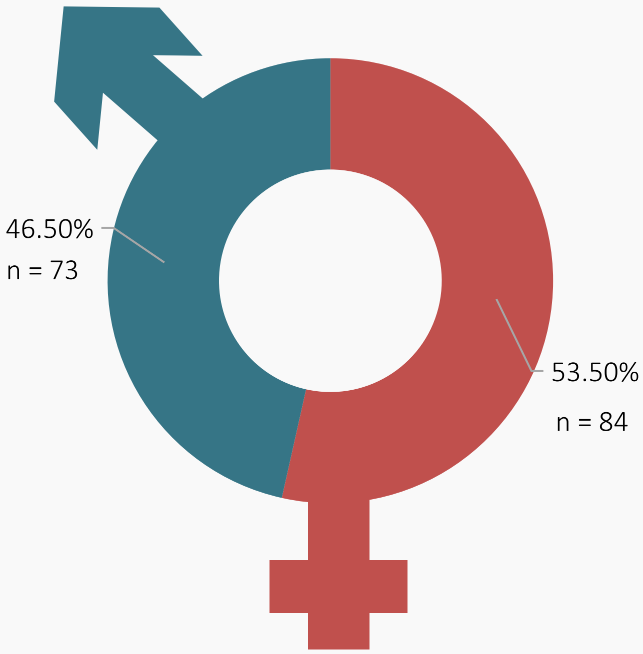

Figure 4.1: Gender distribution of the entire study sample

The gender distribution of the study is displayed in Table 4.1. The sample sizes (n) as well as the relevant percentage values (%) are displayed for the intervention group and the control group respectively.

Table 4.1: Gender distribution between the intervention and control group

	Intervention Group		Control Group	
	n	%	n	%
Girls	37	56.92 %	47	51.09 %
Boys	28	43.08 %	45	48.91 %
Total	65	100%	92	100%

Furthermore, the entire study sample was homogenous with regards to ethnicity, and consisted only of Black African, Xhosa speaking schoolchildren.

4.2.2. Age

The ages of the participants were analysed because young children, falling within the age ranges of the study sample, experience wide variation in growth and development. Body composition and physical fitness parameter changes are closely associated with these growth and development phases, and therefore the effect of age needed to be accounted for. Furthermore, the age in months, as opposed to the age in years, were used for data analysis to further account for age variations.

The descriptive statistics of age, for the intervention and control group, can be found in Table 4.2. Summary descriptive statistics, Figure E.1, for the entire study sample, as well as descriptive statistics for girls, see Table E.1, and boys, see Table E.2, between each of the testing phases, can be found in Appendix E, section 1.

Table 4.2: Descriptive statistics age (months): Comparison within and between the intervention group (IG) and control group (CG), across three testing phases (T1, T2, and T3)

	Intervention group			Control group		
	T1	T2	T3	T1	T2	T3
n	65	65	65	92	92	92
M	118.09	125.40	132.68	112.73	120.71	127.33
S.D.	11.18	11.11	11.11	8.70	8.72	8.67
Min	104.00	112.00	119.00	101.00	109.00	116.00
Quartile 1	110.00	117.00	124.00	107.00	115.00	121.00
Mdn	115.00	122.00	129.00	111.00	119.00	125.00
Quartile 3	124.00	131.00	138.00	116.00	124.00	131.00
Max	152.00	159.00	167.00	143.00	151.00	157.00
SEM	1.39	1.38	1.38	0.91	0.91	0.90
RSD	9.47	8.86	8.37	7.72	7.22	6.81
	Intervention group			**Control group**		
	T2-T1	**T3-T2**	**T3-T1**	**T2-T1**	**T3-T2**	**T3-T1**
Difference	7.31	7.28	14.58	7.98	6.62	14.60
% Difference	6.19	5.80	10.99	7.08	5.48	11.46
	Comparison between the intervention and control group					
	T1 CG-IG		**T2 CG-IG**		**T3 CG-IG**	
Difference	-5.36		-4.69		-5.35	
% Difference	-4.54 %		-3.74 %		-4.03 %	

At baseline testing, the age of the entire study sample ranged from 101 to 152 months (115.19 ± 9.51 months) or eight to 12 years (9.6 ± 0.79 years). The girls and boys of the intervention group were older than the girls and boys of the control group, see Table E.1 and Table E.2.

When considering the age differences between the genders, boys were older than girls in the entire study sample (girls: 111.82 ± 7.51 months / 9.32 ± 0.63 years; boys: 118.55 ± 11.51 months / 9.88 ± 0.96 years), as well as in the intervention group (girls: 113.14 ± 7.17 months / 9.43 ± 0.6 years; boys: 124.64 ± 12.23 months / 10.39 ± 1.02 years) and the control group (girls: 110.79 ± 7.68 months / 9.23 ± 0.64 years; boys: 114.76 ± 9.23 months / 9.56 ± 0.78 years) see Table E.1 and Table E.2.

Table 4.3 shows the distribution of the participants, according to gender and age at baseline testing.

Table 4.3: Frequency distribution: Participants' gender and age (in years)

	Intervention Group		Control Group		Entire Study Sample	
	n	**% Entire Sample**	**n**	**% Entire Sample**	**n**	**% Entire Sample**
Girls 8 years	8	5.10 %	17	10.83 %	25	15.92 %
Girls 9 years	23	14.65 %	25	15.92 %	48	30.57 %
Girls 10 years	5	3.18 %	4	2.55 %	9	5.73 %
Girls 11 years	1	0.64 %	1	0.64 %	2	1.27 %
Girls 12 years	0	0.00 %	0	0.00 %	0	0.00 %
Boys 8 years	0	0.00 %	10	6.37 %	10	6.37 %
Boys 9 years	12	7.64 %	24	15.29 %	36	22.93 %
Boys 10 years	9	5.73 %	8	5.10 %	17	10.83 %
Boys 11 years	4	2.55 %	3	1.91 %	7	4.46 %
Boys 12 years	3	1.91 %	0	0.00 %	3	1.91 %
Total	65	41.40 %	92	58.60 %	157	100%

The control group did not only comprise of a larger percentage of participants, but in respect of both genders the control group had larger percentage of younger participants, particularly in the 8-year-old category.

4.3. Anthropometric Measures

The following section provides the descriptive and inferential statistics for the body composition measures, including body mass index and estimated body fat percentage. For each measure, the section starts with the descriptive statistics, comparing the intervention to the control group for each testing phase – addressing the first study objective. This is followed by descriptive statistics comparing the intervention and control group between the three testing phases – addressing the second and third study objectives. Furthermore, multiple regression analysis using indicator variables[21] with stepwise eliminations, are displayed, with the intervention and control condition as the main predictor, to establish whether the intervention had a statistically significant effect on each measure. Finally, indicators of nutritional status descriptive statistics are displayed, indicating body mass-, stature- and BMI values for age and gender that fall outside normal ranges.

[21] An indicator variable refers to an artificial dichotomous variable used as an independent variable in regression, indicating either the presence or the absence of a characteristic.

4.3.1. Body Mass Index

Body mass index (BMI) was calculated using body mass and stature. The descriptive statistics, comparing the intervention and control group, as well as gender comparisons between each testing phase, for body mass and stature are reflected in Appendix E, section 2. The descriptive statistics for BMI, comparing the intervention and control groups, are presented in Table 4.4.

Table 4.4: Descriptive statistics BMI ($kg.m^2$): Comparison within and between the intervention group (IG) and control group (CG), across three testing phases (T1, T2, and T3)

	Intervention group			Control group		
	T1	T2	T3	T1	T2	T3
n	92	92	92	65	65	65
M	17.46	18.05	18.78	18.28	18.69	18.98
S.D.	2.91	3.21	3.70	4.28	4.35	4.62
Min	13.53	14.24	14.45	11.46	12.11	12.26
Quartile 1	15.65	15.98	16.40	16.24	16.58	16.67
Mdn	16.77	17.29	17.59	17.29	17.91	17.96
Quartile 3	18.32	19.07	19.85	19.30	19.82	20.18
Max	30.09	31.05	32.34	41.74	41.16	43.25
SEM	0.30	0.34	0.39	0.53	0.54	0.57
RSD	16.66	17.80	19.68	23.42	23.28	24.33
	Intervention group			**Control group**		
	T2-T1	**T3-T2**	**T3-T1**	**T2-T1**	**T3-T2**	**T3-T1**
Difference	0.59	0.73	1.32	0.41	0.29	0.70
% Difference	3.40	4.04	7.04	2.24	1.56	3.69
	Comparison between the intervention and control group					
	T1 CG-IG		**T2 CG-IG**		**T3 CG-IG**	
Difference	-0.82		-0.64		-0.20	
% Difference	-4.51 %		-3.42 %		-1.07 %	

BMI descriptive statistics for girls and boys, comparing each of the three testing phases, are presented in Appendix E, Table E.9 and Table E.10 respectively.

The BMI differences between the intervention and control group, and between genders, are highlighted in Figure 4.2 to Figure 4.4, grouped by each testing phase. Figure 4.2 shows the BMI results of the first testing phase in the form of box plots.

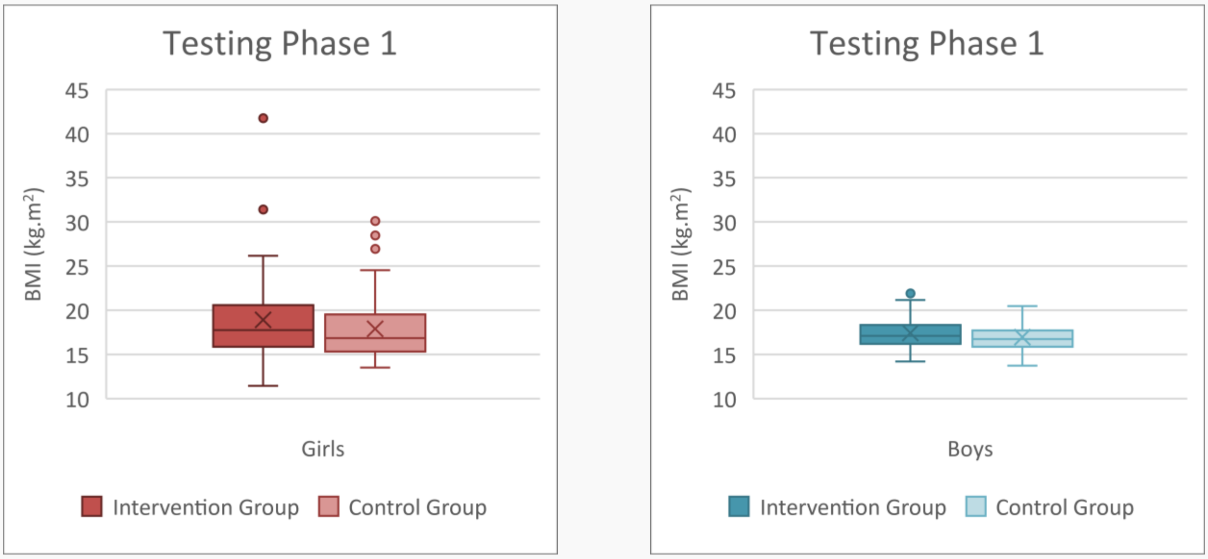

Figure 4.2: Box plots BMI (kg.m^2): Intervention versus control groups, for both genders, at testing phase 1

According to Figure 4.2, based on sample statistics only, the BMI results of the first testing phase indicate that girls had a higher BMI than boys in both the intervention and control group, see Table 4.4. There were more girls falling in the obese BMI category, depicted by the box plot outliers[22], with the highest obesity case found within the intervention group, see Figure 4.2. For both genders, the intervention group showed higher BMI means values in the first testing phase, with a 5.59 % and 2.72 % difference between the intervention and control groups for girls and boys, respectively, see Table 4.4. Figure 4.3 reflects the BMI results for the second testing phase in the form of box plots.

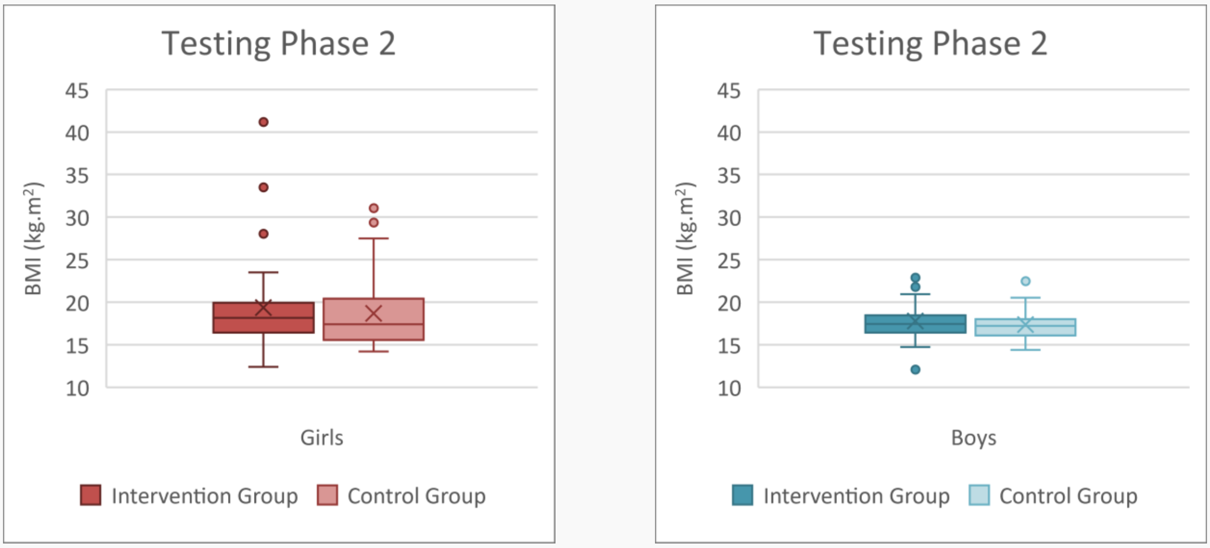

Figure 4.3: Box plots BMI (kg.m^2): Intervention versus control groups, for both genders, at testing phase 2

[22] An outlier is defined as a case greater than 1.5 times the interquartile range. An extreme outlier refers to a case greater than 3 times the interquartile range (Field 2016: 176).

Based on the sample statistics only, the BMI results in the second testing phase again show higher values for girls in both the intervention and control groups compared to boys, see Table 4.4. For both genders, the intervention group showed higher BMI mean values in the second testing phase, with a 3.63 % and 2.35 % difference between the intervention and control groups for girls and boys, respectively, see Table 4.4. Figure 4.4 depicts the BMI results from the third testing phase in the form of a box plots.

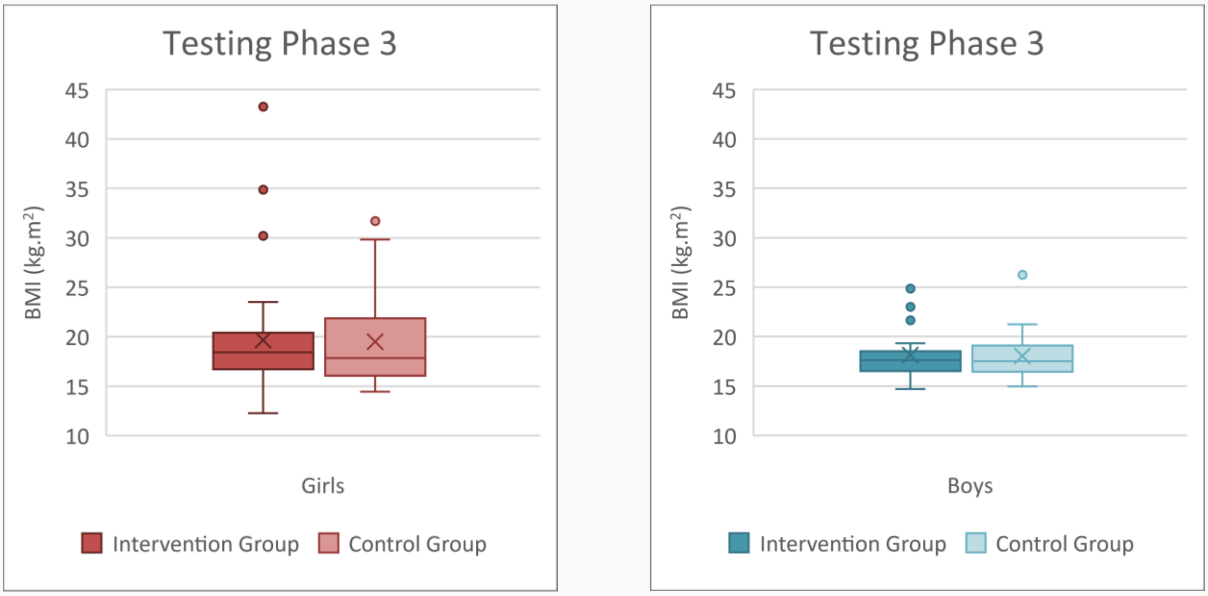

Figure 4.4: Box plots BMI (kg.m^2): Intervention versus control groups, for both genders, at testing phase 3

Based on sample statistics only, the BMI results in the third testing phase again revealed higher values for girls in both groups compared to boys, see Table 4.4. Furthermore, during testing phase three, for both genders, the intervention group again showed higher BMI mean values than the control group, see Table 4.4. For all testing phases therefore, the observed sample mean BMI in the intervention group was higher than the sample mean BMI in the control group. The probability of this happening by chance is 12.5 %.

The intervention group girls displayed an increase of 3.65 % in BMI from the first to the third testing phase, with the control group girls displaying an 8.10 % increase for the same time. The intervention- and control group boys displayed a 3.74 % increase, and a 5.84 % increase, for the same time, respectively, see Table E.9 and Table E.10. Again, these values are based on sample statistics solely, not taking any covariates into consideration.

The BMI distribution was further analysed by testing for normality to ensure that the following inferential analysis, the multiple regression model, could be validated. Figure E.2 in Appendix E, provides a graphical summary, in the form of a histogram and line graph, of the BMI distribution for the entire study. Both graphs show a non-normal distribution.

Due to BMI data displaying a non-normal distribution, the Box Cox transformation was used to transform the data to an asymptotically normal distribution. The Box Cox transformation was performed as per Equation 4.1.

Equation 4.1: BMI Box Cox transformation equation

$$Y_T = \frac{Y^{\lambda} - 1}{\lambda}$$

Where:

Y_T	= Transformed value
Y	= Original observed value
λ	= Parameter used to optimize Y_T to normality, in this case: -2.016

To transform the predicted transformed value $\hat{Y}_T$ back to the predicted value $\hat{Y}$, the following equation, Equation 4.2, was used.

Equation 4.2: BMI Box Cox reverse transformation equation

$$\hat{Y} = \left(\lambda\, \hat{Y}_T + 1\right)^{1^{\lambda}}$$

Where:

$\hat{Y}$	= Estimated Y according to the model applied
λ	= Parameter used to optimize Y_T to normality
$\hat{Y}_T$	= Transformed predicted value

Figure E.3 in Appendix E, shows a graphical summary, in the form of a histogram and line graph, of the transformed BMI data, indicating an asymptotically normal transformed distribution.

The following regression model has been used to describe the BMI data. The model equation is displayed in Equation 4.3.

Equation 4.3: BMI regression model equation

$$\hat{Y}_T = b_0 + b_1 G + b_2 A + b_3 A^2$$

Where:

$\hat{Y}_T$	= Transformed predicted value
b_0	= Intercept
$b_i, i = 1, 2, 3$	= Estimated regression coefficients
G	= Gender indicator variable, where 0 refers to boy and 1 to girl
A	= Age of the participant in months
A^2	= Non-linear effect of age

The multiple regression output for body mass index is summarised in Table 4.5.

Table 4.5: Regression summary: Box Cox transformed BMI results

Statistic	Value
Multiple R	0.224
Multiple R^2	0.050
F (6,432)	8.187
p	< 0.0001
Standard Error of Estimate	4.18E-04

		b	Standard Error	t (442)	p-value
b_0	Intercept	0.490	0.002	313.579	< 0.0001
b_1	G	1.42E-04	4.05E-05	3.518	< 0.0001
b_2	A	6.15E-05	2.46E-05	2.495	< 0.01
b_3	A^2	-2.18E-07	9.66E-08	-2.257	< 0.05
	Excluded outlier cases[23]	114, 271, 288, 428			

Table 4.5 indicates that the model is a significant fit to the data ($p < 0.0001$) and 5 % of the variation in BMI can be explained by the proposed model (Multiple $R^2 = 0.050$). The intervention / control condition did not have a significant effect on the BMI ($p > 0.05$).

4.3.2. Estimated Body Fat Percentage

Body fat percentage was calculated using the sum of triceps and subscapular skinfolds, as described by Slaughter *et al*. (1988). The descriptive statistics of body fat percentage, for the intervention and control group, can be found in Table 4.6.

Table 4.6: Descriptive statistics estimated body fat (%): Comparison within and between the intervention group (IG) and control group (CG), across three testing phases (T1, T2, and T3)

	Intervention group			Control group		
	T1	**T2**	**T3**	**T1**	**T2**	**T3**
n	92	92	92	65	65	65
M	16.26	20.16	18.21	19.97	19.58	19.29
S.D.	6.72	10.14	8.31	9.62	8.13	8.71
Min	6.33	6.26	6.26	6.97	6.04	7.40
Quartile 1	11.53	13.55	11.76	13.73	13.44	12.86
Mdn	14.77	17.29	16.02	17.80	17.68	17.17
Quartile 3	19.13	23.34	22.11	23.59	23.48	22.81
Max	35.18	55.93	42.57	66.23	43.77	48.17
SEM	0.70	1.06	0.87	1.19	1.01	1.08
RSD	41.30	50.28	45.62	48.18	41.54	45.17
	Intervention group			**Control group**		
	T2-T1	**T3-T2**	**T3-T1**	**T2-T1**	**T3-T2**	**T3-T1**
Difference	3.90	-1.95	1.95	-0.39	-0.29	-0.68
% Difference	23.98	-9.68	10.70	-1.95	-1.49	-3.53

	Comparison between the intervention and control group		
	T1 CG-IG	**T2 CG-IG**	**T3 CG-IG**
Difference	-3.71	0.58	-1.08
% Difference	-18.58 %	2.95 %	-5.60 %

[23] Cases are excluded if standard residuals are > 2 and / or < - 2.

Body fat percentage descriptive statistics for girls and boys between each of the three testing phases, can be found in Appendix E, Table E.11 and Table E.12 respectively.

Body fat percentage differences between the intervention and control group are highlighted in the following section. Body fat percentage is categorised according to gender and grouped by each testing phase. Figure 4.5 shows the entire study sample results in the form of a mean graph with 95% confidence intervals (CI).

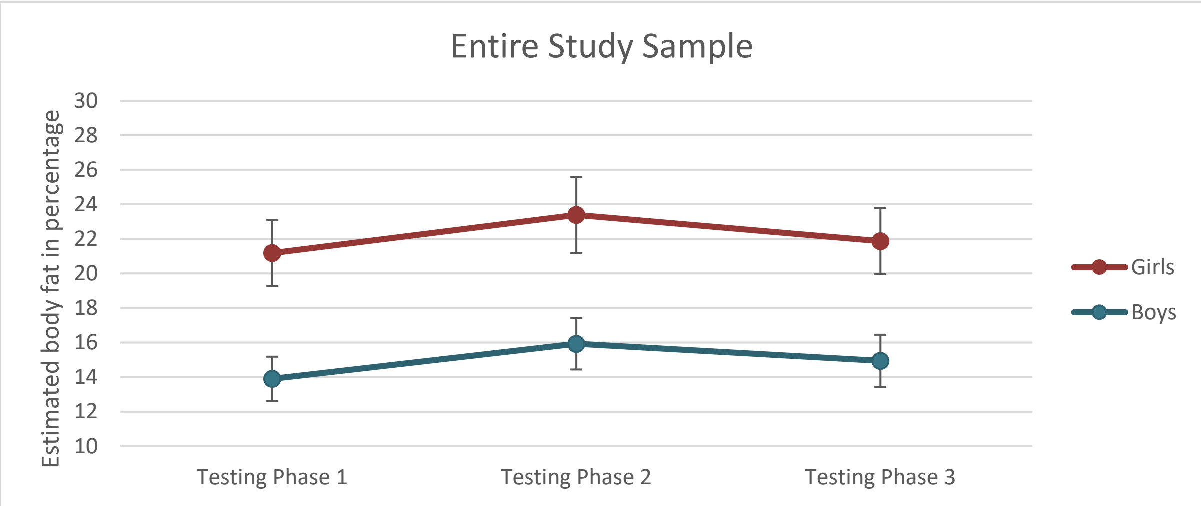

Figure 4.5: Mean plot estimated body fat (%): Results for the entire study sample, comparison between genders, across the three testing phases, with 95% CI

Based on the sample statistics only, girls presented with higher estimated body fat results than boys throughout the study period. Girls show a 34.37 %, 31.89 % and 31.69 % higher body fat result than boys for the first, second and third testing phase, respectively.

Figure 4.6 reflects the body fat percentage for girls as a mean graph with 95% CI for the intervention and control groups respectively.

Figure 4.6: Mean plot estimated body fat (%): Results for the intervention and control groups' girls, across the three testing phases, with 95% CI

The intervention group displayed a decrease in mean body fat percentage from the first to the second testing phase of 5.45 %, and an increase of 1.03 % from testing phase two to three, which equates to a total decrease in mean body fat percentage of 4.68 % for the entire study period, see Table E.11. The control group of girls' percentage body fat increased from the first to the second testing phase by 25.22 %. A decreased was then measured from the second to third testing phase of 11.71 %, which equates to a total increase of 9.55 % in the control group's girls body fat percentage for the entire study period, see Table E.11. These values are based on sample statistics solely, not taking any covariates into consideration.

Figure 4.7 displays the body fat percentage for boys as a mean graph with 95% CI.

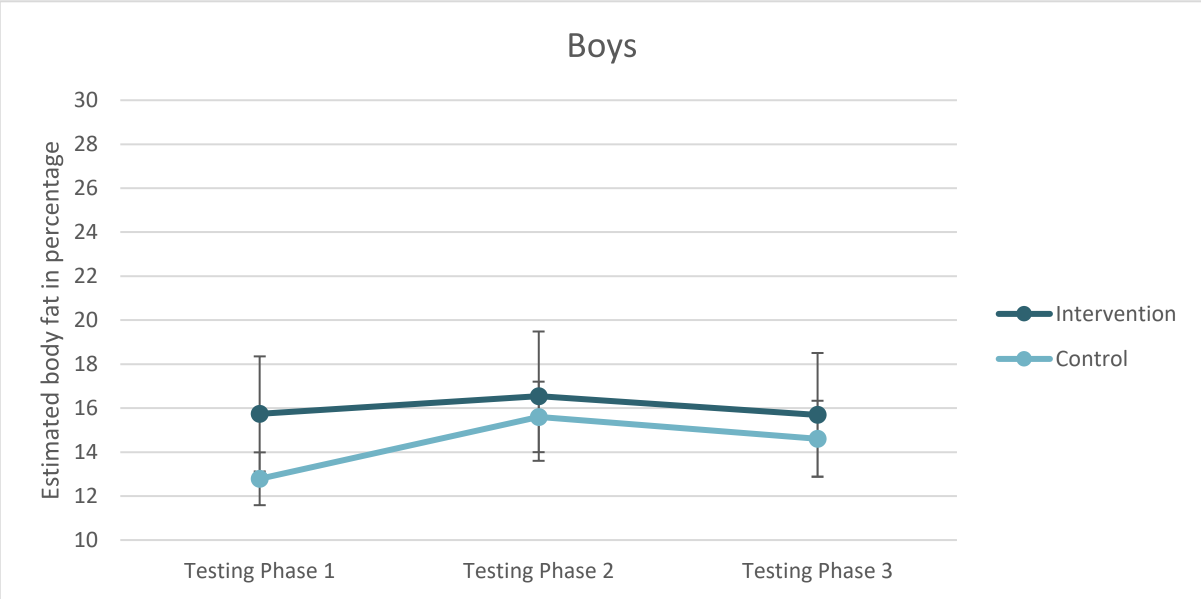

Figure 4.7: Mean plot estimated body fat (%): Results for the intervention and control groups' boys, across the three testing phases, with 95% CI

The intervention group increased in mean body fat percentage from the first to the second testing phase by 4.90 % and decreased from the second to the third testing phase by 5.95%, a total decrease of 1.35 % during the entire study period, see Table E.12. The control group boys increased in mean body fat percentage from the first to the second testing phase by 22 %. A decreased was then measured from the second to third testing phase of 6.34 %, which equated to a total increase of 12.49 % for the entire study period, see Table E.12. Again, these values are based on sample statistics solely, not taking any covariates into consideration.

The body fat percentage distribution was further analysed by testing for normality to ensure that the following inferential analysis, the multiple regression model, could be validated. Appendix E, Figure E.4 provides a graphical summary, in the form of a histogram and line graph, of the body fat percentage distribution for the entire study. Both graphs show a non-normal distribution.

Due to body fat percentage displaying a non-normal distribution, Log transformation was used to transform the data to an asymptotically normal distribution. The Log transformation was performed as per Equation 4.4.

Equation 4.4: Estimated body fat percentage log transformation equation

$$Y_T = log_{10}(Y)$$

Where:

Y_T = Transformed value
Y = Original value

To transform the predicted transformed value $\hat{Y}_T$ back to the predicted values $\hat{Y}$, the following equation, Equation 4.5, was used.

Equation 4.5: Estimated body fat percentage log reverse transformation equation

$$\hat{Y} = 10^{\hat{Y}_T}$$

Where:

$\hat{Y}$ = Estimated Y according to the model applied
$\hat{Y}_T$ = Transformed predicted value

Figure E.5 in Appendix E, shows a graphical summary, in the form of a histogram and line graph, of the transformed body fat percentage data, indicating an asymptotically normal distribution.

The following regression model has been used to describe the body fat percentage data. The model equation is displayed in Equation 4.6.

Equation 4.6: Estimated body fat percentage regression model equation

$$\hat{Y}_T = b_0 + b_1T2 + b_2IC + b_3A + b_4H + b_5W + b_6W^2 + b_7IC * A$$

Where:

$\hat{Y}_T$ = Transformed predicted body fat percentage value
b_0 = Intercept
$b_i, i = 1, 2, \dots 7$ = Estimate regression coefficients
$T2$ = Testing phase indicator variables:

	$T2$	$T3$
Testing phase 1	0	0
Testing phase 2	1	0
Testing phase 3	0	1

IC = Intervention / control condition indicator variables, where 0 refers to control and 1 to intervention
A = Age of the participant in months
H = Height the participant in cm
W = Weight of the participant in kg
W^2 = Non-linear effect of weight
$IC * A$ = Interaction of the intervention / control condition on age

The multiple regression output for body fat percentage is summarised in Table 4.7.

Table 4.7: Regression summary: Log transformed estimated body fat percentage results

Statistic	Value
Multiple R	0.840
Multiple R^2	0.705
F (3,442)	156.665
p	< 0.001
Standard Error of Estimate	0.228

	b	Standard Error	t (442)	p-value
Intercept	3.972	0.254	15.641	< 0.001
T2	0.089	0.022	3.964	< 0.001
IC	0.774	0.228	3.390	< 0.001
A	-0.011	0.001	-7.833	< 0.001
H	-0.025	0.002	-10.956	< 0.001
W	0.109	0.006	19.731	< 0.001
W^2	-0.001	1.00E-04	-13.170	< 0.001
IC*A	0.006	0.002	3.029	< 0.01
Excluded outlier cases[24]	34:35, 293, 397			

Table 4.7 indicates that the model is a significant fit to the data ($p < 0.001$) and 70.5 % of the variance in body fat percentage can be explained by the proposed model (Multiple R^2 = 0.705). The intervention / control condition has a significant effect ($p < 0.001$), indicating the intervention affected a significant body fat percentage increase in relation to the control group.

4.3.3. Indicators of Nutritional Status

Indicators of nutritional status, including weight-for-age z-scores (WAZ), height-for-age z-scores (HAZ) and BMI-for-age z-scores (BAZ) were calculated according to the World Health Organization's growth standards (de Onis *et al.*, 2007). Indicators of nutritional status were calculated using body mass and stature measures and applying standardised age- and gender-specific growth references to obtain WAZ, HAZ and BAZ.

4.3.3.1. Weight-for-Age Z-Scores

Table 4.8 depicts the WAZ categories for the first, second and third testing phases, categorised by intervention and control group, respectively. Growth reference curves for WAZ are only calculated to an age of 10 years. The latter is because WAZ does not distinguish between height and body mass, in an age period where many children are experiencing the pubertal growth spurt. This results in children, older than 10 years, appearing to have excess weight, according to WAZ, when in fact they are actually tall (de Onis *et al.*, 2007).

[24] Cases are excluded if standard residuals are > 2 and / or < - 2.

Table 4.8: Frequency distribution: WAZ for the intervention and control groups across three testing phases

	Testing Phase 1		Testing Phase 2		Testing Phase 3	
	Intervention Group	Control Group	Intervention Group	Control Group	Intervention Group	Control Group
> 10 Years	21	14	39	36	60	75
Normal	44	77	24	56	5	17
Underweight	0	1	0	0	0	0
Severely Underweight	0	0	2	0	0	0
TOTAL	65	92	65	92	65	92

Based on the WAZ classifications, only one participant in the control group, in the first testing phase, and two participants in the intervention group, in the second testing phase, was classified below normal, as underweight, and severely underweight, respectively.

The HAZ distribution and classifications follow.

4.3.3.2. Height-for-Age Z-Scores

Table 4.9 shows the HAZ categories for testing phase one, two and three, categorised by the intervention and control groups.

Table 4.9: Frequency distribution: HAZ for the intervention and control groups across three testing phases

	Testing Phase 1		Testing Phase 2		Testing Phase 3	
	Intervention Group	Control Group	Intervention Group	Control Group	Intervention Group	Control Group
Normal	63	92	62	92	62	88
Stunted	1	0	3	0	2	4
Severely Stunted	1	0	0	0	1	0
TOTAL	65	92	65	92	65	92

As evident from Table 4.9, the majority of the participants were classified as normal with respect to HAZ. In the intervention group, during the first testing phase, one boy was classified as stunted and one boy as severely stunted. During testing phase two, three participants were classified as stunted. During the final testing phase two participant were classified as stunted and one as severely stunted in the intervention group. In the control group, the only non-normal classification was found in the third testing phase, where four participants were rated as stunted, according to HAZ classifications.

The next section explains the BAZ distribution and classifications.

4.3.3.3. BMI-for-Age Z-Scores

Table 4.10 reflects the BAZ categories for testing phase one, two and three, categorised according to the intervention or control groups.

Table 4.10: Frequency distribution: BAZ for the intervention and control groups across three testing phases

	Testing Phase 1		Testing Phase 2		Testing Phase 3	
	Intervention Group	Control Group	Intervention Group	Control Group	Intervention Group	Control Group
Severely Thin	1	0	1	0	1	0
Thin	0	0	1	0	0	0
Normal	44	69	43	68	45	63
Overweight	12	17	13	16	13	20
Obese	8	6	7	8	6	9
TOTAL	65	92	65	92	65	92

When considering below normal BAZ classifications, the intervention group contained one severely thin participant in each testing phase, and a thin participant in the second testing phase. No below normal BAZ classifications were measured in the control group.

When examining above normal BAZ classifications in Table 4.8, the intervention group included 20 participants, 20 participants and 19 participants rated overweight or obese during the first, second and third testing phases, respectively. This can be compared to 23 participants, 24 participants and 29 participants in the control group for the same testing phases.

The physical fitness measures analysed are presented in the following section.

4.4. Physical Fitness Measures

Physical fitness was assessed with various tests from the *EUROFIT European Tests of Physical Fitness* assessment protocol (Council of Europe Committee for the Development of Sport, 1993). The following section provides the descriptive and inferential statistics for the physical fitness measures, including cardiorespiratory fitness, upper- and lower body musculature strength and lower body flexibility. For each measure, the section starts with the descriptive statistics, comparing the intervention to the control group for each testing phase – addressing the first study objective. This is followed by descriptive statistics comparing the intervention and control group between the three testing phases – addressing the second and third study objectives. Furthermore, multiple regression analysis using indicator variables with stepwise eliminations, are displayed, with the intervention and control condition as main predictor to establish whether the intervention had a statistically significant effect on each measure.

4.4.1. Cardiorespiratory Fitness

Cardiorespiratory fitness was measured in terms of estimated maximal oxygen uptake ($\dot{V}O_2max$), determined by the 20-metre multistage shuttle run test. The estimated $\dot{V}O_2max$ was calculated using the number of shuttles completed in the multistage shuttle run test, converting the shuttle number to a speed value, and finally using the speed value in a formula to estimate $\dot{V}O_2max$ as per Léger *et al*. (1988). All the descriptive statistics are presented in terms of estimated $\dot{V}O_2max$, to aid in interpretation. For analysis and the multiple regression inferential statistics, however, the number of laps, as opposed to the estimated $\dot{V}O_2max$ that were calculated, were used. This was done to incorporate more variation found within the raw, uncalculated data.

Estimated $\dot{V}O_2max$ descriptive statistics for girls and boys between each of the three testing phases, can be found in Appendix E, Table E.13 and Table E.14 respectively. The descriptive statistics of for estimated $\dot{V}O_2max$, for the intervention and control group, can be found in Table 4.11.

Table 4.11: Descriptive statistics estimated maximal oxygen uptake (ml.kg^{-1}.min^{-1}): Comparison within and between the intervention group (IG) and control group (CG), across three testing phases (T1, T2, and T3)

	Intervention group			Control group		
	T1	T2	T3	T1	T2	T3
n	92	92	92	65	65	65
M	50.02	48.37	48.05	49.86	46.54	46.13
S.D.	4.45	4.17	4.54	4.24	4.31	3.99
Min	43.38	41.07	39.12	39.12	37.18	35.24
Quartile 1	46.85	45.69	44.57	47.04	43.90	43.90
Mdn	49.60	48.00	46.66	49.71	45.69	46.29
Quartile 3	52.62	50.31	51.06	52.62	49.50	48.67
Max	61.86	59.55	58.22	59.55	56.89	53.45
SEM	0.46	0.43	0.47	0.53	0.53	0.49
RSD	8.89	8.62	9.46	8.50	9.25	8.65
	Intervention group			Control group		
	T2-T1	T3-T2	T3-T1	T2-T1	T3-T2	T3-T1
Difference	-1.65	-0.32	-1.97	-3.31	-0.41	-3.73
% Difference	-3.31	-0.66	-4.11	-6.64	-0.89	-8.08
	Comparison between the intervention and control group					
	T1 CG-IG		T2 CG-IG		T3 CG-IG	
Difference	0.17		1.83		1.92	
% Difference	0.34 %		3.92 %		4.16 %	

The estimated $\dot{V}O_2max$ differences between the intervention and control group is highlighted in the following section. The $\dot{V}O_2max$ is categorised according to gender and grouped by each testing phase.

Figure 4.8 shows the entire study sample results as a mean graph with 95% CI.

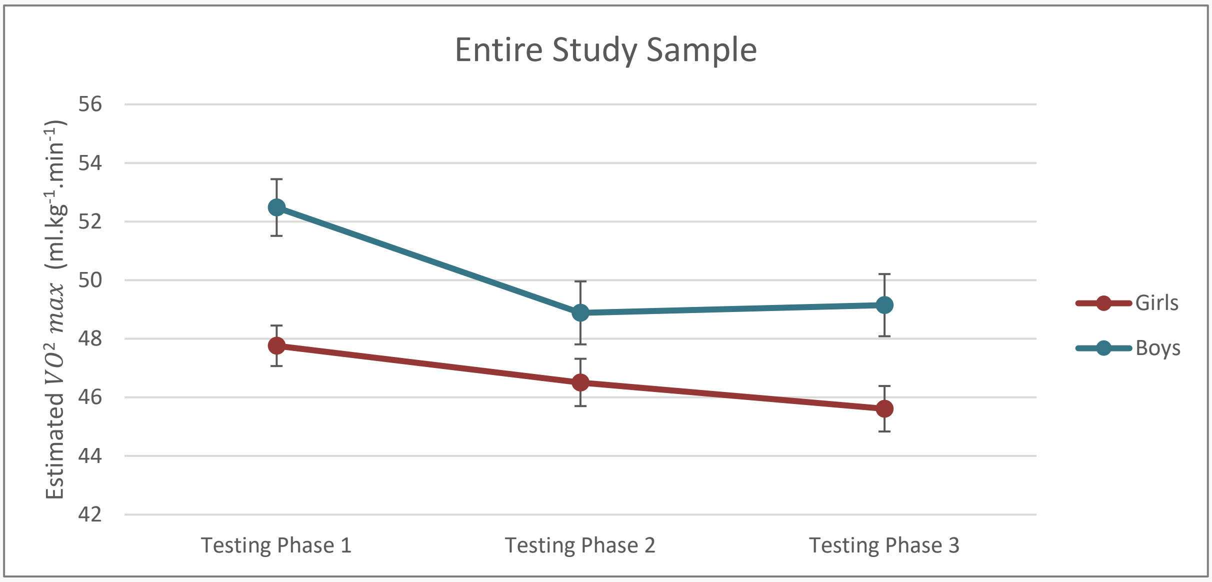

Figure 4.8: Mean plot estimated maximal oxygen uptake (ml.kg^{-1}.min^{-1}): Results for the entire study sample, comparison between genders, across the three testing phases, with 95% CI

Girls presented with a lower $\dot{V}O_2max$ than boys throughout the three testing phases when investigating sample statistics only. The difference between genders for the first, second and third testing phase was 8.99 %, 4.86 % and 7.19 %, respectively. From the first to the final testing phase, girls' $\dot{V}O_2max$ decreased by 4.5 %, compared to a decrease of 6.35 % measured in boys for the same time.

Figure 4.9 shows the $\dot{V}O_2max$ for girls as a mean graph with 95% CI.

Figure 4.9: Mean plot estimated maximal oxygen uptake (ml.kg^{-1}.min^{-1}): Results for the intervention and control groups' girls, across the three testing phases, with 95% CI

Figure 4.9 and Table E.13 in Appendix E, indicate that the $\dot{V}O_2max$ for girls from the intervention group decreased by 4.88% from the first to the second testing phases. A further decreased was seen between the second and the third testing phase of 1.51%. This resulted in a total decrease of 6.74 % from the first to the third testing phase for the intervention group girls, for sample statistics solely.

The control group girls also saw a decreased from the first to the second, and from the second to the third testing phase, of 0.81 % and 2.25 % respectively. This resulted in a total decrease of 3.14 % from the first to the third testing phase for the control group girls, again for sample statistics solely.

Figure 4.10 illustrates the $\dot{V}O_2max$ for boys as a mean graph with 95% CI.

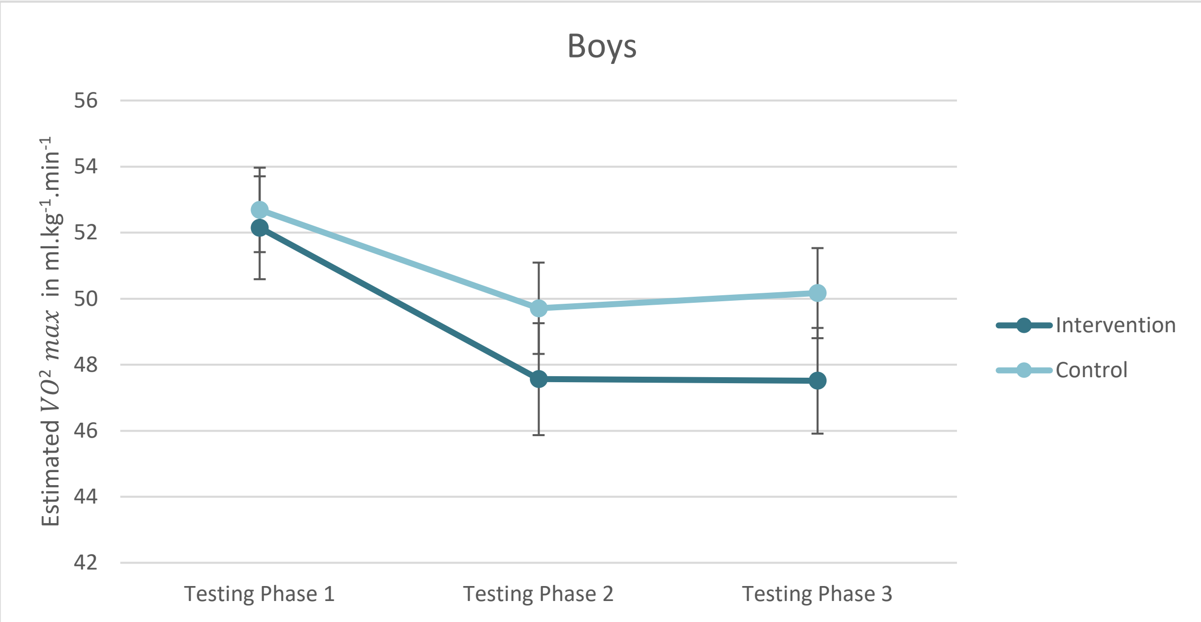

Figure 4.10: Mean plot estimated maximal oxygen uptake (ml.kg^{-1}.min^{-1}): Results for the intervention and control groups' boys, across the three testing phases, with 95% CI

From Figure 4.10 and Table E.14 in Appendix E, investigating sample statistics, it is clear that the intervention group boys also displayed a decrease in estimated $\dot{V}O_2max$ from the first to the second testing phase, as well as from the first to the third testing phase. The same pattern emerged when considering the results for the boys control group. From the first to the second testing phase a decrease of 5.65 %, and from the first to the third testing phase a decrease of 5.03 % were calculated for the control group in estimated $\dot{V}O_2max$. A small increase of 0.92 % was however measured from the second to the third testing phase for the control group boys.

The $\dot{V}O_2max$ distribution, in terms of number of laps completed in the shuttle run, was further analysed by testing for normality to ensure that the following inferential analysis, the multiple regression model, could be validated. Appendix E, Figure E.6 provides a graphical summary, in the form of a histogram and line graph, of the distribution for the entire study. Both graphs show a non-normal distribution.

Due to the non-normal distribution, Log transformation was used to transform the data into an asymptotically normal distribution, to ensure multiple regression validation. The Log transformation was performed as per Equation 4.7.

Equation 4.7: Number of laps ran log transformation equation

$$Y_T = log_{10}(Y)$$

Where:

Y_T = Transformed value
Y = Original value

To transform the predicted transformed value $\hat{Y}_T$ back to the predicted value $\hat{Y}$, the following equation, Equation 4.8 was used:

Equation 4.8: Number of laps ran log reverse transformation equation

$$\hat{Y} = 10^{\hat{Y}_T}$$

Where:

$\hat{Y}$ = Estimated Y according to the model applied
$\hat{Y}_T$ = Transformed predicted value

Figure E.7 in Appendix E, shows a graphical summary, in the form of a histogram and line graph, of the transformed data, indicating a normal transformed distribution.

The following regression model has been used to describe the data for the number of laps ran. The model equation is displayed below in Equation 4.9.

Equation 4.9: Number of laps ran regression model equation

$$Y_T = b_0 + b_1T2 + b_2T3 + b_3IC + b_4G + b_5A + b_6W^2 + b_7IC * W + b_8H + b_9W + b_{10}H^2$$

Where:

Y_T = Transformed predicted value
b_0 = Intercept
$b_i, i = 1, 2, \ldots 7$ = Estimate regression coefficients
$T2$ and $T3$ = Testing phase indicator variables:

	$T2$	$T3$
Testing phase 1	0	0
Testing phase 2	1	0
Testing phase 3	0	1

IC = Intervention / control condition indicator variables, where 0 refers to control and 1 to intervention
G = Gender indicator variable, where 0 refers to boy and 1 to girl
A = Age of the participant in months
W^2 = Non-linear effect of weight
$IC * W$ = Interaction of the intervention / control condition on weight
H = Height the participant in cm
W = Weight of the participant in kg

H^2 = Non-linear effect of height

The multiple regression output is summarised in Table 4.12.

Table 4.12: Regression summary: Log transformed number of laps ran results

Statistic	Value
Multiple R	0.702
Multiple R^2	0.493
F (3,442)	40.440
p	< 0.001
Standard Error of Estimate	0.394

	b	Standard Error	t (442)	p-value
Intercept	13.927	6.100	2.283	< 0.05
T2	-0.259	0.063	-4.101	< 0.001
T3	-0.110	0.054	-2.040	< 0.05
IC	0.361	0.168	2.142	< 0.05
G	-0.466	0.048	-9.764	< 0.001
A	0.007	0.002	3.059	< 0.01
W^2	2.60E-04	1.10E-04	2.451	< 0.01
IC*W	0.013	0.005	2.784	< 0.01
H	-0.159	0.089	-1.799	0.073
W	-0.064	0.012	-5.421	< 0.001
H^2	0.001	3.20E-04	2.033	< 0.05
Excluded outlier cases[25]	219, 406			

The model is a significant fit to the data ($p < 0.001$) and 49.3 % of the variance in number of laps ran can be explained by the proposed model (Multiple R^2 = 0.493). The intervention / control condition has a significant effect ($p < 0.05$), indicating the intervention affected a significant increase in the number of laps ran, in relation to the control group.

4.4.2. Upper Body Muscular Strength

Upper body musculature strength was estimated using handgrip strength, measured with a handheld dynamometer. The descriptive statistics of handgrip strength, comparing the intervention and control groups, can be found in Table 4.13.

Handgrip strength descriptive statistics for girls and boys, between each of the three testing phases, can be found in Appendix E, Table E.15 and Table E.16 respectively.

[25] Cases are excluded if standard residuals are > 2 and / or < - 2.

Table 4.13: Descriptive statistics handgrip strenght (kg): Comparison within and between the intervention group (IG) and control group (CG), across three testing phases (T1, T2, and T3)

	Intervention group			Control group		
	T1	T2	T3	T1	T2	T3
n	92	92	92	65	65	65
M	13.45	13.72	15.11	14.78	14.86	16.63
S.D.	3.48	3.25	3.84	3.09	3.28	3.72
Min	4.00	4.00	8.00	8.00	8.00	8.00
Quartile 1	11.00	11.75	12.00	12.00	12.00	14.00
Mdn	13.00	13.50	14.00	15.00	16.00	16.00
Quartile 3	16.00	16.00	18.00	16.00	18.00	20.00
Max	22.00	20.00	26.00	22.00	20.00	26.00
SEM	0.36	0.34	0.40	0.38	0.41	0.46
RSD	25.87	23.69	25.44	20.90	22.06	22.39
	Intervention group			**Control group**		
	T2-T1	**T3-T2**	**T3-T1**	**T2-T1**	**T3-T2**	**T3-T1**
Difference	0.27	1.39	1.66	0.08	1.77	1.85
% Difference	2.02	10.14	11.01	0.52	11.90	11.10
	Comparison between the intervention and control group					
	T1 CG-IG		**T2 CG-IG**		**T3 CG-IG**	
Difference	-1.34		-1.14		-1.52	
% Difference	-9.06 %		-7.70 %		-9.15 %	

The handgrip strength differences between the intervention and control groups are highlighted next. Handgrip strength is categorised according to gender and grouped by each testing phase. Figure 4.11 shows handgrip strength results as box plots for the girls' intervention and control groups.

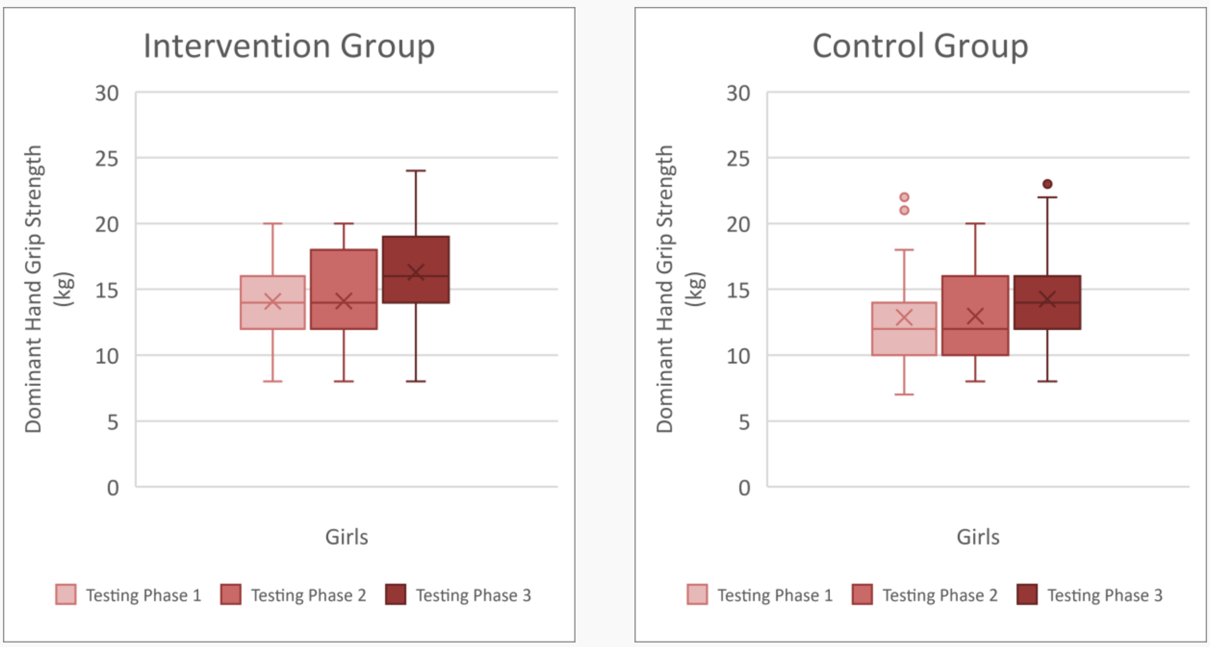

Figure 4.11: Box plots handgrip strength (kg): Comparison for girls across the three testing phase, per intervention and control groups, respectively

From Figure 4.11 and Table E.15 in Appendix E, comparing sample statistics solely, it is clear that the girls in the intervention group had a higher mean grip strength during the first testing phase of 9.39 % compared to girls from the control group (IG G: 14.08 ± 2.82 kg; CG G: 12.87 ± 3.18 kg). The intervention group girls showed an increase of 0.19 % in mean grip strength from the first to the second testing phase. Furthermore, an increase of 15.52 % and 13.60 % were calculated from the second to the third-, and from the first to the third testing phase. This is in comparison to a 0.83 % increase and an 9.84 % increase, for the control group from testing phase one to two and from testing phase two to three. That equates to a 9.70 % increase in the control group girls from the first to the third testing phase.

Figure 4.12 shows the handgrip strength results as box plots for the boys' intervention and control groups.

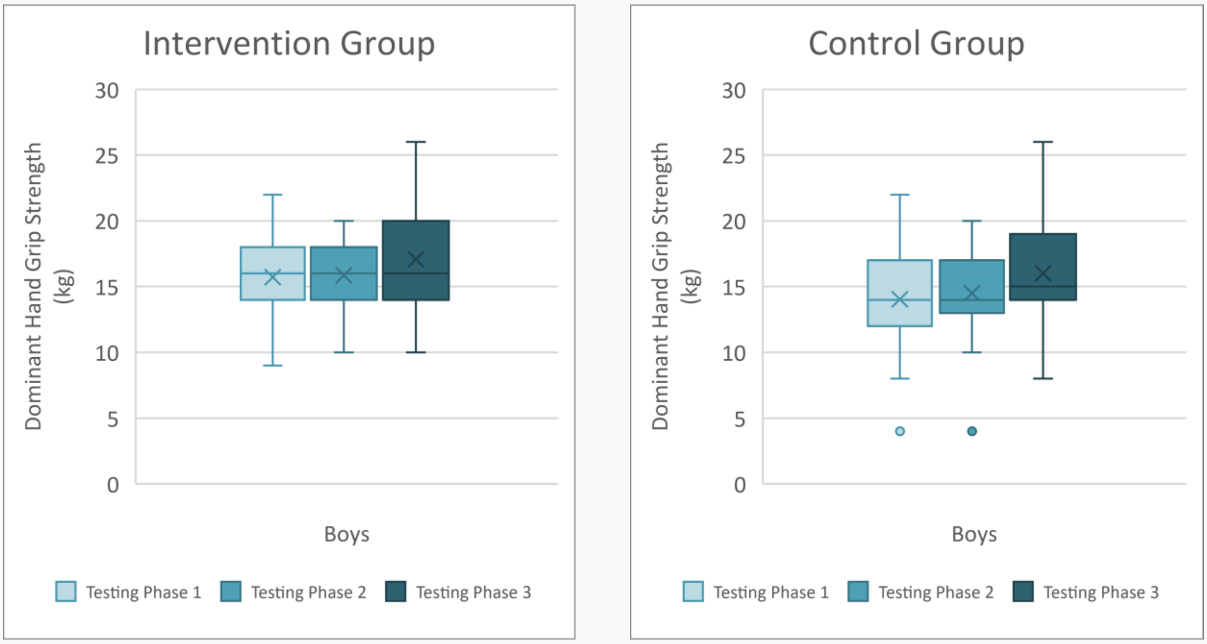

Figure 4.12: Box plots handgrip strength (kg): Comparison for boys across the three testing phase, per intervention and control groups, respectively

Like the girls, the boys in the intervention group showed higher mean grip strength during the first testing phase, compared to the boys from the control group (IG B: 15.71 ± 3.23 kg; CG B: 14.04 ± 3.70 kg), when comparing sample statistics solely. The intervention group showed an increase of 0.91 % in mean grip strength from the first to the second testing phase, 7.66 % from the second to the third testing phase and overall a 7.95 % increase from the first to the third testing phase. The control group showed an increase of 3.16 % in mean grip strength from the first to the second testing phase, 10.43 % from the second to the third testing phase and overall a 12.22 % increase from the first to the third testing phase.

The handgrip strength distribution was tested for normality to ensure multiple regression validation. Figure E.8 in Appendix E provides a graphical summary, in the form of a histogram and line graph, of the handgrip distribution. Both graphs show a normal distribution and no transformation was therefore required for the handgrip strength distribution.

The following regression model has been used to describe the handgrip strength data. The model equation is displayed below in Equation 4.10.

Equation 4.10: Handgrip strength regression model equation

$$Y = b_0 + b_1T2 + b_2T3 + b_3IC + b_4G + b_5H + b_6W^2 + b_7IC * H + b_8IC * W + b_9W + b_{10}A$$

Where:

Y	= Predicted value
b_0	= Intercept
$b_i, i = 1, 2, \dots 10$	= Estimated regression coefficients
$T2$ and $T3$	= Testing phase indicator variables:

	$T2$	$T3$
Testing phase 1	0	0
Testing phase 2	1	0
Testing phase 3	0	1

IC	= Intervention / control condition indicator variables, where 0 refers to control and 1 to intervention
G	= Gender indicator variable, where 0 refers to boy and 1 to girl
H	= Height the participant in cm
W^2	= Non-linear effect of weight
$IC * H$	= Interaction of the intervention / control condition on height
$IC * W$	= Interaction of the intervention / control condition on weight
W	= Weight of the participant in kg
A	= Age of the participant in months

The multiple regression output for handgrip strength is summarised in Table 4.14.

Table 4.14: Regression summary: Handgrip strength results

Statistic	Value
Multiple R	0.713
Multiple R^2	0.508
F (3,442)	47.105
p	< 0.001
Standard Error of Estimate	2.520

	b	Standard Error	t (442)	p-value
Intercept	-34.988	3.656	-9.571	< 0.001
T2	-1.255	0.304	-4.129	< 0.001
T3	-0.681	0.345	-1.973	< 0.05
IC	19.141	5.203	3.679	< 0.001
G	-0.992	0.257	-3.853	< 0.001
H	0.119	0.037	3.224	< 0.01
W^2	-0.003	0.001	-3.944	< 0.001
IC*H	0.160	0.043	3.694	< 0.001
IC*W	-0.107	0.039	-2.754	< 0.01
W	0.363	0.082	4.419	< 0.001
A	0.056	0.014	3.961	< 0.001
Excluded outlier cases[26]	75, 94, 335, 437			

The model is a significant fit to the data ($p < 0.001$) and 50.8 % of the variance in handgrip strength can be explained by the proposed model (Multiple $R^2 = 0.508$). The intervention / control condition has a significant effect ($p < 0.001$), indicating the intervention affected a significant increase in the handgrip strength, in relation to the control group.

4.4.3. Lower Body Musculature Strength

Lower body strength was measured with the standing broad jump and recorded in cm. The descriptive statistics of broad jump distance, comparing the intervention and control groups, can be found in Table 4.15.

Standing broad jump distance descriptive statistics for girls and boys, between each of the three testing phases, can be found in Appendix E,

Table E.17 and Table E.18 respectively.

Table 4.15: Descriptive statistics standing broad jump distance (cm): Comparison within and between the intervention group (IG) and control group (CG), across three testing phases (T1, T2, and T3)

	Intervention group			Control group		
	T1	**T2**	**T3**	**T1**	**T2**	**T3**
n	92	92	92	65	65	65
M	127.47	127.11	122.38	128.49	125.54	121.54
S.D.	19.93	19.97	19.97	23.44	23.16	27.29
Min	76.00	81.00	79.00	48.00	60.00	53.00
Quartile 1	115.00	114.75	106.00	118.00	110.00	104.00
Mdn	128.50	126.50	120.00	129.00	125.00	119.00
Quartile 3	142.00	140.00	135.25	145.00	145.00	138.00
Max	174.00	199.00	172.00	174.00	173.00	202.00
SEM	2.08	2.08	2.08	2.91	2.87	3.39

[26] Cases are excluded if standard residuals are > 2 and / or < - 2.

RSD	15.63	15.71	16.32	18.24	18.45	22.46

	Intervention group			Control group		
	T2-T1	T3-T2	T3-T1	T2-T1	T3-T2	T3-T1
Difference	-0.36	-4.73	-5.09	-2.95	-4.00	-6.95
% Difference	-0.28	-3.72	-4.16	-2.30	-3.19	-5.72

	Comparison between the intervention and control group		
	T1 CG-IG	T2 CG-IG	T3 CG-IG
Difference	-1.02	1.57	0.84
% Difference	-0.80 %	1.25 %	0.69 %

The broad jump differences between the intervention and control groups are highlighted below. The broad jump results are categorised according to gender and grouped by each testing phase. Figure 4.13 shows the broad jump results from the entire study sample as a mean graph with 95% CI.

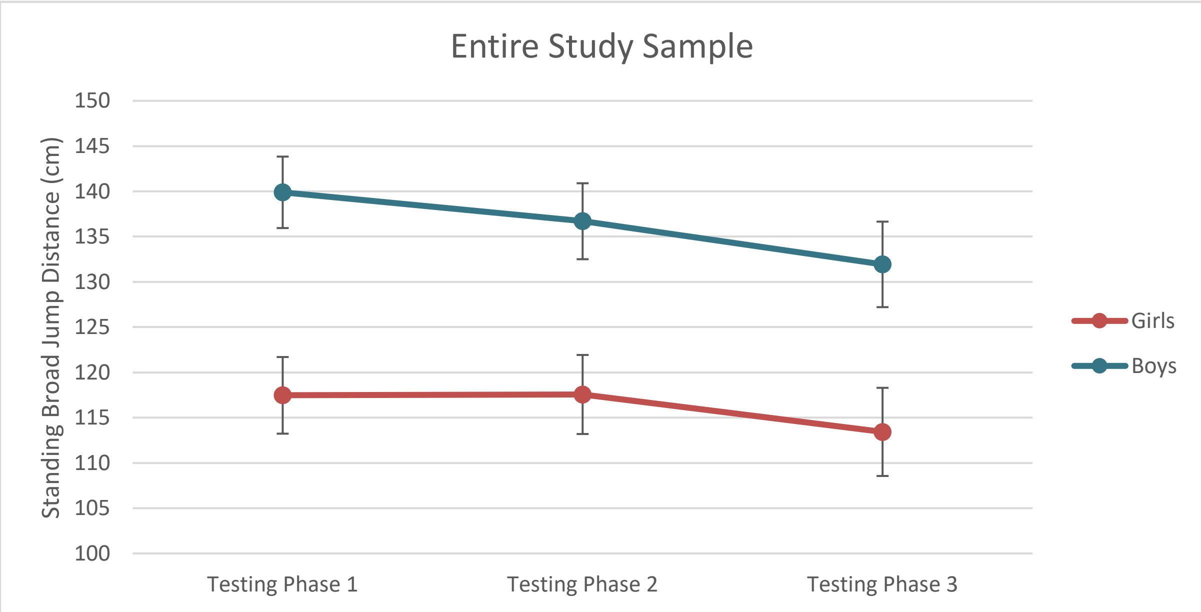

Figure 4.13: Mean plot standing broad jump distance (cm): Results for the entire study sample, comparison between genders, across the three testing phases, with 95% CI

From Figure 4.13 it is clear that boys had a higher standing broad jump distance than girls (G: 117.46 ± 19.40 cm; B: 139.89 ± 16.86 cm), when investigating sample statistics only. The difference between genders in testing phases one, two and three was 16.03 %, 14 % and 14.02 %, respectively. From the first to the final testing phase, the girls' standing broad jump distance decreased by 3.4 %, compared to a decrease of 5.86 % in the boys' distance for the same time.

Figure 4.14 shows the standing broad jump distance for girls in the intervention- and control groups, as mean graphs with 95% CI.

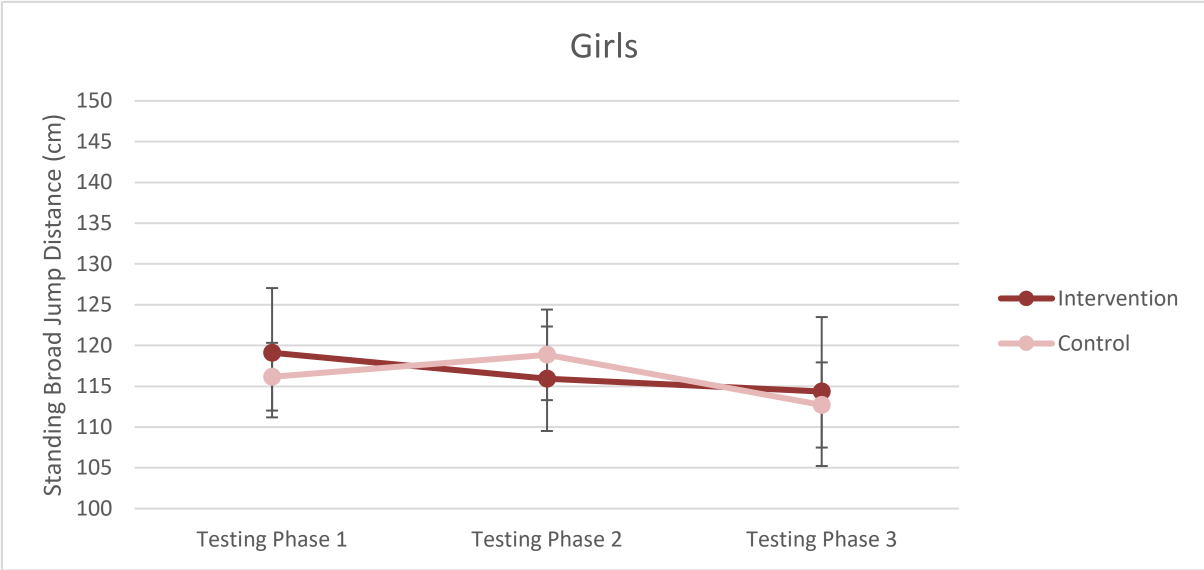

Figure 4.14: Mean plot standing broad jump distance (cm): Results for the intervention and control groups' girls, across the three testing phases, with 95% CI

Figure 4.14 and

Table E.17 in Appendix E, indicate that the intervention group decreased by 2.68 % from the first to the second testing phase and with 1.35 % from the second to the third testing phase, which equates to a total decrease of 4.16 % for the entire study period. The control group increased by 2.31 % from the first to the second testing phase and decreased with 5.17 % from the second to the third testing phase, which equates to a total decrease of 3.08 % for the entire study period. These results are based on the sample statistics only, not taking any covariates into consideration.

Figure 4.15 shows the standing broad jump distance for boys as a mean graph with 95% CI.

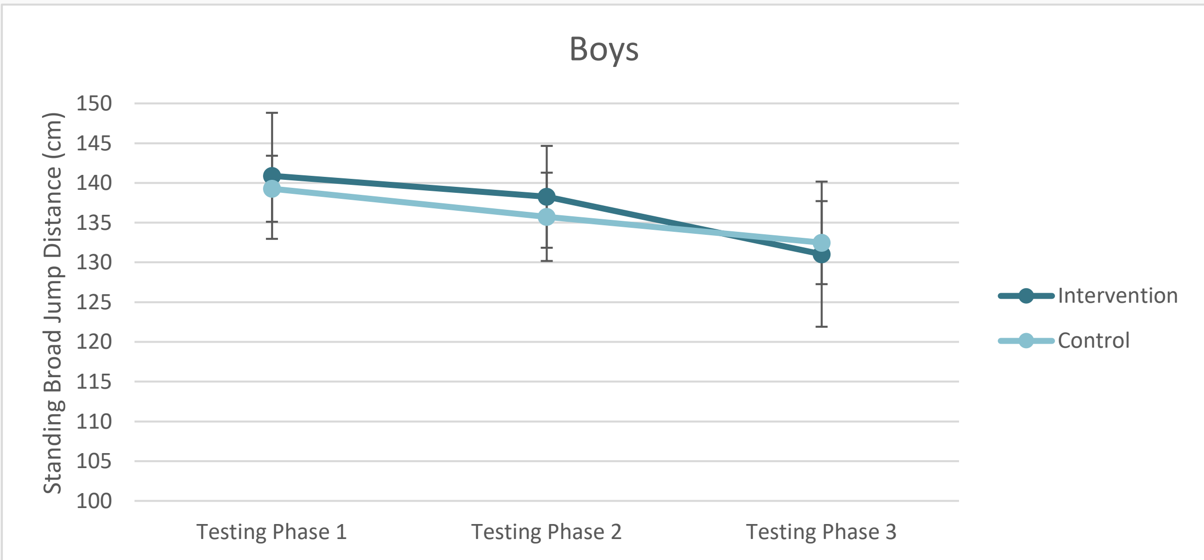

Figure 4.15: Mean plot standing broad jump distance (cm): Results for the intervention and control groups' boys, across the three testing phases, with 95% CI

Figure 4.14 and Table E.18 in Appendix E, indicate that the intervention group decreased by 1.88 % from the first to the second testing phase and with 5.22 % from the second to the third testing phase, which equates to a total decrease of 7.52 % for the entire study period. The same pattern is reflected by the control group. The control group for boys decreased by 2.54 % from the first to the second testing phase and with 2.39 % from the second to the third testing phase. This equates to a decrease of 5.12 % from the first to the third testing phase. Again, these results are based on the sample statistics only.

The standing broad jump distance distribution was tested for normality to ensure multiple regression validation. Figure E.9 in Appendix E provides a graphical summary, in the form of a histogram and line graph. Both graphs show a normal distribution and no transformation was therefore required.

The following regression model has been used to describe the standing broad jump distribution. The model equation is displayed below in Equation 4.11.

Equation 4.11: Broad jump distance regression model equation

$$Y = b_0 + b_1T2 + b_2T3 + b_3IC + b_4A + b_5H + b_6H^2 + b_7W + b_8W^2 + b_9G$$

Where:

Y = Predicted value

b_0 = Intercept

$b_i, i = 1, 2, \dots 9$ = Estimated regression coefficients

$T2$ and $T3$ = Testing phase indicator variables:

	$T2$	$T3$
Testing phase 1	0	0
Testing phase 2	1	0
Testing phase 3	0	1

IC = Intervention / control condition indicator variables, where 0 refers to control and 1 to intervention

A = Age of the participant in months

H = Height the participant in cm

H^2 = Non-linear effect of height

W = Weight of the participant in kg

W^2 = Non-linear effect of weight

G = Gender indicator variable, where 0 refers to boy and 1 to girl

The multiple regression output for handgrip strength is summarised in Table 4.16.

Table 4.16: Regression summary: Standing broad jump distance results

Statistic	Value
Multiple R	0.643
Multiple R^2	0.414
F (3,442)	35.730
p	< 0.001
Standard Error of Estimate	16.300

	b	Standard Error	t (442)	p-value
Intercept	919.386	251.876	3.650	< 0.001
T2	-4.741	1.975	-2.400	< 0.01
T3	-11.399	2.227	-5.119	< 0.001
IC	-0.645	1.629	-0.396	0.692
A	0.402	0.092	4.377	< 0.001
H	-12.257	3.655	-3.353	0.001
H^2	0.046	0.013	3.471	0.001
W	-0.035	0.404	-0.087	0.931
W^2	-0.009	0.004	-2.420	0.016
Gender	-14.591	1.662	-8.782	< 0.001
Excluded outlier cases[27]	115, 192, 218, 291, 391, 440			

The model is a significant fit to the data ($p < 0.001$) and 41.4 % of the variance in standing broad jump distance that can be explained by the proposed model (Multiple $R^2 = 0.414$). The intervention / control condition did not have a significant effect on the standing broad jump distance ($p > 0.05$).

4.4.4. Lower Body Flexibility

Lower body flexibility was measured with the sit-and-reach test and recorded in cm. The descriptive statistics of sit-and-reach distance, comparing the intervention and control groups, can be found in Table 4.17.

Sit-and-reach distance descriptive statistics for girls and boys, between each of the three testing phases, can be found in Appendix E, Table E.19 and Table E.20 respectively.

Table 4.17: Descriptive statistics sit-and-reach distance (cm): Comparison within and between the intervention group (IG) and control group (CG), across three testing phases (T1, T2, and T3)

	Intervention group			Control group		
	T1	T2	T3	T1	T2	T3
n	92	92	92	65	65	65
M	32.58	32.52	29.04	34.47	31.08	30.81
S.D.	4.78	5.48	5.86	6.52	7.39	6.60
Min	19.80	14.80	12.00	20.20	16.50	15.00
Quartile 1	29.80	30.00	25.00	30.60	25.70	26.20
Mdn	32.80	32.55	30.00	35.30	31.50	30.80
Quartile 3	36.03	36.00	33.00	39.60	36.00	35.30
Max	43.80	44.30	41.00	47.70	50.00	44.60
SEM	0.50	0.57	0.61	0.81	0.92	0.82
RSD	14.66	16.84	20.19	18.92	23.77	21.41

[27] Cases are excluded if standard residuals are > 2 and / or < - 2.

	Intervention group			Control group		
	T2-T1	T3-T2	T3-T1	T2-T1	T3-T2	T3-T1
Difference	-0.05	-3.48	-3.53	-3.40	-0.27	-3.67
% Difference	-0.17	-10.70	-12.16	-9.85	-0.88	-11.91
	Comparison between the intervention and control group					
	T1 CG-IG		**T2 CG-IG**		**T3 CG-IG**	
Difference	-1.90		1.44		-1.76	
% Difference	-5.50 %		4.64 %		-5.72 %	

The differences in sit-and-reach distance across the three intervention phases per intervention and control groups respectively, are highlighted next. Sit-and-reach distance is presented separately for girls and boys. Figure 4.16 shows sit-and-reach distance results as box plots for the girls' intervention and control groups.

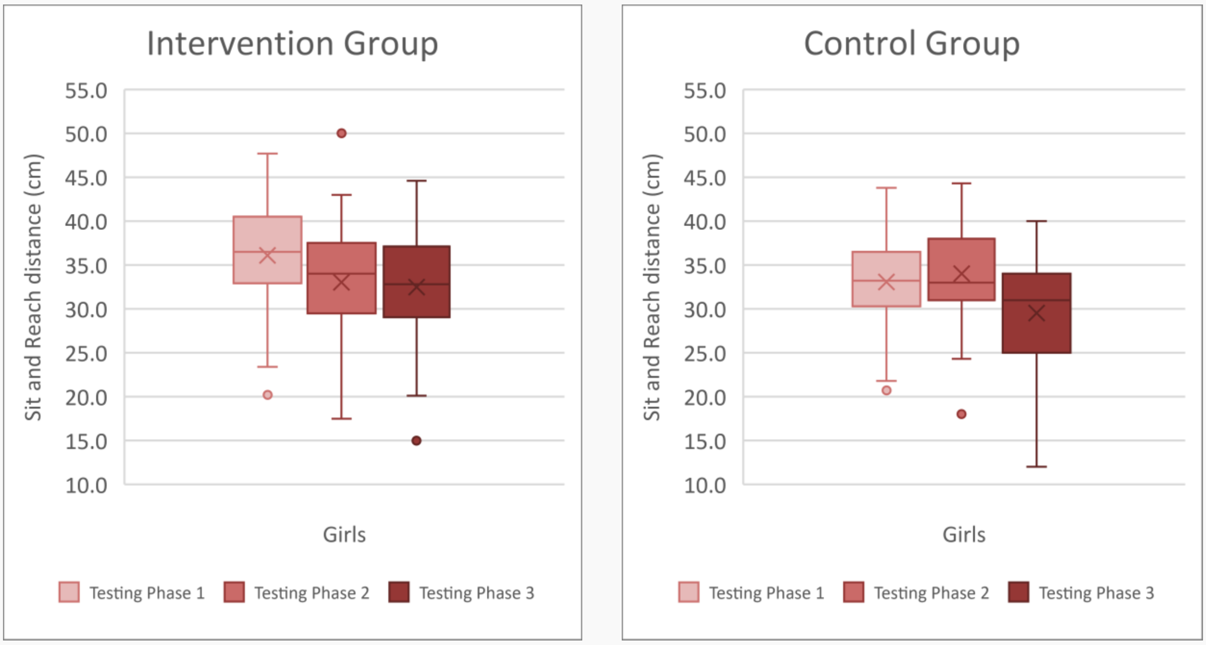

Figure 4.16: Box plots sit-and-reach distance (cm): Comparison for girls across the three testing phase, per intervention and control groups, respectively

When investigating the sample statistics, the intervention group for girls showed a decrease in mean sit-and-reach distance from the first to the second testing phase of 8.51 %, and a further decrease of 1.71 % from the second to the third testing phase as evident from Table E.19, and confirmed in Figure 4.16. This equates to a decrease of 11.20 % from the first to the third testing phase.

The control group girls increased in mean sit-and-reach distance from the first to the second testing phase by 2.87 % and decrease from the second to the third testing phase by 13.20 %. This is a decrease of 12 % from the first to the third testing phase, in the control group girls, also seen in Table E.19, in Appendix E.

Figure 4.17 shows the sit-and-reach results as box plots for the boys' intervention and control groups.

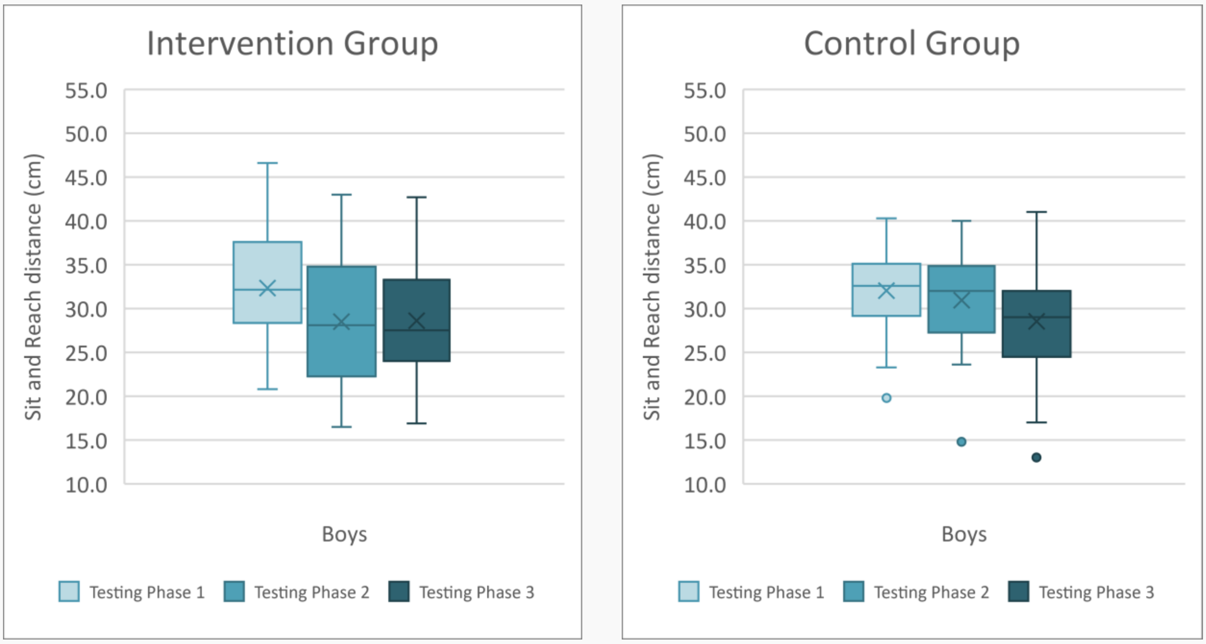

Figure 4.17: Box plots sit-and-reach distance (cm): Comparison for boys across the three testing phase, per intervention and control groups, respectively

From the first to the second testing phase, the intervention group's boys mean flexibility results decreased by 11.83 % and increased by 0.4 % from the second to the third testing phase as indicated in Table E.20, and confirmed in Figure 4.17. This equates to a total decrease of 12.97 % in mean flexibility results from the first to the third testing phase.

The control group boys sit-and-reach distance decreased from the first to the second testing phase by 3.44 %, and further decreases from the second to the third by 7.82 %. This equates a total decrease of 12.34 %, indicated in Table E.20, and confirmed in Figure 4.17, in Appendix E. These results are based on the sample statistics only, not taking any covariates into consideration.

The sit-and-reach distribution was tested for normality to ensure multiple regression validation. Figure E.10, in Appendix E provides a graphical summary, in the form of a histogram and line graph, of the sit-and-reach distribution. Both graphs show a normal distribution and no transformation was therefore required.

The following regression model was used to describe the sit-and-reach distance data. The model equation is displayed below in Equation 4.12.

Equation 4.12: Sit-and-reach distance regression model equation

$$Y = b_0 + b_1T3 + b_2IC + b_3G + b_4A + b_5A^2 + b_6H + b_7W + b_8W^2 + b_9IC * G$$

Where:

Y = Predicted value
b_0 = Intercept
$b_i, i = 1, 2, \dots 9$ = Estimated regression coefficients

$T3$ = Testing phase indicator variables:

	$T2$	$T3$
Testing phase 1	0	0
Testing phase 2	1	0
Testing phase 3	0	1

IC = Intervention / control condition indicator variables, where 0 refers to control and 1 to intervention

G = Gender indicator variable, where 0 refers to boy and 1 to girl

A = Age of the participant in months

A^2 = Non-linear effect of age

H = Height the participant in cm

W = Weight of the participant in kg

W^2 = Non-linear effect of weight

$IC * G$ = Interaction of the intervention / control condition on height

The multiple regression output for handgrip strength is summarised in Table 4.18.

Table 4.18: Regression summary: Sit-and-reach distance results

Statistic	Value
Multiple R	0.413
Multiple R^2	0.171
F (3,442)	10.557
p	< 0.001
Standard Error of Estimate	5.736

	b	Standard Error	t (442)	p-value
Intercept	122.691	22.963	5.343	< 0.001
T3	-2.880	0.651	-4.425	< 0.001
IC	-1.472	0.843	-1.746	0.081
G	5.307	0.907	5.852	< 0.001
A	-1.163	0.352	-3.305	< 0.001
A^2	0.005	0.001	3.612	< 0.001
H	-0.230	0.057	-4.047	< 0.001
W	0.358	0.138	2.583	< 0.01
W^2	-0.003	0.001	-2.590	< 0.01
IC*G	-3.490	1.110	-3.145	< 0.01
Excluded outlier cases[28]	None			

The model is a significant fit to the data ($p < 0.001$) and 17.1 % of the variance in sit-and-reach distance can be explained by the proposed model (Multiple R^2 = 0.171). The intervention / control condition did not have a significant effect on the standing broad jump distance ($p > 0.05$).

[28] Cases are excluded if standard residuals are > 2 and / or < - 2.

4.5. Conclusion

In summary, the physical activity intervention employed had statistically improved cardiorespiratory fitness as well as the upper body musculature strength. Non-significant intervention effects were found for lower body flexibility and lower body musculature strength components. The following chapter, Chapter 5, provides further discussion around the results presented in this chapter, as well as the limitations of the study and future study recommendations.

Chapter 5 : Discussion, Conclusion, Limitations and Recommendations for Future Research

5.1. Introduction

The main aim of the study was to investigate the effects of a physical activity intervention, on the body composition and physical fitness parameters, including the cardiorespiratory fitness, upper- and lower body strength and lower body flexibility, of primary schoolchildren in disadvantaged communities in Port Elizabeth, South Africa.

Chapter 5 discusses the study results displayed in Chapter 4. The discussion is presented in the same order as that of the study results, namely commencing with the demographics of the participants, followed by the anthropometric indicators and finally discussing the physical fitness parameters. For each indicator assessed, the study results are compared to normative results, which are age and gender specific, thereafter, the intervention effects are discussed. The study results are then described and compared to empirical research, discussed in Chapter 2, section 2.4.3.

The chapter concludes with the limitation of the research study and recommendations for future research.

5.2. Demographic Profile of Participants

The study participants consisted of 157 schoolchildren, 65 participants formed part of the intervention group and 92 formed part of the control group. The participants were from two primary schools located in the Motherwell township, in the Nelson Mandela Bay Municipality, in the Eastern Province. Refer to Chapter 2, section 2.3.2, where more background is provided on the township of Motherwell.

5.2.1 Gender and Ethnicity

The intervention group, control group, as well as the entire study sample consisted of more girls than boys, with 57 %, 51 %, and 54 % respectively comprising of girls. Refer to Figure 4.1 and Table 4.1. Furthermore, the study sample was homogenous with regards to ethnicity, and consisted only of Black African, Xhosa speaking schoolchildren.

5.2.2 Age

When age of the participants are evaluated, the age of the entire study sample ranged from eight to 12 years (9.6 ± 0.79 years), with the intervention group found to be older than the control group (intervention group: 9.8 years ± 0.93; control group 9.3 years ± 0.73). The majority of the participants, in both the intervention- and control groups, were nine years of age, see Table 5.1. This is expected as the study sample consisted of grade four learners, who should be nine years of age, turning 10 years old, within the same year. Furthermore, baseline testing was conducted at the beginning of the year, in February 2015, refer to the study design in Table 3.1, in Chapter 3.

Table 5.1: Age distribution between the intervention and control group

	Intervention Group		Control Group	
	n	% Entire Sample	n	% Entire Sample
8 years	8	12.31 %	27	29.35 %
9 years	35	53.85 %	49	53.26 %
10 years	14	21.54 %	12	13.04 %
11 years	5	7.69 %	4	4.35 %
12 years	3	4.62 %	0	0.00 %
Total	65	100.00 %	92	100.00 %

Furthermore, the large number of older participants, falling in the 11- and 12-year age category, in the intervention group is noteworthy. Schools located in lower socioeconomic areas face a multitude of challenges influencing, amongst others, academic performance and therefore grade pass rates (Zulu *et al.*, 2004). These challenges have already been elaborated on in Chapter 2, section 2.3.2. It is therefore not out of the ordinary to see a schoolchild failing a few grades, or the same grade more than once, and consequently becoming much older than his / her peers. The control group therefore presents with, not only a larger number of participants compared to the intervention group, but also with younger participant for both genders.

Age differences, particularly between the ages of eight to 12 years, as in the study sample, become very important as large variations in growth and development can occur. Both body composition- and physical fitness parameters are closely associated with these growth and development phases and should therefore be taken into account when the study's results are interpreted.

The following section discusses the anthropometric results of the study, including the body mass index, estimated body fat percentage as well as the indicators of nutritional status.

5.3. Anthropometric Measures

The anthropometric results of the study are discussed in this section. For each parameter assessed, the study results are compared to age and gender specific normative values, followed by a discussion of the intervention effects.

5.3.1 Body Mass Index

For the purpose of this study, body mass index (BMI) results are not compared to normative values, instead, age and gender specific BMI values, referred to as BMI-for-age z-scores (BAZ), are used. Refer to section 5.3.3 in this chapter, where normative BAZ results are discussed.

BMI results, as opposed to BAZ results, are however used to determine the intervention effect. This was done to incorporate more variation found within uncalculated data. The intervention effects were determined through a series of multiple regression analyses, with the intervention / control condition as main predictor.

When investigating the intervention effects on BMI, although the regression model was found to be a significant fit to the data ($p < 0.0001$), only 5 % of the variation in BMI could be explained by the proposed model and the included variables (Multiple $R^2 = 0.050$). This fact should be taken into consideration when the results are interpreted. The intervention condition, however, did not have a significant effect on BMI ($p > 0.05$). Only gender ($p < 0.0001$), the most important factor associated with BMI, as well as age ($p < 0.01$), and the non-linear effect of age ($p < 0.05$), were found to be significant.

When comparing the BMI intervention effect to empirical research, out of the eight studies examined, only three found significant improvements in BMI, four studies did not find any significant intervention effects, and one study only made use of estimated body fat percentage to report on body composition. Interestingly, all three studies conducted within the South African context, two in the KwaZulu Natal province (Naidoo & Coopoo, 2012; Naidoo *et al.*, 2009) and one in the Western Cape (Uys *et al.*, 2016), could not improve BMI significantly with a school-based physical activity- or physical activity and nutrition combined intervention. The intervention studies that showed a significant effect on BMI, were all located in developed countries, which included Europe (de Greeff *et al.*, 2016; Manios *et al.*, 1998) and Australia (Eather *et al.*, 2013).

Two of the three studies that showed improvements in BMI, made use of external physical education specialists to conduct the physical activity intervention. None of the teachers who taught the Life Skills learning area, and therefore conducted the physical activity intervention within this study, were specifically trained in physical education. The present study tried to decrease the effect of this limitation by making use of a 'teacher coach', who was assigned to assist teachers for one of the two physical education lessons per week. The teacher coaches were postgraduate students with a Human Movement Science degree, from the Nelson Mandela University. The teacher coach visited the school once a week and systematically mentored the Life Skills teacher in lesson conduction. With this limitation taken into consideration, the present study's intervention was designed to be 'low-touch' (limited contact) in nature. This approach aims at fostering capacity building within school structures and limiting contact with researchers and external experts.

The only study that found significant BMI improvements post-intervention, that did not make use of a physical education specialist, incorporated extensive teaching aids, consisting of teaching manuals, audio-tape material, stories, posters as well as learner workbooks to assist the teacher in lesson conduction (Manios *et al.*, 1998). The intervention also incorporated behavioural capabilities, where expectations and self-efficacy in healthy eating, physical activity and physical fitness were fostered, in collaboration with the learners' parents. Not only did the present study not make use of such intensive teaching aids, but no psychological component was included in the present intervention, and due to the low socioeconomic environment in which the present study was conducted, the study had limited parental support.

The present study's results furthermore indicated that girls within the study, possess significantly higher BMI values compared to boys. These findings concur with the latest Healthy Active Kids Report Card South Africa, published in 2018, which emphasises the fact that overweightness and obesity are increasing rapidly in the South African population (Uys *et al.*, 2018). The report card highlights high risk groups, and identified girls, particularly in the age ranges of eight to 10 years, which includes the age ranges of participants within this study, as having the highest risk for overweightness and obesity.

It is therefore not surprising that girls in this study have significantly higher BMI values compared to boys.

This study's results further highlight the effect of age on BMI. As the participants within this study increased in age, BMI increased as well, up until a point, between the ages of 11 and 12 years, where after BMI starts decreasing with an increase in age. This relationship is shown in Figure 5.1.

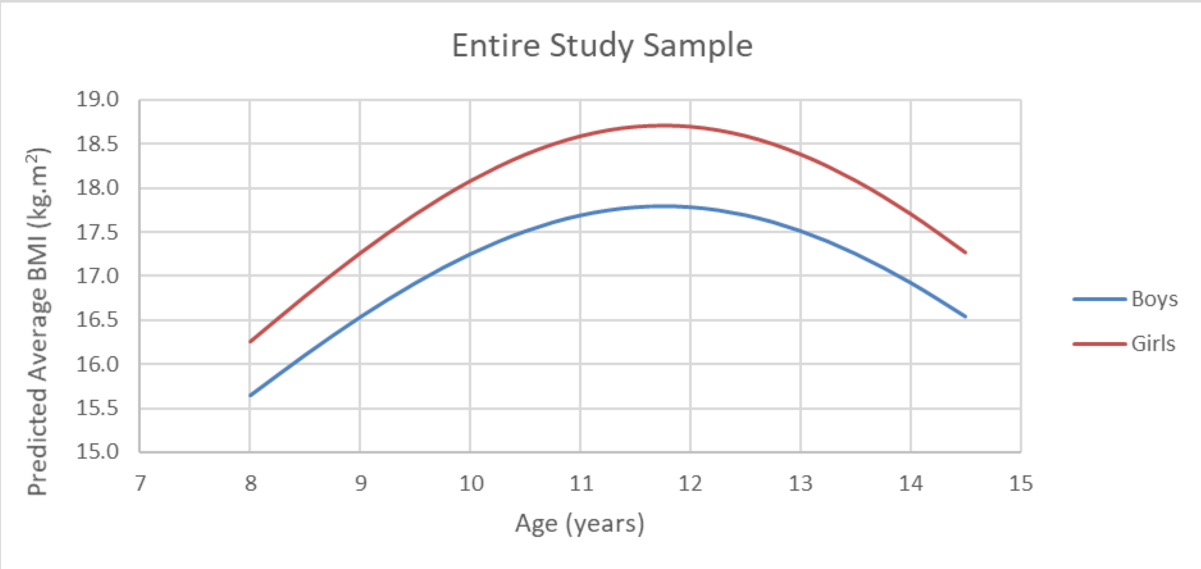

Figure 5.1: Line graph predicted average BMI (kg.m^2): Non-linear effect of age on BMI, for boys and girls shown separately, for the entire study period

This non-linear effect of age on BMI is unique to this study, compared to international data which shows a slow but steady increase in BMI, after an exponential growth spurt, as age increases (Cole, Bellizzi, Flegal & Dietz, 2000). A possible explanation of this observed effect could be the small sample size used within this study and increasing the number of participants could negate the observed effect. Moreover, it is important to take the small effect of only 5 % into consideration, of the variation in BMI that could be explained by the proposed regression model and all included variables. The following section discusses the study results for estimated body fat percentage.

5.3.2 Estimated Body Fat Percentage

Body fat percentage was estimated through the two-site skinfold measurement, using the subscapular- and the triceps skinfold, where after the skinfold equation, established by Slaughter *et al.* (1988) was applied.

When comparing sample statistics only, the intervention group had a lower body fat percentage during the first testing phase, compared to the control group (T1: IG:16.26 ± 6.72 %; CG: 19.97 ± 9.62 %) see Table 4.6. After a 3.9 % increase from the first to the second, and a 1.95 % decrease from the second to the third, the total intervention group body fat percentage changed pre- to post-testing, by an increase of 1.95 % (T3: IG: 18.21 ± 8.31 %). This is compared to a decrease of 0.39 %, a further decrease of 0.29 % and a final pre- to post-testing decrease of 0.68 % in the control group for the same time (T3: CG: 19.29 ± 8.71 %).

Although girls of both the intervention and the control groups presented with higher body fat percentages compared to boys, see Figure 4.5, the majority of the participants fell within normal body fat percentage ranges, according to international reference charts (McCarthy, Cole, Fry, Jebb & Prentice, 2006). Three quarters of the participants in the intervention group fell below 19.13 % body fat percentage shown by the third quartile, compared to 23.59 % for the control group, see Table 4.6.

When considering overweightness and obesity across the three testing phases, the largest number of participants classified were the control group girls, where eight, 14 and 14 girls were overweight or obese for the first, second and third testing phase, compared to seven girls in each testing phase for the intervention group girls. For the intervention and control group boys, both groups presented with similar numbers of overweight or obese classifications. For the control group boys, one, six and six boys were classified as overweight or obese for the first, second and third testing phase, respectively, compared to the intervention group boys where four, five and five boys were classified as such, respectively.

When investigating the intervention effects on body fat percentage, the regression model was found to be a significant fit to the data ($p < 0.001$), with 70.5 % of the variance in body fat percentage being explained by the proposed model (Multiple $R^2 = 0.705$). The intervention / control condition was not only found to significantly influence body fat percentage ($p < 0.001$) but was also found to be the most important factor associated between the tested variables. The average intervention effect was shown to be associated with an increase in body fat percentage, see Table 4.7. Although this might seem contradictory to the sample descriptive statistics presented in Table 4.6, Table E.11 and Table E.12, a phenomenon referred to as the Simpson's paradox is presented here. Defined as a phenomenon where marginal trends may seem present, but disappear or reverses after controlling for one or more other variables, the Simpson's paradox can be found if true randomization is not used, as is the case with the present study (Salkind, 2010: 1380-1383). Statistical relationships are therefore not absolute, and a relationship might increase, decrease, or even change direction depending on the set of variables being controlled, as was done within the multiple regression model.

As expected, participants' weight further influenced body fat percentage significantly ($p < 0.001$), with a higher weight corresponding to a higher body fat percentage. A significant increase ($p < 0.001$) was also noted between the first and the second testing phase. Furthermore, an increase in height and an increase in age corresponded to lower body fat percentage values, and both were found to be significant ($p < 0.001$).

When the study results are compared to empirical results presented in Chapter 2, out of the eight studies examined, only two studies incorporated skinfold measures to report on body composition. One study conducted in Europe incorporated sum of five skinfolds, and found significantly lower results in the intervention group compared to the control group (Verstraete *et al.*, 2007). The study incorporated physical education lessons, extracurricular activity during breaktimes, classroom-based lessons, activity 'homework', as well as after school activity lessons – all conducted by external specialists. A further explanation for the positive results obtained can be the intervention duration, which was two years. Not only was the duration of the European study much longer than the intervention duration of the present study (two years compared to two 10-week periods), but the intervention components were also more rigorous when compared to the present study. The Manios *et al.* (1998) study used the suprailiac, biceps, triceps and the subscapular skinfolds. Of these measures, only the intervention group's suprailiac skinfold improved significantly, with no significant effects found for the other three skinfold measurements.

Although the resulting increase in body fat percentage for the intervention group is not favourable, one cannot attribute these findings to the physical activity intervention itself. The increased age of the intervention group, their lower body fat percentage values at baseline testing, as well as the non-linear effect of age, displayed in Figure 5.1, should be considered when interpreting the body fat percentage increase. The following section discusses the indicators of nutritional status, which includes weight-for-age z-scores (WAZ), height-for-age z-scores (HAZ) and BMI-for-age z-scores (BAZ).

5.3.3 Indicators of Nutritional Status

The indicators of nutritional status refers to age- and gender-specific growth references, established by the World Health Organization's growth standards (de Onis *et al.*, 2007). The following section discusses weight-for-age z-score (WAZ) categories.

5.3.3.1. Weight-for-Age Z-Score

Figure 5.2 shows the WAZ categories for the first, second and third testing phases, categorised by intervention and control group. The majority of the participants were classified as normal, or older than 10 years, and therefore unable to be categorised according to WAZ, in both the intervention and control groups, throughout the three testing phases. Two participants were classified as severely underweight, namely one girl and one boy, in the second testing phase in the intervention group, and one participant, a girl, was classified as underweight in the control group during the first testing phase.

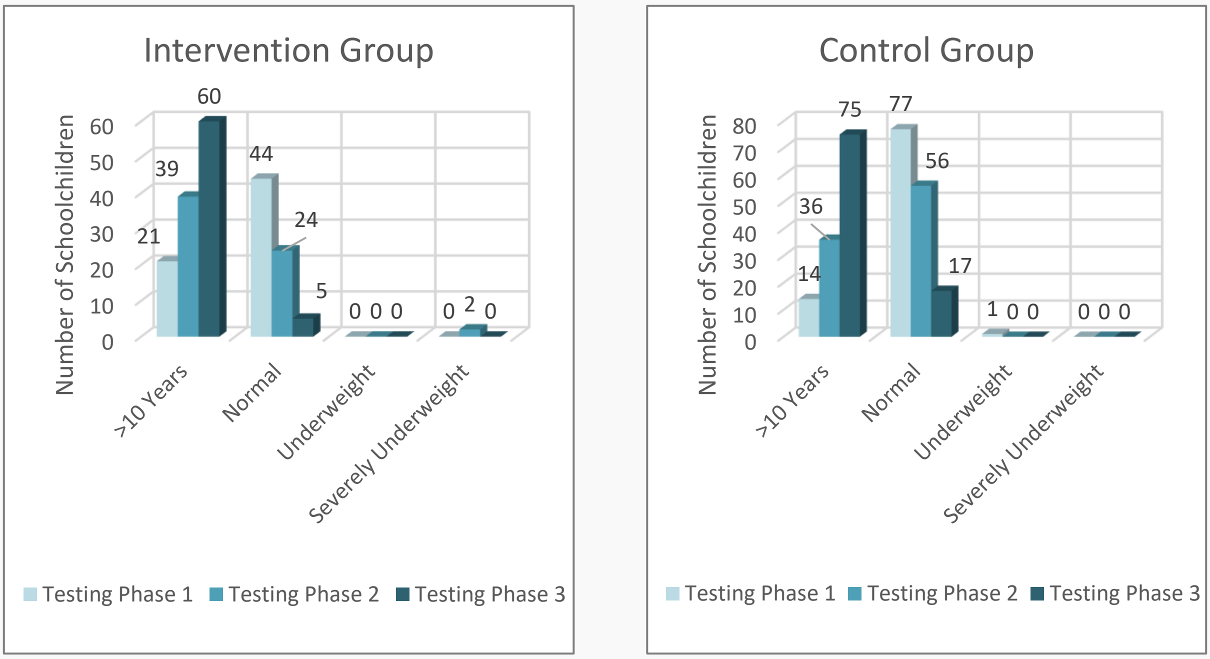

Figure 5.2: WAZ for the intervention and control groups across the three testing phases

The HAZ distribution and classifications follow.

5.3.3.2. Height-for-Age Z-Score

Figure 5.3 shows the HAZ categories for testing phase one, two and three, categorised by the intervention and control groups.

The majority of the participants were classified as normal with respect to height-for-age and gender. In the intervention group, during the first testing phase, one boy was classified as stunted and one boy as severely stunted. During testing phase two, three participants were classified as stunted, namely one girl and two boys. During the final testing phase two boys were classified as stunted and one boy as severely stunted in the intervention group. When considering the intervention group classifications longitudinally, the same boy was rated as stunted during testing phase one, two and three. The boy rated severely stunted in the first testing phase was also rated as severely stunted in the third testing phase. Lastly, the boy rated as stunted in the second testing phase was also rated in the same manner in the third testing phase. In the control group, the only non-normal classification was found in the third testing phase, where two boys and two girls were rated as stunted, according to HAZ classifications.

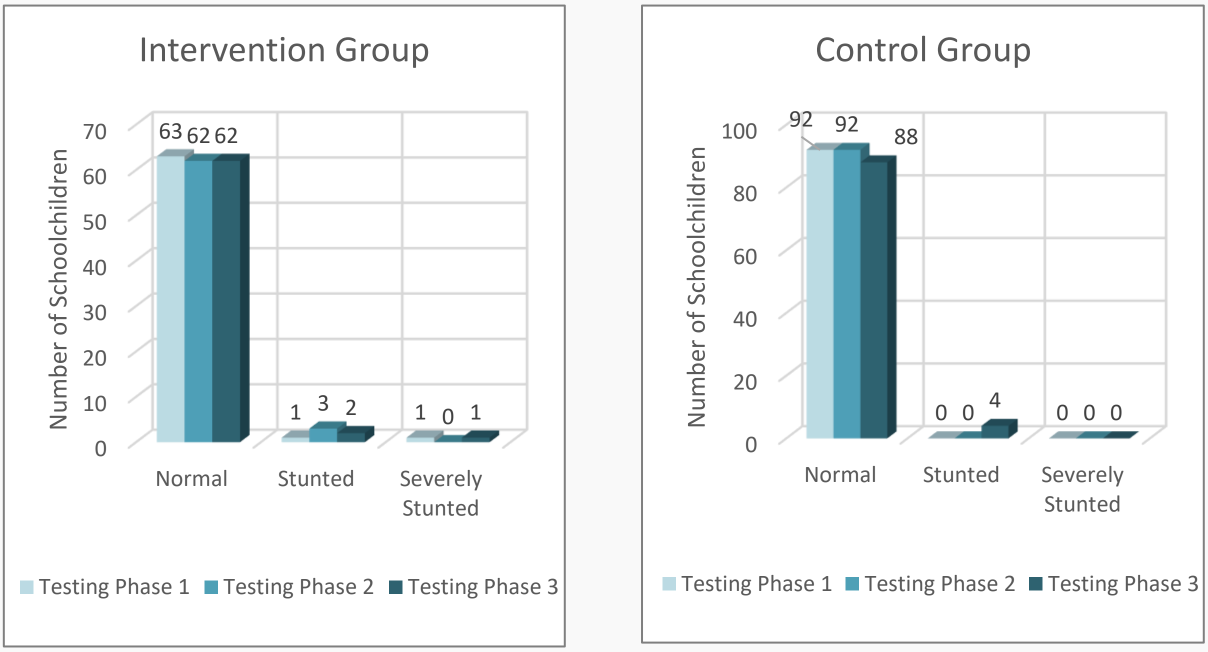

Figure 5.3: HAZ for the intervention and control groups across the three testing phases

The next section explains the BAZ distribution and classifications.

5.3.3.3. BMI-for-Age Z-Score

Figure 5.4 reflects the BAZ categories for testing phase one, two and three, categorised according to the intervention or control groups.

When considering below normal BAZ classifications, the intervention group contained one severely thin participant in each testing phase, and a thin participant in the second testing phase. The same girl was classified as severely thin in the first and third testing phases, and thin in the second testing phase. A boy was classified as severely thin in the second testing phase. These two participants were also classified as severely underweight by the WAZ measurement during testing phase two, seen in Figure 5.2. The control group had no participants below a normal BAZ classification.

When examining above normal BAZ classifications in Figure 5.4, the intervention group included 20 participants, 20 participants and 19 participants rated overweight or obese during the first, second and third testing phases, respectively. This can be compared to 23 participants, 24 participants and 29 participants in the control group for the same testing phases. This equates to 30.26 % of the intervention sample and 27.54 % of the control sample being classified as either overweight or obese throughout the testing period. The number of overweight or obese participants in the intervention group either remained stable or decreased, whereas an increase in the control group was noticed, based on sample statistics solely.

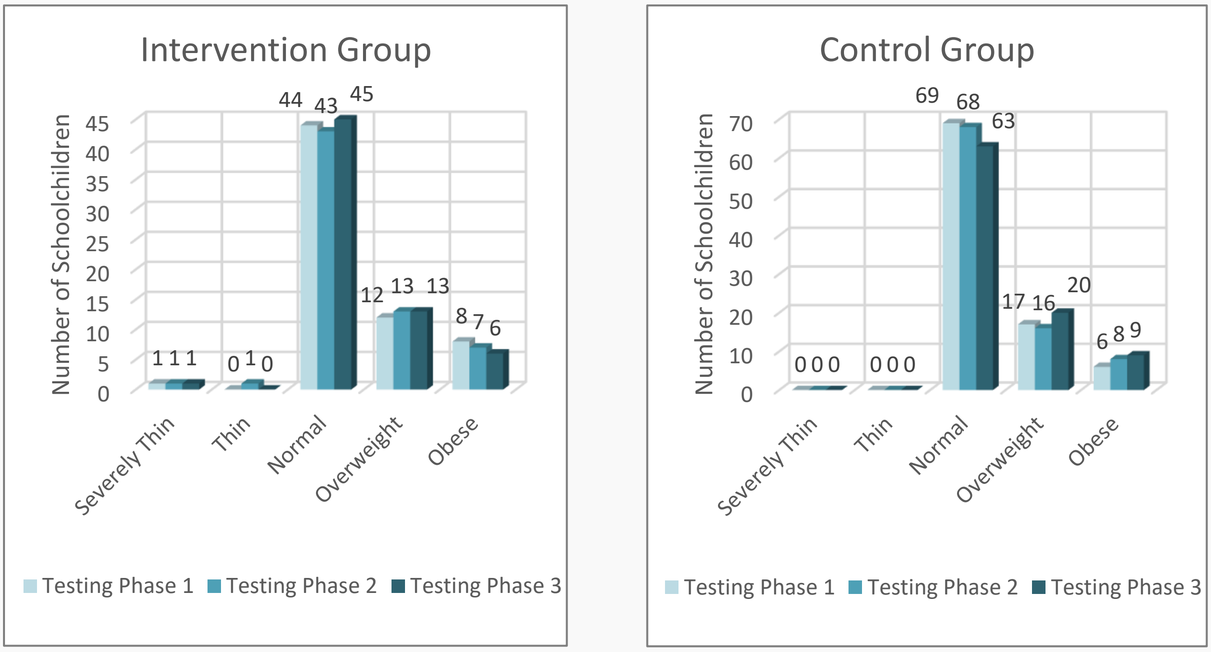

Figure 5.4: BAZ for the intervention and control groups across the three testing phases

When comparing the indicators of nutritional status to the empirical research, only two studies made use of indicators of nutritional status to report on body composition, both only making use of the BAZ indicator. A study conducted in Ecuador in South America, could not improve the BAZ indicator significantly after a physical activity intervention (Andrade *et al.*, 2014). A study conducted in Australia however, managed to obtain significant improvements in BAZ after implementing the Fit-4-Fun physical intervention by trained physical educators, even though the intervention lasted only for a short duration of eight-weeks, compared to the present study's two 10-week intervention durations (Eather *et al.*, 2013). The following section discusses the physical fitness study results.

5.4. Physical Fitness Measures

Physical fitness assessment in this study was done through selected tests from the Eurofit testing battery. The components assessed included cardiorespiratory fitness, upper- and lower body strength, as well as lower body flexibility. The section to follow discusses the cardiorespiratory fitness study results.

5.4.1 Cardiorespiratory Fitness

Cardiorespiratory fitness was measured in terms of estimated maximal oxygen uptake ($\dot{V}O_2max$), determined by the 20-metre multistage shuttle run test (Léger *et al.*, 1988). The section starts off by comparing estimated $\dot{V}O_2max$ results to normative values, where after the intervention effects are discussed and comparisons made to empirical studies. Estimated $\dot{V}O_2max$ results are provided to aid in understanding and for comparison purposes, but for analysis, the number of laps, as opposed to the estimated $\dot{V}O_2max$ that were calculated, was used. This was done to incorporate more variation found within the raw, uncalculated data.

When investigating the sample statistics only, the intervention group presented with slightly larger estimated $\dot{V}O_2max$ results compared to the control group during the first testing phase (IG: 50.02 ± 4.45 $ml.kg^{-1}.min^{-1}$; CG: 49.85 ± 4.24 $ml.kg^{-1}.min^{-1}$), see Table 4.11. Both groups however decreased from the first to the second, and from the second to the third testing phase. The intervention group's total estimated $\dot{V}O_2max$ decrease pre- to post-testing was 4.11 % compared to 8.08 % seen in the control group. This resulted in a 4.16 % difference between the intervention- and control group for the third testing phase, compared to only a 0.34 % difference in the first testing phase, see Table 4.11. A study comparing worldwide variation in 20-metre shuttle run results, found that generally linear improvements are seen in shuttle run tests until early post-pubertal years, at about 12 years of age in girls and 16 years of age in boys (Olds, Tomkinson, Léger & Cazorla, 2006). One would therefore expect linear improvements within the present study's sample as well, due to the majority of the study sample falling below early post-pubertal years. A possible explanation for the decreasing estimated $\dot{V}O_2max$ results, can however be lack of motivation, especially during the second and third testing phases, as motivation has been found to be a large factor influencing maximal effort activities (Malina & Katzmarzyk, 2006). During the second and third testing phases, the novelty of performing the 20-metre multistage shuttle run test could have worn off, and participants may have stopped running before reaching their true maximal capacity.

It was furthermore found that boys had a larger estimated $\dot{V}O_2max$ than girls, in both the intervention and control groups. Boys did however see larger percentage decreases, with a 9.75 % and a 5.03 % decrease, from the first to the third testing phase for the intervention group boys and control group boys respectively, compared to a 6.74 % and a 3.14 % decrease of the intervention and control group girls for the same time interval, see Table E.13 and Table E.14. These findings concur with the same study comparing worldwide variation in 20-metre shuttle run results, where boys performed significantly better than girls ($p < 0.0001$) (Olds *et al.*, 2006). An increase in the performance gap between genders (increasing with age), was also reported in the Olds *et al.* (2006) study. As this was not the case during the present study, further support is given to the argument that a lack of motivation might be a possible reason for the study results.

When investigating the intervention effects, the regression model was found to be a significant fit to the data ($p < 0.001$) and 49.3 % of the variance in number of laps ran could be explained by the proposed model (Multiple $R^2 = 0.493$). The regression model found the intervention / control condition had a significant effect ($p < 0.05$), indicating the intervention affected a significant increase in the number of laps ran. This result is in relation to the control group, and does not necessarily indicate an increase in the mean sample statistics provided in Table 4.11, Table E.13 and Table E.14. Again the Simpson's paradox is applicable here, where a relationship might increase, decrease, or even change direction depending on the set of variables being controlled, as was done within the multiple regression model (Salkind, 2010: 1380-1383).

Further variables found to have significant influence on the number of shuttle laps ran, included gender ($p < 0.001$), as well as significant differences between the second- and the first testing phases ($p < 0.001$), and the third- and the first testing phases ($p < 0.05$). Girls were found to have statistically lower estimated $\dot{V}O_2max$ than boys, and both the second and third testing phases were measured significantly lower than the first testing phase, when the entire study sample is taken into consideration.

Of the eight empirical studies discussed in Chapter 2, two studies did not use the 20-metre multistage shuttle run test (Naidoo *et al.*, 2009; Uys *et al.*, 2016), and four studies could not obtain significant improvements in estimated $\dot{V}O_2max$. The studies which reported an improvement in estimated $\dot{V}O_2max$, were conducted in Europe (Manios *et al.*, 1998), and Australia (Eather *et al.*, 2013). The study conducted in Australia was of a similar duration to the present study and employed the Fit-4-Fun intervention for 8-weeks, compared to the present study's 2 X 10-week intervention. The study conducted in Europe did not make use of expert physical educators, which was also the case with the current study, and adaptions to the physical education component was made to focus more on cardiorespiratory, than motor development components. Although the present study complimented the CAPS Life Skills module, and therefore focused the majority of physical education classes on motor development and teaching fundamental movement skills, the main aim of the move-to-music dance classes was developing the cardiorespiratory system and improving fitness levels. The practicality of the improved number of laps ran in the multistage shuttle run test, on cardiorespiratory fitness improvements, however, requires further investigation. One can therefore not state that the present study's physical activity intervention significantly improved cardiorespiratory fitness, and should only report on the significant effect of number of laps ran in the multistage shuttle run test. The section to follow discusses the upper body musculature strength results obtained in the study.

5.4.2 Upper Body Musculature Strength

The study measured upper body musculature strength with a handheld dynamometer. Again, this section will start by comparing the study results to normative values, thereafter the intervention effects will be explained, followed by comparisons to empirical studies.

Grip strength was assessed as a common measure representing upper body musculature strength and a measure most often used in epidemiological studies (Ortega, Ruiz, Castillo & Sjöström, 2008). When comparing the grip strength results to normative values, it is important to mention that different studies make use of different handgrip protocols using a dynamometer. Studies often require the participant to stand, squeezing the dynamometer with a straight arm, hanging down. This study made use of a seated protocol, where the elbow position was maintained at 90˚, refer to Chapter 3, section 3.6.2 which elaborates on the protocol used.

The study's handgrip strength results were therefore only compared to a study conducted in Australia, where the health related physical fitness of children between the ages of 9- and 17-years were reported on, using the same seated handgrip strength protocol employed in this study (Catley & Tomkinson, 2013). Although the Australia study employed the same protocol, an average of dominant and non-dominant handgrip strength results is reported on, whereas the present study used the highest result of the dominant hand only. This is important in light of result comparisons, as average handgrip strength results of girls within the present study, fell below the 30th percentile, and boys below the 20th percentile compared to the Australian study results. Indeed, far below recommended age and gender specific normative grip strength values, even more so as the normative results compared against, used an averaged grip strength value of the dominant- and non-dominant hand.

The intervention group presented with lower handgrip strength results of 9.06 %, 7.7 % and 9.15 % difference, for testing phase one, two and three, respectively, compared to the control group. The intervention group increased on average, with 0.27 kg, 1.39 kg and 1.65 kg from the first to the second, the second to the third and the first to the third testing phase, respectively. This is compared to a 0.08 kg, 1.77 kg and 1.85 kg increase in the control group for the same testing phases.

When investigating the intervention effects on handgrip strength, the regression model was a significant fit to the data ($p < 0.001$) and 50.8 % of the variance in handgrip strength can be explained by the proposed model (Multiple $R^2 = 0.508$). The regression model indicated that the intervention / control condition had a significant effect ($p < 0.001$), indicating the intervention effected a significant increase in the handgrip strength, in relation to the control group, when accounting for all variables within the regression model. Additionally, the intervention / control condition was the strongest predictor for handgrip strength. Gender was also proven to significantly influence grip strength ($p < 0.001$), with boys showing higher values compared to girls. This concurs with results found in the normative study of Australian children, where boys reflected significantly higher results compared to girls (Catley & Tomkinson, 2013). Height ($p < 0.01$) and weight ($p < 0.001$) furthermore significantly influenced grip strength, as expected, with an increase in both height and weight leading to higher grip strength values. Older children also showed to have significantly higher results, as age was to be a significant predictor of grip strength ($p < 0.001$).

When comparing the results to empirical research referred to in Chapter 2, four studies did not make use of the handheld dynamometer static upper body strength assessment, and of the four studies that did, none could improve upper body grip strength significantly pre- to post- intervention (Andrade *et al.*, 2014; de Greeff *et al.*, 2016; Manios *et al.*, 1998; Verstraete *et al.*, 2007). This present study's significant increase in grip strength is therefore novel but should be seen in the light of extremely low grip strength results throughout the study, when compared to age and gender specific normative values. Lower body musculature strength results are discussed in the following section.

5.4.3 Lower Body Musculature Strength

Lower body muscular strength was estimated through the standing broad jump test. This section commences by comparing the study results to normative values, thereafter the intervention effects will be explained, followed by comparisons with empirical studies.

The intervention and control groups scored similarly during the first testing phase, for standing broad jump distance (IG: 127.47 ± 19.93 cm; CG: 128.49 ± 23.44 cm), with the mean results only showing a 1.02 cm difference in favour of the control group, see Table 4.15. Both groups decreased from the first to the second, and from the second to the third testing phase, with a total decrease of 4.16 % in the intervention group, and 5.72 % decrease in the control group, from the first to the third testing phase. This resulted in a difference between the intervention and control group, during the third testing phase, of 0.84 cm or 0.69 %, see Table 4.15. The results were compared to the Health of the Nation study, conducted amongst 10 295 South African children between the ages of 6 and 13 years (Armstrong, Lambert & Lambert, 2012). With average results for Black children in the same age ranges of the present study, falling between 138.4 cm and 148.5 cm, the present study's sample scored much lower broad jump distances, even when compared to the first testing phase, where the highest distances were achieved. It is furthermore important to note that the Health of the Nation study found that Black children scored distances below children of mixed ancestry, Coloured children, who scored lower distances compared to White children. Statistically significant differences was therefore found in socioeconomic statuses, which are closely linked to ethnicity within the South African context (Armstrong *et al.*, 2012).

When investigating the intervention effects on standing broad jump distance, the regression model was a significant fit to the data ($p < 0.001$) and 41.4 % of the variance in standing broad jump distance could be explained by the proposed model (Multiple $R^2 = 0.414$). The intervention / control condition did not have a significant effect on the standing broad jump distance ($p > 0.05$). The strongest predictor however was gender ($p < 0.001$) and the broad jump distance was significantly shorter for girls, compared to boys, see Figure 4.16. Furthermore, height significantly influenced broad jump distance ($p < 0.001$), with greater height decreasing distance jumped. Older children jumped further than younger children ($p < 0.001$), as age influenced distance jumped significantly. Lastly, significant decreases were also found from the first to the second ($p < 0.01$), and from the first to the third testing phases ($p < 0.001$).

Comparing the standing broad jump distance to empirical research, only one of the empirical studies reported a significant increase in standing broad jump distance (Manios *et al.*, 1998), one study did not make use of standing for broad jump distance to assess lower body strength (Andrade *et al.*, 2014), and the remaining six studies did not show significant improvement in standing broad jump distance pre- to post-intervention. A possible explanation for the significant increase in standing broad jump distance found by Manios *et al.* (1998) could be ascribed to the age of the study sample. Children from grades one to three participated in the study, much younger than the present study's grade four, and post-intervention, grade five study sample. Armstrong *et al.* (2012) reported on a statistically significant increase with age in both the boys and girls, especially with younger children six and seven years of age. The following section discusses the last physical fitness parameter, lower body flexibility.

5.4.4 Lower Body Flexibility

Lower body flexibility was assessed with the widely used sit-and-reach test. Normative values of the sit-and-reach test will be discussed, followed by the intervention effects and finally comparisons to empirical studies will be made.

The control group started with a 1.9 % greater sit-and-reach distance, compared to the intervention group (IG: 32.58 ± 4.78 cm; CG: 34.47 ± 6.52 cm), see Table 4.17. Both groups decreased from the first to the second, and from the second to the third testing phase, with a total decrease of 12.16 % in the intervention group, compared to 11.91 % in the control group, from the first to the third testing phase. The sit-and-reach distance results were compared to the Health of the Nation study, which showed children of the present study, obtaining better results (Armstrong *et al.*, 2012). Black children within the Health of the Nation study scored far below the sit-and-reach distances within the present study, with an average distance ranging from 21.2 cm to 22.7 cm, compared to 32.5 cm to 34.4 cm in the present study. Of interest, the Black children within the Health of the Nation study achieved better sit-and-reach scores compared to children from mixed ancestry or White children.

When investigating intervention effects on the sit-and-reach distance, the regression model was a significant fit to the data ($p < 0.001$) and 17.1 % of the variance in sit-and-reach distance could be explained by the proposed model (Multiple $R^2 = 0.171$). The intervention / control condition did not have a significant effect on the sit-and-reach distance ($p > 0.05$). Gender was found to be the largest influence on sit-and-reach distance ($p < 0.001$), with girls obtaining statistically higher distances compared to boys as expected, see Table E.19 and Table E.20. Concurring with known findings, as the participants increased in age, the sit-and-reach distance was found to decrease significantly ($p < 0.001$), and taller participants were further found to obtain lower sit-and-reach distances ($p < 0.001$). Lastly, a statistically significant decrease was found between the first- and the third testing phase ($p < 0.001$).

When comparing these results in light of the empirical research used within this study, all studies incorporated the sit-and-reach test, except one study making use of the modified back-saver sit-and-reach test (Eather *et al.*, 2013). Five studies could not show significant improvements in lower body flexibility whereas one South African study found significant improvements in both the intervention as well as the control groups (Naidoo & Coopoo, 2012). Therefore, only one study, conducted in Europe and incorporating specialist Physical Educators, could significantly improve sit-and-reach distance (Manios *et al.*, 1998). Possible explanations for the positive results could be linked to the age of the sample, grade one to three, compared to grade four, and post-intervention grade five children within the present study. When investigating optimal training ages for physical fitness components, flexibility training is done during the younger ages, between five and eight years, due to this window being identified as accelerated adaption to flexibility training (Oliver, Moosavi, De Ste Croix, Lloyd, Williams, Meyers, Ford & Till, 2011). The study's intervention further specifically focused on fitness components, as opposed to motor development which is prevalent within the South African CAPS curriculum Life Skills module, and therefore the focus of the intervention's physical education components as well. The following section concludes this chapter, thereafter study limitations and recommendations for future research is provided.

5.5. Conclusion

The main aim of the study was to investigate the effect of a physical activity intervention, incorporating physical education lessons, move-to-music dance classes, in-class physical activity breaks, physical activity 'homework', and the creation of a low-cost physical activity-friendly school environment, on the physical fitness parameters of primary schoolchildren from a disadvantaged community. The physical fitness parameters assessed were body composition, cardiorespiratory fitness, upper- and lower body musculature strength and lower body flexibility. The parameters found to have been significantly improved post-intervention, included the number of laps ran in the multistage shuttle run test, indicating cardiorespiratory fitness and upper body musculature strength.

The study further highlights low levels of health-related physical fitness in schoolchildren from lower socioeconomic areas and emphasises the need for physical education and physical activity promotion within public school settings. These physical activity promoting interventions should be conducted regularly and consist of higher intensity activities, so that physical fitness parameters and the body composition of primary schoolchildren can be improved.

The following section elaborates on the limitations of the study, as well as suggestions for future research.

5.6. Limitations

Although all possible precautions have been taken, the results of the study should be seen in the light of the following limitations.

Firstly, the selected study sample was relatively small and homogenous in nature. It included only Black, Xhosa speaking schoolchildren, between the ages of eight and 13 years. The sample size comprised 157 children from two primary schools, within close proximity of each other. The study acknowledges that the uniformity of ethnicity, the sample size and the proximity of the two primary schools might limit the generalisability of the current study's results.

Secondly, the study took place within disadvantaged communities, only incorporating quintile three, public primary schools, and consequently the variation in socioeconomic status is limited, which further constrains extrapolation.

Thirdly, true randomisation was not possible, due to the natural occurring clusters, schools or classes, involved. The allocation to the intervention and control condition was therefore done school-wise and not class-wise. Certain criteria, required by the larger DASH study, was used to select participating schools. These included more than a hundred schoolchildren within the fourth grade, as well as specific geographic locations, including township areas, as well as Port Elizabeth's northern areas, to ensure an equal distribution between Black African and Coloured participants.

The fourth study limitation involves the cardiorespiratory fitness assessment. The 20-metre multistage shuttle run test was used to assess participants' cardiorespiratory fitness, an indirect maximal measurement of $\dot{V}O_2$max. The research team acknowledges that some participants might not have performed to their best abilities due to lack of motivation or due to social dynamics (Malina & Katzmarzyk, 2006). However, this test was chosen due to its ease of application within a resource constrained setting (Léger *et al.*, 1988).

The final study limitation involves the physical activity intervention itself. Although the intervention material was well perceived by schoolchildren and teachers alike, the practical implementation thereof might have been problematic due to the teachers not being specialist physical educators. The research team tried to overcome this limitation by systematically mentoring the teachers into the teaching of physical education, using a collaborative teaching approach, through the use of 'teacher coaches'. The coaches mentoring the teachers were graduate students with a Human Movement Science degree. Unfortunately, due to resource constraints, the coach was not able to conduct each lesson. Thus, the level of the teacher's compliance and adherence to a high intervention quality might have varied considerably. The motivation of teachers, especially within the practical lesson conduction, may have been less optimal at times. Furthermore, the length of the intervention was relatively short (two 10-week periods, separated by the December holiday school break). Hence, it may be that a longer, more intensive intervention is needed to positively impact factors such as body composition and physical fitness components in general, among primary schoolchildren.

The following section focuses on possible recommendations for future research.

5.7. Recommendations for Future Research

As physical inactivity during childhood can lead to poor health outcomes in adulthood, the promotion of physical activity among school-aged children is crucial in preventing conditions that can relate to increased morbidity later in life.

Since the present study results could not show improvements in body composition measures, lower body strength or flexibility, the following topics for future research are recommended, namely that:

- The current study be repeated with the school-based physical activity interventions being of longer duration and involve activities of a higher intensity.
- The effect of close collaboration between teachers and physical education specialists on the quality and intensity of the physical education lessons, be investigated.
- The impact of regular health assessments and relevant feedback on the implementation of regular physical education classes and on primary schoolchildren in lower socioeconomic communities reaching age and gender specific body composition and physical fitness levels, be determined.
- Physical education workshops for teachers within the framework of in-service training be implemented and the impact thereof in ensuring increased teacher skills and sustainable capacity building in school settings, be investigated.

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List of Appendices

Appendix A : DASH Project Consent Forms

1. Informed Consent Form (English)
2. Oral Assent Form for Child Participants (English)
3. Project Information Sheet (English)

1. Informed Consent Form (English)

10 April 2014

DASH INFORMED CONSENT FORM

Project Title:

Impact of disease burden on schoolchildren's physical fitness and psychosocial health in Port Elizabeth, South Africa, and effects of setting-specific interventions

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 ____________________________ telephone no_____________________________________

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 or legal guardian:

I have read the letter of information of the study or it has been read to me in a language that I understand. I had the opportunity to ask questions 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 or legal guardian ____

Place ____

Date ____________________________ Signature ____

If parent or guardian 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 parent or guardian:

Thank you very much for your invested time!

Nandi Joubert
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Nelson Mandela Metropolitan University
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Research Ethics Committee: Human (REC-H) at Nelson Mandela University

Prof. Charmain Cilliers
Chairperson: Research Ethics Committee: Human
Nelson Mandela University
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Email: Ethics@Mandela.ac.za

2. Oral Assent Form for Child Participants (English)

15 April 2014

DASH PROJECT ORAL ASSENT FORM FOR CHILD PARTICIPANTS

Project Title:

Impact of disease burden and setting-specific interventions on schoolchildren's physical fitness and psychosocial health in Port Elizabeth, South Africa

Directions:

These explanations will be discussed verbally with the learners.

Explanation of the study (what will happen to me in this study?)

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

Risks or discomforts of participating in the study (can anything bad happen to me?)

You may feel shy about giving a stool and urine sample, but you will do this at home and your parents will help you with this. You may feel a bit tired during and after the exercises. If you feel sick or have any pain after the exercises, please tell your parents or your teacher.

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

If you are found to be ill or sick, doctors will give you medication to get better.

Confidentiality (will anyone know I am in the study?)

Nobody will know that you were in the study. We will not list your name on any of the reports.

Compensation for participation / medical treatment (what happens if I get hurt?)

Your parents or caregiver have been given information about the study. You should not get hurt in any way. But if you do, your parents will let us know and you will be taken to a doctor for treatment.

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

You can contact Prof Cheryl Walter if you have any questions about the study. The phone number is 041 504 2628

Voluntary Participation (What if I do not want to do this?)

You can stop being in the study at any time without getting in trouble.

Do you understand this study and are you willing to participate?

YES	NO

____________________________________ ____________________________

Signature of Child Date

Any other questions?
Do not hesitate to contact us if you have any other questions.

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Nelson Mandela University
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3. Project Information Sheet (English)

25 April 2014

DASH Project Information Sheet

Project Title:

Impact of disease burden and setting-specific interventions on schoolchildren's physical fitness and psychosocial health in Port Elizabeth, South Africa

Identity of researchers and sponsoring institution:

This study will be carried out in collaboration with Prof. Rosa du Randt and Prof. Cheryl Walter from the Nelson Mandela Metropolitan University and Mr Bruce Peter Damons from the Sapphire Road Primary School. The following institutions will form the complete study team, namely the Department for Sports, Movement and Health (DSBG), University of Basel and the Swiss Tropical and Public Health Institute (Swiss TPH), Switzerland. The study is funded by the Swiss National Science Foundation (SNSF) and will last for 3 years (April 2014 – March 2017).

Study objectives:

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

Research procedures:

Approximately 50 schools (20 learners per school) in the Port Elizabeth area will be selected for participation in a rapid appraisal. Out of these 50 schools, 30 schools (30 learners per school) will be selected for further participation in a cluster randomized controlled trial assessing the impact of health intervention on overall child health.

In both stages of the study, each child will be asked to submit a stool and urine sample to assess prevalence of communicable diseases. Finger prick, in which a finger is pricked with a lancet to obtain a small quantity of capillary blood to test for anaemia (haemoglobin) and diabetes, is a slightly uncomfortable procedure, but doesn't cause any long-lasting pain. Clinical examination and measurement of anthropometric indicators (e.g. height, weight and body composition) will be performed. Furthermore, levels of physical fitness and cognitive performance will be determined, and the children's psychosocial health will be rated. Based on these results, several interventions on will be specifically designed and implemented to improve your child's health and wellbeing.

Risk and benefits:

There are no specific risks associated with this study. Submission of stool and urine samples by schoolchildren as study participants might be perceived as shameful. Appropriate treatment will be offered, for free, to all individuals from the selected schools regardless of participation in study. Treatment will be administered by medical staff from the district hospital according to national and international treatment guidelines.

The proposed research will provide a comprehensive update on the status of communicable diseases (e.g. helminth infections) and non-communicable chronic conditions (e.g. type 2 diabetes and obesity) in the selected communities in Port Elizabeth, South Africa. Since such data is currently not available in this area, there will be a need to generate more evidence. By linking them with the physical fitness, cognitive performance and psychosocial health of children, this wealth of information will help to shed light on the true health consequences incurred by this potential dual burden of disease and provide guidance for further health interventions to be implemented among schoolchildren in this area.

Confidentiality:

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

Consent:

There is absolutely no obligation to participate in this study, but your consent is required for the participation of your child / children. Participation of your child / children in this study is entirely voluntary and they can withdraw any time even after you have signed the consent form.

Alternative to participation:

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

Consequences if you decide to withdraw your child / children from the study and the methodical procedure at the end of the participation:

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

Any other questions?

Do not hesitate to contact us if you have any further questions.

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Appendix B : Clinical and Physical Fitness Assessment Capturing Form

CLINICAL ASSESSMENT CAPTURING FORM

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

ID: ☐ ☐ ☐ ☐ ☐

First name: ____________________ Last name: ____________________________

Gender: ❑ Female ❑ Male

DONE BY INVESTIGATOR:

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

FUNCTIONAL SIGNS:

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

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

  Against worms: ____

  Others: ____

DONE BY NURSE / DOCTOR:

- **Temperature:** ___________ **°C**
- **Results of the blood pressure measurement:**

  Pulse _____________ bpm Blood pressure__________________ mmHg
- **Result of the haemoglobin (Hb) test using HemoCue® Hb 301 system:**

  ____________ g / mL
- **Results of the blood glucose (HbA1c) test using Alere Afinion AS 100 Analyzer:**

  ____________ % HbA1c

  ____________ mmol/mol HbA1c

  ____________ estimated average glucose (eAG)

CONCLUSION:

Included ________________________________

Excluded (pattern) ________________________________

Name of the nurse / doctor in block letters:

____

Signature of the nurse / doctor:

____

PHYSICAL FITNESS ASSESSMENT CAPTURING FORM

BIOGRAPHICAL INFORMATION			
ID	☐ ☐ ☐ ☐ ☐	TEST DATE	(dd / mm): _____/_____/ 2015
NAME		SURNAME	
BIRTHDAY	(dd / mm / yyyy): _____/_____/20____		

BODY COMPOSITION			
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	Cardiorespiratory fitness	20 m Shuttle Run Test (20 m SRT)		Start Number		
				Laps		

Appendix C : DASH Project Physical Activity Intervention

The DASH Project Physical Activity Intervention material is found in the following sections within this appendix:

1. Example of DASH Physical Education Lesson Plans for Grade 4

DASH Physical Education Lesson Plans
Grade 4






SSAJRP
University of Basel, CH, and Nelson Mandela Metropolitan University, Port Elizabeth, ZA

‚Education is the most powerful weapon that can be used to change the world'. (Nelson Mandela)

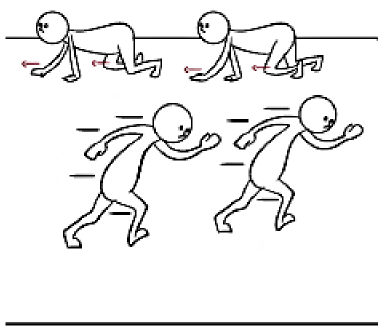
DASH study

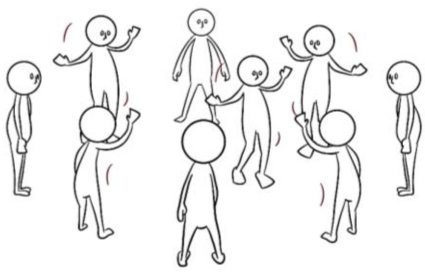
Physical Education Lesson Plans
Table of Contents

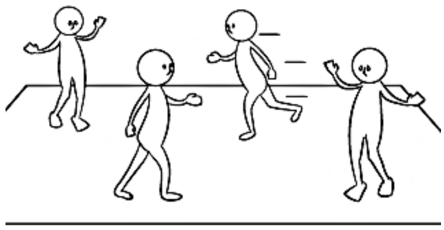
Physical Education Lesson Plans Grade 4

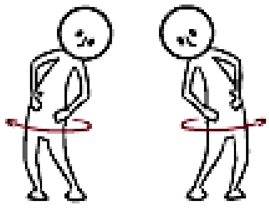
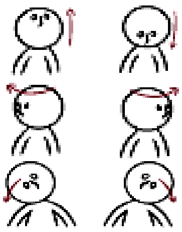
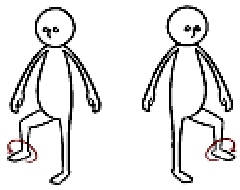
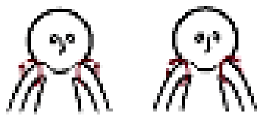
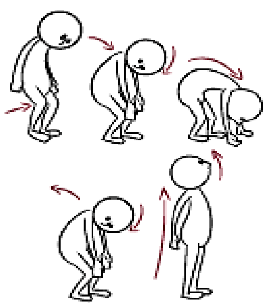
Term	3
Week	1
Lesson	1

Lesson Focus	Participation in rhythmic movements with the focus on posture. Safety measures during rhythmic movements.
Equipment	1. Coloured cones, enough to mark the playing area 2. Whistle

Warm-up	**10 min**	**Animal Movements** Mark out a playing field with coloured cones, roughly a 20 m square. Instruct the learners, roughly every 30 sec, to imitate the following animals: 1. Move like a snake 2. Gallop like a horse 3. Walk like a lion 4. Hop like a rabbit 5. Move like a cow 6. Jump like a dolphin 7. Fly like a butterfly 8. Run like a dog	

Main Section	**10 min**	**Dancing Circle** • Divide the class into 4 or 5 groups and instruct them to stand in big circles. • One learner starts by performing a dance movement in the middle of the circle. The rest of the circle copies the move. • Once all the learners have copied the move, the learner in the centre chooses another learner to perform the next move. • This continues until everyone has been given a chance to perform a movement.	

Main Section	**10 min**	**Move to Mood** • Re-divide the class into 4 or 5 different groups. • Instruct the learners to create a dance in their group to show two different emotions: happy and sad. • Instruct the learners to use their whole body and facial expressions to express the emotions. • Allow 5 minutes of practice before each group shows their dance to the class. • Allow the class to guess which emotion are displayed when each group is showing their dance.	

Cool Down	**10 min**	**Mobilisation and Isolation** Ensure that the learners are properly cooled down before they return to class by performing the stretches below. Perform each stretch for 20 seconds and repeat twice. **1. Hip circles** Instruct the learners to make big circles with their hips, moving both right and left. **2. Neck movements** The learners should look up and down, left and right, and lower their ear to their shoulder. **3. Ankle twists** The learners should balance on one leg while rolling the other ankle around, rolling both right and left way. **4. Shoulder rolls** Learners should make big circles with their shoulders, rolling them forward and backwards. **5. Full body roll down** While the learners bend their knees, slowly start at the head and roll down the spine until their hands touch the ground. Do this slow and steady, for a count of eight seconds. Stay down for three seconds, before slowly rolling up again to standing.	    

2. Example of DASH Physical Education Lesson Plans for Grade 5

DASH Physical Education Lesson Plans
Grade 5






SSAJRP
University of Basel, CH, and Nelson Mandela Metropolitan University, Port Elizabeth, ZA

‚Education is the most powerful weapon that can be used to change the world'. (Nelson Mandela)

DASH study

Physical Education Lesson Plans
Table of Contents

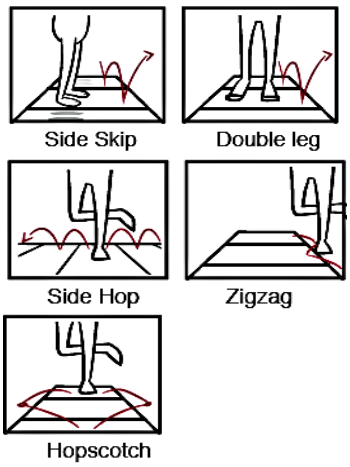
,Education is the most powerful weapon that can be used to change the world'. (Nelson Mandela)

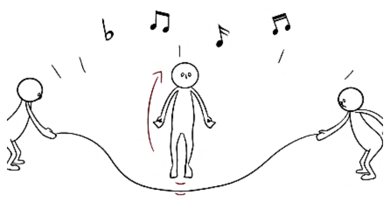
DASH study

Physical Education Lesson Plans
Grade 5

Term	1
Week	1
Lesson	1

Lesson Focus	Participation in movement sequences that require consistency and control in smooth and continuous combinations: rotation, balance, locomotion and elevation. Safety measures relating to movement sequences.
Equipment	1. Whistle 2. Chalk 3. Hula hoops, roughly 10 4. Skipping ropes, roughly 10

Warm-up	**10 min**	**Fast Ladder** • Before the class starts, draw 5 'ladders', such as used in soccer drills, on the playing ground with chalk. • Divide the class into roughly 5 groups. • Instruct the learners to take turns to complete the following movement. Wait until all the groups have completed the movement before instructing the next one. 1. Skip sideways in each block 2. Double leg hops in each block 3. Single leg side hops in each block 4. Single leg zigzag hops 5. Hopscotch through the ladder	

Main Section	**10 min**	**Rope Skipping Together** • Divide the class into roughly 10 groups, if 10 skipping ropes are available. • Two learners hold the ends and swing the rope, while 1 or more learners jump in the centre. • Any song the learners know can be sung during the jumping. • Some examples may include Ugqaphu, Kgati or Ntimo	

Main Section	**10 min**	**Moving through the Hoop** • Re-divide the class in roughly 10 different groups, if 10 hula hoops are available. • Instruct the learners to stand in a circle and to hold hands. • Place a hula hoop between 2 learners. • Instruct the learners to climb through the hula hoop and move it along the circle until it reaches the starting point. • When one full circle with the hula hoop is complete, move the hula hoop the other direction, until the hoop reaches the start. • A competition between the groups can also be initiated to see which group can move the hoop the fastest.	

Cool Down	**10 min**	**Mystic Knot** • Divide the class in groups of roughly 10 learners. • Ensure that each group stands in a circle. • Instruct the learners to hold hands at random, crossing arms and taking hands with people from across the circle. • Once everybody is holding hands, instruct the learners to twist and turn and climb over each other to try to untangle the knot, without letting go of any hands in the process. • Encourage the learners to work as a team to solve the problem.	

3. Example of DASH Physical Activity Cards

Intervention of the DASH study

2014 - 2017

Legend:

Difficulty level 1:	Difficulty level 2:	Difficulty level 3:
For beginners	For advanced learners	For experts
Indoor activity *(in-class activity)*	***Outdoor*** activity	
Flexibility activity	***Coordination*** activity	***Strength*** activity
Individual activity	Partner activity	Group activity

Flamingo

Level 1: Balance on one leg.

Level 2: Now close your eyes.

Level 3: Close your eyes and put your head back.

Arm Stretch

Level 1: Fold your hand and stretch your arms as far as you can towards the sky.

Level 2: Stand broadly and lean towards the right side. Hold the position for 10 seconds and then lean towards the left side.

Level 3: Keep your legs straight and touch your right foot with your left hand, right hand extended towards the sky. Change after 10 seconds.

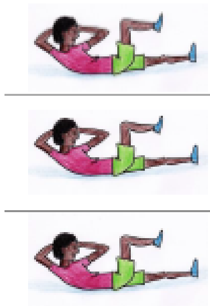
Lunges

Level 1: Performing slowly controlled lunges (do not let your knees go over the toes).
Repetition 5 times.

Level 2: Performing slowly controlled lunges (do not let your knees go over the toes).
Repetition 10 times.

Level 3: Performing slowly controlled lunges (do not let your knees go over the toes).
Repetition 15 times.

Cycling on spot



Level 1: Cycling on spot by lifting your back and cycle slowly with your legs keeping your stomach tight.
Repetition → 10 times.

Level 2: Cycling on spot by lifting your back and cycle slowly with your legs keeping your stomach tight.
Repetition → 20 times.

Level 3: Cycling on spot by lifting your back and cycle slowly with your legs keeping your stomach tight.
Repetition → 30 times.

Balance with Jumps

Level 1: Balance on one leg and then try to jump and land on the same spot. Repetition → 5 times.

Level 2: Balance on one leg and then try to jump and land on the same spot. Repetition → 10 times.

Level 3: Balance on one leg and then try to jump and land on the same spot. Repetition → 15 times.

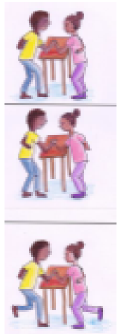
Leg Stretch

Level 1: Stand on one leg, lift your right foot towards your back and hold onto your ankle. Push your hips forward to stretch your upper leg. Change legs.

Level 2: Take a big step forward. Bend the forward leg and sink down with your hips. Change legs.

Level 3: Take a small step forward. Keep the forward leg straight, feet pointing towards the sky. The back leg is bent. Change legs.

Arm Wrestling



Level 1: Use your strong arm
Stand face to face with a friend. Put your elbows on the table. Try to press the back our opponents hand onto the table.

Level 2: Use your weak arm.

Level 3: Stand on one leg.

Wide Squads

Level 1: Performing wide squads. Repetition → 10 times.

Level 2: Performing wide squads. Repetition → 20 times.

Level 3: Performing wide squads. Repetition → 30 times.

4. DASH Physical Activity Equipment Provided

Before the intervention commenced, the school was supplied with small equipment to assist in the facilitation of the physical activity intervention. See Figure C.1, showing the equipment received by each school.

Each school received the following small equipment:

- Whistle;
- Stopwatches;
- Big ball bag;
- Laundry basket;
- Flat cones;
- Batons;
- Tennis balls;
- Soccer balls;
- Netballs;
- Bean bags;
- Colour bands;
- Skipping ropes; and
- Hula hoops

Figure C.1: Physical activity equipment used to conduct the physical activity intervention
Photos taken by researcher

5. Move-to-Music Dance Classes

Figure C.2 displays the mass move-to-music dance classes that were conducted as part of the DASH physical activity intervention.

Figure C.2: Mass move-to-music dance class setting
Photos taken by researcher

6. Physical Activity-Friendly School Environment

As part of the physical activity intervention, the school terrain was upgraded to encourage more free play. Pictures of the school terrain before and after the intervention was implemented, are provided in Figure C.3, Figure C.4 and Figure C.5.

Figure C.3: School terrain before the physical activity-friendly school environment was created
Photos taken by researcher

Figure C.4: Physical play structures that were used during the intervention, including: jungle gyms, balance beams, monkey bars, tyre stations and over-and-under bars
Photos taken by researcher

Figure C.5: Colourful painted games created on the school terrain to increase physical activity and brighten the school environment
Photos taken by researcher

Appendix D : Ethical Approval Forms

The DASH Project Ethical Approval Forms in English can be found in the following sections:

1. Ethical Committee Northwest and Central Switzerland
2. Nelson Mandela University Research Ethics Committee (Human) – DASH project
3. Nelson Mandela University Research Ethics Committee (Human) – This Research Study
4. Eastern Cape Department of Education
5. Eastern Cape Department of Health

1. Ethical Committee Northwest and Central Switzerland

Ethikkommission Nordwest- und Zentralschweiz EKNZ

Präsident
Prof. André P. Perruchoud
Vizepräsidenten
Prof. Gregor Schubiger

Dr. Marco Schärer

Prof Dr. U. Pühse
DSBG University of Basel
Birsstrasse 320 B
4052 Basel

Basel, 01 August 2014

EKNZ: 2014-179

Impact of disease burden and setting-specific interventions on schoolchildren's physical fitness and psychosocial health in Port Elizabeth, South Africa

Dear Professor, Pühse

On the occasion of its meeting (17/06/2014), the Ethics Committee of North-western and Central Switzerland EKNZ checked the research project "Impact of disease burden and setting-specific interventions on schoolchildren's physical fitness and psychosocial health in Port Elizabeth, South Africa".

This research project was evaluated according to the ICH – GCP (International Conference on Harmonisation - Good Clinical Practice) guidelines. It conforms to the conditions that must be met for research studies in Switzerland, namely:

- Scientific validity and relevance of the research project and of the results that are to be expected; favourable benefit-risk ratio;
- Consent of the study subjects;
- Protection of the private sphere and confidentiality;
- Professional qualification of the Swiss research scientists involved in the project;
- Definitions of the qualifications that are required of the other research scientists involved.

Whether the project can be accepted from ethical points of view depends on the local circumstances, which could not be assessed. The present statement does not consider the following points:

- Procedure and documentation for recruitment of the study subjects, especially the information sheets and consent forms written in the local language; the adequacy of the local infrastructure (material, premises, personnel etc.) about the best possible protection of the study subjects;

- Professional qualification of the non-Swiss research personnel.

The points listed above should be assessed by the responsible ethical research committee(s) of the place(s) where the project is carried out.

The Ethics Committee of North-western and Central Switzerland acknowledges the revised Documents (Study Protocol - Version 7 17/07/14, the Information Sheet and Consent Form - Version 2 17/07/14) & Study Insurance).

Sincerely yours,

f. A. P. P

Prof. André P. Perruchoud
President of the EKNZ

Ref. Nr. EKNZ: 2014-179

2. Nelson Mandela University Research Ethics Committee (Human) – DASH Project

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

Nelson Mandela Metropolitan University
for tomorrow

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

Prof CB Cilliers

Chairperson: Research Ethics Committee (Human)

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

3. Nelson Mandela University Research Ethics Committee (Human) – This Research Study

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

Nelson Mandela Metropolitan University
for tomorrow

Faculty of Health Sciences
Tel. +27 (0)41 504 2956
Fax. +27 (0)41 504 9324
Marilyn.Afrikaner@nmmu.ac.za

Copies to Supervisor: **Prof C Walter**

29 April 2016

Ms N Joubert

RE: OUTCOME OF PROPOSAL SUBMISSION

QUALIFICATION: MA (HUMAN MOVEMENT SCIENCE)

FINAL RESEARCH / PROJECT PROPOSAL: EFFECT OF A PHYSICAL ACTIVITY INTERVENTION ON THE PHYSICAL FITNESS OF PRIMARY SCHOOL CHILDREN IN DISADVANTAGED COMMUNITIES IN PORT ELIZABETH

Please be advised that your final research project was approved by the Faculty Postgraduate Studies Committee (FPGSC) subject to the following amendments / recommendations being made to the satisfaction of your Supervisor:

COMMENTS / RECOMMENDATIONS:

1. A very good investigation that could motivate healthy lifestyles.
2. Rationale for choosing quintile-three primary schools might be a vital information to consider including.
3. Measuring instrument and validity (reliability). The measuring instrument and tools used to assess the students fits the study. It was suggested that the researcher explore the implication of errors made while doing certain calculations. For example, the VO_2 max estimation would be calculated manually? Would a second researcher be confirming these calculations and scores?

FPGSC grants ethics approval. The ethics clearance reference number is **H16-HEA-HMS-003** and is valid for three years. We wish you well with the project.

Kind regards,

Marilyn Afrikaner

FPGSC Secretariat Faculty of Health Sciences

4. Eastern Cape 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 • 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.palma@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 CARDIORESPIRATORY PHYSICAL FITNESS AND PSYCHOSOCIAL HEALTH IN PORT ELIZABETH, SOUTH AFRICA

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1. Thank you for your application to conduct research.

2. Your application to conduct the above-mentioned research in fifty (50) selected Primary Schools under the jurisdiction of Port Elizabeth District of the Eastern Cape Department of Education is hereby approved based on the following conditions:

    a. Consent from parents of learners involved will be sought.
    b. There will be no financial implications for the Department.
    c. Institutions and respondents must not be identifiable in any way from the results of the investigation.
    d. You present a copy of the written approval letter of the Eastern Cape Department of Education to the Cluster and District Directors before any research is undertaken at any institutions within that particular district.
    e. You will make all the arrangements concerning your research.
    f. The research may not be conducted during official contact time, as educators' programmes should not be interrupted.

g. 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.
h. Your research will be limited to those schools or institutions for which approval has been granted, should changes be affected 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 Eastern Cape Department of Education 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 Eastern Cape Department of Education.

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

5. The Department wishes you well in your undertaking. You can contact the Director, Ms. NY Kanjana on the numbers indicated in the letterhead or email nykaniana@live.co.za should you need any assistance.

NY Kaniana

Director: Strategic Planning Policy Research and Secretariat Services
For Superintendent-General: Education

PROVINCIAL GROWTH AND DEVELOPMENT PLAN
PGDP
EASTERN CAPE
2004 - 2014

Ikamva eliqaqambileyo!

5. Eastern Cape Department of Health

07 / 11 / 2014 22:14

Province of the
EASTERN CAPE
HEALTH

Enquiries:	Zonwabele Merle	**Tel No:**	040 608 0830
Date:	November 2014	**Fax No:**	043 642 1409
Email Address:	zonwabete.merile@impilo.ecprov.gov.za		

Dear Professor Rosa du Randt

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 and Surveillance Management

PROVINCIAL GROWTH AND DEVELOPMENT PLAN
PGDP
EASTERN CAPE
2004 - 2014

Ikamva eliqaqambileyo!

Appendix E : Study Results

1. Demographic Profile of Participants

   - Age

2. Anthropometric Measures

   Body Composition

   - Body Mass
   - Stature
   - Body Mass Index
   - Estimated Body Fat Percentage

3. Physical Fitness Measures

   - Cardiorespiratory Fitness
   - Upper Body Musculature Strength
   - Lower Body Musculature Strength
   - Lower Body Flexibility

1. Demographic Profile of Participants

- **Age**

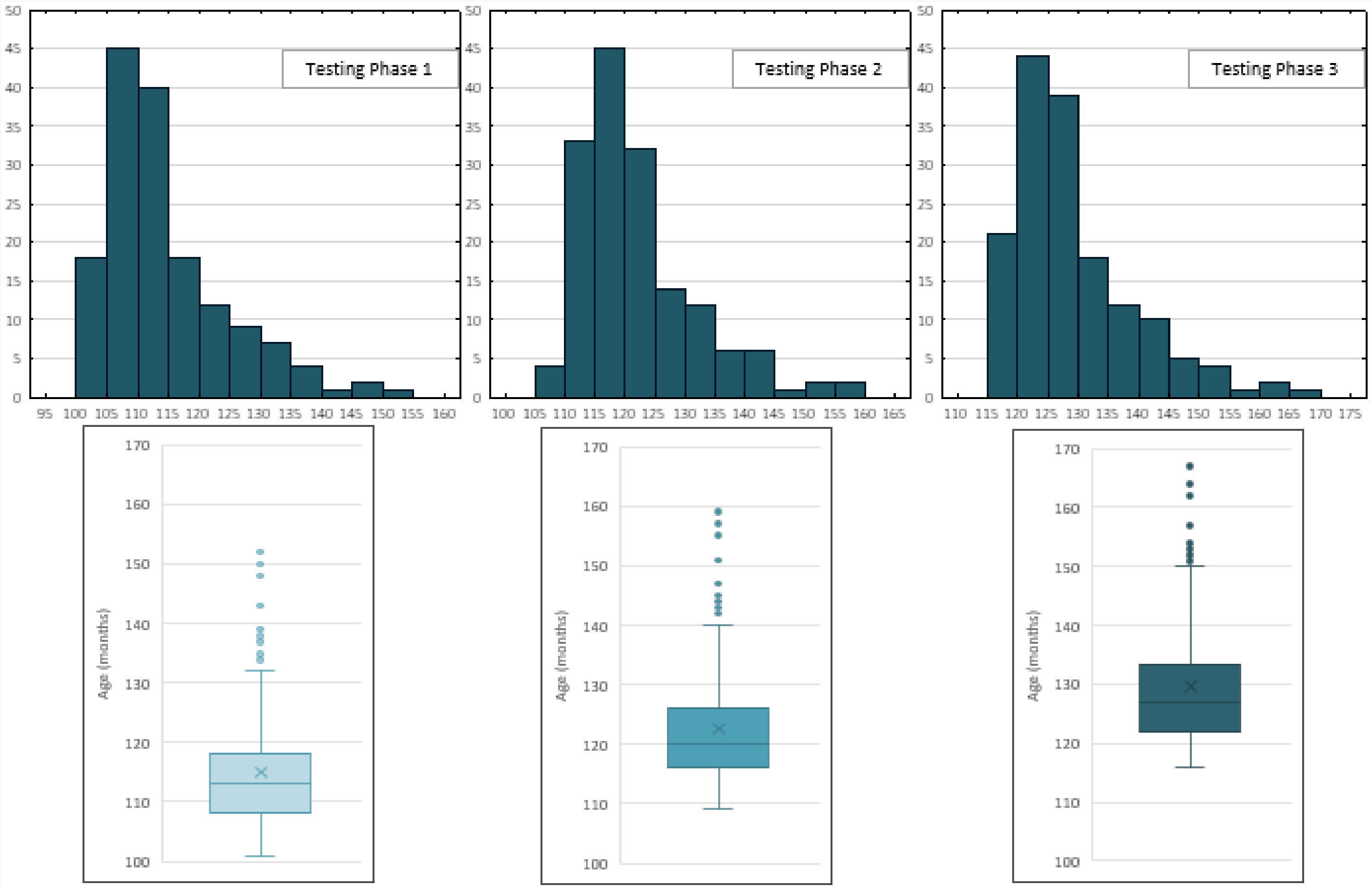

Figure E.1: Summary descriptive statistics: Age (months)

Table E.1: Descriptive statistics age (months): Comparison within and between the intervention group (IG) and control group (CG) girls, across three testing phases (T1, T2, and T3)

	Intervention group girls			Control group girls		
	T1	T2	T3	T1	T2	T3
n	37	37	37	47	47	47
M	113.14	120.54	127.81	110.79	118.77	125.32
S.D.	7.17	7.13	7.14	7.68	7.69	7.56
Min	104.00	112.00	119.00	101.00	109.00	116.00
Quartile 1	108.00	115.00	123.00	106.00	114.00	121.00
Mdn	113.00	120.00	128.00	108.00	116.00	123.00
Quartile 3	117.00	124.00	131.00	114.00	122.00	128.00
Max	138.00	145.00	153.00	143.00	151.00	157.00
SEM	1.18	1.17	1.17	1.12	1.12	1.10
RSD	6.34	5.92	5.59	6.93	6.48	6.03
	Intervention group girls			**Control group girls**		
	T2-T1	**T3-T2**	**T3-T1**	**T2-T1**	**T3-T2**	**T3-T1**
Difference	7.41	7.27	14.68	7.98	6.55	14.53
% Difference	6.55	6.03	11.48	7.20	5.52	11.60
	Comparison between the intervention and control group girls					
	T1 CG-IG		**T2 CG-IG**		**T3 CG-IG**	
Difference	-2.35		-1.77		-2.49	
% Difference	2.12 %		1.49 %		1.99 %	

Table E.2: Descriptive statistics age (months): Comparison within and between the intervention group (IG) and control group (CG) boys, across three testing phases (T1, T2, and T3)

	Intervention group boys			Control group boys		
	T1	T2	T3	T1	T2	T3
n	28	28	28	45	45	45
M	124.64	131.82	139.11	114.76	122.73	129.42
S.D.	12.23	12.24	12.22	9.32	9.34	9.33
Min	109.00	116.00	123.00	101.00	109.00	116.00
Quartile 1	115.00	122.00	129.75	108.00	116.00	122.00
Mdn	124.00	131.00	138.50	112.00	120.00	127.00
Quartile 3	131.75	139.00	146.00	119.00	127.00	134.00
Max	152.00	159.00	167.00	139.00	147.00	154.00
SEM	2.31	2.31	2.31	1.39	1.39	1.39
RSD	9.81	9.28	8.78	8.12	7.61	7.21

	Intervention group boys			Control group boys		
	T2-T1	T3-T2	T3-T1	T2-T1	T3-T2	T3-T1
Difference	7.18	7.29	14.46	7.98	6.69	14.67
% Difference	5.76	5.53	10.40	6.95	5.45	11.33

	Comparison between the intervention and control group boys		
	T1 CG-IG	T2 CG-IG	T3 CG-IG
Difference	-9.89	-9.09	-9.68
% Difference	8.62 %	7.40 %	7.48 %

2. Anthropometric Measures

Body Composition

- **Body Mass**

Table E.3: Descriptive statistics body mass (kg): Comparison within and between the intervention group (IG) and control group (CG), across three testing phases (T1, T2, and T3)

	Intervention group			Control group		
	T1	T2	T3	T1	T2	T3
n	92	92	92	65	65	65
M	31.21	34.11	36.26	33.69	36.03	38.46
S.D.	6.00	7.10	8.33	10.37	11.14	12.26
Min	20.60	22.60	23.40	17.60	19.90	21.20
Quartile 1	27.28	29.20	30.60	27.10	29.30	31.20
Mdn	30.30	32.80	34.60	31.30	33.50	35.90
Quartile 3	33.23	36.70	39.98	38.20	40.00	42.70
Max	55.90	62.60	68.00	87.40	90.90	99.00
SEM	0.63	0.74	0.87	1.29	1.38	1.52
RSD	19.24	20.81	22.97	30.77	30.91	31.88
	Intervention group			**Control group**		
	T2-T1	**T3-T2**	**T3-T1**	**T2-T1**	**T3-T2**	**T3-T1**
Difference	2.90	2.15	5.05	2.34	2.43	4.77
% Difference	9.28	6.31	13.93	6.95	6.73	12.40

	Comparison between the intervention and control group		
	T1 CG-IG	T2 CG-IG	T3 CG-IG
Difference	-2.48	-1.93	-2.20
% Difference	-7.36 %	-5.34 %	-5.72 %

Table E.4: Descriptive statistics body mass (kg): Comparison within and between the intervention group (IG) and control group (CG) girls, across three testing phases (T1, T2, and T3)

	Intervention group girls			Control group girls		
	T1	T2	T3	T1	T2	T3
n	37	37	37	47	47	47
M	34.64	37.04	39.82	31.87	35.31	37.82
S.D.	12.68	13.30	14.81	7.42	8.72	10.09
Min	17.60	19.90	21.20	22.60	23.50	24.00
Quartile 1	27.10	30.10	31.50	27.15	29.20	30.45
Mdn	31.80	33.20	36.20	29.30	32.80	35.70
Quartile 3	38.60	40.00	42.90	35.55	40.00	43.95
Max	87.40	90.90	99.00	55.90	62.60	68.00
SEM	2.08	2.19	2.43	1.08	1.27	1.47
RSD	36.60	35.90	37.19	23.28	24.70	26.69
	Intervention group girls			**Control group girls**		
	T2-T1	**T3-T2**	**T3-T1**	**T2-T1**	**T3-T2**	**T3-T1**
Difference	2.41	2.78	5.19	3.44	2.51	5.95
% Difference	6.94	7.51	13.02	10.78	7.12	15.73

	Comparison between the intervention and control group girls		
	T1 CG-IG	T2 CG-IG	T3 CG-IG
Difference	-2.76	-1.73	-2.00
% Difference	8.67 %	4.91 %	5.28 %

Table E.5: Descriptive statistics body mass (kg): Comparison within and between the intervention group (IG) and control group (CG) boys, across three testing phases (T1, T2, and T3)

	Intervention group boys			Control group boys		
	T1	T2	T3	T1	T2	T3
n	28	28	28	45	45	45
M	32.44	34.70	36.65	30.52	32.85	34.62
S.D.	6.13	7.42	7.61	4.00	4.64	5.62
Min	23.20	20.40	26.40	20.60	22.60	23.40
Quartile 1	27.58	28.78	30.60	27.30	29.50	31.20
Mdn	30.95	33.80	34.95	30.70	32.80	34.20
Quartile 3	37.30	39.50	40.60	32.30	35.00	37.20
Max	44.40	47.90	53.50	40.50	48.60	57.50
SEM	1.16	1.40	1.44	0.60	0.69	0.84
RSD	18.91	21.39	20.76	13.12	14.12	16.23

	Intervention group boys			Control group boys		
	T2-T1	T3-T2	T3-T1	T2-T1	T3-T2	T3-T1
Difference	2.26	1.96	4.21	2.33	1.78	4.11
% Difference	6.96	5.64	11.50	7.65	5.41	11.87

	Comparison between the intervention and control group boys		
	T1 CG-IG	T2 CG-IG	T3 CG-IG
Difference	-1.92	-1.85	-2.03
% Difference	6.30 %	5.62 %	5.86 %

- **Stature**

Table E.6: Descriptive statistics stature (cm): Comparison within and between the intervention group (IG) and control group (CG), across three testing phases (T1, T2, and T3)

	Intervention group			Control group		
	T1	T2	T3	T1	T2	T3
n	92	92	92	65	65	65
M	133.52	137.21	138.63	134.91	137.95	141.39
S.D.	5.72	5.99	6.25	7.31	7.77	8.05
Min	122.00	125.20	125.10	120.80	122.90	125.90
Quartile 1	129.38	133.00	134.30	128.70	131.40	135.00
Mdn	132.75	136.75	138.20	134.40	136.80	140.20
Quartile 3	137.93	141.28	143.23	141.90	145.50	149.00
Max	145.60	149.60	152.40	149.80	153.00	157.30
SEM	0.60	0.62	0.65	0.91	0.96	1.00
RSD	4.29	4.37	4.51	5.42	5.63	5.69
	Intervention group			Control group		
	T2-T1	T3-T2	T3-T1	T2-T1	T3-T2	T3-T1
Difference	3.69	1.42	5.11	3.04	3.44	6.48
% Difference	2.76	1.03	3.69	2.25	2.49	4.59

	Comparison between the intervention and control group		
	T1 CG-IG	T2 CG-IG	T3 CG-IG
Difference	-1.39	-0.74	-2.76
% Difference	-1.03 %	-0.54 %	-1.95 %

Table E.7: Descriptive statistics stature (cm): Comparison within and between the intervention group (IG) and control group (CG) girls, across three testing phases (T1, T2, and T3)

	Intervention group girls			Control group girls		
	T1	T2	T3	T1	T2	T3
n	37	37	37	47	47	47
M	134.15	137.15	141.18	133.17	137.13	138.92
S.D.	7.32	7.87	8.04	5.33	5.58	5.86
Min	120.80	122.90	125.90	123.50	126.80	126.70
Quartile 1	128.50	131.00	135.10	129.35	133.15	135.45
Mdn	133.70	135.90	140.20	132.50	137.00	138.40
Quartile 3	141.90	145.70	149.50	136.40	139.90	142.60
Max	147.00	150.60	156.60	144.00	149.60	152.40
SEM	1.20	1.29	1.32	0.78	0.81	0.85
RSD	5.46	5.74	5.69	4.00	4.07	4.22
	Intervention group girls			**Control group girls**		
	T2-T1	**T3-T2**	**T3-T1**	**T2-T1**	**T3-T2**	**T3-T1**
Difference	3.00	4.04	7.04	3.96	1.79	5.75
% Difference	2.24	2.94	4.98	2.98	1.30	4.14

	Comparison between the intervention and control group girls		
	T1 CG-IG	T2 CG-IG	T3 CG-IG
Difference	-0.98	-0.01	-2.26
% Difference	0.73 %	0.01 %	1.63 %

Table E.8: Descriptive statistics stature (cm): Comparison within and between the intervention group (IG) and control group (CG) boys, across three testing phases (T1, T2, and T3)

	Intervention group boys			Control group boys		
	T1	T2	T3	T1	T2	T3
n	28	28	28	45	45	45
M	135.91	139.01	141.66	133.88	137.29	138.32
S.D.	7.31	7.65	8.20	6.15	6.46	6.69
Min	124.90	127.00	130.40	122.00	125.20	125.10
Quartile 1	129.35	132.15	134.38	130.00	133.00	133.90
Mdn	135.55	138.90	141.25	133.40	136.50	138.00
Quartile 3	141.78	145.20	147.33	138.60	142.50	143.30
Max	149.80	153.00	157.30	145.60	148.70	150.40
SEM	1.38	1.44	1.55	0.92	0.96	1.00
RSD	5.38	5.50	5.79	4.59	4.71	4.83

	Intervention group boys			Control group boys		
	T2-T1	T3-T2	T3-T1	T2-T1	T3-T2	T3-T1
Difference	3.10	2.65	5.75	3.41	1.03	4.44
% Difference	2.28	1.91	4.06	2.54	0.75	3.21
	Comparison between the intervention and control group boys					
	T1 CG-IG		**T2 CG-IG**		**T3 CG-IG**	
Difference	-2.03		-1.72		-3.34	
% Difference	1.52 %		1.25 %		2.42 %	

- **Body Mass Index**

Table E.9: : Descriptive statistics BMI (kg.m^2): Comparison within and between the intervention group (IG) and control group (CG) girls, across three testing phases (T1, T2, and T3)

	Intervention group girls			Control group girls		
	T1	T2	T3	T1	T2	T3
n	37	37	37	47	47	47
M	18.93	19.38	19.64	17.92	18.70	19.50
S.D.	5.32	5.29	5.70	3.78	4.12	4.69
Min	11.46	12.44	12.26	13.53	14.24	14.45
Quartile 1	16.27	16.66	16.88	15.35	15.70	16.10
Mdn	17.76	18.17	18.42	16.87	17.40	17.82
Quartile 3	20.53	19.94	20.20	19.45	20.36	21.65
Max	41.74	41.16	43.25	30.09	31.05	32.34
SEM	0.87	0.87	0.94	0.55	0.60	0.68
RSD	28.10	27.28	29.00	21.09	22.03	24.06
	Intervention group girls			**Control group girls**		
	T2-T1	**T3-T2**	**T3-T1**	**T2-T1**	**T3-T2**	**T3-T1**
Difference	0.46	0.26	0.72	0.78	0.80	1.58
% Difference	2.41	1.35	3.65	4.34	4.29	8.10
	Comparison between the intervention and control group girls					
	T1 CG-IG		**T2 CG-IG**		**T3 CG-IG**	
Difference	-1.00		-0.68		-0.14	
% Difference	5.59 %		3.63 %		0.71 %	

Table E.10: Descriptive statistics BMI (kg.m²): Comparison within and between the intervention group (IG) and control group (CG) boys, across three testing phases (T1, T2, and T3)

	Intervention group boys			Control group boys		
	T1	T2	T3	T1	T2	T3
n	28	28	28	45	45	45
M	17.44	17.78	18.11	16.97	17.37	18.03
S.D.	2.10	2.47	2.43	1.44	1.64	2.02
Min	14.23	12.11	14.70	13.73	14.42	14.95
Quartile 1	16.23	16.53	16.62	15.95	16.19	16.45
Mdn	17.12	17.46	17.61	16.74	17.24	17.51
Quartile 3	17.90	18.49	18.32	17.62	17.95	19.11
Max	22.65	23.08	24.86	20.50	22.49	26.25
SEM	0.40	0.47	0.46	0.22	0.24	0.30
RSD	12.07	13.92	13.43	8.51	9.44	11.23
	Intervention group boys			**Control group boys**		
	T2-T1	**T3-T2**	**T3-T1**	**T2-T1**	**T3-T2**	**T3-T1**
Difference	0.35	0.33	0.68	0.40	0.65	1.05
% Difference	1.98	1.87	3.74	2.35	3.76	5.84
	Comparison between the intervention and control group boys					
	T1 CG-IG		**T2 CG-IG**		**T3 CG-IG**	
Difference	-0.46		-0.41		-0.09	
% Difference	2.72 %		2.35 %		0.48 %	

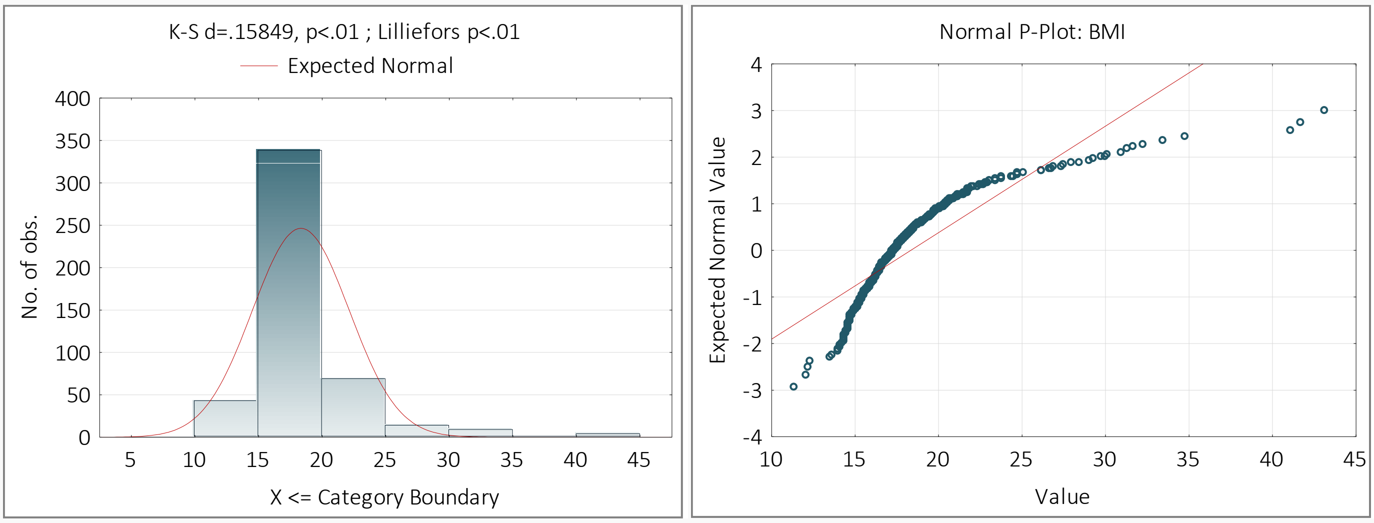

Figure E.2: Graphical representation, histogram and line graph: BMI distribution

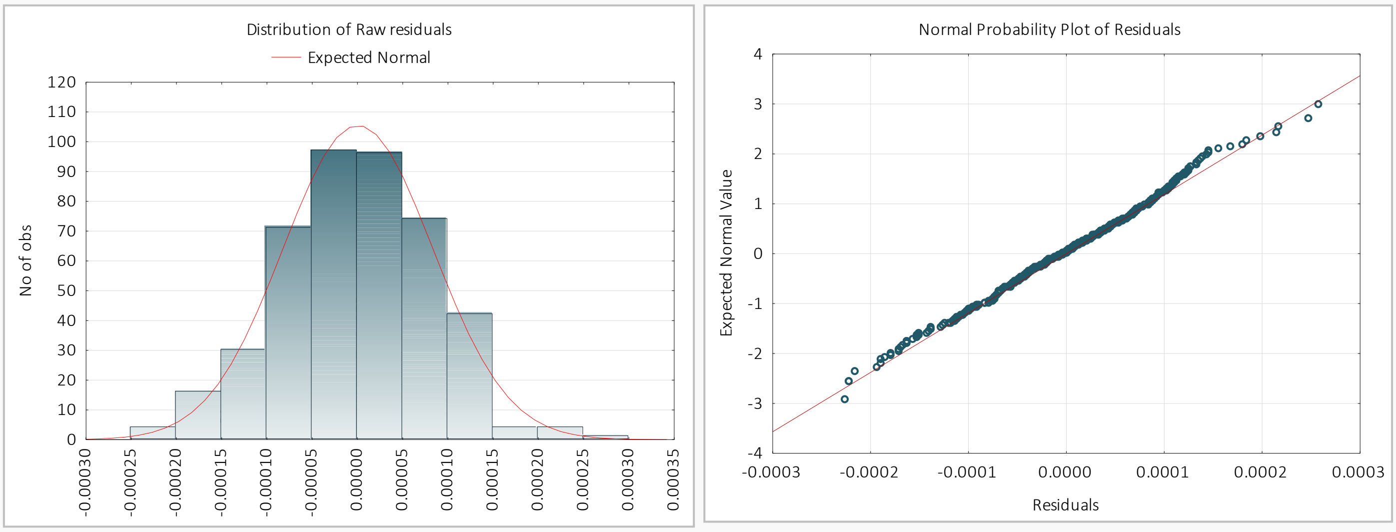

Figure E.3: Graphical representation, histogram and line graph: Box Cox transformed BMI distribution

- **Estimated Body Fat Percentage**

Table E.11: Descriptive statistics estimated body fat (%): Comparison within and between the intervention group (IG) and control group (CG) girls, across three testing phases (T1, T2, and T3)

	Intervention group girls			Control group girls		
	T1	T2	T3	T1	T2	T3
n	37	37	37	47	47	47
M	23.21	21.94	22.17	19.59	24.53	21.65
S.D.	10.18	7.68	8.58	7.11	11.65	8.93
Min	8.05	9.21	9.57	8.34	12.06	10.35
Quartile 1	17.77	16.06	16.17	14.62	16.85	14.49
Mdn	21.93	22.35	20.97	16.82	19.85	19.49
Quartile 3	25.44	24.75	24.90	24.52	29.21	28.17
Max	66.23	43.77	48.17	35.18	55.93	42.57
SEM	1.67	1.26	1.41	1.04	1.70	1.30
RSD	43.86	34.98	38.69	36.32	47.51	41.26
	Intervention group girls			**Control group girls**		
	T2-T1	**T3-T2**	**T3-T1**	**T2-T1**	**T3-T2**	**T3-T1**
Difference	-1.26	0.23	-1.04	4.94	-2.87	2.07
% Difference	-5.45	1.03	-4.68	25.22	-11.71	9.55
	Comparison between the intervention and control group girls					
	T1 CG-IG		**T2 CG-IG**		**T3 CG-IG**	
Difference	-3.62		2.58		-0.52	
% Difference	18.49 %		-10.53 %		2.38 %	

Table E.12: Descriptive statistics estimated body fat (%): Comparison within and between the intervention group (IG) and control group (CG) boys, across three testing phases (T1, T2, and T3)

	Intervention group boys			Control group boys		
	T1	T2	T3	T1	T2	T3
n	28	28	28	45	45	45
M	15.69	16.46	15.48	12.79	15.60	14.61
S.D.	6.92	7.78	7.45	4.03	5.38	5.78
Min	6.97	6.04	7.40	6.33	6.26	6.26
Quartile 1	10.77	11.76	10.57	9.69	12.37	10.84
Mdn	14.57	14.21	13.25	12.04	14.49	12.70
Quartile 3	17.16	18.50	15.84	14.93	18.91	18.27
Max	33.60	42.94	38.30	22.43	30.36	33.60
SEM	1.31	1.47	1.41	0.60	0.80	0.86
RSD	44.11	47.26	48.12	31.50	34.47	39.54
	Intervention group boys			**Control group boys**		
	T2-T1	**T3-T2**	**T3-T1**	**T2-T1**	**T3-T2**	**T3-T1**
Difference	0.77	-0.98	-0.21	2.81	-0.99	1.82
% Difference	4.90	-5.95	-1.35	22.00	-6.34	12.49

	Comparison between the intervention and control group boys		
	T1 CG-IG	T2 CG-IG	T3 CG-IG
Difference	-2.91	-0.86	-0.87
% Difference	22.74 %	5.54 %	5.98 %

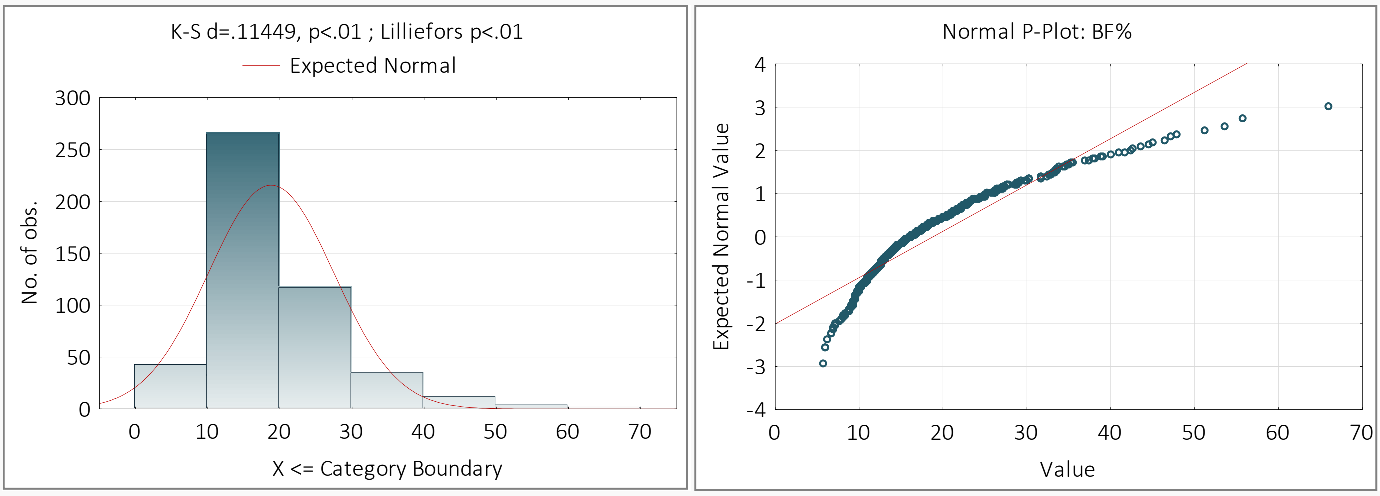

Figure E.4: Graphical representation, histogram and line graph: Estimated body fat percentage distribution

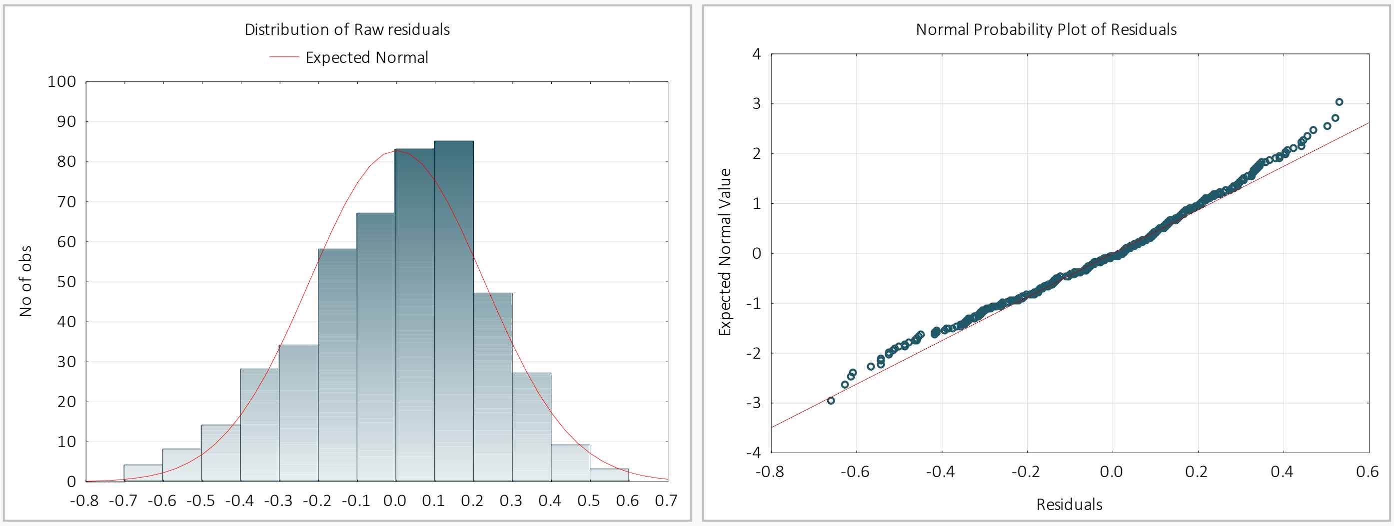

Figure E.5: Graphical representation, histogram and line graph: Log transformed estimated body fat percentage distribution

3. Physical Fitness Measures

- **Cardiorespiratory Fitness**

Table E.13: Descriptive statistics estimated maximal oxygen uptake ($ml.kg^{-1}.min^{-1}$): Comparison within and between the intervention group (IG) and control group (CG) girls, across three testing phases (T1, T2, and T3)

	Intervention group girls			Control group girls		
	T1	T2	T3	T1	T2	T3
n	37	37	37	47	47	47
M	48.12	45.78	45.09	47.48	47.09	46.03
S.D.	3.56	4.15	3.59	2.86	3.27	3.55
Min	39.12	37.18	35.24	43.38	41.07	39.12
Quartile 1	45.69	43.38	42.11	45.69	45.69	43.90
Mdn	48.00	45.69	45.40	47.48	46.29	45.69
Quartile 3	50.31	48.00	46.29	48.33	49.49	46.66
Max	56.41	54.93	53.45	56.41	54.93	57.24
SEM	0.58	0.68	0.59	0.42	0.48	0.52
RSD	7.39	9.07	7.97	6.03	6.95	7.70

	Intervention group girls			Control group girls		
	T2-T1	T3-T2	T3-T1	T2-T1	T3-T2	T3-T1
Difference	-2.35	-0.69	-3.04	-0.39	-1.06	-1.45
% Difference	-4.88	-1.51	-6.74	-0.81	-2.25	-3.14

	Comparison between the intervention and control group girls		
	T1 CG-IG	T2 CG-IG	T3 CG-IG
Difference	-0.65	1.31	0.94
% Difference	1.37 %	-2.79 %	-2.05 %

Table E.14: Descriptive statistics estimated maximal oxygen uptake ($ml.kg^{-1}.min^{-1}$): Comparison within and between the intervention group (IG) and control group (CG) boys, across three testing phases (T1, T2, and T3)

	Intervention group boys			Control group boys		
	T1	T2	T3	T1	T2	T3
n	28	28	28	45	45	45
M	52.15	47.56	47.51	52.69	49.71	50.17
S.D.	4.02	4.37	4.13	4.26	4.60	4.54
Min	43.38	39.65	39.65	43.90	41.51	42.86
Quartile 1	50.11	43.90	43.90	50.31	46.29	47.04
Mdn	52.82	46.29	47.85	52.62	48.67	48.67
Quartile 3	54.93	51.06	51.20	54.93	52.62	53.45
Max	59.55	56.89	53.45	61.86	59.55	58.22
SEM	0.76	0.83	0.78	0.63	0.69	0.68
RSD	7.71	9.19	8.69	8.08	9.26	9.05
	Intervention group boys			**Control group boys**		
	T2-T1	**T3-T2**	**T3-T1**	**T2-T1**	**T3-T2**	**T3-T1**
Difference	-4.59	-0.05	-4.63	-2.98	0.46	-2.52
% Difference	-8.79	-0.10	-9.75	-5.65	0.92	-5.03

	Comparison between the intervention and control group boys		
	T1 CG-IG	T2 CG-IG	T3 CG-IG
Difference	0.54	2.15	2.65
% Difference	-1.03 %	-4.32 %	-5.29 %

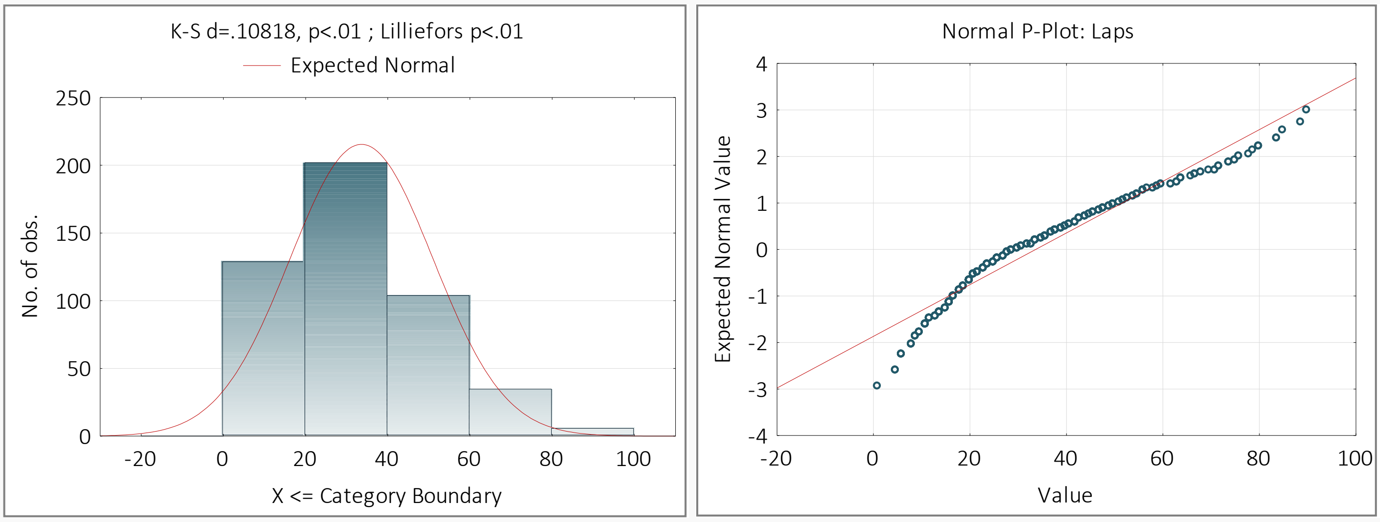

Figure E.6: Graphical representation, histogram and line graph: Estimated maximal oxygen uptake distribution

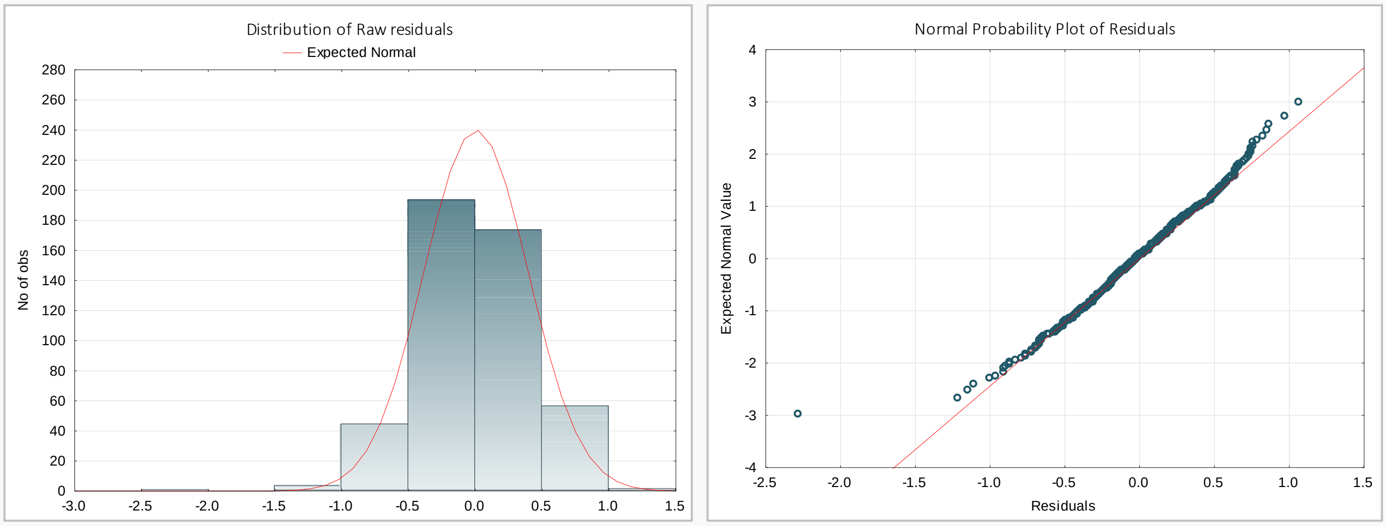

Figure E.7: Graphical representation, histogram and line graph: Log transformed estimated maximal oxygen uptake distribution

- **Upper Body Musculature Strength**

Table E.15: Descriptive statistics handgrip strenght (kg): Comparison within and between the intervention group (IG) and control group (CG) girls, across three testing phases (T1, T2, and T3)

	Intervention group girls			Control group girls		
	T1	T2	T3	T1	T2	T3
n	37	37	37	47	47	47
M	14.08	14.11	16.30	12.87	12.98	14.26
S.D.	2.82	3.49	3.85	3.18	3.26	3.54
Min	8.00	8.00	8.00	7.00	8.00	8.00
Quartile 1	12.00	12.00	14.00	10.00	10.00	12.00
Mdn	14.00	14.00	16.00	12.00	12.00	14.00
Quartile 3	16.00	18.00	18.00	14.00	15.00	16.00
Max	20.00	20.00	24.00	22.00	20.00	23.00
SEM	0.46	0.57	0.63	0.46	0.48	0.52
RSD	20.04	24.77	23.63	24.71	25.12	24.80
	Intervention group girls			**Control group girls**		
	T2-T1	**T3-T2**	**T3-T1**	**T2-T1**	**T3-T2**	**T3-T1**
Difference	0.03	2.19	2.22	0.11	1.28	1.38
% Difference	0.19	15.52	13.60	0.83	9.84	9.70
	Comparison between the intervention and control group girls					
	T1 CG-IG		**T2 CG-IG**		**T3 CG-IG**	
Difference	-1.21		-1.13		-2.04	
% Difference	9.39 %		8.70 %		14.32 %	

Table E.16: Descriptive statistics handgrip strenght (kg): Comparison within and between the intervention group (IG) and control group (CG) boys, across three testing phases (T1, T2, and T3)

	Intervention group boys			Control group boys		
	T1	T2	T3	T1	T2	T3
n	28	28	28	45	45	45
M	15.71	15.86	17.07	14.04	14.49	16.00
S.D.	3.23	2.72	3.57	3.70	3.09	3.99
Min	9.00	10.00	10.00	4.00	4.00	8.00
Quartile 1	14.00	14.00	14.00	12.00	13.00	14.00
Mdn	16.00	16.00	16.00	14.00	14.00	15.00
Quartile 3	18.00	18.00	20.00	17.00	17.00	18.00
Max	22.00	20.00	26.00	22.00	20.00	26.00
SEM	0.61	0.51	0.67	0.55	0.46	0.59
RSD	20.56	17.14	20.90	26.38	21.30	24.93

	Intervention group boys			Control group boys		
	T2-T1	T3-T2	T3-T1	T2-T1	T3-T2	T3-T1
Difference	0.14	1.21	1.36	0.44	1.51	1.96
% Difference	0.91	7.66	7.95	3.16	10.43	12.22
	Comparison between the intervention and control group boys					
	T1 CG-IG		T2 CG-IG		T3 CG-IG	
Difference	-1.67		-1.37		-1.07	
% Difference	11.89 %		9.44 %		6.70 %	

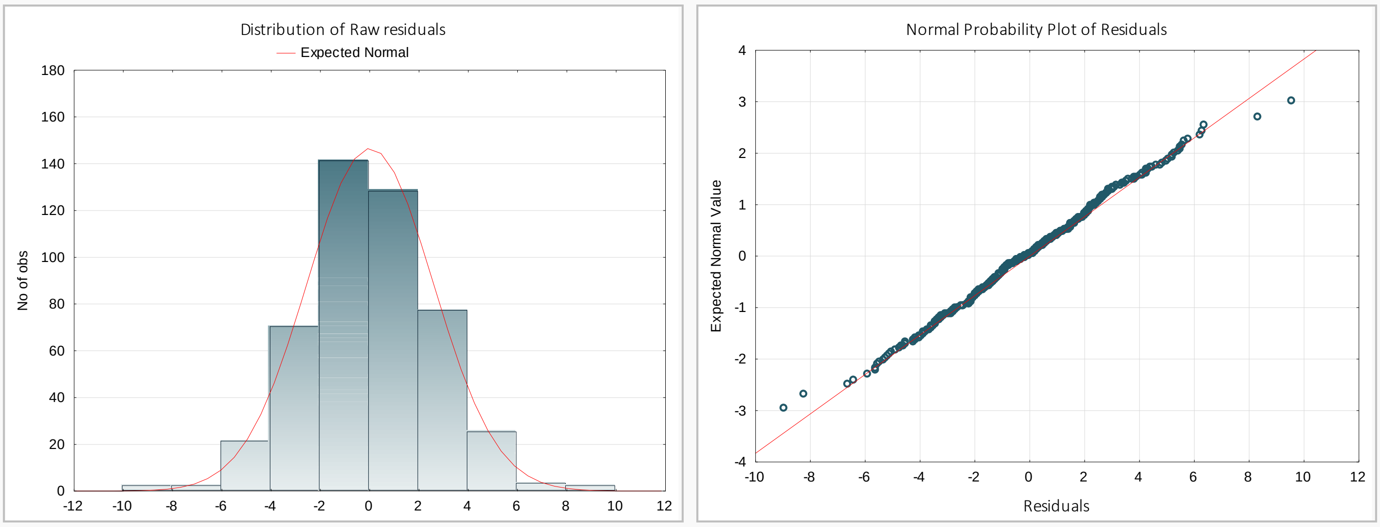

Figure E.8: Graphical representation, histogram and line graph: Handgrip strength distribution

- **Lower Body Musculature Strength**

Table E.17: Descriptive statistics standing broad jump distance (cm): Comparison within and between the intervention group (IG) and control group (CG) girls, across three testing phases (T1, T2, and T3)

	Intervention group girls			Control group girls		
	T1	T2	T3	T1	T2	T3
n	37	37	37	47	47	47
M	119.11	115.92	114.35	116.17	118.85	112.70
S.D.	20.89	22.74	27.63	18.27	17.72	17.31
Min	48.00	60.00	53.00	76.00	81.00	79.00
Quartile 1	108.00	104.00	101.00	106.50	107.00	102.00
Mdn	122.00	117.00	112.00	118.00	117.00	111.00
Quartile 3	130.00	126.00	127.00	128.50	129.00	120.00
Max	156.00	160.00	202.00	154.00	181.00	168.00
SEM	3.43	3.74	4.54	2.66	2.59	2.52
RSD	17.54	19.62	24.16	15.72	14.91	15.36

	Intervention group girls			Control group girls		
	T2-T1	T3-T2	T3-T1	T2-T1	T3-T2	T3-T1
Difference	-3.19	-1.57	-4.76	2.68	-6.15	-3.47
% Difference	-2.68	-1.35	-4.16	2.31	-5.17	-3.08
	Comparison between the intervention and control group girls					
	T1 CG-IG		**T2 CG-IG**		**T3 CG-IG**	
Difference	-2.94		2.93		-1.65	
% Difference	2.53 %		-2.47 %		1.46 %	

Table E.18: Descriptive statistics standing broad jump distance (cm): Comparison within and between the intervention group (IG) and control group (CG) boys, across three testing phases (T1, T2, and T3)

	Intervention group boys			Control group boys		
	T1	T2	T3	T1	T2	T3
n	28	28	28	45	45	45
M	140.89	138.25	131.04	139.27	135.73	132.49
S.D.	20.98	16.95	24.16	13.93	18.63	17.52
Min	93.00	103.00	93.00	115.00	98.00	95.00
Quartile 1	129.00	127.50	112.75	130.00	122.00	121.00
Mdn	146.00	137.50	132.00	138.00	137.00	133.00
Quartile 3	154.25	150.00	146.25	147.00	146.00	139.00
Max	174.00	173.00	186.00	174.00	199.00	172.00
SEM	3.96	3.20	4.57	2.08	2.78	2.61
RSD	14.89	12.26	18.44	10.00	13.73	13.22
	Intervention group boys			**Control group boys**		
	T2-T1	**T3-T2**	**T3-T1**	**T2-T1**	**T3-T2**	**T3-T1**
Difference	-2.64	-7.21	-9.86	-3.53	-3.24	-6.78
% Difference	-1.88	-5.22	-7.52	-2.54	-2.39	-5.12
	Comparison between the intervention and control group boys					
	T1 CG-IG		**T2 CG-IG**		**T3 CG-IG**	
Difference	-1.63		-2.52		1.45	
% Difference	1.17 %		1.85 %		-1.10 %	

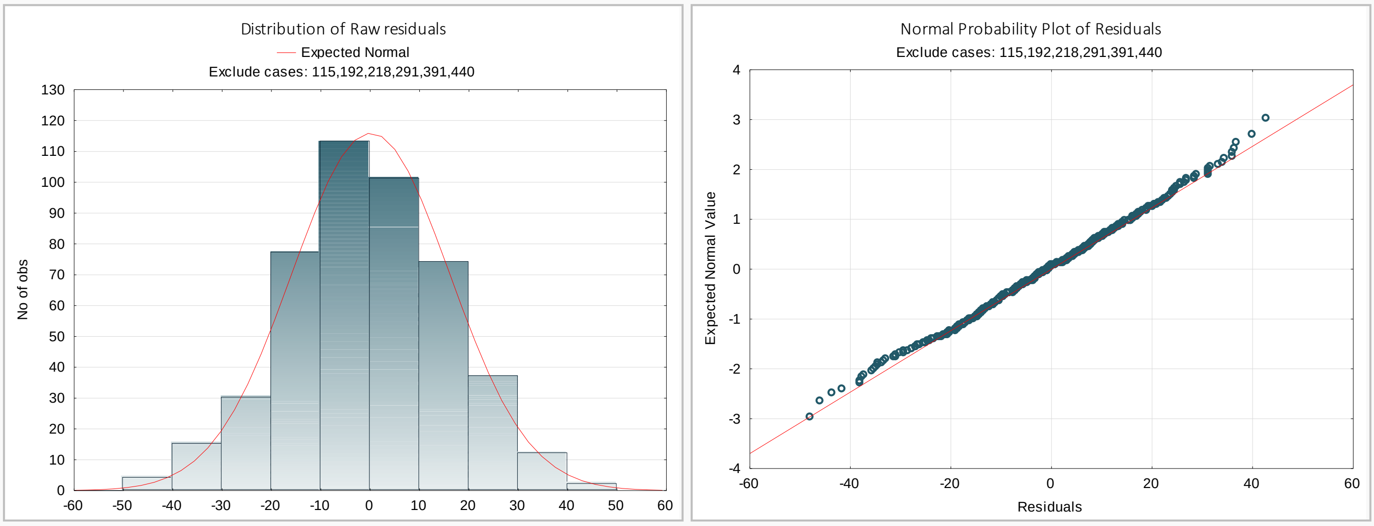

Figure E.9: Graphical representation, histogram and line graph: Standing broad jump distance distribution

- **Lower Body Flexibility**

Table E.19: Descriptive statistics sit-and-reach distance (cm): Comparison within and between the intervention group (IG) and control group (CG) girls, across three testing phases (T1, T2, and T3)

	Intervention group girls			Control group girls		
	T1	T2	T3	T1	T2	T3
n	37	37	37	47	47	47
M	36.10	33.03	32.46	33.07	34.02	29.53
S.D.	6.06	6.79	6.37	5.06	5.26	6.15
Min	20.20	17.50	15.00	20.70	18.00	12.00
Quartile 1	34.60	30.00	29.50	30.30	31.00	25.00
Mdn	36.50	34.00	32.80	33.20	33.00	31.00
Quartile 3	40.20	37.50	36.80	36.35	37.50	34.00
Max	47.70	50.00	44.60	43.80	44.30	40.00
SEM	1.00	1.12	1.05	0.74	0.77	0.90
RSD	16.78	20.55	19.61	15.29	15.47	20.81
	Intervention group girls			**Control group girls**		
	T2-T1	**T3-T2**	**T3-T1**	**T2-T1**	**T3-T2**	**T3-T1**
Difference	-3.07	-0.56	-3.64	0.95	-4.49	-3.54
% Difference	-8.51	-1.71	-11.20	2.87	-13.20	-12.00
	Comparison between the intervention and control group girls					
	T1 CG-IG		**T2 CG-IG**		**T3 CG-IG**	
Difference	-3.02		1.00		-2.93	
% Difference	9.14 %		-2.93 %		9.92 %	

Table E.20: Descriptive statistics sit-and-reach distance (cm): Comparison within and between the intervention group (IG) and control group (CG) boys, across three testing phases (T1, T2, and T3)

	Intervention group boys			Control group boys		
	T1	T2	T3	T1	T2	T3
n	28	28	28	45	45	45
M	32.33	28.50	28.62	32.06	30.95	28.53
S.D.	6.60	7.47	6.36	4.46	5.30	5.57
Min	20.80	16.50	16.90	19.80	14.80	13.00
Quartile 1	29.05	22.75	24.20	29.30	27.50	25.00
Mdn	32.15	28.10	27.50	32.60	32.00	29.00
Quartile 3	37.40	33.93	33.03	35.00	34.70	32.00
Max	46.60	43.00	42.70	40.30	40.00	41.00
SEM	1.25	1.41	1.20	0.67	0.79	0.83
RSD	20.41	26.21	22.21	13.92	17.14	19.54
	Intervention group boys			**Control group boys**		
	T2-T1	**T3-T2**	**T3-T1**	**T2-T1**	**T3-T2**	**T3-T1**
Difference	-3.83	0.11	-3.71	-1.10	-2.42	-3.52
% Difference	-11.83	0.40	-12.97	-3.44	-7.82	-12.34

	Comparison between the intervention and control group boys		
	T1 CG-IG	T2 CG-IG	T3 CG-IG
Difference	-0.27	2.45	-0.08
% Difference	0.85 %	-7.91 %	0.30 %

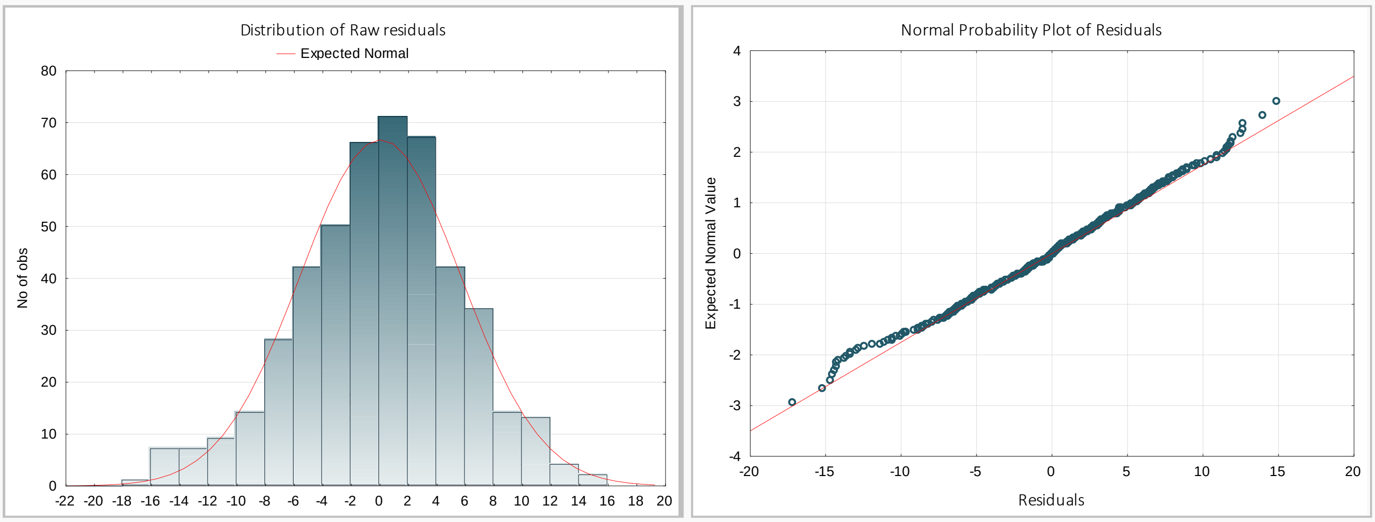

Figure E.10: Graphical representation, histogram and line graph: Sit-and-reach distance distribution

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