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EFFECT OF SCHOOL-BASED INTERVENTIONS ON ATTENTION AND ACADEMIC PERFORMANCE OF PRIMARY SCHOOLCHILDREN FROM LOWER SOCIOECONOMIC COMMUNITIES IN PORT ELIZABETH

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Submitted in fulfilment of the requirements for the degree of Master of Arts (Human Movement Science) in the Faculty of Health Sciences at the Nelson Mandela University

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NELSON MANDELA UNIVERSITY

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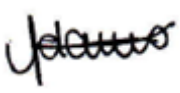
DECLARATION: In accordance with Rule G5.6.3, I hereby declare that the above-mentioned thesis is my own work and that it has not previously been submitted for assessment to another University or for another qualification.

SIGNATURE: 

DEDICATION

This dissertation is dedicated to my beloved parents

Mr. Garnet Jerome Adams

and

Mrs. Yvette Heather Adams

I love you with all my heart and I am proud to be yours.

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LIST OF ACRONYMS AND ABBREVIATIONS

ADHD	Attention-deficit hyperactivity disorder
ANA	Annual National Assessments
AP	Academic performance
CP	Concentration performance
DASH	Disease Activity and Schoolchildren's Health
DBE	Department of Basic Education
E%	Percentage of errors
EoYR	End of year results
EF	Executive function
FET	Further Education and Training
GET	General Education and Training
LO	Life Orientation
LS	Life Skills
MVPA	Moderate-to-vigorous physical activity
PA	Physical activity
PE	Physical education
PF	Physical fitness
NA	Northern areas
NSNP	National School Nutrition Programme
SA	South Africa
T	Township
TN-E	Total performance

ABSTRACT

Introduction: Health benefits associated with regular physical activity (PA) have been widely established. Regular PA is not only associated with improved physical and psychological well-being, but also with improved brain function and cognition, thereby enhancing academic performance (AP). Despite these benefits, decreasing levels of PA and increasing levels of overweight and obesity exist world-wide, making childhood physical inactivity a global concern. Research suggests children who meet the recommended PA guidelines of 60-minutes of moderate-to-vigorous intensity attain substantially higher academic grades. Schools provide ideal settings for PA promotion due to the substantial amount of time children spend at school. However, in many countries, including South Africa (SA), Physical Education (PE) programmes have been reduced and replaced with other subjects to increase AP. Furthermore, a scarcity of water, limited accessibility to improved sanitation and lack of personal hygiene at home and in school substantially contributes to the burden of preventable childhood diseases. These hygiene-related illnesses augment the cycle of poverty and disease through its detrimental effect on children's school attendance, academic performance and productivity. Studies also show that obesity, poor nutrition and food insufficiency affect children's school achievement. Hence, the school environment plays an essential role in improving children's health, since many teaching opportunities about important health and nutrition practices are provided.

Aim: The primary aim of this study was to determine the effect of various combinations of school-based interventions on the attention and AP of primary schoolchildren from disadvantaged communities in Port Elizabeth.

Methodology: Overall, 857 schoolchildren (n = 434 boys and n = 423 girls, aged 8 – 13 years) participated in the study. A 10-week cluster randomised controlled trial using four experimental and four control schools was conducted. Setting-specific interventions incorporated PA, health and hygiene education and nutrition components. The d2 Test of Attention measured selective visual attention and concentration with outcome measures of the percentage of errors, total performance and concentration performance. End of year school results were used to assess AP.

Results: Post-intervention and pre- to post-intervention differences between the inter-school comparisons revealed mixed results for the attention and AP measurements, therefore, no conclusions could be drawn regarding the assessed variables. Intervention group comparisons at post-intervention indicated that the PA intervention group achieved a statistically significant improvement ($p < .05$ and $d > 0.8$) for AP, when compared with the non-PA intervention group. No significant differences were found for AP in relation to intervention group comparisons for the health and hygiene education and nutrition intervention groups. Similarly, the intervention group comparisons revealed no significant differences regarding attention for post-intervention and pre- to post-intervention differences.

Conclusion and Recommendations: Findings suggest that a school-based PA intervention can positively affect children's AP. The current study emphasises the necessity of PA and reinforces the importance of PE in the school curriculum. Therefore, it is strongly recommended that PE regains its rightful place and be actively taught within the school curriculum.

Keywords: Attention, academic performance, executive function, cognitive performance, physical activity, physical education, primary schoolchildren, and school-based intervention.

CHAPTER 1
PROBLEM IDENTIFICATION

1.1 INTRODUCTION

This study investigates the effect of school-based PA interventions on the attention and AP of primary schoolchildren from socioeconomically disadvantaged communities in Port Elizabeth. It centres around the level of PA, the health status, and the effects of PA on the attention and AP of children from socioeconomically marginalised regions and government schools situated in former black and coloured communities. This introductory chapter contextualises the study through the provision of a concise summary of its rationale, its significance and relevance to the domain of PA, children's health, and cognition and educational performance. The sections to follow delineates the aims and objectives of the study, clarifies certain concepts related to the study, as well as the scope of the study and provides a succinct outline of the remaining chapters.

1.2 CONTEXTUALISATION

The health benefits associated with regular PA and physical fitness (PF) is widely established (Eveland-Sayers, Farley, Fuller, Morgan & Caputo, 2009:99; Singh, Uijtdewilligen, Twisk, van Mechelen & Chinapaw, 2012:49; Lennox & Pienaar, 2013:154). Research has shown that an increased level of PA reduces the risk of cardiovascular diseases, type II diabetes, some cancers, and obesity (Penedo & Dahn, 2005:189). The recent analysis by The Lancet Physical Activity Series Working Group on the global burden of non-communicable diseases and mortality estimated that 6% of coronary heart disease, 7% of type II diabetes and 10% of breast and colon cancers, are directly attributable to lack of PA (Tremblay, 2014:S1). Despite the benefits of regular PA, there are decreasing levels of PA and increasing levels of overweight and obesity amongst children world-wide, thus making childhood and

youth physical inactivity a global concern (Hallal, Andersen, Bull, Guthold, Haskell & Ekelund, 2012:247).

South African studies have revealed unsatisfactory levels of PA, PF, overweight and obesity among children (McVeigh, Norris & de Wet, 2004b:982; Armstrong, Lambert & Lambert, 2011:1000; Draper, Basset, de Villiers, Lambert & HAKSA Writing Group, 2014:S98). In the South African 2014 Report Card on Physical Activity for Children and Youth, overall PA levels received a D-grade, as approximately 50% or more children and youth were not meeting the recommended levels of PA (Sport Science Institute of South Africa, 2014:3). Although the most recent 2018 Healthy Active Kids South Africa Report Card indicated that overall PA levels have increased to a C-grade, the percentage of SA children engaging in the recommended amount of PA remains the same, with no evidence indicative of children and adolescents being more active (Sport Science Institute of South Africa, 2018:3). South African children and youth also spent a large proportion of time in sedentary behaviour and watched, on average, nearly 3 hours of television a day (Statistics South Africa, 2013:60).

There is a growing body of knowledge suggesting that PA has beneficial effects on mental health and psychological well-being (Keeley & Fox, 2009:198; Singh *et al.*, 2012:49). Regular participation in PA has also been linked with improved brain function and cognition (Hillman, Erickson & Kramer, 2008:58), thereby positively enhancing AP (Singh *et al.*, 2012:49). Reasons given as to why exercise benefits cognition include the increased blood and oxygen supply to the brain (Hillman *et al.*, 2008:58), the reduction of stress and improvement of mood resulting from increased levels of norepinephrine and endorphins (Fleshner, 2000:S14), and improved synaptic transfer (Hillman *et al.*, 2008:58; Trudeau & Shephard, 2008:18).

Although PA is believed to positively influence children's AP, learning and cognitive functions, such as attention, general information-processing, memory, and problem-solving ability, inconsistent findings have been found. In a review examining the association between school-based PA (including PE and AP), 50.1% of the 251 associations identified between PA and AP were positive, 48% not significant and 1.5% negative (Rasberry, Lee, Robin, Laris, Russell, Coyle & Nihiser, 2011:S10). Another systematic review found evidence of a significant longitudinal relationship

between PA and AP in children (Singh *et al.*, 2012:53). Several population level studies in the United States have demonstrated positive associations between PF and AP in children (Castelli, Hillman, Buck & Erwin, 2007:239; Cottrell, Northrup & Wittberg, 2007:3170; Eveland-Sayers *et al.*, 2009:99). These studies used composite fitness scores and reported positive associations between aerobic fitness and AP (Shelton, 2009:5). A study by Van Dusen, Kelder, Kohl lll, Ranjit and Perry (2011:733) revealed that cardiovascular fitness showed a dose-response relationship with AP and recommended that policy makers consider increasing PE time in the school curriculum and that PE practitioners emphasise cardiovascular fitness in lessons. Research suggests children who meet the recommended PA guidelines attained substantially higher academic grades (Stevens, To, Stevenson & Lochbaum, 2008:368; Eveland-Sayers *et al.*, 2009:99).

Very few South African studies investigating PA, PF and academic achievements were found in the literature. An earlier study by Themane, Koppes, Kemper, Monyeki and Twisk (2006:48) found no strong evidence in the association between PA, PF and academic achievement in rural South African children aged 7 – 14 years. However, the results were attributed to the unique education problems and elevated levels of PA and PF of the group. A more recent study by du Toit, Pienaar and Truter (2011:23) showed a significant correlation between strength test scores and AP among primary school children aged 9 – 12 years. Significant correlations were also found between specific strength tests and AP among boys (12 years) and girls (11 and 12 years). Several fitness parameters also discriminated against high and low academic achievers.

Schools are ideal settings for the promotion of PA and fitness due to the large amount of time that children spend at school (Walter, 2014:359). There are two main periods during a school day in which children can be physically active; namely PE classes and during recess or break-times (Mota, Silva, Santos, Ribeiro, Oliveira & Duarte, 2005:269). However, world-wide, PE programmes have been reduced and been replaced with other classes in an effort to increase academic achievement (Coe, Pivarnik, Womack, Reeves & Malina, 2006:1515). Research has revealed that PE policies were not implemented in 75% of African countries, with 86% not acknowledging its significance (Edginton, Chin, Amusa & Toriola, 2012:434). Similarly,

in SA, PE lost its stand-alone status in the school curriculum with the introduction of Curriculum 2005 in 1997 (Van Deventer, 2004:107; du Toit, van der Merwe & Rossouw, 2007:241; Van Deventer, 2007:136; Van Deventer, 2009:127). Curriculum reform in SA is no new phenomenon. In the latest curriculum reform, PE is included in the learning areas of Life Skills (LS) or Life Orientation and is disadvantaged by the absence and neglect of facilities and equipment (Van Deventer, 2011:823; Van Deventer, 2012:153).

School health programmes are potential avenues to contribute to the improved health of children in low- and middle-income countries (Duijster, Monse, Dimaisip-Nabuab, Djuharnoko, Heinrich-Weltzien, Hobdell, Kromeyer-Hauschild, Kunthearith, Mijares-Majini, Siegmund, Soukhanouvong & Benzian, 2017:7). Furthermore, a scarcity of water, limited accessibility to improved sanitation and lack of personal hygiene at home and in school substantially contributes to the immense burden of preventable childhood diseases (Duijster *et al*., 2017:2). These hygiene-related illnesses augment the cycle of poverty and disease through its detrimental effect on children's school attendance, academic performance and productivity. Studies also show that obesity, poor nutrition and food insufficiency affect children's school achievement (Hollar, Messiah, Lopez-Mitnik, Hollar, Almon & Agatston, 2010:646). Hence, the school environment plays an essential role in improving children's health, since many teaching opportunities about important health and nutrition practices are provided.

Very few South African studies were found in relation to school-based PA interventions in children. A study by Naidoo and Coopoo (2012:75) measured the impact of an 18 month school-based intervention program on PF; and Lennox and Pienaar (2013:154) investigated the effects of an after-school PA program on aerobic fitness and PA levels of adolescents. No studies were found to investigate the effect of a school-based intervention program on the AP of school-aged children. Given the shortage of research in this area and the potential positive effects of PA on the health and well-being of children, this study was aimed at investigating the effect of school-based PA interventions on the attention and AP of primary schoolchildren from lower socioeconomic communities in Port Elizabeth.

1.3 AIM AND OBJECTIVES OF THE STUDY

1.3.1 Aim of the Study

The primary aim of this study was to determine the effect of a school-based PA intervention, on its own, and in combination with health and hygiene education and/or nutrition on the attention and AP of Grade 4 children from lower socioeconomic communities in Port Elizabeth.

This study occurred under the auspices of a larger 3-year joint research project funded by the Swiss South African Joint Research Programme (SSAJRP), entitled "Impact of disease burden and setting-specific interventions on school children's cardio-respiratory physical fitness and psychosocial health in Port Elizabeth, South Africa".

1.3.2 Objectives of the Study

This study set out to address the following objectives in order to successfully achieve the primary aim of this study:

- To explore, describe and compare the effect of the school-based PA intervention, and no intervention, on the attention and AP of the experimental and control groups, respectively;
- To explore, describe and compare the effect of the school-based PA intervention in combination with health and hygiene education, and no intervention, on the attention and AP of the experimental and control groups, respectively;
- To explore, describe and compare the effect of the school-based PA intervention in combination with health and hygiene education and nutrition versus no intervention, on the attention and AP of the experimental and control groups, respectively.
- To explore, describe and compare the effect of the health and hygiene education and nutrition intervention versus no intervention, on the attention and AP of the experimental and control groups, respectively.
- To compare the three intervention options (PA, health and hygiene education, and nutrition) with one another, in respect of the effect on the attention and AP.

1.4 CONCEPT CLARIFICATION

Several conceptual aspects are central to the understanding the effects of PA on the attention and AP of children; and therefore, need to be clarified in order to facilitate understanding of the research project:

1.4.1 Cognitive Performance

Cognitive performance denotes a child's performance when evaluated utilising recognised and validated tests of cognitive function. These tests evaluate elements of cognition, namely attention, reaction time, stimulus response and reaction time (collectively known as executive control). Cognitive and AP are thought to interrelate as aspects of cognition, such as attention and working memory, are vital for academic success (Keeley & Fox, 2009:201).

1.4.2 Attention

Attention is a major topic of interest in the fields of education, psychology and neuroscience, and is defined as the behavioural and cognitive process of selectively concentrating on a discrete aspect of information, while ignoring other perceivable information (Anderson, 2014:54). According to Magill (2011:195), in human performance, attention is referred to as a characteristic associated with consciousness, awareness, and cognitive effort as it relates to the performance of skills with particular reference to the limitations associated with the simultaneous performance of multiple skills and the detection of relevant information in the performance environment.

1.4.3 Selective Attention

Selective attention is an individual's ability to select and focus on a specific task, whilst at the same time suppressing irrelevant or distracting information. This contesting of information occurs both internally and externally due to auditory or visual distractions or distracting thoughts (Stevens & Bavelier, 2012:S31). Selective attention is related to essential domains in education, including language processing (Sussman &

Steinschneider, 2009:771), literacy (Stevens, Lauinger & Neville, 2009:634), and numeracy (Checa & Rueda, 2011:1018); and therefore, has an integral role in AP.

1.4.4 Academic Performance

Adediwura and Tayo (2007:167) defined AP as the display of knowledge attained or skills developed in school subjects designated by test and examination scores or marks assigned by the subjects' teachers. According to Rasberry *et al.* (2011:S12) and Gray, Dueck, Rogers and Tannock (2017:19), academic achievement can be determined through standardised tests of achievement or classroom performance measures. This includes measures of standardised achievement test scores in subject areas such as Literacy and Numeracy; classroom performance test scores or other formal assessments generally measured at the end of a school term or after a certain amount of the curriculum has been taught (Rasberry *et al.*, 2011:S12; Rasmussen & Laumann, 2013:947).

1.4.5 Physical Activity

The American College of Sports Medicine (2014:2) describes PA as any bodily movement that is produced by musculo-skeletal contraction and increases energy expenditure above resting levels. The term PA should not be misinterpreted with exercise, which is considered a subcategory of PA comprising of planned, structured and repetitive bodily movements, with the intent of improving or maintaining the various components of PF (American College of Sports Medicine, 2014:2; World Health Organization, 2017b). PA denotes complex multi-dimensional behaviour that can be commonly categorised by the FITT (frequency, intensity, time and type of activity) principle of Thomas, Nelson and Silverman (2005:305):

- Frequency: The number of times within a certain time frame that an individual is physically active.
- Intensity: The physiological effort of the activity.
- Time: The duration of time spent partaking in a certain activity.
- Type of Activity: This may include active play, games, dance and sport.

The PA recommendations differ according to age, children between the ages of 5 and 17 years should participate in at least 60 minutes of moderate-to-vigorous intensity activity each day; whereas adults (18 years +) should participate in at least 150 minutes of moderate intensity activity each week (World Health Organization, 2017b).

1.4.6 Physical Education

PE forms part of a standardised school curriculum and is one component of a comprehensive and co-ordinated school programme. The educational objectives of PE are clearly defined and includes the promotion of a physically active lifestyle, developing PF, focusing on knowledge acquisition and developing emotional, social and physical skills. Hence, it is unlike recess, which involves free play (McKenzie & Kahan, 2008:172).

1.5 SCOPE OF THE STUDY

This study occurred under the auspices of a larger 3-year joint research project funded by the Swiss South African Joint Research Programme (SSAJRP), entitled “Impact of disease burden and setting-specific interventions on school children’s cardio-respiratory physical fitness and psychosocial health in Port Elizabeth, South Africa”. The commencement of this study took place in 2014, once all the approvals necessitated had been obtained from the Faculty of Research, Technology and Innovation (FRTI), Faculty of Postgraduate Studies Committee (FPGSC), and the Research Ethics Committee-Human (REC-H) of the Nelson Mandela University. Phase 1 of the research project, the collection of the baseline data, was completed in March 2015. Phase 2 of the research project, the basis for this study, formed part of investigating the effect of setting-specific interventions on school children’s cardio-respiratory PF, cognitive performance and psychosocial health, in which the data collection was completed in November 2015.

This study is a cluster randomised controlled trial and utilised quantitative research methods as it set out to determine the effect of school-based PA interventions, on its own, and in combination with health education and/or nutrition on the attention and AP

of Grade 4 children from lower socioeconomic communities in Port Elizabeth. The population for this study included children, aged 9 – 12 years, from socioeconomically disadvantaged schools. Schools from quintile 3 (or less) communities were approached to participate, from which 1009 children were identified and randomly selected to be involved in this study.

A school-based PA intervention, which included a PE intervention, a health and hygiene education intervention, a nutrition intervention, and medication/treatment of parasitic infections, was implemented for a period of ten weeks. The present study used the baseline data of the Disease Activity and Schoolchildren's Health (DASH) study, which was collected in March 2015. The school-based PA interventions were conducted at the four intervention schools during the third school term (July, August, and September 2015). Thereafter, the post-intervention data for the current study was collected at the end of September to the beginning of November 2015. The data collection protocols used in the DASH baseline testing (parasitological examinations, clinical examinations, anthropometric measurements, PF tests, cognitive performance, and psychosocial health questionnaire) was repeated during this post-intervention phase. Data pertaining to the measurement of attention and AP (the d2 Test of Attention and school test grades) in the baseline testing, as well as the post-intervention testing were used in the study.

1.6 FORMAT OF DISSERTATION

To conceptualise this study within the widespread fields of health, PA, PE, sport, recreation, attention and AP, the following chapters reveal a synthesised theoretical background of the research, the processes involved, the development thereof and the key outcomes. This was performed to put the research into context and to provide a thorough interpretation and understanding of the current study.

Chapter 2: Provides a synopsis of PA, attention and AP universally, in South African-based research, and in relation to adults in general; but with specific emphasis on children aged 9 to 13 years. This chapter delineates the afore-mentioned aspects, with reference to South African

studies associated with the various components of health and PA. Factors relating to attention and AP in children (9 to 13 years) are also discussed. To conclude this chapter, a summary and justification for this study are provided.

Chapter 3: Describes the research methodology utilised in the study to achieve the aims and objectives thereof. This chapter is comprised of details pertaining to the research design, participants and sampling, measuring instruments, the data collection procedures, and data analysis techniques employed.

Due to the nature of the research design, Chapters 4 and 5 consists of the results and discussion of the study. More specifically:

Chapter 4: Centres around the results of the quantitative data analysis, ultimately to attain the aim and objectives of the study; whereas

Chapter 5: Discusses the quantitative data analysis to draw conclusions regarding the findings of this study. Therefore, this chapter forms the conclusion of the study which provides a summation of the key outcomes and discusses the limitations and implications found within the study. The outcomes and implications subsequently provide guidelines, which aid in the promotion of PA participation amongst children (aged 9 to 13 years), due to its effects on attention and AP.

The following chapter will present a theoretical background of the research through the application of current literature on PA, attention and AP universally, in South African-based research, and in relation to adults; but with specific emphasis on children aged 9 to 13 years. Furthermore, factors relating to cognition, specifically attention, as well as AP are also discussed.

CHAPTER 2
LITERATURE REVIEW

2.1 INTRODUCTION

PA is universally accepted as an important element for the promotion of health and well-being (Janssen & LeBlanc, 2010:1). Despite the growing evidence of health-related benefits of regular PA amongst children (Owen, Nightingale, Rudnicka, Sattar, Cook, Ekelund & Whincup, 2010:1620; Biddle & Asare, 2011:886; Brown, Pearson, Braithwaite, Brown & Biddle, 2013:195), concerns have been raised about decreasing PA and fitness levels in children and adolescents (Dollman, Norton & Norton, 2005:892; Andersen, 2011:155). Physical inactivity and sedentary lifestyles have become increasingly more common in recent decades, along with numerous societal changes. Internationally, approximately 3.2 million deaths are associated with physical inactivity, which has been recognised as the fourth leading risk factor for mortality (World Health Organization, 2017a).

Evidence suggests that regular PA not only contributes to improved physical health (Dobbins, Husson, De Corby & La Rocca, 2013:1), but also has a favourable effect on children's cognitive functioning, such as EF (Ludyga, Gerber, Brand, Holsboer-Trachsler & Pühse, 2016:1611), attention (Tomporowski, McCullick, Pendleton & Pesce, 2015:47), and AP (Tomporowski, Davis, Miller & Naglieri, 2008:111), all of which are important conditions for AP gains. Both fitness and fatness also appear to be associated with cognitive function (Li, Dai, Jackson & Zhang, 2008:1809; Roberts, Freed & McCarthy, 2010:711; Yu, Han, Cao & Guo, 2010:656) and academic achievement (Datar, Sturm & Magnabosco, 2004:58; Shore, Sachs, Lidicker, Brett, Wright & Libonati, 2008:1535).

Due to the variations existing in studies, conclusions about relationships between academic achievement and cognitive performance, specifically attention, are rather complex (Gray *et al.*, 2017:18). A primary and necessary goal for the development of scientific knowledge is to contribute to this field by identifying areas of strength and gaps in the literature and examining the strength of the current evidence for the relationship that exists. The present study aims to determine the effect of school-based interventions on the attention and AP of primary schoolchildren from lower socioeconomic communities in Port Elizabeth. This chapter provides a discussion of cognitive performance and EFs, particularly attention; AP; and PA, with specific emphasis on children aged 8 to 13 years. Furthermore, the state of PE universally, as well as in a South-African context has been described. Empirical studies assessing the effectiveness of school-based interventions on attention and AP are also described and discussed. The chapter concludes with a summary and justification for this study.

2.2 COGNITIVE PERFORMANCE AND EXECUTIVE FUNCTIONS

Cognitive performance denotes the performance of a child when evaluated, utilising recognised and validated tests of cognitive function. Elements of cognition, namely attention, reaction time, stimulus response and working memory [collectively known as executive functions (EFs)], are evaluated by these tests. Chan, Shum, Toulopoulou and Chen (2008:201) state that the term “executive functions” is a hypernym for functions such as planning, working memory, inhibition, mental flexibility, as well as the initiation and monitoring of action. More specifically, that EFs encompass an extensive range of cognitive processes and behavioural competencies which include verbal reasoning, problem-solving, planning, sequencing, the ability to sustain attention, resistance to interference, utilisation of feedback, multitasking, cognitive flexibility, and the ability to deal with novelty (Stuss, Shallice, Alexander & Picton, 1995:192; Grafman & Litvan, 1999:1921; Burgess, Veitch, de Lacy Costello & Shallice, 2000:848-849). Additionally, Diamond (2013:135) describes EFs (also termed executive control or cognitive control) as a set of top-down mental processes required when an individual has to concentrate and pay attention, when depending on automatic or relying on instinct or intuition would be ill-advised, insufficient, or impossible (Miller & Cohen, 2001:167-168; Espy, 2004:379-380).

A consensus exists that there are three core EFs (Miyake, Friedman, Emerson, Witzki, Howerter & Wager, 2000:54-55; Lehto, Juujärvi, Kooistra & Pulkkinen, 2003:60), namely: inhibition [inhibitory control, including self-control (behavioural inhibition) and interference control (selective attention and cognitive inhibition)], working memory, and cognitive flexibility (also referred to as set shifting, mental flexibility, or mental set shifting and closely linked to creativity) (refer to figure 2.1). Higher-order EFs such as reasoning, problem solving, and planning are built from these afore-mentioned core functions (Collins & Koechlin, 2012:1; Lunt, Bramham, Morris, Bullock, Selway, Xenitidis & David, 2012:65). A comprehensive systematic review highlighted the importance of EFs in various aspects of life and stated that essentially, EFs are the competencies inherent for mental and physical health; success in school and in life; and cognitive, social and psychological growth and development (Diamond, 2013:42).

EFs develop gradually over time, changing across a person's lifespan, and can be improved at any stage from infancy to late adulthood (Diamond, 2013:21). Similarly, these cognitive processes may be unfavourably influenced by the occurrence of an array of events, ultimately affecting an individual (Diamond, 2013:19). To measure EFs, both neuropsychological tests (for example, the Stroop Test) and rating scales such as the Behaviour Rating Inventory of Executive Function are employed. The Stroop effect, which is a demonstration of interference in the reaction time of a task, is named after Stroop (1935:643). The Behaviour Rating Inventory of Executive Function is an assessment of EF behaviours at home and at school for children and adolescents aged 5 – 18 years and was originally developed by Gioia, Isquith, Guy and Kenworthy (2000:235). Typically, these tests are employed and performed as part of a more comprehensive assessment for the diagnosis of neurological and psychiatric disorders. In this section, cognitive performance and EF has been described. The next sub-section will elaborate on the developmental phases thereof.

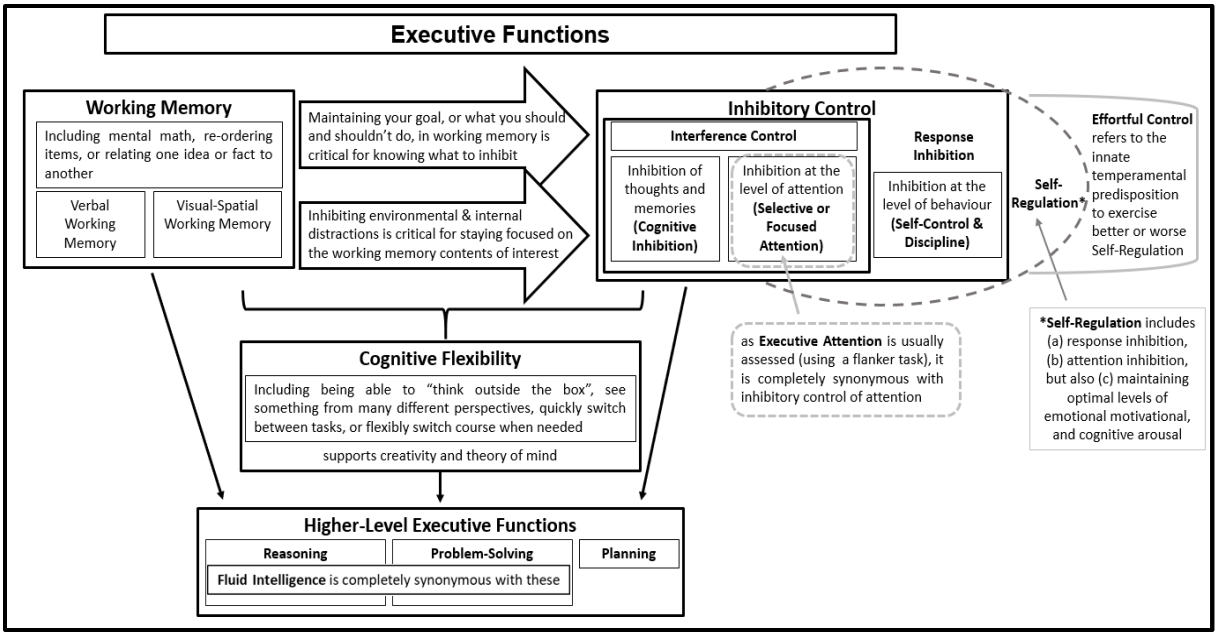

Figure 2.1: Executive Functions and Related Terms [adapted from Diamond (2013:41)]

2.2.1 Development of Executive Functions

Research suggests that EFs are the amongst the last of the mental functions to develop and reach a mature state. This is because of the late onset of the maturation of the prefrontal cortex, which is not fully myelinated until well into an individual's third decade of life. EF development occurs in spurts, when new skills, strategies, and forms of awareness transpire. These spurts are understood to signify maturational events in the frontal areas of the brain (De Luca & Leventer, 2010:24-26). Attentional control emerges in infancy and rapidly develops in early childhood. Cognitive flexibility, goal setting, and information processing generally develop rapidly between the ages of 7 to 9 years, maturing by the age of 12. Executive control characteristically emerges shortly after a transition period at the start of adolescence (Anderson, 2002:71). It is unclear whether there is a single sequence of stages in which EFs appear, or whether different environments and early life experiences can cause the development to occur in differing sequences (De Luca & Leventer, 2010:26).

In early childhood, inhibitory control and working memory serve as basic EFs, enabling more complex EFs like problem-solving to develop (Senn, Espy & Kaufmann, 2004:458-459). Inhibitory control and working memory are amongst the earliest to appear, with initial signs observed in infants, 7 to 12 months old (Anderson, 2002:76; De Luca & Leventer, 2010:28). Thereafter, in pre-school years, children demonstrate

a spurt in performance on tasks of inhibition and working memory, typically between the ages of 3 to 5 years (Best, Miller & Jones, 2009:180; De Luca & Leventer, 2010:31). Also during this time, cognitive flexibility, goal-directed behaviour, and planning starts to develop (De Luca & Leventer, 2010:31-32). However, pre-school children do not have fully mature EFs and continue to make errors related to these emerging abilities – often not because of the absence of abilities, but rather due to the lack of awareness of knowing when and how to use particular strategies in specific contexts (Espy, 2004:380).

During preadolescence, children continue to demonstrate certain growth spurts in EFs, insinuating that this development does not necessarily occur linearly, as with the preliminary maturation of particular functions (Anderson, 2002:77; De Luca & Leventer, 2010:33). Preadolescent children exhibit major increases in verbal working memory; goal-directed behaviour (with a potential spurt around 12 years of age); response inhibition and selective attention; and strategic planning and organisational skills. Furthermore, cognitive flexibility particularly starts to match adult levels between the ages of 8 to 10. Though, like patterns in childhood development, there is a limitation in preadolescents' EF since these children do not apply these EFs reliably across multiple contexts because of the on-going development of inhibitory control (De Luca & Leventer, 2010:35).

In adolescence, when the various brain systems become better integrated, youth implement EFs, such as inhibitory control, more efficiently and effectively and improve throughout this period. Like inhibitory control emerges in childhood and improves over time, planning and goal-directed behaviour also demonstrate an extended time course with on-going growth over adolescence (Best *et al.*, 2009:191). Similarly, functions such as attentional control, with a potential spurt at age 15, along with working memory, continue to develop at this stage. At age 20 to 29, EFs skills are at its peak, enabling individuals of this age to engage in some of the most challenging mental tasks. In later adulthood, these skills start to decline (De Luca & Leventer, 2010:39-40). The decline is most easily noted in the areas of working memory and spatial span, whilst cognitive flexibility generally does not begin to decline until around the age of 70 (De Luca & Leventer, 2010:41-42). In the elderly, impaired executive functioning has been identified as the best predictor of functional decline.

Cognitive performance and AP are thought to interrelate as aspects of cognition, such as attention and working memory (Keeley & Fox, 2009:201). This section has provided insight into the developmental phases of cognition and EFs. In the following section, an element of EF, namely attention, is discussed.

2.3 ATTENTION

Many theorists suggest that assorted definitions of attention exist, and that the term is used in a variety of ways (Schmidt & Lee, 2011:97; Steele, Karmiloff-Smith, Cornish & Scerif, 2012:2028). Attention is a major topic of interest in the fields of education, psychology and neuroscience, and is defined as the behavioural and cognitive process of selectively concentrating on a discrete aspect of information, while ignoring other perceivable information (Anderson, 2014:54). According to Magill (2011:195), in human performance, attention is referred to as characteristics associated with consciousness, awareness, and cognitive effort as they relate to the performance of skills with particular reference to the limitations associated with these characteristics on the simultaneous performance of multiple skills and the detection of relevant information in the performance environment. The practicing of a skill results in the automaticity of that skill. Developing automaticity in learned skills is advantageous in enhancing performance and managing the intricacy of common complex tasks (Sussman & Steinschneider, 2009:771).

Previously, attention was considered a singular construct, however, is now considered as having multiple constructs. These constructs are all related, but separate processes which comprise sustained attention or vigilance, selective attention and executive attention or attention shifting and divided attention (Steele *et al*., 2012:2028). Attention is perceived as a gateway to learning in adults, children, infants; in auditory or visual processing; and in cognitive domains such as language, number and space. It is well documented as being intimately linked to learning, since it is believed to be a key element in academic success. Duncan, Dowsett, Claessens, Magnuson, Huston, Klebanov, Pagani, Feinstein, Engel and Brooks-Gunn (2007:1428) indicated that school-entry mathematics, reading and attention skills are the strongest predictors of later AP. The ability to control and sustain attention, as well as engage and partake in

classroom activities, is associated with grades and test scores during pre-school and the early primary school years (Raver, 2004:348). Effortful control, which is the ability to self-regulate attention and inhibit or activate certain behaviours as needed, appears to be a key mediator in children's social adjustment to school and AP (Checa & Rueda, 2011:1019). Several studies revealed the beneficial effects of executive attention on learning in school, particularly for subjects such as literacy and numeracy, through its involvement on cognitive flexibility and regulation (Bull & Scerif, 2001:273; Blair & Razza, 2007:647; Checa, Rodríguez-Bailón & Rueda, 2008:177).

Attention-deficit hyperactivity disorder (ADHD) is another element linking attention and academic achievement. ADHD is a behavioural condition that produces inattention, hyperactivity and impulsivity, and therefore, results in challenges when focusing on daily tasks. Barkley (1997:84) also described ADHD as an EF deficit. In a study by Barry, Lyman and Klinger (2002:277), results indicated that children with ADHD did not exhibit significant impairments in EF but were clearly impaired behaviourally, as well as being significantly more impaired academically. Similarly, the findings of previous researchers are replicated by the findings of underachievement in ADHD (Frick, Kamphaus, Lahey, Loeber, Christ, Hart & Tannenbaum, 1991:289). Essentially, these findings highlight that attention is a pre-requisite of AP. A discussion surrounding the types of attention follows.

2.3.1 Types of Attention

The concept of attention is complex and encompasses a very broad research area. Here, a few types of attention will be discussed.

2.3.1.1 Attention and Consciousness

James' (1890) statement implied that attention was related to the idea of consciousness, which is loosely defined as "what we are aware of at any given time" (Schmidt & Lee, 2011:98). Consciousness has also been associated with the concept of controlled versus automatic processing (discussed later). Jacoby, Ste-Marie and Toth (1993:265) and Roediger and McDermott (1993:63) suggest there is an independence between conscious and unconscious influences on behaviour. For instance, automatic (unconscious) processing seems to be well-preserved in older

adults, whereas controlled (conscious) processing is prone to decline with increasing age. Performance errors, such as what Norman (1981) refers to as action slips, are frequently described as situations whereby an unconscious or automatic action is unsuccessfully inhibited or counteracted by conscious, controlled processing (Reason, 1990:2; Hay & Jacoby, 1996:1323).

2.3.1.2 Attention as Effort or Arousal

Attention as effort or arousal occurs when individuals execute attention-demanding tasks such as balancing a check book or diving in competitive swimming (Schmidt & Lee, 2011:98). Various psychological measures indicate that they are exerting mental effort. Therefore, attention can be viewed as an aspect signifying the degree to which the subject is activated or excited, as reflected by several physiological measures of arousal.

2.3.1.3 Attention as a Capacity Resource

Another view of attention suggests that humans have a limited capacity (or resources) that can deal with information from the surrounding environment (Schmidt & Lee, 2011:98). This is demonstrated in the ability to simultaneously perform two tasks. One task demands attention and competes or interferes with the other when the joint need for resources surpasses the total amount of available attentional capacity. Subsequently, this creates a limitation. This interference or competition for attentional resources could provide insight regarding the nature of the restrictions in capacity (Schmidt & Lee, 2011:98).

2.3.1.3 (a) Interference as a Measure of Attention

If two tasks can be conjointly executed as well as either one when individually executed, then at least one of them does not necessitate attention, or a portion of the limited capacity (Schmidt & Lee, 2011:99). Hence, at least one of the tasks is considered “automatic”. Conversely, if one task is poorly executed when combined with a secondary task, then both tasks are believed to necessitate some of the limited capacity. Therefore, both tasks are attention-demanding. This interference criterion has been established as the critical test of whether a

task "necessitates attention" over the past few decades (Schmidt & Lee, 2011:99).

2.3.1.3 (b) Structural Interference and Capacity Interference

Interference between the conjoined execution of two tasks can be caused by various reasons, of which only some would be explained as interference attributed to limitation in some central capacity (attention) (Schmidt & Lee, 2011:99). To address this issue, two kinds of interference has been defined by researchers: structural and capacity interference. Structural interference occurs when physical (or neurological) structures are the source of the decrement. Conversely, a capacity interference – or a decrement in performance due to some limitation in central capacity (attention) – is inferred only when one can reasonably rule out the possibility that structural interference between two tasks is occurring (Schmidt & Lee, 2011:99).

2.3.1.4 Selective Attention

The concept that we can direct, or allocate, attention to different inputs or tasks is very closely related to the limited-capacity view (Schmidt & Lee, 2011:99). Depending on how a specific allocation was accomplished, selective attention can be either intentional or incidental (Eimer, Nattkemper, Schröger & Prinz, 1996:155). Intentional selection arises through the purposive direction of attention to one information source whilst avoiding or inhibiting attention to other sources. An involuntary capture of attention arises in response to an external stimulus. Occasionally, theorists refer to involuntary selection as bottom-up processing and intentional selection as top-down processing, to signify that the orienting of attention is conceptually, as opposed to perceptually driven (Schmidt & Lee, 2011:99). Selective attention as it relates to AP is described next.

2.3.2 Selective Attention and Academic Performance

Selective attention is an individual's ability to select and focus on a specific task, whilst at the same time suppressing irrelevant or distracting information. This contesting of information occurs both internally and externally due to auditory or visual distractions or distracting thoughts (Stevens & Bavelier, 2012:S31). Selective attention is related to essential domains in education, including language processing (Sussman & Steinschneider, 2009:771), literacy (Stevens *et al.*, 2009:634), and numeracy (Checa & Rueda, 2011:1018); and therefore, has an integral role in AP. Mathematics, reading and spelling are complex skills that require a child to effectively plan, update working memory, shift attention or inhibit impulsive behaviour (Best, Miller & Naglieri, 2011:328).

Sussman and Steinschneider (2009:771) investigated attention effects on auditory scene analysis in children and suggested that stream segregation differences between children and adults reveal an under-development of basic auditory processing mechanisms, which signifies a developmental role of attention for determining physiological responses that optimise processes engaged during passive audition. Furthermore, as a prerequisite of learning, attention is imperative for accurate sound organisation that undertakes an additional significance regarding individuals who have difficulties with sound processing, including children with language impairments or individuals with hearing loss (Sussman & Steinschneider, 2009:784). While new theories emphasise the importance of attentional dysfunction in developmental language disorders, these authors suggest that attention is not a general and non-specific aspect influencing sound processing. Rather, attentional mechanisms perform a specific role in the reorganisation of passive, low-level acoustic processes during normal development. For children with disordered auditory processes, attentional impairments might hinder the ability to develop and refine these automatic sound organisation processes, ultimately impacting perception.

Earlier research conducted with preschool children exhibited that the inhibition of irrelevant information is an important predictor of literacy (Blair & Razza, 2007:647; Duncan *et al.*, 2007:1428). These two results may appear incongruent; however, literacy is mostly related to pre-reading and reading skills during the preschool years,

which may well be dependent on processes such as representing and monitoring information in working memory. Phonological processes, letter knowledge and word recognition may necessitate the inhibition of irrelevant information, to a greater extent, to choose the correct sound that matches a certain letter, or combination of the two (McClelland, Cameron, Connor, Farris, Jewkes & Morrison, 2007:948). Stevens *et al.* (2009:634) examined the differences in neural mechanisms of selective attention in children from different socioeconomic backgrounds and found that their data is supported by previous findings of deficits in selective attention, particularly in the filtering of distracting or irrelevant stimuli, amongst children from lower socioeconomic backgrounds. These attention deficits influence the very early stages of perceptual processing and may possibly have cascading effects on the development of other skills, including literacy, specifically language and reading (Stevens *et al*., 2009:644). Research also suggests that children from lower socioeconomic backgrounds present more attention deficits in comparison to children from more affluent backgrounds (Stevens *et al*., 2009:634; Gall, Müller, Walter, Seelig, Steenkamp, Pühse, du Randt, Smith, Adams & Nqweniso, 2017:2).

Checa and Rueda (2011:1018) studied the role of executive attention on school competence in early adolescence using the Flanker and Go/No-Go Tasks; temperamental effortful control (Early Adolescence Temperament Questionnaire-Revised); schooling skills (Health Resources Inventory); academic achievement (mean grades in Life Science, Social Science, PE, Literacy, Mathematics, Music and Technology), whereby grades in Mathematics and Literacy were examined separately given its central role on school learning and achievement; and intelligence (Kaufman Brief Intelligence Test). An observation found was that individual differences in executive attention and effortful control predict most dimensions of school competence. Also, individual differences in the efficiency of interference suppression predicts school achievement and some skills important for school (Checa & Rueda, 2011:1030). Interference suppression is a significant predictor of grades in mathematics, but not in literacy. Solving mathematical problems requires the representation of information in working memory, shifting attention between elements pertinent for solving the problem, and inhibiting elements within the problem that are irrelevant to finding the correct solution, as well as other potentially distracting stimulation. These processes may be less relevant for literacy in fourth grade which

mostly involves learning of school material, such as literary style, grammar, and vocabulary (Checa & Rueda, 2011:1029). These results were found to be consistent with the role attributed to executive attention in self-regulation (Checa & Rueda, 2011:1018).

It has been established that EFs play a vital role in sustaining and calibrating the development of academic skills and in school performance and is seen as a multi-faceted construct, related to multiple academic outputs (Visu-Petra, Cheie, Benga & Miclea, 2011:240). This section has provided insight into an element of EF, specifically attention, and has elaborated on the several types of attention. Furthermore, selective attention and how it relates to AP has been discussed in more detail. In the following section, AP will be described.

2.4 ACADEMIC PERFORMANCE

2.4.1 Academic Performance Defined

After a comprehensive review of the literature on the concept of AP, several terms have emerged that are used to refer to this concept. AP, academic achievement, educational achievement, educational attainment, educational competence, and scholastic achievement are constructs that are interchangeably used to indicate that an evaluation of an individual's level of accomplishment within an educational environment has been made (Adediwura & Tayo, 2007:167; Best *et al.*, 2011:328; Rasberry *et al.*, 2011:S12; Gray *et al.*, 2017:19). Adediwura and Tayo (2007:167) defined AP as the display of knowledge attained or skills developed in school subjects designated by test and examination scores or marks assigned by the subjects' teachers.

According to Rasberry *et al.* (2011:S12) and Gray *et al.* (2017:19), academic achievement can be determined through standardised tests of achievement or classroom performance measures. This includes measures of standardised achievement test scores in subject areas such as Literacy and Numeracy; classroom performance test scores or other formal assessments generally measured at the end

of a school term or after a certain amount of the curriculum has been taught (Rasberry *et al.*, 2011:S12; Rasmussen & Laumann, 2013:947). Raudenbush, Kidchanapanish and Kang (1991:255) uses educational achievement and educational attainment interchangeably and refers to it as the cognitive outcomes of schooling; whilst Klieme, Hartig and Rauch (2008:6) refers to the concept of educational competence as the ideal and complex goals of education. Furthermore, Rapport, Denney, Chung and Hustace (2001:538) constructed and depicted a conceptual model highlighting the inter-relationship between intelligence (IQ), classroom performance, cognitive function, and scholastic achievement in children and stated that scholastic achievement is mediated by classroom performance, cognitive function and IQ. In the present study, the definition of Adediwura and Tayo (2007:167) was employed, with AP referring to the display of knowledge attained or skills developed in school subjects designated by test and examination scores or marks assigned by the subjects' teachers.

In this section, it has been determined that many definitions and concepts exist to describe the different educational factors that may influence students' success in school. Indicators of AP include standardised tests of achievement, classroom performance measures, and test and examination scores or marks assigned by subject teachers. The next sub-section describes the compulsory AP measures for SA.

2.4.2 Academic Performance Measurements

In SA, education is managed and regulated by two national departments, specifically the Department of Basic Education (DBE), which is responsible for primary and secondary schools, and the Department of Higher Education and Training (DHET), which is responsible for tertiary education and vocational training (South Africa, 2010:4; South Africa Education, 2019:1). The DBE formally categorises grades into two "bands" named General Education and Training (GET), which encompasses grade 0 and grades 1 to 9, and Further Education and Training (FET), which encompasses grades 10 to 12 as well as non-higher education vocational training. The GET band is further dichotomised into three "phases" called the Foundation Phase (grade 0 plus grade 1 to 3), the Intermediate Phase (grades 4 to 6), and the

Senior Phase (grades 7 to 9) (South Africa, 2010:8; South Africa Education, 2019:1). However, most ordinary schools do not reflect these bands and phases divisions in their administrative construct. The following represents the curriculum requirements, assessment methods, recording and reporting techniques and progression requirements mandatory for the measurement of AP in SA.

Programme Requirements: In accordance with the National Curriculum Statement (South Africa, 2013:14), a learner must offer and complete six (6) approved subjects for each of grades 4 to 6, as listed below:

1. Two (2) official languages selected from a list of official and non-official languages, provided that one of the two languages are offered on the Home Language level, and the other official language on at least First Additional Language level, and provided further that one of the two languages offered is the language of learning and teaching;
2. Mathematics listed in the Physical, Mathematical, Computer and Life Science subjects;
3. Natural Sciences and Technology listed in the Physical, Mathematical, Computer and Life Science subjects;
4. Life Skills (LS) listed in the Human and Social Studies subjects; and
5. Social Sciences listed in the Human and Social Studies subjects.

Assessment: Learners are evaluated internally in compliance with the requirements detailed in the policy document National Protocol for Assessment Grades R-12 (South Africa, 2012:3-11) and the Curriculum and Assessment Policy Statements of the required subjects as considered in paragraph 12 (South Africa, 2013:14). Additionally, School-Based Assessment (SBA) is a mandatory element of the progression marks. The SBA element performed throughout the year must be 75%, and the final examination element 25% of the total progression mark (South Africa, 2013:17).

Recording and Reporting: The National Curriculum Statement and Assessment Policy for Grades R-12 (South Africa, 2013:17-18) defined seven (7) competency levels for the subjects listed therein. These achievement levels, the achievement descriptions, the corresponding percentage ranges, and the representative symbols are all contained in the scale of achievement table, table 2.1, depicted below. Learners'

performance must be recorded and reported by the teachers, in terms of these achievement descriptors (South Africa, 2013:17-18).

Table 2.1: Scale of Achievement for the National Curriculum Statement Grades 4 – 6

Achievement Level	Achievement Description	Marks (%)	Symbol
7	Outstanding Achievement	80 – 100	A
6	Meritorious Achievement	70 – 79	B
5	Substantial Achievement	60 – 69	C
4	Adequate Achievement	50 – 59	D
3	Moderate Achievement	40 – 49	E
2	Elementary Achievement	30 – 39	F
1	Not Achieved	0 – 29	FF

[adapted by South Africa (2013:17)]

Progression Requirements: Furthermore, determined from the table above, the following guidelines are considered for the progression requirements of a learner; which also constitutes a passing grade (South Africa, 2013:15-16):

1. Upon any less condition than if the learner presents an inadequacy in competence to cope with the next grade's work, progression from one grade to the next grade within the applicable age cohort should be the accepted norm.
2. The following are guidelines for determining a learner's progression from Grade 4 to 6 in the Intermediate Phase:
   a) Adequate Achievement (Level 4) (50-59%) in one official language at Home Language level as contemplated in *paragraph 12(1)*;
   b) Moderate Achievement (Level 3) (40-49%) in the second required official language at First Additional Language Level as contemplated in *paragraph 12(1)*;
   c) Moderate Achievement (Level 3) (40-49%) in Mathematics as contemplated in *paragraph 12(2)*; and
   d) Subject to *subparagraph (e)*, Moderate Achievement (Level 3) (40-49%) in any other two (2) of the remaining approved subjects as contemplated in *paragraphs 12(3)*, *12(4)* and *12(5)*.
3. To prevent the learner being retained in this phase for longer than four years, a learner may only be retained once in the Intermediate Phase.
4. A learner who is not ready to perform at the expected level and who has been retained in the first phase for four years or more and who is likely to be retained in

the second phase for four years or more, should receive the necessary support to progress to the next grade.

The measurement of classroom performance used for the present study were class tests and grades designated by test and examination scores or marks assigned by the subjects' teachers. Details pertaining to the latter are provided next.

2.4.3 Classroom Performance, School Tests and Grades

Classroom performance is comprised of several operational indices; namely grades, grade point averages (GPA) and school dropout, in addition to teacher ratings of AP within a classroom environment. School tests and grades are nationally performed tests and classroom performance measures evaluating the AP of South African learners in the GET Band. SA's academic scale of achievement ranges from level 1 (very poor) to 7 (excellent), with the level 4 in one official Home Language and level 3 in the remaining subjects representing a passing grade (South Africa, 2013:15-17).

The South African national DBE implemented the Annual National Assessments (ANAs) which are standardised national assessments for languages and mathematics in the intermediate phase (grades 4 to 6) and in literacy and numeracy for the foundation phase (grades 1 to 3). This provided essential feedback to schools, teachers, learners and parents, and encouraged the implementation of intervention strategies to address areas of weakness (South Africa, 2014:6 & 8). The question papers and marking memoranda (exemplars) were supplied by the national DBE and the school managed the conduction of the tests, as well as the marking and internal moderation. In 2015, the ANAs were not conducted in many schools in SA due to opposition from teacher unions, and since then, it has been suspended indefinitely. Consequently, Basic Education Minister Angie Motshekga announced in 2017 that the controversial ANAs are to be replaced by the National Integrated Assessment Framework (NIAF) (Gerber, 2017).

The above sub-section represents the curriculum requirements, assessment methods, recording and reporting techniques and progression requirements mandatory for the measurement of AP in SA. Given that the focus of the present study, among others,

is to determine the effect of PA and PF on attention and AP, the following section elucidates these concepts and relevant assessment methods in more detail.

2.5 PHYSICAL ACTIVITY AND PHYSICAL FITNESS

After performing a comprehensive review of the literature on the concept of PA, like AP, several terms have emerged that are used to define to this concept and the various variables associated with PA. Additionally, there are also many methods in which each of these variables, or combination of variables, may be assessed. In the following section, these concepts and the measurement of the different variables are discussed.

2.5.1 Physical Activity and Physical Fitness Defined

Since several ways of describing PA exists, defining these are essential to increased consistency of measurement and reduction of variability across studies (Thomas *et al.*, 2005:305). Traditionally, the term PA is described as any bodily movement that is produced by musculo-skeletal contraction and increases energy expenditure above resting levels (Caspersen, Powell & Christenson, 1985:126; American College of Sports Medicine, 2014:2). These are comprised of, but not limited to, movements related to occupation, sport, exercise, active play, domestic, or other daily and recreational activities, such as dancing and gardening (Dishman, Heath & Lee, 2013:39; Monyeki, 2014:326). Sport is a sub-set of PA that involves structured competitive situations guided by rules, although it is often used in a wider context to include both exercise and leisure-time activities. In contrast, physical inactivity refers to a lower level of activity that is insufficient for maintaining good health (Hoeger & Hoeger, 2011:7). Inactivity is time spent doing things that do not markedly increase energy expenditure (Monyeki, 2014:326).

The term PA should not be misinterpreted with exercise, which is a subcategory of PA. Exercise is comprised of planned, structured and repetitive bodily movements with the intent of improving or maintaining the various components of PF (American College of Sports Medicine, 2014:2; World Health Organization, 2017b). Examples include aerobics, cycling, swimming, walking, running and strength training (Hoeger & Hoeger, 2011:7). PF is a state or a condition that enables an individual to carry out his or her

daily activities without undue fatigue and with enough reserve to enjoy active leisure pursuits. Furthermore, PF refers to the set of attributes or characteristics individuals possess or attain, which relates to the individual's ability to perform PA. It is often assumed to be a correlate of PA, although relationships are generally moderate (Malina & Katzmarzyk, 2006:S295).

Historically, PF was comprised of three components: muscular strength and endurance, cardiorespiratory endurance, and motor ability (Malina & Katzmarzyk, 2006:S295). Over the last five to six decades, surveys of youths PF have largely examined performances in a variety of strength and motor tasks (performance-related fitness) and smaller-scale studies of cardiorespiratory endurance. Since then, the concept of PF has evolved from focusing primarily on motor and strength components to more emphasis on health (health-related PF) in the late 1970s (Malina & Katzmarzyk, 2006:S295). Although there is variation in specific tests, health-related fitness includes tests of cardiorespiratory endurance, muscular strength and endurance, musculoskeletal function of the lower trunk and upper thighs, and/or body composition, specifically fatness. The concept of PF continues to evolve. Morphological and metabolic components have been added to the more traditional muscular strength and endurance, motor, and cardiovascular components. Currently, these attributes are divided into health- and skill-related constituents of PA (Caspersen *et al.*, 1985:128; American College of Sports Medicine, 2014:2). The ability to perform activities of daily living without excessive fatigue is referred to as health-related PF; which consists of cardiorespiratory endurance, body composition, muscular strength and endurance, as well as muscular flexibility. These elements improve the individual's overall health and reduce the risks related to physical inactivity. Skill-related PF consists of elements essential to success in sport and motor skill performance; and is comprised of agility, balance, coordination, reaction time, speed and power (Hoeger & Hoeger, 2011:18).

This sub-section has provided insight into the different concepts and terms employed to describe PA. Furthermore, there are also several indicators of PA that are used to effectively measure the various components that constitute PA. In the following sub-section, these measures are described.

2.5.2 Measurement or Assessment of Physical Activity and Physical Fitness

Many methods are frequently used for the estimation of habitual PA levels and energy expenditure in children and adolescents. The choice or selection of a method, or combination of methods, is contingent on the specific objectives of a study, participants' age, and availability of equipment and personnel (Malina & Katzmarzyk, 2006:S296). The doubly labeled water method is the gold standard and most comprehensive way for assessing total energy expenditure, however, it is not often used in research as it is expensive, time-intensive and has high subject burden (Malina & Katzmarzyk, 2006:S296; Ellery, Weiler & Hazell, 2013:5). Direct observation is a popular method for young children and is considered the gold standard for specific behavioural aspects of activity. It is used when activity is restricted to a specific area like a classroom or playground, but is time consuming and lacks objectivity (Malina & Katzmarzyk, 2006:S296; Sylvia, Bernstein, Hubbard, Keating & Anderson, 2014:200). Several devices, namely, heart rate monitors, accelerometers and pedometers are frequently used in research. The advantages of these devices are that they are small, light, and non-intrusive. Accelerometers and heart rate monitors are more sophisticated and measure more PA parameters than pedometers (Ellery *et al.*, 2013:3), whereas heart rate monitors have more consistent standards and greater comparability than accelerometers (Ellery *et al.*, 2013:5). The disadvantages of these devices also include expense (heart rate monitors, accelerometers), lack of standardised protocols (accelerometers), limited PA parameters (pedometers), amongst others (Ellery *et al.*, 2013:3; Sylvia *et al.*, 2014:201). For large-scale surveys of PA, self-reported PA questionnaires are the preferred instrument of choice, but they are less robust in measuring light or moderate PA and may be limited by language and other external factors (Sylvia *et al.*, 2014:200). PA is a multi-dimensional construct and for many studies, combining multiple measures is recommended.

The measurement of PF in youth received great prominence in the 1950s (Malina & Katzmarzyk, 2006:S305). The development of PF test batteries was first initiated in the United States of America (USA) post-World Wars I and II. The USA were at the forefront of fitness test batteries, however, Australia, Canada and some European countries swiftly followed suit and started developing their own test batteries (Council of Europe, 1983:5; Harris & Cale, 2006:210). In 1954, research conducted by Kraus

and Hirschland indicated that almost 60% of American youth failed the test in comparison to only 9% of their European counterparts (Freedson, Cureton & Heath, 2000:S78; Morrow Jr., Jackson, Disch & Mood, 2011:246), suggesting that American youth were unfit, and hence, placed themselves and their country at risk (Mood, Jackson & Morrow Jr., 2007:218). The inability of American youth to meet the minimum criterions for muscular strength and flexibility was of grave concern to the USA, which ultimately incentivised the introduction of standardised testing within schools (Kemper & Van Mechelen, 1996:204; Morrow Jr. *et al.*, 2011:246). A society for physical educators was founded in 1957, called the American Alliance for Health, Physical Education and Recreation (AAHPER). During 1976, the acronym was amended to AAHPERD (as it is known today) for the inclusion of 'Dance'. Originally, this society developed a standardised fitness test battery, the AAHPER PF Test, that was mainly skill-related. However, by 1964 and in 1974, the test battery was adapted, but remained primarily skill-related (Freedson *et al.*, 2000:S78). Another revised version of the test emerged in 1976, emphasising health-related components (AAHPERD Health-Related Physical Fitness Test), in addition to the development of a modified skill-related test (Youth Fitness Test) (Pate, Oria & Pillsbury, 2012:2-6).

Over the years, the assessment of children's PF has changed and shifted from a skill-related emphasis to a more health-related fitness approach (Morrow Jr. *et al.*, 2011:249). It was considered beneficial to monitor health-related PF from childhood into adulthood, since childhood health status is a predictor of adult morbidity and mortality (Pate *et al.*, 2012:1-5). Consequently, several organisations became involved in developing and implementing PF test batteries. There are over 15 test batteries, of which some are displayed in table 2.2, in existence for the assessment of children and adolescents' PF, with numerous key components of PF currently used universally (Cvejić, Pejović & Ostojić, 2013:135).

In Europe, majority of the schools implement the Eurofit test battery, whereas American schools mostly employ the Fitnessgram (Cvejić *et al.*, 2013:136). The Fitnessgram was developed by the Cooper Institute in the USA in 1982 and was the first recognised test battery that implemented health-related, criterion-referenced standards (Morrow Jr. *et al.*, 2011:250). Concurrently, European countries also started publishing test batteries, and consequently, a coordinated effort developed into the

establishment of the Council of Europe in 1978. In 1983, a provisional and in 1988 the final Eurofit handbook was published (Council of Europe, 1983:7; Kemper & Van Mechelen, 1996:204). The Eurofit test battery combines health-related, skill (performance)-related and motor-related abilities (Mood *et al*., 2007:222; Morrow Jr. *et al*., 2011:255). Table 2.2 details the Fitnessgram and Eurofit test batteries with respect to the various tests employed to measure each component. Both the Fitnessgram and Eurofit test batteries encompasses four health-related PF components. However, only the Eurofit includes skill-related components since it was especially designed to assess the effectiveness of PE (Tomkinson, Olds & Borms, 2007:105). There are many similarities between the various PF test batteries that have evolved over the years.

The several indicators of PA and PF employed to effectively measure the various components that constitute PA and PF are well established, as is evident in the previous discussion. Therefore, PA and PF is perceived as a multi-dimensional and complex construct (Thomas *et al*., 2005:305). When participating in PA, there are specific evidence-based guidelines and recommendations that exist to ensure that an individual acquires the maximal benefits thereof (Strong, Malina, Blimkie, Daniels, Dishman, Gutin, Hergenroeder, Must, Nixon, Pivarnik, Rowland, Trost & Trudeau, 2005:737; World Health Organization, 2017b). In the following section, these PA guidelines and recommendations will be elaborated on.

2.5.3 Physical Activity Guidelines and Recommendations for Children

PA is deemed as an essential element for growing children since it facilitates optimal physical growth, development and psychological well-being (Haskell, Montoye & Orenstein, 1985:206). Children have an innate tendency towards active play, which is favourable, particularly in the absence of sedentary alternatives. Nonetheless, when participating in PA, there are specific principles and guidelines to follow in relation to the frequency, intensity, duration and type of activity. Thomas *et al.* (2005:305) considered PA as complex multi-dimensional behaviour that can be commonly categorised by the FITT (frequency, intensity, time and type of activity) principle, which is outlined as follows:

- Frequency: The number of times within a certain time frame that an individual is physically active.
- Intensity: The physiological effort of the activity.
- Time: The duration of time spent partaking in a certain activity.
- Type of Activity: This may include active play, games, dance and sport.

Additionally, PA, exercise and PF can be classified according to a wide range of intensities related to PA, but the most useful, convenient and standardized way is through utilising the metabolic equivalent (MET). A MET is defined as the ratio of energy expenditure whilst active to the rate of energy expenditure at rest (American College of Sports Medicine, 2014:176). One MET equals the rate of energy expended whilst seated at rest. Therefore, light PA requires less than 3 METS, moderate between 3 and 6 METS, and vigorous more than 6 METS. For children, PA encompasses a comprehensive range of activities involving movement which can be free play, games, PE, sports and even domestic activities. Child's play is natural; and as such, PA should be fun and exciting. Conversely, to achieve maximal benefits and behavioural health outcomes, it should also be simultaneously developmentally appropriate (Boreham & Riddoch, 2001:915; Strong *et al.*, 2005:737; Centers for Disease Control and Prevention, 2015).

Table 2.2: Comparison of Frequently Used Children and Youth's PF Test Batteries

Fitness Component or Outcome Measure	AAHPERD (Shephard, 2007:96)	Young Men's Christian Association (YMCA) (Morrow Jr. *et al.*, 2011:225)	Fitnessgram (Morrow Jr. *et al.*, 2011:254)	Canadian Association for Health, Physical Education, and Recreation (CAHPER) (Shephard, 2007:96)	Eurofit (Tomkinson *et al.*, 2007:106)
Skill-related PF Tests					
Agility	• 27.4-metre (30-yard) run			• Shuttle run	• 10 x 5-metre shuttle run
Balance					• Flamingo test
Coordination					
Reaction time					
Speed				• Shuttle run	• 10 x 5-metre shuttle run • Plate tapping
Power	• Standing long jump • Softball throw (omitted later)			• Standing broad jump	• Standing broad jump
Health-related PF Tests					
Cardiorespiratory endurance or aerobic capacity	• 548-metre (600-yard) walk/run	• 3-minute step test	• PACER • Mile run • Walk test	• 274-metre (300-yard) run	• 20-metre shuttle run • Bike ergometer test
Body composition		• Height • Weight • Skinfolds	• Skinfolds • Body mass index		• Height • Weight • Skinfolds
Muscular strength & endurance	• Pull-ups (boys) • Flexed arm hang (girls) • Sit-ups (untimed)	• Bench press test • Half sit-up test	• Pull-ups • Modified pull-ups • Flexed arm hang • Sit-ups • Trunk lift	• One-minute sit-ups • Flexed arm hang	• Bent arm hang • 30-second sit-ups • Hand-grip strength
Muscular flexibility		• Sit-and-reach	• Sit-and-reach • Shoulder stretch		• Sit-and-reach
Additional Tests					
Anaerobic capacity	• 45.7-metre (50-yard) run			• 45.7-metre (50-yard) run	

Developmental changes such as body size, muscular strength or cardiovascular endurance during childhood are influenced by children's physiological and metabolic response to PA (Simons-Morton, Parcel, O'Hara, Blair & Pate, 1988:410). With respect to PA, growth and development differs in early childhood when compared to late childhood. In early childhood, PA requirements are rudimentary because fundamental movement skills (FMS) development is emphasised. FMS present the foundation for the child's ability to execute more complex and integrated movement patterns (Strong *et al.*, 2005:736). Three categories construct FMS: locomotor skills (walking, running and jumping); object control skills (catching, throwing and kicking); and stability skills (static and dynamic balance) (Lubans, Morgan, Cliff, Barnett & Okely, 2010:1020). In later childhood, FMS become more established, added with an emphatic transition toward a health and fitness-oriented approach, ultimately contributing to a physically active lifestyle (Strong *et al.*, 2005:736; Tinazci & Emiroglu, 2009:88). Strong *et al.* (2005:736) and Janssen and LeBlanc (2010:2) highlighted the beneficial effects of PA on musculoskeletal health, adiposity and CRF when searching for evidence-based literature to confirm this finding and reviewed in excess of 850 articles. Evidently, numerous health benefits are associated with PA for children. Furthermore, active children demonstrate healthier cardiovascular profiles, as well as possess higher peak bone mass and lower body composition in comparison to their sedentary counterparts (Boreham & Riddoch, 2001:915).

The World Health Organization (2017b) and Strong *et al.* (2005:737) recommended that children between 5 and 17 years old should participate in at least 60 minutes of moderate-to-vigorous PA (MVPA) daily. These activities should be mostly aerobic to stress the cardiovascular and respiratory systems, resulting in the greatest health benefit (Janssen & LeBlanc, 2010:1; World Health Organization, 2010:7). For muscle and bone strengthening benefits, more vigorous intensity activities should be incorporated on at least 3 days per week. Similarly, the Centers for Disease Control and Prevention (2015) recommends increased participation in activities for enhancing and maintaining muscular strength, endurance and flexibility and increased time for MVPA to promote the development and maintenance of CRF.

PA for children can be achieved and accumulated during PE, school breaks, extra-mural activities or at home. During a school day, multiple opportunities exist for

children to be active since a considerable portion of their day is spent at school. For a holistic educational outcome, children are recommended to participate in at least two hours of PE per week. Schools should serve as the ideal setting for the promotion of PA and reduction in sedentary behaviour (Zahner, Puder, Roth, Schmid, Guldimann, Pühse, Knöpfli, Braun-Fahrländer, Marti & Kriemler, 2006:10). Evidently, PA and PE are vital for healthy and active children (Rajput & van Deventer, 2010:158; Amusa, Goon, Amey & Toriola, 2011:4678). This should be prioritised from an early age; yet, a substantial proportion of children are not as active as they could be, with only a few engaging in PA across various segments of the school day (Hohepa, Scragg, Schofield, Kolt & Schaaf, 2009:284).

Additional measures of PA intervention strategies are necessary and pivotal in achieving PA recommendations and creating an awareness of healthy lifestyles. Positive attitudes towards exercise should be encouraged through children's PA and PF experiences, which develops a firm knowledge base of healthy behaviour that persists into adulthood. Lifelong PA participation might be initiated and facilitated through the regular assessment of PF during childhood. Essentially, children's overall quality of life can be improved through the encouragement to be active and live healthy lifestyles (Van Deventer, 2008:4 & 6; Monyeki, 2014:335). However, a decline in PA and PE, as well as a trend of physical inactivity has emerged. The following section discusses this trend in more detail.

2.6 PHYSICAL EDUCATION AND PHYSICAL ACTIVITY DECLINE

Literature confirms that PA is a fundamental contributor to the functioning capacity of every individual (Simons-Morton *et al.*, 1988:405). Most children engage in unstructured free play (Malina & Katzmarzyk, 2006:S299). Therefore, many assume that children automatically meet their daily PA requirements, which is not necessarily true. In the last three decades, PE opportunities within schools has gradually diminished and a lack of active experiences during the school day have become apparent (du Toit *et al.*, 2007:241; Trost & van der Mars, 2009:60). In many low- and middle-income countries, PE has been neglected whilst more time is being allocated to academic subjects. Some teachers and parents believe that participation in PA

might hinder learners' academic success (Van Deventer, 2009:128). Contrastingly, evidence suggests that the addition of PE to the curriculum results in small positive gains in AP (Strong *et al.*, 2005:735).

According to the United States Surgeon General's Report of Physical Activity and Health, daily PA participation amongst high school youth at a national level was found to be 29%. This participation decreases as learners progress through grades 9 (42%), 10 (30%), 11 (20%) and 12 (20, 1%), and was suspected to be due to decreased PE classes (U.S. Department of Health and Human Services, 1996:190). No evidence exists proving that increased time for PE classes improves learners' AP. On the other hand, allocating more curricular time to PA programmes does not negatively affect AP. Cross-sectional observations revealed a positive association between AP and PA and PF (Strong *et al.*, 2005:735). Furthermore, Michigan State University (2006) discovered that the enrollment of learners in PE alone had no influence on their grades. However, learners who performed better academically were the most active. It was found that PA also has a positive influence on concentration, memory and classroom behaviour (Strong *et al.*, 2005:735).

In New Zealand, Hohepa *et al.* (2009:284) found that the percentage of students considered more active depended on the PA variable of interest (after-school, 56.3%; active transportation, 58.1%; morning recess, 26.4%; lunchtime recess, 32.4%); and that only 11.1% of participants were classified as more active across all four PA opportunities. It was concluded that multiple opportunistic periods exist for youth to be active in a school day; yet, a substantial proportion of students are not as active as they could be. In Australia, Tinning (2004:243) and Morgan and Bourke (2005:7) highlighted the adverse effects of insufficient teacher training and unqualified personnel on the quality of PE as reasons for decreased PA participation. Elsewhere in Africa, researchers have also expressed concerns about the marked reduction in PA levels. Benefice, Garnier and Ndiaye (2001:319) found that younger children are far more active than older children, and that the maximum decrease in activity is between 11 to 14 years of age. Other authors found that a 50% reduction in PA in girls occurred before puberty, between 6 and 9 years of age (Goran, Gower, Nagy & Johnson, 1998:887). The reason attributed to this finding is that a higher percentage

of children live in poorly developed countries and must confront a daily existence involving subsistence tasks (Benefice *et al.*, 2001:320).

In accordance with international trends, PE in SA has followed a similar course. Since 1994, PE was officially excluded from the South African school curriculum (Barnard, Van Deventer & Oswald, 2014:2; du Toit *et al.*, 2007:244); losing its stand-alone status with the introduction of Curriculum 2005 in 1997 (Van Deventer, 2004:115; du Toit *et al.*, 2007:244; Van Deventer, 2007:136-137; Van Deventer, 2009:127). Reasons attributing to this decline include the continuous elimination of PE due to a crowded curriculum and the lower perceived status of PE (du Toit *et al.*, 2007:241). In the South African school curriculum, PE forms one component of and is included in the Life Skills subject for the Foundation Phase; whereas in the Intermediate, Senior and FET phases the subject is referred to as Life Orientation (Rajput & Van Deventer, 2010:149). Rajput and Van Deventer (2010:149) further found that South African schools only allocate 8% of the total learning time to Life Orientation, of which only 33% is spent on PA. The current South African education system has incorporated PE into the Life Skills subject, whereby PE or physical development and movement are amongst the learning outcomes (Rajput & Van Deventer, 2010:149). These outcomes play an integral role in providing children with at least 30 to 60 minutes PA per week during school hours. Although, this time falls far short of the afore-mentioned recommendations for PA. Results from the South African National Youth Risk Survey reported that 56.8% of learners do not participate in adequate amounts of vigorous PA (Reddy, James, Sewpaul, Koopman, Funani, Sifunda, Josie, Masuka, Kambaran & Omardien, 2008:44). Phillips (2006:44) conducted a study amongst high school learners in the Western Cape and found that more than 60% were irregularly active. Similarly, Frantz (2006:73) found that 32% of learners either insufficiently participated or did not participate in PA at all. Additionally, one study by McVeigh, Norris, Cameron and Pettifor (2004a:1006) and another by McVeigh *et al.* (2004b:982) discovered a significant racial difference in the patterns of PA, whereby Black children were less active, participated in less PE classes at school and watched more television than White children. More than 30% of learners do not participate in PA at all, only about 40% of the children were acquiring little PA or MVPA each week; and less than 50% of learners partook in PE at school, of which less than 60% engaged in vigorous activity (McVeigh *et al.*, 2004b:986-987). South African children also spent a large

proportion of their time in sedentary behaviour and watched, on average, nearly 3 hours of television a day (Statistics South Africa, 2013:60). This highlights that, although primary school children fare better in comparison to high school learners, none of these learners are achieving the recommended PA guidelines for children between the ages of 5 to 17 years old, as prescribed by Strong *et al.* (2005:737) and the World Health Organization (2017b).

Several environmental and social barriers associated with physical inactivity exist, including poverty, crime, lack of basic infrastructure and equipment, as well as the absence of PE in schools (Monyeki, 2014:331-332); which negatively impacts children's lives. This is reverberated in the afore-mentioned survey which found that 13.3% of respondents did not participate in PA owing to the inaccessibility of facilities and equipment, 10% felt unsafe, 28.8% lacked the desire and motivation to participate, whilst the remaining 30.1% had no justification for their inactivity (Reddy *et al.*, 2008:45, 120). Considering these results, addressing the barriers to PA in vulnerable populations such as children, particularly those from impoverished communities, should be a priority. Despite the substantial benefits associated with regular PA, it is still the most under-utilised, low cost resource of health (Rajput & Van Deventer, 2010:151). The next sub-section describes the history and state of PE in South African schools.

2.6.1 Physical Education in South African Schools

The history of apartheid affected the quality of PE and how the subject was offered in schools (Edginton *et al.*, 2012:436). Majority of the population was deprived participation in PE by perpetuating race, class, gender and ethnic divisions; and separateness rather than common citizenship and nationhood was emphasised (Chappell, 2005:1). These policies empowered historically White communities and discriminated against and negatively affected the rest of the population (Rajput & Van Deventer, 2010:155; Walter, 2014:358). In most schools, the apartheid government assigned PE a reasonably high political status to further its ideological agenda. Thus, PE was a mandatory programme offered to all White schools to which one weekly hour was devoted. However, this was not the case in most disadvantaged schools as

PE was subsequently dropped from the curriculum (Rajput & Van Deventer, 2010:155). PE and sport were considered unimportant due to lack of qualified specialists and insufficient financial and material resources (Fredericks, Kokot & Krog, 2006:29). Consequently, a wide disparity ensued between schools with and without access to school sport facilities, resulting in largely disproportionate degrees of participation.

Since the inception of democracy in SA after the 1994 elections, the formation of a new democratically elected government launched many initiatives, such as the reconstruction, development and planning (RDP) programme, to address the inequalities of the past (Edginton *et al.*, 2012:436). Although eradication of these inequalities has begun to emerge, expectations for transformation in sport and the provisioning of PE and school sport is still not satisfactory (Rajput & Van Deventer, 2010:148). A goal of the afore-mentioned initiatives is to ensure young individuals access to opportunities to play and exercise in pursuit of healthier and productive lifestyles (Department of International Relations and Cooperation, 2007). Similarly, the objective of PE is to improve the quality of life for young individuals so that they may function effectively and live healthy lives (Rajput & Van Deventer, 2010:151).

The South African democracy effectuated transformation, including the remodeling of the education system which gave birth to an outcomes-based education (OBE) system (Rajput & Van Deventer, 2010:148). Amongst these developments, PE was marginalised and officially excluded from the curriculum in 1994 since it was considered non-examinable and incorrectly perceived for having a low educational status in comparison to other academic subjects (du Toit *et al.*, 2007:244). As a new learning area, the OBE system introduced the subject of LS for the incorporation of PE (Rajput & Van Deventer, 2010:149). However, when several learning domains are consolidated into one learning area, specialising therein becomes very challenging; consequently, compromising LS as a subject (Rajput & Van Deventer, 2010:157). The quality of the subject was further attenuated as it was mostly taught by generalist teachers who were insufficiently qualified to teach all the learning outcomes (Rajput & Van Deventer, 2010:150). According to the DBE, the level of training of teachers particularly in these disadvantaged schools is sub-standard (Themane, Monyeki, Nthangeni, Kemper & Twisk, 2003:638). Majority of these teachers passed standard

8 (grade 10) and have acquired a two-year teachers' diploma called the Primary Teachers' Certificate (PTC). In many schools, the staff compliment is comprised of mostly females, presenting additional adversities. The OBE system was proposed for an expeditious transformation process which enabled learners to excel maximally in a system that promoted quality education and equality for all (Rajput & Van Deventer, 2010:148). Unfortunately, the unsuccessful execution of this system ensued and in 1997, a revised OBE system - Curriculum 2005 (C2005), was effected. By 2002, C2005 was amended to the National Curriculum Statement (NCS) (du Toit *et al.*, 2007:244; Rajput & Van Deventer, 2010:156).

The apartheid legacy is still apparent across ethnic and socioeconomic disparities, despite more than two decades of democratic governance (Walter, 2014:358). At present, South African schools manifest two social backgrounds stemming from the apartheid era: (i) advantaged schools (previously reserved for White South Africans only), and (ii) previously disadvantaged schools (formerly reserved for Black Africans, Coloured and Indian South Africans only) (du Toit *et al.*, 2007:244-245). To eliminate past inequalities and make education more accessible to all, the present government allocates funds to public schools through annual fund allotment to supplement and alleviate daily operational expenses, such as maintaining the grounds, administrative costs, salaries, educational materials, and extramural activities, on a varied basis (South Africa, 2004:7; Gadebe, 2006; Kanjee & Chudgar, 2009:7). Most schools supplement the government grant with other streams of income, such as school fees paid by parents, fundraising events, and receiving donations. There is no limit to the amount of the fees that a school may set, and hence, higher school fees prevent poorer children from attending more affluent schools since most parents cannot afford the demands made on them by the schools. In addition, parents may apply to the school for full or partial reduction of school fees, and many affluent schools do provide financial assistance to a small number of learners (for example, if non-fee learners are enrolled at the school), but it is not a legal requirement (Gadebe, 2006).

The South African government determines and regulates the allocation of funds to individual public schools based on their socioeconomic status, or poverty score; whereby schools from the poorest communities receive a larger proportion of funds than the least poor schools (Sayed & Motala, 2012:676). A quintile rank (ranging from

quintile 1, representing the poorest; to quintile 5, representing the least poor schools) is assigned to each school with this poverty score (Kanjee & Chudgar, 2009:18). These quintile ranks are based on the poverty level of the community it is situated in and the poverty score is calculated utilising national census data; specifically, weighted household data on income, unemployment rate or level of employment and level of education of individuals within the community (Kanjee & Chudgar, 2009:18; Sayed & Motala, 2012:676). Schools ranked in quintiles 4 and 5, which are the more affluent quintiles, are declared to be fee charging schools; whereas schools ranked in quintiles 1 to 3 are poorer, and therefore, receive larger subsidies from the government since they are declared to be no fee schools (Sayed & Motala, 2012:676).

A visible contrast between quintile 1 to 3 schools and quintile 4 and 5 schools is still evident; thus, highlighting the unequal status of PE in schools (Rajput & Van Deventer, 2010:157). Although several attempts by the government have been made to reintroduce PE into the national school curriculum, in many schools it is often either ineffectively offered or not offered at all (Rajput & Van Deventer, 2010:158; du Toit *et al*., 2011:24; Walter, 2014:359). Resultantly, the lack of PE may detrimentally affect the lifestyles of many children (Van Deventer, 2008:14). McVeigh *et al.* (2004b:987) reported that no White children attended schools in the lowest three quintile categories and that Black African children were less active compared to White children. Hence, it was surmised that the lack of PE in schools may directly translate into decreased activity levels of the children. South African researchers have appealed for the reinstatement of PE as a stand-alone subject within the school curriculum (Amusa, Goon, Amey & Toriola, 2011:4678; Armstrong *et al*., 2011:999; Monyeki, 2014:335). The onus lies with the South African DBE to ensure that PE forms part of the school curricula and is fervently taught (Edginton *et al*., 2012:436).

Children living and attending schools in these low-income settings are faced with a multitude of challenges that may jeopardise their AP. Despite children from lower SES communities being most at risk, fewer PA opportunities exist for these children when compared to children from more affluent communities (Walter, 2011:781). In quintile 4 and 5 schools, the status of PE within the curriculum has been thoroughly upheld. The maintenance of facilities and the improvement of relevant infrastructure are prioritised within these schools; and thus, its learners are afforded a balanced variety of sport

(Edginton *et al*., 2012:436). Impoverished communities depend heavily on schools and the local provincial government for the provision of the necessary resources required for PE and sport (Walter, 2011:786). In addition to the misfortune of PE not being offered in most disadvantaged schools, there is often a lack of adequate infrastructure, resources and qualified educators, which may also discourage children from participating in PE (Walter, 2014:359). Educators also often teach several subjects and lack the knowledge and confidence to systematically instruct PE, sports and exercise as part of the school curriculum. Teachers feel unable to present attractive and didactically well-conducted PE classes. Furthermore, some do not possess the motivation to be physically active. Hence, PE is not being taught in most public schools. As a result, a substantial number of children do not engage in the recommended daily 60 minutes of MVPA (Gall, Adams, Joubert, Ludyga, Müller, Nqweniso, Pühse, du Randt, Seelig, Smith, Steinmann, Utzinger, Walter & Gerber, 2018:2). Consequently, sedentary lifestyles are inevitable for these children. Amusa and colleagues hypothesised that since the inception of democracy in 1994, South African children are becoming increasingly inactive, resulting in deteriorating levels of PF (Amusa *et al*., 2011:4666).

Given the decline of PE in schools and the subsequent increase in inactivity of children, several studies have been conducted to determine the effect of certain interventions on the PA and PF of children. The following section will review school-based intervention studies, both internationally and nationally, in relation to children's PA, attention and AP.

2.7 SCHOOL-BASED INTERVENTION STUDIES AND DESCRIPTIVE STUDIES

In the next section, international and national school-based intervention studies (table 2.3 and table 2.4, respectively) conducted on primary schoolchildren are described. The results specifically pertaining to attention and AP are reported and summarised in the tables below. All studies have been listed from the oldest to the most recently published. The school-based intervention studies are arranged according to the intervention type implemented; namely, PA and nutrition on attention and/or AP, PA only on attention and/or AP, and nutrition only on attention and/or AP.

The empirical studies included in the data extraction tables displayed above, in tables 2.3 and 2.4, respectively, encompass 27 international and three national studies. These studies investigated the effects of various interventions and combinations of interventions on promoting regular PA during class and after school, improving fitness, encouraging healthy dietary habits and improving children's attention and/or AP. The methods of accessing EFs included either direct observation of on-task behaviour; a cognitive assessment system (planning, attention, simultaneous and successive cognitive processes); the d2 and d2-R Test of Attention; the Fluid Intelligence Test and the Perceptual Speed Test; components of EF (inhibition, shifting, updating and working memory); the modified Erikson Flanker Task; or the Kaufman Assessment Battery (KABC-II). AP measures typically included language; reading; and/or mathematics; amongst others such as science, social studies, world studies and PE. Majority of the PA intervention types included PE classes, in-class PA activities, PA during break-times, after school PA and PA homework, and were primarily conducted by the schools' certified PE teachers or trained classroom teachers. Nutrition interventions mostly involved nutrition education or school meal programmes. The duration of the interventions varied from as little as 12 minutes to a period over 9 years. Given the present study's focus, only the results pertaining to attention and AP will be discussed.

Table 2.3: International School-Based Interventions Studies and the Effect on Attention and/or Academic Performance of Primary Schoolchildren

Authors, Publication Year and Country	Sample Size	Participants	Intervention (Number of Sessions and Duration)	Outcomes of Interest and Assessment Tool(s)	Main Findings
Physical Education, Nutrition on Attention and/or Academic Performance					
Hollar *et al.* (2010) United States	• Total Sample: N = 1197 • N = 974 (4 experimental schools) • N = 119 (1 control school)	• Age Range: 6 - 13 years • Mean Age: 7.84 ± 1.67 years	• Physical Activity (Year 1): No intervention. • Physical Activity (Year 2): Daily 10-15 min desk-side PA, structured recess PA & other activities. • Nutrition: Dietary modifications to school-provided meals. • Curriculum: School-based holistic nutrition & healthy lifestyle management programme.	Academic Performance: • Florida Comprehensive Achievement Test: reading and math scores.	• Intervention group had significantly higher math scores both years ($p < .001$). • Not significantly so, intervention group also had higher reading scores both years.
Treu, Doughty, Reynolds, Njike and Katz (2017) United States	• Total Sample: N = 1487 • N = 416 (standard intervention) • N = 512 (enhanced intervention) • N = 559 (control)	• Third Grade Learners • Mean Age: 8.7 ± 0.4 years	• Duration: 1 year • 30 daily mins of brief bursts of PA over 1 year. • 90 min Nutrition Detective programme followed 3 months later by 30 min booster session.	Academic Performance: • AIMSweb: reading fluency, reading comprehension, math problem solving skills and math computation performance.	• No apparent effects on AP.
Physical Education only on Attention and/or Academic Performance					
Sallis, McKenzie, Kolody, Lewis, Marshall and Rosengard (1999) United States	• Total Sample: N = 759 • N = 177 (2 specialist condition) • N = 312 (2 trained teacher condition) • N = 265 (3 control)	• Fourth Grade Learners • Mean Age Range: 9.49 - 9.62 years	• Duration: 2 years • PE classes: 3 x 30 min/week.	Academic Performance: • Metropolitan Achievement Tests (MAT6 and MAT7): reading, math, language & basic battery composite score.	• Specialist condition was significantly superior to Control on Reading ($p = .02$), but inferior on Language ($p = .99$). • On language, percentage decline was significantly less in Trained Teacher condition than Control ($p = .04$).

Coe *et al*. (2006) United States	• Total Sample: N = 214	• Sixth Grade Learners • Age Range: 10 - 12.9 years • Mean Age: 11.5 ± 0.4 years	• Duration: 1 semester/6 months • 5 x 55 min PE class for 1 semester (either 1st or 2nd semester). • In semester with no PE: 5 x 55 min alternative exploratory class (i.e. arts & computer classes).	Academic Performance: • Math, Science, English & World Studies Grades. • Terra Nova test scores: Reading or Language Arts, Math, Science & Social Studies.	• Students performing vigorous PA had significantly higher grades ($p < .05$) than those not performing vigorous PA in both semesters.
Mahar, Murphy, Rowe, Golden, Shields and Raedeke (2006) United States	• Total Sample: N = 243 • N = 135 (Experimental) • N = 108 (Control)	• Third and Fourth Grade Learners • Age Range: 8 - 11 years • Mean Age: 9.1 ± 0.9 years	• Duration: 12 weeks • Classroom-based PA: 1 x 10 min/day.	Attention: • Direct observation of on-task behaviour.	• Significant improvement ($p < .017$) of 8% in on-task behaviour between pre-Energizers & post-Energizers observations. • Least on-task students significantly improved ($p < .001$) on-task behaviour by 20% after Energizers activities.
Ahamed, Macdonald, Reed, Naylor, Liu-Ambrose and McKay (2007) Canada	• Total Sample: N = 287 • N = 214 (6 intervention schools) • N = 74 (2 usual practice schools)	• Fourth and Fifth Grade Learners • Age Range: 9 - 11 years	• Duration: 16 months • Experimental: -Classroom-based PA 15 min/day, 5 days/week. -2 x 40 min PE classes/week. • Control: Usual practice: 2 x 40 min PE classes/week.	Academic Performance: • Canadian Achievement Test: Math, Reading, & Language.	• Participants attending UP schools had significantly higher baseline scores than those attending intervention schools. • No significant difference in AP scores between groups at follow-up & between boys & girls at baseline & follow-up.
Davis, Tomporowski, Boyle, Waller, Miller, Naglieri and Gregoski (2007) United States	• Total Sample: N = 94 • N = 33 (Low-dose) • N = 32 (High-dose) • N = 29 (Control)	• Age Range: 7 - 11 years • Mean Age: 9.2 ± 0.84 years	• Duration: 15 weeks • Experimental: -Low-dose = 1 x 20 min exercise programme/day, plus 1 x 20 min sedentary activity/day. -High-dose = 2 x 20 min exercise programme/day. • Control: No exercise.	Cognitive Performance: • Cognitive Assessment System: Planning, attention, simultaneous & successive cognitive processes.	• Planning scores for the high-dose group were significantly greater ($p = .03$) than those of the control group. • No effect on attention, simultaneous & successive scales.

Carlson, Fulton, Lee, Maynard, Brown, Kohl III and Dietz (2008) United States	• Total Sample: N = 5316	• Kindergarten to Fifth Grade Learners • Weighted Mean Age: 6.2 years	• No Intervention • Assessed according to time (mins/week) spent in PE: -Low: 0-35 mins -Medium: 36-69 mins -High: 70-300 mins	Academic Performance: • Math & Reading.	• A small significant benefit for AP in Math & Reading was observed for girls enrolled in higher amounts (70-300 mins/week) of PE. • Higher amounts of PE were not positively or negatively associated with AP among boys.
Davis, Tomporowski, McDowell, Austin, Miller, Yanasak, Allison and Naglieri (2011) United States	• Total Sample: N = 171 • N = 55 (Low-dose) • N = 56 (High-dose) • N = 60 (Control)	• Age Range: 7 - 11 years • Mean Age: 9.3 ± 1.0 years	• Duration: 13 ± 1.6 weeks • Experimental: -Low-dose = 1 x 20 min exercise program/day, plus 1 x 20 min sedentary activity/day. -High-dose = 2 x 20 min exercise programme/day. • Control: No exercise.	Cognitive Performance: • Cognitive Assessment System: Planning, attention, simultaneous & successive cognitive processes Academic Performance: • Woodcock-Johnson Tests of Achievement III: Broad Reading and broad Math.	• Planning scores for high-dose & low-dose groups were significantly greater ($p = .03$) than control group. • No effect on attention, simultaneous & successive scales. • Broad math scores were significantly greater ($p = .45$) in exercise groups than control group. • No effect on broad reading.
Tine and Butler (2012) United States	• Total Sample: N = 164 • N = 86 (Experimental) • N = 78 (Control)	• Sixth and Seventh Grade Learners • Age Range: 10.4 - 13.6 years	• Duration: 12 minutes • Experimental: Indoor track run at speed maintaining HR within target range. • Control: Viewed a film clip about exercise.	Attention: • d2 Test of Attention.	• A 12-min session of aerobic exercise significantly improved ($p < .001$) the selective attention of both lower- and higher-income children.
Reed, Maslow, Long and Hughey (2013) United States	• Total Sample: N = 470 • N = 165 (Experimental) • N = 305 (Control)	• Second to Eighth Grade Learners • Mean Age: Experimental: 10.2 ± 2.3 years Control: 11.2 ± 1.9 years	• Duration: 8 months • Experimental: -Elementary and Middle School: 1 x 45 min PE class/day. • Control: -Elementary School: 1 x 45 min PE class/week for entire year.	Cognitive Performance: • Fluid Intelligence Test: The Standard Progressive Matrices (SPM) Test. • The Perceptual Speed Test	• Experimental participants observed significantly greater improvements compared with control participants on 8 of 26 cognitive measures. • Differences were more noticeable among females.

			-Middle School: 1 x 50 min PE class/day for fall semester only.		
Crova, Struzzolino, Marchetti, Masci, Vannozzi, Forte and Pesce (2014) Italy	• Total Sample: N = 70 • N = 37 (Experimental) • N = 33 (Control)	• Age Range: 9 - 10 years	• Duration: 6 months/21 weeks • Experimental: 1 x PE class/week, plus 2 x 1h of skill-based & tennis training. • Control: 1 PE class/week.	Cognitive Performance: • 2 components of EF: inhibition and working memory updating.	• Significantly better (p = .020) inhibition in higher- than lower-fit children. • No significant effect on working memory updating between groups.
Ericsson and Karlsson (2014) Sweden	• Total Sample: N = 220 • N = 129 (Experimental) • N = 91 (Control)	• Age Range: 7 - 9 years	• Duration: 9 years • Experimental group: daily PE (5 × 45 min/week); and, if needed, 1 extra lesson of adapted motor training. • Control group: 2 PE lessons/week.	Academic Performance: • School achievements by marks in Swedish, English, Mathematics, and PE.	• Sum of evaluated marks significantly higher (p < .05) among boys in experimental than in control group. • Sum of marks also significantly higher (p <.01) in pupils with no motor skills deficit than among pupils with motor skills deficits.
Hansen, Herrmann, Lambourne, Lee and Donnelly (2014) United States	• Total Sample: N = 687 • N = 129 (Experimental) • N = 91 (Control)	• Second and Third Grade Learners • Mean Age: 7.8 ± 0.6 years	• Duration: 3 years • 2 x 10-min PA academic lessons 5 days/week	Academic Performance: • Weschsler Individual Achievement Test – 3rd Edition: reading comprehension, reading fluency, spelling, math problem solving, and numerical operations.	• Fitness, but not PA, had a significant quadratic association (p < .01) with both spelling and mathematics performance.
Gallotta, Emerenziani, Iazzoni, Meucci, Baldari and Guidetti (2015) Italy	• Total Sample: N = 157 • N = 78 (Traditional PA) • N = 83 (Coordinative PA) • N = 69 (Control)	• Third to Fifth Grade Learners • Age Range: 8 - 11 years	• Duration: 5 months • 2 x 1h PA sessions per week. • Traditional PA: Promoted health, fitness, sensory-motor, social and communicative development; and focused on endurance, strength & flexibility exercises, and CDV health.	Attention: • d2-R test of attention	• Significant effects on Time (p <. 01) and Time x Group interaction (p < .001), revealing significant different effects of intervention/exercise modality on attentional performance. • Coordinative PA yielded most significant improvement in attention.

			• Coordinative PA: Focused on improving coordination & dexterity in sports games, rhythmic activities, gymnastics and/or fitness activities.		
Jäger, Schmidt, Conzelmann and Roebers (2015) Switzerland	• Total Sample: N = 219 • N = 54 (Physical games) • N = 62 (Aerobic exercise) • N = 60 (Cognitive games) • N = 58 (Control)	• Age Range: 10 - 12 years	• Duration: 20 minutes • Physical games: 3 x 5-7 min cognitive games. • Aerobic exercise: short tasks of different running forms. • Cognitive games: Card game. • Control: Seated story time	Executive Function: • Updating, inhibition & shifting. Academic Performance: • Math & language • Writing & reading.	• No significant effects found on EFs in overall sample. • Only children with higher fitness and/or higher AP significantly benefitted ($p < .01$) from the interventions in terms of their updating performance.
McClelland, Pitt and Stein (2015) Trial 1 United Kingdom	• Total Sample: N = 235 • N = 8 (Intervention Schools) • N = 8 (Control Schools)	• Age Range: 10 - 11 years	• Duration: 12 weeks • Daily 20 min activity.	Academic Performance: • English & Math SAT scores.	• Intervention schools showed a significant increase ($p = .034$) in English and Math SAT scores when compared to control schools.
McClelland *et al.* (2015) Trial 2 United Kingdom	• Total Sample: N = 113 • 3 participating schools in a total of 5 classes	• Age Range: 8 - 10 years	• Duration: 12 weeks • Daily 20 min activity.	Academic Performance: • Assessments of National Curriculum Levels in reading, writing and Math.	• The whole group showed a significant increase ($p < .001$) in reading, an 88% increase in progress rate (large effect size, $g = 1.06$) for Math, and a 19% increase in progress rate (small effect size, $g = 0.29$) for writing in comparison to control schools.
McClelland *et al.* (2015) Trial 3 United Kingdom	• Total Sample: N = 51 • 1 participating school	• Age Range: 7 - 10 years	• Duration: 12 weeks • Daily 20 min activity.	Academic Performance: • Group mean reading scores.	• Significant increase ($p = .006$) in reading scores when comparing pre- and post-intervention results.
Mullender-Wijnsma, Hartman, de Greeff,	• Total Sample: N = 228 • 6 schools	• Second and Third Grade Learners • Mean Age:	• Duration: 21 weeks • 3 x 30 min F&V PA lessons/week	Attention: • Direct observation of on-task behaviour.	• Children's on task behaviour during lessons was above 70%; and 2nd

Bosker, Doolaard and Visscher (2015a) Northern Netherlands	• N = 58 (Grade 2 Intervention) • N = 62 (Grade 2 Control) • N = 52 (Grade 2 Intervention, Grade 3 Control) • N = 56 (Grade 2 Control, Grade 3 Intervention)	8.1 years	• Split into 10-15 min PA math lessons; and 10-15 min PA language lessons.	Academic Performance: • Math & reading ability.	grade learners spent less time on the specific exercise (on task) than 3rd grade learners. • Significantly higher post-test math ($p < .05$) & reading ($p < .05$) scores in 3rd grade experimental children. • Significantly lower ($p < .05$) post-test math scores in 2nd grade intervention children when compared to 2nd grade control children. • No effect in reading ability of 2nd grade children.
Mullender-Wijnsma, Hartman, de Greeff, Bosker, Doolaard and Visscher (2015b) Northern Netherlands	• Total Sample: N = 81 • N = 23 socially disadvantaged children (SDC) • N = 63 children without a disadvantage (non-SDC)	• Second and Third Grade Learners • Mean Age: 8.3 ± 0.8 years	• Duration: 22 weeks • 3 x 30 min F&V PA lessons/week • Split into 10-15 min PA math lessons; and 10-15 min PA language lessons.	Attention: • Direct observation of time-on-task behaviour.	• Time-on-task was significantly lower ($p < .05$) in SDC than non-SDC at start post-control, post-intervention and midway post-control. • Time-on-task was significantly higher (ES = 0.41) in all children during post-intervention in comparison with post-control lessons.
Goh, Hannon, Webster, Podlog and Newton (2016) United States	• Total Sample: N = 210 • 9 classes (3 per grade)	• Third to Fifth Grade Learners • Age Range: 8 - 12 years	• Duration: 8 weeks • Daily 10 min PA.	Attention: • Direct observation of on-task behaviour.	• Significant decrease ($p = .001$) in mean percentage on-task behaviour in control groups from preno- to postno-TAKE10. • Significant increase ($p = .001$) in mean percentage on-task behaviour from pre- to post-TAKE10 during the intervention.

Resaland, Aadland, Moe, Aadland, Skrede, Stavnsbo, Suominen, Steene-Johannessen, Glosvik, Andersen, Kvalheim, Engelsrud, Andersen, Holme, Ommundsen, Kriemler, van Mechelen, McKay, Ekelund and Anderssen (2016) Norway	• Total Sample: N = 1129 • 28 intervention schools and 29 control schools • N = 596 (Intervention) • N = 533 (Control)	• Fifth Grade Learners • Mean Age: 10.2 ± 0.3 years	• Duration: 7 months • 90 min/week of physically active educational lessons. • Classroom PA breaks of 5 min/day. • PA homework: 10 min/day.	Academic Performance: • Standardized Norwegian national tests in numeracy, reading & English.	• No effect of intervention on AP in primary analyses. • Subgroup analyses revealed a favourable intervention effect (p = .005) for those who performed the poorest at baseline (lowest tertile) for numeracy compared to controls.
Tarp, Domazet, Froberg, Hillman, Andersen and Bugge (2016) Denmark	• Total Sample: N = 632 • 7 intervention schools and 7 control schools • N = 194 (Intervention) • N = 438 (Control)	• Age Range: 12 - 14 years • Mean Age: 12.9 ± 0.6 years	• Duration: 20 weeks • 60 mins PA during school, on all school days. • PA homework: 5-10 mins daily activities. • Scheduled PA during recess. • 2-week daily cycling campaign, mid-intervention. • Controls continued with normal practice.	Cognitive Performance: • Modified Erikson Flanker Task: Test of inhibition (accuracy & reaction time) Academic Performance: • Custom-made grade specific math tests.	• No significant difference in change, comparing the intervention group to the control group, was observed on primary outcomes, or math skills.
Nutrition only on Attention and/or Academic Performance					
Shilts, Lamp, Horowitz and Townsend (2009) United States	• Total Sample: N = 84	• Sixth Grade Learners • Mean Age: 11.0 ± 0.5 years	• Duration: 5 weeks • Experimental: 5-week education programme on dietary & PA skills & behaviours. • Control: 5-week usual classroom education.	Academic Performance: • 25-question, multiple-choice survey assessing 5 education standards for 6th grade Math & English.	• Changes in total scores were statistically different ($P < 0.05$), with treatment scores (T3 - T2) generating more gains. • The change scores for 1 English ($P < 0.01$) and 2 mathematics standards ($P < 0.05$; $P < 0.001$) were statistically greater for the treatment period (T3 - T2) compared to the control period (T2 - T1).

Desai, Kurpad, Chomitz and Thomas (2015) India	• Total Sample: N = 273	• Age Range: 7 - 10.5 years • Median Age (Q1, Q3) 8.83 (8, 9.67) years	• Duration: 4 months • Daily administration of a multi-micronutrient-fortified beverage.	Academic Performance: • School-wide exam scores in Math & Kannada language.	• Significant positive correlations ($p < .05$) between aerobic capacity (VO_2 peak) & academic scores were observed. • After standardizing scores across grade levels and adjusting for school, gender, socioeconomic status, and weight status (BMI Z-score), children with greater aerobic capacities (mL * kg-1 * min-1) and whole-body endurance had greater odds ($p < .05$ and $p < .01$, respectively) of scoring above average on Math and Kannada exams.
Hjorth, Sorensen, Andersen, Dyssegaard, Ritz, Tetens, Michaelsen, Astrup, Egelund and Sjödin (2016) Denmark	• Total Sample: N = 828	• Third and Fourth Grade Learners • Age Range: 8 - 11 years • Mean Age: 9.9 ± 0.6 years	• Duration: 3 months • New Nordic Diet: mid-morning snack, hot lunch & afternoon snack. • Dessert served twice a week, either fresh fruit or fruit-based.	Cognitive Performance: • d2 Test of Attention, Academic Performance: • Reading & math test.	• Normal weight children had higher cognitive test scores than overweight/obese and underweight children of up to 89% and 48% of expected learning within one school year ($p < .05$). • Daily breakfast consumption, fewer sleep problems, higher CRF, less total PA, more sedentary time, and less light PA were associated with higher cognitive performance independently of each other in at least one of the three cognitive tests ($p < .05$).

Table 2.4: National School-Based Intervention Studies on Attention and/or Academic Performance of Primary Schoolchildren

Authors, Publication Year and Country	Sample Size	Participants	Intervention (Number of Sessions and Duration)	Outcomes of Interest and Assessment Tool(s)	Main Findings
Physical Education only on Attention and/or Academic Performance					
Barnard *et al.* (2014) South Africa	• Total Sample: N = 149 • 1 Quintile 3 and 5 school - 1 group from each school in either experimental or control • N = 97 (Experimental) • N = 52 (Control)	• Second Grade Learners • Mean Age Range: 7.33 - 7.47 years	• Duration: 8 weeks • Integrated academic skill & physical development: 3 x 30 min/week; or • Moderate to strenous PA: 3 x 30 min/week.	Academic Performance: • VASSI Mathematical Skills & ESSI Reading & Spelling Skills Tests: standardised tests for literacy & numeracy skills.	• Both schools showed progress in Literacy and Numeracy, although it was not statistically significant ($p < .05$).
Nutrition only on Attention and/or Academic Achievement					
Taljaard, Covic, van Graan, Kruger, Smuts, Baumgartner, Kvalsvig, Wright, van Stuijvenberg and Jerling (2013) South Africa	• Total Sample: N = 414 • Four treatment groups: (1) micronutrients with sugar; (2) micronutrients with a non-nutritive sweetener; (3) no micronutrients with sugar; or (4) no micronutrients with a non-nutritive sweetener.	• First to Third Grade Learners • Age Range: 6 - 11 years	• Duration: 8.5 months • Consume beverages (200 ml per child per day) containing: (1) micronutrients with sugar, (2) micronutrients with a non-nutritive sweetener, (3) no micronutrients with sugar or (4) no micronutrients with a non-nutritive sweetener.	Cognitive Performance: • Kaufman Assessment Battery (KABC-II)	• Significant micronutrient x sugar interaction effects on the Atlantis, Number recall, Rover and Discrimination Index scores ($p < .05$).
Graham, Hochfeld, Stuart and Van Gent (2015) South Africa	• Total Sample: N = 1390 • 41 Quintile 1 - 3 Schools • N = 570 (NSNP) • N = 541 (NSNP & TBF) • N = 276 (Control)	• Age Range: 6 - 14 years	• Duration: 1 year • NSNP offers 1 mid-morning meal: 1 protein, 1 starch and 1 vegetable. • TBF in-school breakfast programme provides breakfast daily: fortified sorghum, maize or oats-based porridge.	Academic Performance: • Impact on school performance: Term marks or grades •	• For AP in Term 1, the difference between control and NSNP & TBF schools was statistically significant ($p < .05$). • Overall, learners in all groups improved performance from Term 1 to Term 4, but not significantly so.

From the 27 international studies, only two school-based intervention studies were found (both conducted in the USA), investigating the effect of a PE and nutrition intervention on the AP of primary school aged learners, with varying results reported. Hollar *et al.* (2010:646) reported significantly higher Maths scores in the intervention group as opposed to the control, whereas no significant changes were found for AP in the study by Treu *et al.* (2017:143). Twenty out of the 27 international studies examined the effect of PE only on attention and/or AP, ten each in Europe and North America. Ten studies revealed significant and favourable intervention effects (Coe *et al.*, 2006:1515; Mahar *et al.*, 2006:2086; Carlson *et al.*, 2008:721; Tine & Butler, 2012:821; Ericsson & Karlsson, 2014:273; Hansen *et al.*, 2014:2279; Gallotta *et al.*, 2015:4; McClelland *et al.*, 2015:89, 91 & 92; Mullender-Wijnsma *et al.*, 2015b:1; Goh *et al.*, 2016:712); six studies had mixed results (Sallis *et al.*, 1999:131; Davis *et al.*, 2011:95; Reed *et al.*, 2013:185; Crova *et al.*, 2014:207; Jäger *et al.*, 2015:1; Mullender-Wijnsma *et al.*, 2015a:369); and four studies (Ahamed *et al.*, 2007:371; Davis *et al.*, 2007:510; Resaland *et al.*, 2016:322; Tarp *et al.*, 2016:1) showed no change in cognitive performance and/or attention between intervention and control groups.

Three international studies (one in Denmark, one in India and one in the USA) investigated the effect of nutrition only on attention and/or AP, with all three revealing similar findings. In Denmark, Hjorth *et al.* (2016:398) investigated whether normal weight children have higher cognitive performance, independent of PA, sleep and diet and reported that normal weight children had higher cognitive test scores than overweight or obese and underweight children. Additionally, daily breakfast consumption, fewer sleep problems, higher cardiorespiratory fitness, less total PA, more sedentary time, and less light PA were significantly associated with higher cognitive performance, independently of each other, in at least three cognitive tests. In India, Desai *et al.* (2015:1) examined aerobic fitness, micronutrient status and academic achievement in Indian school-aged children and found significant positive correlations between aerobic capacity and academic scores. Children with greater aerobic capacity and whole-body endurance had significantly greater odds of scoring above average on mathematics and language examinations. In the USA, Shilts *et al.* (2009:127) studied the impact of a nutrition education programme on student AP as measured by achievement of education standards and observed that changes in total

scores were statistically different with treatment scores generating more gains. The change in scores for one English and two Mathematics standards were statistically greater for the treatment period (T3 to T2) compared to the control period (T2 to T1).

Of the three national studies, only one investigated the effect of PE only on AP, whereas two studies examined the effect of nutrition on attention or AP, with two studies reporting similar results and one incongruent study. Barnard *et al.* (2014:1) implemented two eight-week intervention programmes (an integrated academic skills and physical development programme and a PA programme) at two primary schools and reported no statistically significant effects on AP between the two schools. Taljaard *et al.* (2013:2271) investigated the effect of a multi-micronutrient-mortified beverage, with and without sugar on cognition in South African children over a period of eight months and found significant micronutrient plus sugar interaction effects on the Atlantis, Number recall, Rover and Discrimination Index scores of the KABC-II. Graham *et al.* (2015:35) studied the impact of a one-year nutrition programme on school performance in 41 quintile 1 to 3 schools that were allocated into three groups, namely, the National School Nutrition Programme (NSNP) group, the NSNP and Tiger Brands Food (TBF) group and the control group. Results indicated that, overall, learners in all groups improved on AP at post-intervention, but not significantly so.

From these summarised results, it can be noted that the main concerns related to attention and AP were specifically focused on increasing PA levels to improve attention and AP. Evidence suggests that this is particularly challenging in low- and middle-income countries, such as SA, since PE is not being taught in most public schools and as a result, a substantial number of children do not engage in the recommended daily 60 minutes of MVPA (Gall *et al.*, 2018:2). Furthermore, Stevens *et al.* (2009:634) found that their data was supported by previous findings of deficits in selective attention, particularly in the filtering of distracting or irrelevant stimuli, amongst children from lower socioeconomic backgrounds, which may possibly have cascading effects on the development of academic skills. Hence, these results highlight that increasing levels of PA participation is of vital importance for positively influencing attention and enhancing academic gains.

2.8 SUMMARY

PE may be used as a vehicle for advocacy to promote active lifestyles for children. However, the legacy of apartheid in SA has resulted in ethnic and socioeconomic disparities that affect the status of PA in the country for many individuals, children and adults alike. In addition, PE is seen as inferior to other subjects in the school curricula and is often neglected. With children already exhibiting insufficient PA levels, lifelong PA participation could be hindered further without the appropriate foundation of PE instituted within the curricula of socioeconomically disadvantaged schools.

This chapter also investigated the factors influencing the PA, attention and AP of South African schoolchildren. From an early age, these children are faced with many adversities that may discourage their interest in PA and their ability to pay attention and perform academically. Subsequently, all these factors have a predisposing and compromising effect on children's future health and optimal development.

Furthermore, a comprehensive discussion of the contextual evidence specifically pertaining to children's attention, AP and PA was provided. Additionally, it reported on extensively used measurements for the assessment of attention, AP and PA, the methods employed to obtain these measurements, as well as the relevant reference data that can be used when comparing the present study's results. The following chapter, Chapter 3, provides a detailed description of the methods and procedures applied to accomplish the aims and objectives of this study, as outlined in Chapter 1.

CHAPTER 3
METHODS AND PROCEDURES

3.1 INTRODUCTION

The primary aim of this study was to establish the effect of school-based interventions on the attention and AP of primary schoolchildren from lower socioeconomic communities in Port Elizabeth. This chapter describes the research methodology implemented to allow for the repeatability of the study, as well as for the interpretation of the results.

The present study was conducted under the auspices of a larger 3-year research project funded by the Swiss South African Joint Research Programme (SSAJRP), entitled "Impact of disease burden and setting-specific interventions on schoolchildren's cardiorespiratory physical fitness and psychosocial health in Port Elizabeth, South Africa". This larger study is a collaboration between the University of Basel in Switzerland; the Nelson Mandela University in Port Elizabeth, South Africa; and the Swiss Tropical and Public Health Institute. The methodology employed in this chapter coincides with the relevant sections of the overall protocol published in Yap, Müller, Walter, Seelig, Gerber, Steinmann, Damons, Smith, Gall, Bänninger, Hager, Htun, Steenkamp, Gresse, Probst-Hensch, Utzinger, Du Randt and Pühse (2015). The sections to follow include a detailed discussion on the research design; participants and sampling technique; school grouping with the relevant intervention allocation; measuring instruments; school-based interventions; data collection procedures and testing protocol; statistical analysis techniques; and ethical considerations applied to accomplish the aims and objectives outlined in Chapter 1. A description of the components of the research design employed in this study follows in the next sub-section.

3.2 RESEARCH DESIGN

A research design is defined as "a plan outlining how observations will be made and how the researcher will carry out the project" (Monette, Sullivan & De Jong, 2011:9). It is critical to the success of any study to select an appropriate and practicable design, to meet the aims and objectives of the research. The research design utilised in this study is quantitative and can be categorised as experimental, specifically quasi-experimental, in nature, which is appropriate for the understanding and interpretation of the effect of school-based interventions on the attention and AP of primary schoolchildren from lower socioeconomic communities.

This study, being quantitative research, is dependent on the degree of scientific meticulousness entailed in verifying a relationship (Fouché, Delport & de Vos, 2011:144). Quantitative research designs are comprehensively tailored to acquire data that is relevant to the specific research hypothesis and/or question being investigated, and therefore, provide interpretable information (Cozby, 2004:100; Fouché *et al.*, 2011:143-144). Quantitative methods generate numerical data and focuses on analysis – that is, the dissecting and inspecting of the components of a phenomenon to determine a relationship (Thomas *et al.*, 2005:346; Jones, 2015:24).

Quantitative research designs can be categorised into two main classes, experimental and non-experimental designs. The research method employed here is primarily experimental in nature. Essentially, the concept of an experiment is that there are two comparison groups, one of which is administered an intervention (experimental group) and the other group (control group) is not. The groups are then compared or tested for differences between them on some outcome (Fouché *et al.*, 2011:144-145). The current study has an experimental design. Furthermore, experimental designs can be categorised as pre-experimental, quasi-experimental, and true experimental.

Quasi-experimental studies are in the middle of the experimental continuum, as they contain some, but not all, the requisites of a model experiment. In this study there was a considered lack of random allocation of research participants to two or more groups (Fouché *et al.*, 2011:148-149), and this categorises it as quasi-experimental. Quasi-experimental studies generally allow us to form conclusions about causal relationships

with reduced assertion when compared to true experimental studies; however, it still enables the researcher to make conclusions about these relationships with greater assurance than pre-experimental studies (Welman, Kruger & Mitchell, 2005:88). The quasi-experimental method was applied in this study to establish a causal relationship in the effect of school-based interventions on the attention and AP of primary schoolchildren from lower socioeconomic communities.

This study was conducted by implementing an intervention with pre- and post-intervention tests performed. The study can therefore be further categorised into a comparison group pretest-posttest design. This design is the standard structure of an experimental study (Fouché *et al.*, 2011:150). This justifies the above classification as experimental, specifically a quasi-experimental and comparison group pretest-posttest study, suitable for determining the effect of school-based interventions on the attention and AP of primary schoolchildren from lower socioeconomic communities.

The present study was implemented under a larger two-year longitudinal cohort study involving three cross-sectional surveys (baseline, mid- and final follow-up) which sought to explore, describe and compare the effect of setting-specific interventions in eight quintile 3 primary schools from disadvantaged communities in Port Elizabeth. At each survey time point, data collection performed on each participant included the following:

- A clinical examination to identify disease status;
- Anthropometric measurements;
- Parasitological screening;
- Cognitive performance assessment – including attention and AP elements (reported on in this study);
- Psychosocial assessment;
- PA level assessment via a questionnaire; and
- PF component assessments, namely cardiorespiratory endurance, body strength, flexibility, co-ordination and speed.

Based on the results from the baseline survey, a package of setting-specific interventions was designed by the research team, in consultation with subject experts

in the areas of PE, dietetics and health education. The eight quintile 3 schools were then match-paired, with each school in a pair randomly allocated to either the experimental or control groups; specifically, four schools were assigned to each group according to geographical location, medical examination and helminthic infection results, as well as the social and ethnic composition of schools. The match-pair technique is a method of controlling internal validity threats used as an alternative to the random assignment of participants (Thomas *et al*., 2005:327). This decision, however, results in the study being classified quasi-experimental.

For the purposes of this report, data pertaining to the first two cross-sectional surveys were utilised [Baseline (T1) and Mid Follow-Up (T2)]. The intervention was implemented in the experimental group, in addition to pre- and post-intervention tests performed in both the experimental and control groups. Data specifically pertaining to attention and AP was collected and utilised. Illustrated below, figure 3.1 represents the research framework with respective timelines for the present study and the larger study. Following figure 3.1, the next section describes the participants and the sampling selection, which formed part of the planning phase of the research process.

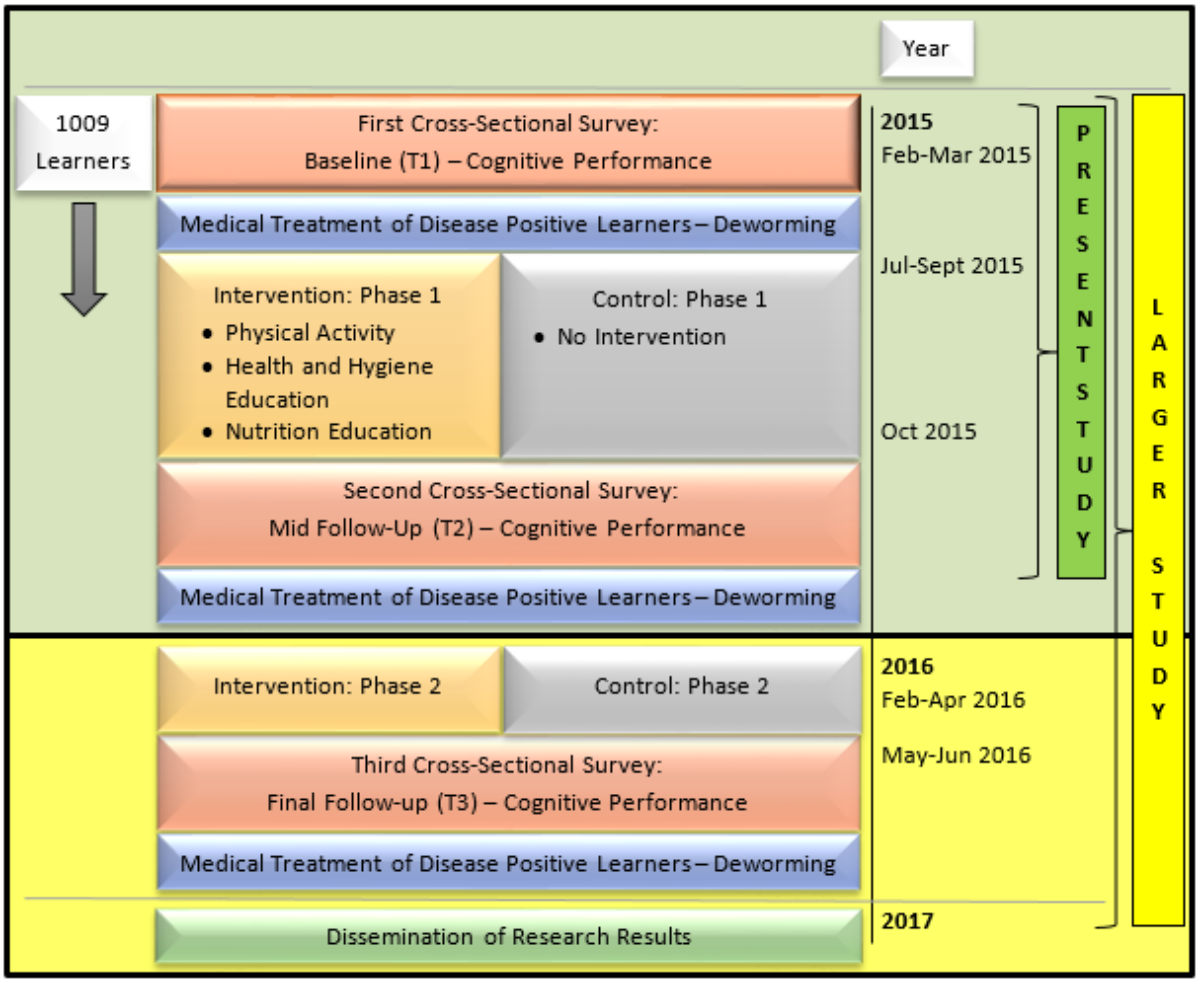

Figure 3.1: DASH Study Research Framework with Respective Timelines (adapted from Yap et al., 2015:4)

3.3 PARTICIPANTS AND SAMPLING TECHNIQUE

A research population is defined as an entire group or set of individuals of interest possessing distinctive characteristics that can be measured and subsequently studied (Morrow Jr. *et al.*, 2011:70; Levy & Lemeshow, 2013:11). The present study was conducted in socioeconomically marginalised regions and government schools situated in former black and coloured communities in and around Port Elizabeth. Children from these areas formed the population this study focused on. Since a population is characteristically comprised of a large number of individuals and is often challenging to research, a more suitable option, utilised herein, is focusing on a sample of the population of interest (Johnson & Kuby, 2011:5).

A representative sample is essential when generalisations from the sample to the larger population need to be made (Marlow, 1998:135). To achieve representivity, the

sample should be randomised and ought to integrate the entire population. In adherence with the DASH study protocols, the sampling technique utilised was a cluster-randomised controlled trial for the collection and analysis of data pertaining to the present study. The cluster sampling method must represent the entire population. It is utilised as it employs a sampling frame, such as the relevant geographic location, when a list of names is unavailable (Strydom, 2011b:230). The sample for this study included eight quintile 3 schools situated in historically disadvantaged areas of Port Elizabeth. The following sub-section describes the sampling strategy employed for the present study.

3.3.1 Sampling Strategy

The sampling strategy was further characterised as cluster and criterion-based. Cluster sampling, also referred to as area or multistage sampling (Monette, Sullivan & De Jong, 2013:138), is frequently employed in cases where the population is too large even for random sampling and where participants already form part of a group or "cluster", as the name implies (Jackson, 2015:98). It is utilised when economic considerations and cluster criteria are significant for the study. One advantage of this method is the ability to concentrate the field of study in a specific section of the greater geographical area, thus reducing costs and saving time (Strydom, 2011b:230).

Criterion-based sampling allows for the identification and recognition of specific criteria to be included in the sample (Polit & Hungler, 1993:252). The following criteria for inclusion in the sample had to be met by the schoolchildren invited to participate in the study:

- Willingness to voluntarily participate in the study;
- Possession of written informed parental and/or legal guardian consent on behalf of the child;
- No participation in other studies during the present study's period; and
- Be a male or female primary school Grade 4 learner (aged 8 – 13 years).

Since many public schools in Port Elizabeth do not have access to operational telephones, fax machines or email, 103 primary schools were personally approached

and presented with a research study brochure. Written responses were received from a total of 25 interested schools. Principals, Grade 4 teachers and School Governing Body members from the schools were invited by the study leaders to attend a comprehensive information meeting, held in October 2014, regarding details pertaining to participation in the study. Eight schools were selected to participate based on the following set criteria: n > 100 Grade 4 learners and geographic location. Meetings were also held to disclose information regarding the sensitive nature of the clinical assessment in the study; as well as to disseminate consent forms. Consent forms were collected at the end of the school year in 2014; on two separate occasions early in the academic year in 2015; and were accepted up until the morning of testing, to encourage the inclusion of as many learners as possible.

Figure 3.2 below represents the study cohort and sampling strategy for final statistical analysis of the present study. A total of n = 1009 Grade 4 learners with written informed consent and assent participated in the study. At T1, complete data were available from n = 899 learners; whereas for T2, complete data were only available from n = 866 learners. For statistical purposes, a total of n = 152 learners had to be excluded from the study. Reasons for exclusion were: dropping out or transferal to other schools; absenteeism during data collection; falling outside the age range specified (8 – 13 years on the day of testing); as well as incomplete data. Subsequently, for final statistical analyses, a total of n = 857 participants was utilised in the present study; of which 51% were male and 49% were female. Regarding the ethnicity of the learners, 61% represented learners of black race and 39% represented learners of coloured race. Following figure 3.2, the next sub-section describes the geographical location wherein the present study was conducted.

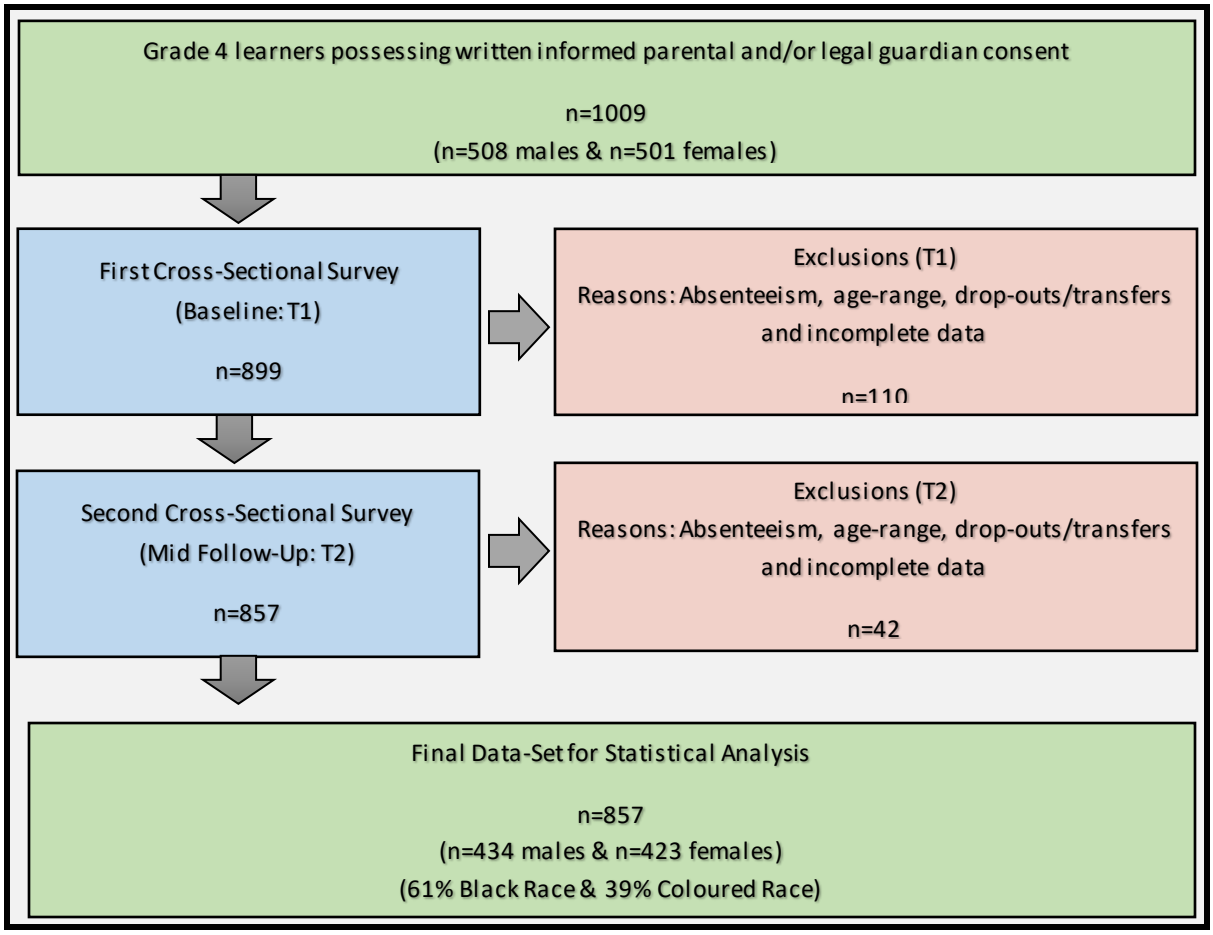

Figure 3.2: Study Cohort and Sampling Strategy for Final Statistical Analysis

3.3.2 Geographic Location

The present study was conducted in socioeconomically marginalised regions and government schools based in former black and coloured communities in and around Port Elizabeth, as is illustrated in figure 3.3. In Port Elizabeth, regions inhabited by black South Africans are commonly termed Townships; whereas regions inhabited by coloured people are referred to as the Northern Areas. Northern Areas project schools are situated in the suburbs of Booysens Park, Helenvale and Schauderville; and Township project schools in the suburbs of KwaZakhele, Motherwell, New Brighton and Walmer Township. These areas were developed on the remote outskirts of Port Elizabeth when people, because of their ethnicity, were forcibly segregated from the city's central business district under the institutionalization of apartheid and implemented under the Group Areas Act of 1950 (du Plessis, 2013:80). Due to apartheid legislation, schools and communities within these areas had also been subjected to adverse conditions of extreme poverty and other social issues (Walter, 2011:787).

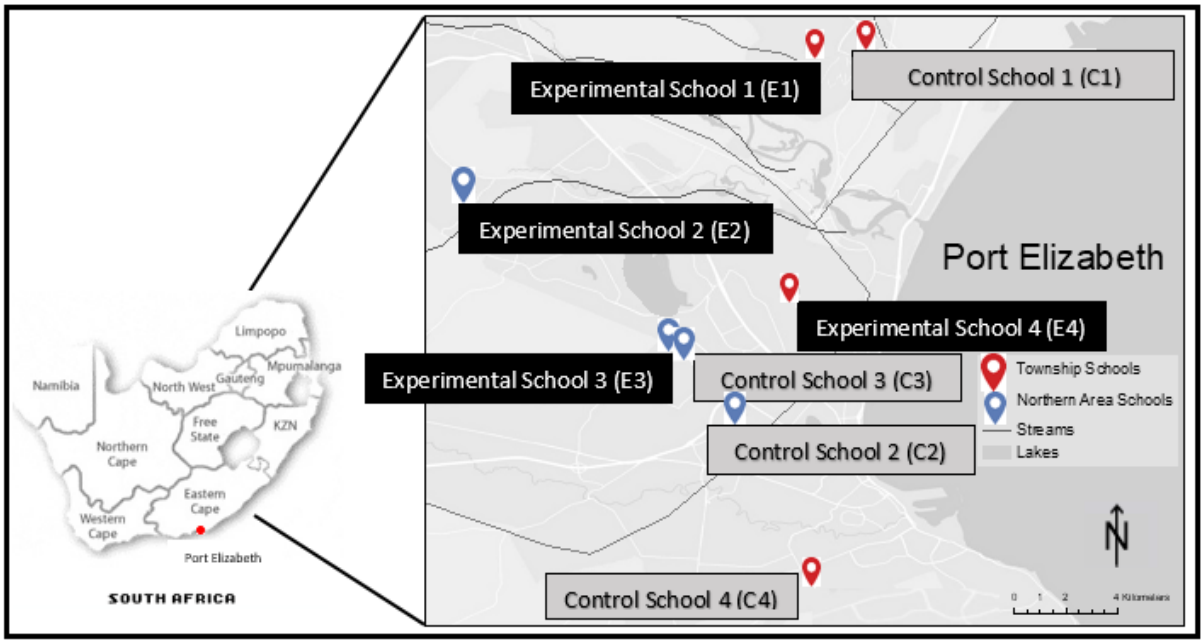

Figure 3.3: Study Areas and Location of Schools Participating in the DASH Study (adapted from the DASH Study Protocol) (Yap et al., 2015:4)

Schools in the Northern Areas are comprised of predominantly coloured learners, sometimes both black and coloured learners; whereas schools in the Township Areas comprised of only black learners. Black parents residing in the Township Areas perceive Northern Areas schools to be better than Township schools (South Africa, 2004:16). Additionally, black learners who are enrolled in Northern Areas schools travel lengthy distances to attend these schools and since these areas have been developed on the remote outskirts of the city, daily travelling expenses can become costly. In terms of residential distribution, a total of 38% of the learners resided in the Northern Areas and 62% resided in the Township Areas. The following section describes the school grouping with the relevant interventions allocated in the present study.

3.4 SCHOOL GROUPING WITH RELEVANT INTERVENTIONS

The eight primary schools participating in the study were match-paired, with each school in a pair randomly allocated to either the experimental or control groups. As previously stated, the match-pair technique is a method of controlling internal validity threats, an alternative to the random assignment of participants (Thomas *et al.*, 2005:327). Using the match-pair technique and based on the results from the baseline

survey, the eight schools were assigned to each group by means of similar geographical location, medical examination and helminthic infection results, and the social and ethnic composition of schools. Outlined in table 3.1, various intervention combinations were also assigned to the different schools, contingent on the results yielded from the baseline survey. Furthermore, helminthic infection medication treatment was distributed amongst all the participating schools, control schools included. The following section describes the measuring instruments utilised for the data collection of the present study.

Table 3.1: School Experimental and Control Grouping with Relevant Intervention

EXPERIMENTAL GROUP	CONTROL GROUP
Experimental School 1: E1 • Physical Education/Fitness • Medication/Deworming Treatment	**Control School 1: C1** • Medication/Deworming Treatment
Experimental School 2: E2 • Physical Education/Fitness • Health and Hygiene Education • Medication/Deworming Treatment	**Control School 2: C2** • Medication/Deworming Treatment
Experimental School 3: E3 • Physical Education/Fitness • Health and Hygiene Education • Nutrition • Medication/Deworming Treatment	**Control School 3: C3** • Medication/Deworming Treatment
Experimental School 4: E4 • Health and Hygiene Education • Nutrition • Medication/Deworming Treatment	**Control School 4: C4** • Medication/Deworming Treatment

3.5 MEASURING INSTRUMENTS

The primary aim of this study was to establish the effect of school-based interventions on the attention and AP of primary schoolchildren from lower socioeconomic communities in Port Elizabeth. Cognitive and academic performance are thought to interrelate as aspects of cognition, such as attention and working memory, are crucial to academic success (Keeley & Fox, 2009:201). The use of measuring instruments is necessitated for quantitative data collection methods. Specifically pertaining to this study, for the measurement of attention, the d2 Test of Attention was employed; and for AP, the end of year school results as per the Internal Progression Schedule were utilised. The following sub-sections describe the measuring instruments and provide

detail pertaining to the purpose of the instruments, the equipment utilised, the implementation method, the scoring method, as well as the validity and reliability thereof; and commences with the measurement of attention.

3.5.1 The d2 Test of Attention

The d2 Test of Attention (for example, refer to Appendix 1) is a user-friendly, reliable and valid, timed test of selective attention (Brickenkamp & Zillmer, 1998:v & 1). Originally developed in 1962, the d2 Test is an extensively used neuropsychological test (Brickenkamp & Zillmer, 1998:4-6) that was employed to measure sustained, selective visual attention and concentration under stressful, time-constrained settings (Gallotta, Guidetti, Franciosi, Emerenziani, Bonavolonta & Baldari, 2012:552). Several other aspects such as visual perception, visual scanning ability, perceptual and processing speed are also considered to be contained within this well-known test that has a total administration time of 8 minutes (Brickenkamp & Zillmer, 1998:4; Wassenberg, Hendriksen, Hurks, Feron, Keulers, Vles & Jolles, 2008:196). The d2 Test is a standard version of a visual cancellation test (Brickenkamp & Zillmer, 1998:1), entailing the simultaneous presentation of stimuli that is visually similar; and which has been recommended to be a particularly useful measure of attention and concentration processes (Bates & Lemay, 2004:392).

This one-paged paper-and-pencil test contains 14 different rows, intermixed with 47 random “d” and “p” letters in each row, totalling 658 items to be processed (Brickenkamp & Zillmer, 1998:1). These letters have between one and four dashes organised individually or in pairs, either above and/or below each letter. The participant’s task is to search across each row to identify and cross out as many target letters (“d” letters with two dashes above or below – hence termed the d2 Test of Attention), whilst simultaneously avoiding the non-target letters (“d” letters with more than or less than two dashes, and “p” letters with any number of dashes); as well as moving from left to right within a time frame of 20 seconds per row. After completing each row, the participant is instructed to proceed to the next line using the words “next line” followed by the line number; for example, “next line, line 2”. The participant is requested to perform the test as quickly and efficiently – with as few mistakes – as possible, and without any pauses (Brickenkamp & Zillmer, 1998:8-9). The ability to

centralise one stimulus/fact, whilst neglecting cognisance of competing non-target letters is demonstrated though this test. Selective attention processes are also necessitated to successfully complete the test since the letters "d" and "p" are not only orthographically similar, there are also numerous non-target letters ("d" letters with more or less than two dashes, and "p" letters with any number of dashes) (Brickenkamp & Zillmer, 1998:1 & 3). Visual perceptual speed and concentrative abilities are therefore reflected through the performance of this test (Brickenkamp & Zillmer, 1998:4).

Compared to other attention tests, the d2 Test exhibits benefits in that it is terse; cost-effective; easy to administer; renders extensive instruction unnecessary; effective for large age-ranges, and individual or group settings alike – the latter applies to this study – in addition to the possession of good psychometric qualities (Wassenberg *et al.*, 2008:197). If a participant does not achieve an acceptable passing score in the d2 Test, it can indicate that the individual has a hindered ability to concentrate, including hindrances to averting distractions. Based on the reactions to the different visual stimuli, the test measures processing speed, rule compliance, and performance quality; thus allowing for individual attention and mental concentration performance evaluation (Brickenkamp & Zillmer, 1998:3).

Described below and in table 3.2, several measures of each participant's attention are assessed and scored based on:

1. Total number of items processed (TN), a highly reliable measure of processing speed;
2. Errors of omission (O);
3. Errors of commission (C);
4. Total errors (E);
5. Percentage of errors (E%), measures the qualitative aspects of performance;
6. Total correctly processed (TN-E), as an indication of the implications of the combined speed and accuracy scores for attentional and inhibitory control; and
7. Concentration performance (CP).

Table 3.2: Abbreviations, Descriptions and Calculation of d2 Test Measures

Standard Abbreviations	Description of Measures	Calculation
TN	Total number of items processed	Sum of all items processed before the final cancellation of each trial
O	Errors of omission	Sum of number of target symbols not cancelled
C	Errors of commission	Sum of number of non-target symbols cancelled
E	Total errors	Sum of all errors of omission and commission
E%	Percentage of errors	Total number of errors divided by the total number of items processed
TN-E	Total correctly processed	Total items processed minus total errors made
CP	Concentration performance	Total number of correctly cancelled minus total number of incorrectly cancelled

Criterion, construct and the predictive validity and reliability of the d2 test are well documented amongst children aged 7 years and older (Bates & Lemay, 2004; Wassenberg *et al*., 2008; Gallotta *et al*., 2012; Van Dijk, De Groot, Savelberg, Van Acker & Kirschner, 2014). According to Gallotta *et al.* (2012:552), the range of the test reliability was between 0.95 and 0.98, and the validity co-efficient was 0.47 (Brickenkamp & Zillmer, 1998:17-18, 21). Wassenberg *et al.* (2008:200) affirmed that the reliability and validity of the d2 Test were reported to be good. Specifically, internal consistency of the total number of items processed ranged from 0.84 to 0.98 in different studies, test-retest reliability was 0.87 in a group of students retested after 6 months, and construct validity was supported in a factor analytic study in which the d2 Test was compared with other tests of selective attention (Brickenkamp & Zillmer, 1998:17-23). Reliability and validity have also been established in children: internal consistency of TN was 0.93 in a study of 9 to 16-year-old German children with deviant behaviour; test-retest reliability was 0.75 in 18 German adolescents with behaviour problems when they were retested after 4 months; and significant correlations of medium to high effect size were found between d2 Test and Tower of London performance in a study of American children with ADHD. The Tower of London is a modified version of the Tower of Hanoi. Tower tasks are typical measures of planning and organisation which has been associated with prefrontal functioning in adults and has been quite extensively used in children. Performance on the task is assessed by task difficulty, which distinguishes the performance of children from 5 to 8 years of age, to that of young adults (De Luca & Leventer, 2010:32).

Bates and Lemay (2004:394) stated that to examine the construct validity of pre-established performance scores, intercorrelations among d2 scores should be determined, and their relatedness to other measures of neuropsychological functioning analysed. Subsequently, two overall d2 performance measures, TN-E and CP, were strongly correlated with TN (r = 0.95 and 0.72, respectively) and were more moderately correlated with E (r = -0.32 and -0.65, respectively) in a large U.S. college sample (Brickenkamp & Zillmer, 1998). Furthermore, the test provides a comprehensive list of norms in accordance with age, gender and education. For the present study, only the concentration performance (CP) and percentage of errors (E%) was utilised for measuring attention. The following sub-section describes the measurement of AP utilised for data collection in the present study.

3.5.2 Academic Performance

According to Gray *et al.* (2017:19), academic achievement can be determined though standardised tests of achievement or classroom performance measures. This includes measures of standardised achievement test scores in subject areas such as Literacy and Numeracy; classroom performance test scores or other formal assessments generally measured at the end of a school term or after a certain amount of the curriculum has been taught (Rasberry *et al.*, 2011:S12; Rasmussen & Laumann, 2013:947). The measurement of classroom performance used for the present study were class tests and grades. Details pertaining to the latter are provided next.

3.5.2.1 Classroom Performance, School Tests and Grades

Classroom performance is comprised of several operational indices; namely grades, grade point averages (GPA) and school dropout, in addition to teacher ratings of AP within a classroom environment. It is considered to be a suitable measure of AP, as it contains greater ecological validity than standardised achievement (Langberg, Molina, Arnold, Epstein, Altaye, Hinshaw, Swanson, Wigal & Hechtman, 2011:521); however, it is also predisposed to teacher subjectivity and/or bias (Hoge & Coladarci, 1989:297). School tests and grades are nationally performed tests and classroom performance measures evaluating the AP of South African learners in the General Education and Training Band. In co-operation with the participating schools, the end of year academic

results as recorded in the Internal Progression Schedule: Intermediate Phase, as well as learner's report cards, were utilised to measure AP.

As previously described in Chapter 2, South Africa's academic scale of achievement ranges from level 1 (very poor) to 7 (excellent), with the level 4 in one official Home Language and level 3 in the remaining subjects representing a passing grade (South Africa, 2013:15-17). For the purposes of this study, the average score of only four academic subjects as per the end of year school results was used for final data analysis. This score is representative of the average level achieved by the learner in each of the following four subjects; namely Home Language, Additional Language, Mathematics and Life Skills.

For the first cross-sectional survey, the end of year results from the fourth-grade learners were collected at the beginning of the year in 2015; therefore, the results of the third-grade year were received. For the second cross-sectional survey, the end of year results from the fourth-grade learners were collected in the beginning of the year in 2016.

Originally, results of the ANA scores were intended for use as a measure of AP in the current study; however, due to most of the schools not conducting the ANAs, it was decided that this would be excluded from the final data analysis. In 2015, the ANAs were not conducted in many schools in SA due to opposition from teacher unions, and since then, it has been suspended indefinitely (Gerber, 2017). Hence only, the end of year academic results, as described above, were used. The two assessment phases of this study [Baseline (T1) and Mid Follow-Up (T2)] was filled with school-based interventions. The following section describes the school-based interventions implemented in the present study.

3.6 SCHOOL-BASED INTERVENTIONS

A compilation of setting-specific interventions was designed and developed by the DASH research team from Nelson Mandela University and the University of Basel, incorporating four focal elements, specifically: a PA intervention; a health and hygiene

education intervention; a nutrition intervention and a medication/deworming treatment intervention. These interventions were planned at the onset of the study and were subsequently devised from the first cross-sectional survey's findings and were implemented during the third term of the 2015 school academic year, for a period of ten weeks (July – mid-September).

A two-day workshop was conducted for the relevant school principals, Grade 4 teachers and school volunteers in June 2015, prior to the implementation of the interventions. The workshop enabled these role-players to become acquainted with the interventions and to facilitate successful and effective implementation. The first day of the workshop comprised of both the health education and nutrition interventions and was primarily theoretically-based. The second day comprised of only the PA intervention but was both theoretically- and practically-based, with the practical component including experiences of selected aspects of the PA manual and lessons. A qualified PE teacher assisted with the presentation and demonstration of the PA lesson plans.

Furthermore, the venue was arranged to exhibit, and present posters related to the various interventions. Those attending were educated on several aspects pertaining to the various interventions which will be discussed later in this section, examples of which can be seen in Appendices 10 to 18. The workshop concluded with a feedback session to resolve any uncertainties pertaining to the interventions.

All necessary intervention material and equipment required by the relevant schools were sourced and provided by the DASH project. Teachers were presented with the various intervention manuals at the workshop; whereas materials such as posters and charts, sports and hand-washing equipment were delivered to the schools on the first day the intervention was implemented. The following sub-section provides detail pertaining to the PA intervention implemented in the present study.

3.6.1 Physical Activity Intervention

The PA intervention included two PA lessons per week, one dance-to-music lesson per week, short activity breaks between lessons, and PA homework for the learners.

In addition, a PA-friendly environment was created through the implementation of playground murals (painted games), to encourage learners to play and be active during the school's recess times and after school. The relevant schools were provided with all the sports equipment needed for the implementation of the PA intervention; namely 20 x bean bags, 40 x colour bands (10 x each of the colours red, green, blue and yellow), 20 x hoola hoops (in the colours red, green, blue and yellow), 20 x skipping ropes, 8 x relay batons, 50 x field marking cones, 5 x netball balls, 5 x soccer balls, 20 x tennis balls, 1 x stopwatch and whistle. Further details of the intervention are described below.

3.6.1.1 PA Lessons

Firstly, a PA manual was compiled by the research team containing information pertaining to PA; the importance and benefits thereof; PA recommendations for children; methods to manage large numbers of learners; safety guidelines; and 20 PA lessons which were performed twice weekly for ten weeks (for an example, refer to Appendix 4a). One lesson was approximately 40 minutes in duration, which is consistent with universal PA recommendations for children (Centers for Disease Control and Prevention, 2015; World Health Organization, 2017b) and the standardised national school curriculum requirements for PE in the Intermediate Phase (South Africa, 2011:10).

During the first week of the intervention, facilitation of a demonstration lesson was performed at the relevant schools by a qualified and experienced PE teacher. Thereafter, to encourage and ensure effective implementation of the PA intervention, experienced PE assistants from Nelson Mandela University assisted the teachers with the teaching of one PA lesson per week, with the understanding that teachers would conduct the second lesson independently. These teachers required considerable support for the PA lessons and were taught simple class management techniques and were supported by a trained PE teacher-coach on a weekly basis. The PE teacher-coach would teach the first part of the lesson and would then assist the teacher who taught the rest of the lesson. The structured format of the lesson plan follows:

❖ Introduction and Warm-Up (5 – 10 minutes)

The introduction and warm-up component involved low-to-moderate intensity aerobic and muscular endurance activities. To promote flexibility, dynamic stretches were also included in the introduction and warm-up. Examples of activities include whistle freeze and traffic lights.

❖ Fitness Component (10 – 15 minutes)

This component comprised of cardiorespiratory endurance; muscular strength and endurance; aerobic, resistance, neuromotor exercises, and elements of various sporting codes. Examples of activities include team relays and running circuits.

❖ Modified Invasion Game (10 – 15 minutes)

Modified invasion games are time-restricted team games with the nature and primary purpose of resolving a problem and successfully invading the opposition's territory. These games are highly strategic and provide numerous transferable skills. Invasion games are sport-based and tailored to compensate for the age, size, skill, ability and experience of the individuals playing them (Webb & Pearson, 2008). Activities integrated included adapted netball, soccer, track and field athletics, and indigenous or community games (South Africa, 2011:27). Examples of activities include piggy in the middle and robbing the nest.

❖ Cool-Down and Stretches (5 – 10 minutes)

The cool-down and stretching component followed the above components and incorporated low-to-moderate intensity aerobic and muscular endurance activities. The purpose of this component was to enable the heart rate and blood pressure to gradually recover, and to facilitate metabolic waste product removal from the muscles utilised during the more intense components.

3.6.1.2 Aerobic Dance-to-Music Lessons

The aerobic dance-to-music lessons were designed to integrate topics from compulsory study areas of the creative and performing art forms within the Life Skills subject, followed by a cool-down component. The dance lessons were conducted by student-dancers from Nelson Mandela University and were presented after school to

the entire grade (ranging from 80 to 160 learners at one time), once weekly, for a duration of 40 minutes. The lessons were structured to contain a fast-paced dance to form the warm-up component, followed by an aerobic dance-to-music sequence as the main component, and concluded with a slow-paced routine to music for the cool-down component. Music was utilised not only as a compulsory study area, but also to capture the learners' attention and for enjoyment purposes. The short, intermittent activity breaks and PA homework are described below.

3.6.1.3 Activity Breaks and Physical Activity Homework

Activity breaks, which comprised of two- to three-minute activities, were conducted by the teachers and performed two to four times daily between lessons to assist learners in regaining concentration and attention during class. Teachers also instructed learners to perform PA homework, which was to be completed at leisure, outside of school. As learners were expected to perform PA homework unsupervised, to promote adherence, constant encouragement and motivation was provided by the teachers. Charts and posters for the activity breaks and PA homework were supplied, demonstrating the various activities (for an example, refer to Appendix 4b). These materials were displayed against the walls on the inside of the classrooms to enable quick and easy access for the activity breaks; and teachers were expected to select two to four activities daily for the PA homework as well. The creation of a PA friendly environment is described below.

3.6.1.4 PA-Friendly Environment

Lastly, for the creation of a PA-friendly environment at schools, school playgrounds were adapted to promote PA and encourage learners to play and be active during recess and after school. Various activity stations (for example, balance beams, jungle gyms, monkey bars and tyre obstacles) were constructed and several playground murals were painted around the schools' premises (for an example, refer to Appendix 4c). The following sub-section describes the health and hygiene education intervention implemented in the present study.

3.6.2 Health and Hygiene Education Intervention

One or more types of helminthic and intestinal protozoa infections were found in 60% of learners after the first cross-sectional survey. Subsequently, owing to the elevated level of parasitic infections found, the health and hygiene education intervention was devised to promote and increase awareness of health and hygiene amongst the learners. Teachers were provided with a health and hygiene education manual comprising of lessons (for an example, refer to Appendix 4d) and activity tasks to be completed by the learners (for an example, refer to Appendix 4f), as well as health promoting charts and posters (for an example, refer to Appendix 4e) for seven health and hygiene education topics designed and developed for implementation at the relevant schools. In addition, the relevant schools were provided with hand-washing materials needed for the implementation of the health and hygiene education intervention; namely a basin and liquid soap. The sequentially structured lesson plans of the health and hygiene education intervention follow below:

- Lessons 1 and 2: Intestinal Parasites

  This was comprised of two lessons pertaining to the mechanisms and reasons involved in attaining parasite infections, the location sites of parasites and infection preventing techniques and methods (for example, drinking clean water; washing hands before and after eating, as well as after using the toilet; and wearing shoes when walking on soil).

- Lesson 3: Hand-Washing Hygiene

  This lesson aimed to promote and encourage healthy and regular hand-washing habits, as well as to raise awareness and prevent the spread of germs from unclean hands. The lesson included proper hand-washing techniques prior to preparing food and eating; and after playing outside, sneezing and coughing, and urination and defecation. Additionally, teachers were provided with hand-washing materials such as washing basins and liquid soap and were expected to monitor and remind learners to wash their hands.

- Lessons 4 and 5: Little Toilet Experts

  This was comprised of two lessons encompassing information about the varying types of toilets and the prevention of parasitic infections. An activity task was

included herein, whereby learners inspected and assessed home and school toilets to establish whether they were in a satisfactory condition.

- Lesson 6: Detecting Germs

  This was to increase awareness of germs and the occurrence thereof within the home and school.

- Lesson 7: Clean Water and Food

  This lesson comprised of the safe handling, storage and preparation of raw fruits and vegetables to promote, encourage and increase awareness thereof.

Furthermore, three schools participating in the study formed part of the health and hygiene intervention group. Of these three schools, two schools had received newly renovated ablution facilities, funded by the Department of Education; and one school required an upgrade. Subsequently, the DASH project was instrumental in and undertook the upgrading of the third school's ablution facilities, prior to the implementation of the intervention phase and in support of the health and hygiene education intervention. The following sub-section describes the nutrition intervention implemented in the present study.

3.6.3 Nutrition Intervention

In support of the NSNP programme, a nutrition intervention was devised to complement the system already in place. The nutrition intervention comprised of three components, specifically: (i) the evaluation of the NSNP; (ii) weekly lesson plans; and (iii) a supplementation programme. During the first cross-sectional survey and prior to the implementation of the interventions, an evaluation of the NSNP was performed at all eight schools participating in the study. The food preparers from all participating schools were interviewed and observed by a qualified and experienced dietitian. The purpose of this was to assess the facilities, health and hygiene practices, as well as the procedures involved and followed in the preparation, cooking and distribution of food to the learners. This was considered essential, as the food preparers had never undergone any training in an official capacity relating to catering or basic health, hygiene and safety practices. Interviews and observations performed at all the

participating schools also highlighted that basic kitchen utensils were in short supply and that the same utensils were used for the preparation of meat and vegetables.

The DASH team took into consideration all these challenges; and consequently, a training workshop was arranged for the food preparers to assist in alleviating some of the challenges faced. A qualified and experienced dietitian conducted the training workshop which comprised of basic health, hygiene and safety practices involved in food preparation, handling and catering; specifically, hand-washing hygiene when preparing food, raw and cooked foods separation, separate cutting board utilisation for raw and cooked foods, utensil washing between various dishes, and washing of raw fruits and vegetables prior to use or consumption. In addition, basic cooking utensils (knives and cutting boards) were donated to the schools.

Furthermore, teachers were provided with a nutrition manual comprising of lessons (for an example, refer to Appendix 4g) and activity tasks to be completed by the learners (for an example, refer to Appendix 4i), as well as healthy nutrition promotion charts and posters for display in classrooms (for an example, refer to Appendix 4h), for six nutrition topics designed and developed for implementation at the relevant schools. These topics, aimed at promoting and encouraging healthy eating habits, included the importance of fruits and vegetables, the nutrient information and content of food, and the importance thereof, as well as the importance of a well-balanced meal and recommended portion sizes. The sequentially structured lesson plans of the nutrition intervention follow below:

❖ Lesson 1: Eat Well

This lesson comprised of the various food groups, specifically fruits and vegetables; carbohydrates; proteins; fats, sugar and salt. A crossword puzzle activity task was included, in which learners had to solve clues pertaining to the lesson to fill in the blank grid.

❖ Lesson 2: Fruits and Vegetables

This entailed the importance of consuming fruits and vegetables daily, their functions, as well as the various benefits they provide.

❖ Lesson 3: Carbohydrates

This lesson focused on the importance, benefits, and favourable sources of carbohydrates, as well as the emphasis that it is the foundation of most meals.

❖ Lesson 4: Protein

This involved the various types of protein, its functions and benefits. A crossword puzzle activity task was also included.

❖ Lesson 5: Fats, Sugar and Salt

This lesson comprised of the various types of fat, specifically good and bad fats, and which is better to consume. Additionally, foods with a high sugar and salt content and the detrimental effects of consuming these in excessive amounts were also highlighted.

❖ Lesson 6: Lunch-Box and Plates

This summary lesson, aimed at reviewing the preceding lessons, comprised of the various food groups and guidelines of how to make up a food plate with the appropriate portion sizes. Learners were also educated on healthy lunch-box options, in addition to selecting healthy choices when purchasing food from the school tuck-shop and vendors.

Lastly, the nutrition intervention provided learners at all the relevant schools with a UNICEF approved nutritional supplement. The RUSF (Ready to Use Supplementary Food) is a nutrient-dense supplement with low water activity, and is safer to use in comparison to other conventional supplements, especially in developing countries where challenges of clean water and optimal storage exists (Steenkamp, Lategan & Raubenheimer, 2015:323). These supplements, packaged in a sachet, are typically comprised of a peanut butter base in vegetable oil with added protein, vitamins and minerals. Learners received one sachet at the beginning of every school day and were to consume it slowly over a time-period of 30 minutes. The following sub-section describes the medication/deworming treatment intervention implemented in the present study.

3.6.4 Medication/Deworming Treatment

Based on the results of the laboratory testing from the first and second cross-sectional survey performed in February to March and October 2015, respectively; medication/deworming treatment for soil-transmitted helminth infections (STH) were distributed amongst all the affected learners, in accordance with the World Health Organization's treatment guidelines (World Health Organization, 2006:10-25,41).

3.7 DATA COLLECTION PROCEDURES AND TESTING PROTOCOL

Prior to the commencement of any data collection, authorisation to conduct the larger study, as well as the present study, was sought and granted from the following committees (refer to Appendices 3a to 3e):

- Nelson Mandela Metropolitan University Research Ethics Committee: Human (reference number: H14-HEA-HMS-002; acquired 04 July 2014)
- Ethics Committee Northwest and Central Switzerland (EKZN) (reference number: 2014 – 179; acquired 01 August 2014)
- Eastern Cape Department of Education (acquired 13 August 2014)
- Eastern Cape Department of Health (acquired 07 November 2014)
- Nelson Mandela Metropolitan University Faculty Postgraduate Studies Committee (FPGSC) (reference number: H15-HEA-HMS-009; acquired 01 September 2015)

3.7.1 Research Assistants

To facilitate data collection, given the sample size, research assistants were required to support the test administration, in conjunction with the researchers. The research assistants recruited included Grade 4 teachers and volunteers from the specific schools, as well as students sourced and appointed from Nelson Mandela University.

Both the Grade 4 teachers and university students assisted with management and supervision of the learners; whereas the Nelson Mandela University students assisted with not only the management and supervision, but also with the test administration. A one-day training workshop was conducted with the research assistants to communicate all necessary information and instructions, as well as to clarify any uncertainties pertaining to the measurements and tests involved. This was to provide clarification and/or support to the learners prior to test administration, in addition to assisting in the reduction of errors and inaccuracy during test administration for increased overall efficiency. The following sub-section further elaborates on the data collection procedures followed in this study.

3.7.2 Data Collection

Data collection for the first cross-sectional survey in the study occurred from February to March 2015, and the second cross sectional survey from September to October 2015. Since the present study functions within the scope of another larger study comprising of clinical and physical component assessments, two days of testing were scheduled at each school and were performed during the school's operational hours, commencing at approximately 08h30 and ceasing at 14h00. On data collection days, the research team arrived at the scheduled location at 08h00 and prepared a classroom for testing.

The first day entailed clinical assessment components; namely anthropometric and psychosocial measurements, parasitological screening and PA level questionnaires. The second day entailed the PF component assessments; namely cardiorespiratory endurance, body strength, flexibility, co-ordination and speed. Due to the length of the psychosocial assessment and depending on the rate at which it was completed, the d2 Test of Attention assessment pertaining to this study was conducted on both days, as this was attached to the end of the psychosocial assessment. Prior to testing commencement, all protocols and procedures were explained and demonstrated to the participants at each testing station to facilitate efficient operation throughout the day.

For conducting and collecting the d2 Test of Attention, trained assistants accompanied the researcher to all data collecting sites. The test was administered by the researcher, wherever possible; however, in schools where isiXhosa was the preferred language, a trained assistant conducted the test. For AP data, since only the Internal Progression Schedule: Intermediate Phase necessitated collection at the relevant schools, the researcher obtained this unaccompanied.

Data capturing procedure: All data was double-entered and cross-checked with Epi-Data 3.1 (EpiData Association; Odense, Denmark); then exported into a single database using Microsoft Excel version 1805, prior to statistical analysis. The following section describes the statistical analysis methods utilised post-data collection for the present study.

3.8 STATISTICAL ANALYSIS

Statistical analyses were performed using Microsoft Excel 2010 and the statistical software package, Statistica version 13. To assess the impact of the various interventions on attention and AP, the statistical techniques employed for this study are as follows:

i. To increase accuracy and minimise error, the data set was screened, and a double-entry of all data was performed.
ii. To describe and analyse attention and AP scores, descriptive statistics such as measures of central tendency (mean and median), as well as measures of distribution (range and standard deviation) were utilised. If normally distributed, attention and AP were characterised by mean and standard deviation; otherwise, by median and inter-quartile range.
iii. In addition, to assess the impact of the various interventions between control and experimental groups in respect of pre- and post-test results, inferential statistical techniques such as analysis of variance (ANOVA), analysis of covariance (ANCOVA) and post-hoc analysis were utilised, where appropriate. Pearson Product Moment correlations were calculated to determine the relationship between the various interventions and attention and AP.

iv. Where reference is made to significant differences, this indicates a statistical significance ($p < .05$). Practical significance by means of Cohen's d test was applied where statistically significant differences existed, where $d > 0.20$. Chi square (Chi^2) and Cramer's V tests - where $V > 0.10$ for 1 degree of freedom, were also used to determine significant statistical and practical differences between categorical variables respectively.

For accurate analysis and interpretation of the data obtained, a qualified statistician based at Nelson Mandela University was consulted. The following section describes the ethical considerations applied in and relative to the present study.

3.9 ETHICAL CONSIDERATIONS

Consideration of ethical concerns are fundamental to the manner in which research is conducted (Christensen, 1997:129). Ethics is a collection of moralistic principles, proposed by an individual or group, that is subsequently universally recognised, and which govern the rules and behavioural expectations of experimental researchers, employers, sponsors, assistants and participants. These ethical principles serve as standards by which the researcher evaluates his or her conduct (Strydom, 2011a:114), and guides the researcher in making the most appropriate decisions (Christensen, 1997:129).

Since social sciences studies deals with humans, and often children (Thomas *et al.*, 2005:88), unique ethical issues arise, that would be irrelevant in pure, clinical laboratory settings of the natural sciences (Strydom, 2011a:113). Therefore, it is imperative that the researcher is concerned with, and takes into consideration, any circumstances in the research environment that could harm the participants (Thomas *et al.*, 2005:88), especially since the current study in PA, attention and AP necessitates the participation of children. The ethical considerations specifically pertaining to this study are as follows:

- Protection of human participants and avoidance of harm: Fundamentally, the researcher had to ensure that participants were not subjected to any physical or emotional harm and/or discomfort (Thomas *et al.*, 2005:88); and hence, general health, welfare and safety was preserved (Christensen, 1997:150). The study

needed to exhibit maximum benefits to society, as well as the participants; and therefore, minimise and outweigh the risks involved (Cozby, 2004:36). Under no circumstances were the participants in any form of danger, humiliation, unfair treatment, nor were they negatively affected in any way. The participants were always well informed, and all information was treated and kept private and confidential.

- Voluntary participation and informed consent: All participants have non-participation rights (Thomas *et al.*, 2005:88) and permission was acquired using a written consent form and information sheet (refer to Appendices 2a and 2c), or an oral assent form (refer to Appendix 2b) which provided all the necessary information regarding the study, specifically the purpose, objectives, significance, research procedures and ethical principles to enable an informed decision regarding participation. All necessary information pertaining to the study was communicated in detail to the parents/legal guardians at a comprehensive information meeting conducted at all the involved schools to allow for comprehension regarding the processes of the testing and study. Time was allocated to clarify any uncertainties and concerns pertaining to the study. For illiterate parents, the information sheet was read aloud and, if necessary, an oral translation of the information sheet into the local languages was provided. Project coordinators first contacted the school's authorities. Subsequently, school principals and teachers of the selected schools were informed about the objectives, procedures, potential risks and benefits of the study. If requested, participants had the right to withdraw or decline participation, without penalty, once information regarding the study had been revealed. Although a consent form was signed by the parents/legal guardian authorising participation, children also provided oral assent prior to commencing the study (Strydom, 2011a:117-118).

- Violation of privacy, anonymity and confidentiality: The researcher has a responsibility of limiting distribution of each participant's identity and any other personal information irrelevant to the study (Strydom, 2011a:119-121). Hence, certain protocols need to be adhered to, such as informing the participants of all individuals who have access to the information. The personal information of the children will remain anonymous by means of an encrypted ID-number and all data

obtained will be used exclusively for scientific research. Records of the studies will remain confidential and to maintain confidentiality, the primary investigators will keep records in secured cupboards. After 5 years, these records will be destroyed. Data entered into computerised files will be accessible only by authorised investigators directly involved in the study.

- Actions and competence of researchers: For successful execution of the study, it was necessary that researchers be competent, experienced, honest and sensitive to the participants' dignity (Strydom, 2011a:123). Acknowledgement of responsibility was a key aspect involved (Thomas *et al.*, 2005:88). To obtain cooperation from everyone associated with the study, researchers had to present themselves in an ethically correct manner, as well as be aware of and respect the ethical guidelines throughout the duration of the study. The researchers had to ensure the accuracy and completeness of the data reported in the study and had to timeously submit the required progress and final reports, as indicated by Strydom (2011a:123). Ethics regarding plagiarism, fabrication and falsification of data included acknowledging authors and sources from the data researched and used, as well as no manipulation or creation of false data, as indicated by Thomas *et al.* (2005:79). For the present study, the researcher has acknowledged and given reference to the authors and/or writers by paraphrasing words or ideas that were not presented as the individual's own.

In the above chapter, the research methodology, specifically the research design; participants and sampling technique; data verification methods; measuring instruments; school-based interventions; school grouping with the relevant intervention allocation; data collection procedures and testing protocol; statistical analysis techniques; and ethical considerations applied to accomplish the aims and objectives outlined in Chapter 1, have been thoroughly discussed. The following chapter provides a detailed description on the results obtained from the present study.

CHAPTER 4
RESULTS

4.1 INTRODUCTION

The aim of this study was to explore, describe and compare the effects of various combinations of school-based interventions [physical activity (PA), health and hygiene education (HHE) and nutrition (N)] on the attention and AP of primary schoolchildren from lower socioeconomic communities in Port Elizabeth. Chapter 4 presents the results and main findings of the study. For this purpose, the measures utilised included the learners' performance on the d2 Test of Attention and AP in Home and Additional Languages, Mathematics and Life Skills. These measures provided objective information on the cognitive performance of the learners.

4.2 PARTICIPANT INFORMATION

In this section, the participant information measured in the study is reflected separately for the entire sample. It starts with age and gender, then concludes with ethnicity. A total of 857 schoolchildren, between 8 – 13 years of age, participated in the study.

4.2.1 Age

The frequency distribution of the participants according to age categories at baseline (T1) is presented in Table 4.1 for experimental schools (E1 – E4) and control schools (C1 – C4).

Table 4.1: Frequency Distribution by Age for Experimental and Control Schools

School	Age Category T1				Total	
	8 - 9 Years		10 - 13 Years			
E1	60	69%	27	31%	87	100%
C1	89	86%	14	14%	103	100%
E2	75	74%	26	26%	101	100%
C2	67	83%	14	17%	81	100%
E3	53	31%	120	69%	173	100%
C3	42	49%	43	51%	85	100%
E4	40	47%	45	53%	85	100%
C4	88	62%	54	38%	142	100%
Total	514	60%	343	40%	857	100%

For both the experimental and control schools, the younger age category (8 - 9 years old) represents the highest age frequency and constitutes 60% of the participants; whereas the older age category (10 – 13 years old) represents the lowest age frequency and constitutes 40% of the participants. Experimental schools (E1 and E2) and control schools (C1, C2 and C4) had the highest number of participants in the younger age category and the lowest number in the older age category; whereas experimental school (E3) had the highest number of participants in the older age category and the lowest in the younger age category. Conversely, control school (C3) and experimental school (E4) exhibited an almost even distribution of participants in both age categories.

4.2.2 Gender

The gender distribution within the experimental and control schools is displayed in Table 4.2.

Table 4.2: Frequency Distribution by Gender for Experimental and Control Schools

School	Gender				Total	
	Males		Females			
E1	37	43%	50	57%	87	100%
C1	51	50%	52	50%	103	100%
E2	52	51%	49	49%	101	100%
C2	37	46%	44	54%	81	100%
E3	91	53%	82	47%	173	100%
C3	43	51%	42	49%	85	100%
E4	47	55%	38	45%	85	100%
C4	76	54%	66	46%	142	100%
Total	434	51%	423	49%	857	100%

Table 4.2 shows the almost even gender distribution between the experimental and control schools, whereby the proportion of males was 51% and females was 49% for the whole group. Similarly, for individual schools, there was generally an even split with E1 exhibiting the biggest difference (43% versus 57% for males and females, respectively).

4.2.3 Ethnicity

The distribution of the two ethnic groups participating in the study is shown in Table 4.3.

Table 4.3: Frequency Distribution by Ethnicity for Experimental and Control Schools

School	Ethnicity				Total	
	Black		Coloured			
E1	87	100%	0	0%	87	100%
C1	103	100%	0	0%	103	100%
E2	65	64%	36	36%	101	100%
C2	44	54%	37	46%	81	100%
E3	1	1%	172	99%	173	100%
C3	0	0%	85	100%	85	100%
E4	85	100%	0	0%	85	100%
C4	141	99%	1	1%	142	100%
Total	526	61%	331	39%	857	100%

Table 4.3 illustrates the ethnic distribution in which 61% were black learners and 39% were coloured learners. Ethnicity and the geographical location were criteria for the pairing of the schools. The experimental and control schools were match-paired with children of similar ethnicities. However, two schools (E2 and C2) had a combination of both ethnic groups and were match-paired for this reason.

4.3 COMPARATIVE RESULTS FOR THE INTERVENTION COMPONENTS

To compare the experimental and control groups in respect of pre- and post-test results, inferential statistics were employed. ANOVA and ANCOVA were used to determine whether observed mean differences were statistically significant, and post-hoc analyses were conducted to determine which two means differed significantly. Furthermore, where statistical significance was identified for numerical variables, practical significance by means of Cohen's d tests were applied. Chi-square (Chi^2) and Cramér's V tests were also used to determine significant statistical and practical differences between categorical variables, respectively. Statistical significance was set at $p < .05$ and a practical significance was interpreted according to the following: for Cohen's d ($d < 0.2$ = no significance; $d = 0.20 – 0.49$ small; $d = 0.50 – 0.79$ medium and $d > 0.80$ large) and Cramér's V ($V = 0.1 – 0.29$ small; $V = 0.3 – 0.49$ medium and $V =$ or > 0.5 large) (Gravetter & Wallnau, 2011:253 & 586).

In the section to follow, the results are reported according to the objectives of the study, as described in Chapter 1. Tables are employed to display the results, together with a brief explanation of the tables. Before the various interventions are compared, descriptive statistics for the entire sample from pre-intervention (T1), post-intervention (T2), as well as pre- to post-intervention differences (D2-1) are provided. Where interventions are compared, the values highlighted in red represent results that showed significant differences, both small and large.

4.3.1 Overall Comparison of the Intervention Components Regarding Attention and Academic Performance Variables

Table 4.4 provides the descriptive statistics of the entire sample for pre-intervention (T1) and post-intervention (T2), as well as pre- to post-intervention differences (D2-1) for the assessed variables, namely attention [percentage of errors (E%), total performance (TN-E) and concentration performance (CP)]; and academic performance, namely end of year results (EoYR). Regarding the percentage of errors, a lower percentage of errors score reflects better accuracy, quality of work and degree of carefulness (Brickenkamp & Zillmer, 1998:1).

Table 4.4: Descriptive Data for Pre- (T1), Post- (T2) and Pre- to Post-Intervention Differences (D2-1) for the Total Sample (n = 857)

Variable	Mean	S.D.	Minimum	Quartile 1	Median	Quartile 3	Maximum
Pre-Intervention (T1)							
E% T1	17.09	12.72	0.00	6.29	14.10	25.57	70.65
TN-E T1	185.00	57.21	10.00	151.00	182.00	214.00	448.00
CP T1	53.50	30.12	-60.00	35.00	56.00	73.00	153.00
EoYR T1	4.22	1.50	1.00	3.25	4.25	5.25	7.00
Post-Intervention (T2)							
E% T2	13.45	13.04	0.00	3.60	8.27	20.30	60.10
TN-E T2	218.26	58.14	4.00	185.00	218.00	254.00	754.00
CP T2	72.36	35.41	-54.00	55.00	78.00	96.00	153.00
EoYR T2	3.99	1.13	1.00	3.50	4.00	4.75	7.00
Pre- to Post-Intervention Differences (D2-1)							
E% D2-1	-3.63	11.42	-62.10	-9.42	-3.42	1.61	49.41
TN-E D2-1	33.26	54.45	-244.00	8.00	39.00	65.00	464.00
CP D2-1	18.86	26.26	-94.00	6.00	21.00	34.00	133.00
EoYR D2-1	-0.22	1.40	-5.00	-1.00	0.00	0.75	3.50

As indicated in Table 4.4, two of the attention variables [total performance (TN-E) and concentration performance (CP)] revealed an increase from pre- to post-intervention. Conversely, the pre- to post-intervention differences showed a decrease for the percentage of errors (E%) – indicating an improvement in scores, as well as for the end of year results (EoYR), indicating a worse result.

4.3.2 Comparisons Between Experimental and Control Schools Regarding Specific Interventions

In this sub-section, comparisons between each experimental and its control school are referred to separately within the entire sample. It starts with (i) experimental school (E1) receiving the PA intervention only and its control school (C1) with no intervention; (ii) experimental school (E2) receiving the PA and Health and Hygiene Education intervention and its control school (C2) with no intervention; (iii) experimental school (E3) receiving the PA, Health and Hygiene Education and Nutrition intervention and its control school (C3) with no intervention; and concludes with (iv) experimental school (E4) receiving the Health and Hygiene Education and Nutrition intervention and its control school (C4) with no intervention.

The variables measured in this section include age, attention and AP. Details pertaining to mean values, standard deviations and range values are provided. Furthermore, where statistical significance was identified for numerical variables, practical significance represented by Cohen's d values are provided. Chi-square (Chi^2) and Cramér's V tests were also used to determine significant statistical and practical differences between categorical variables, respectively. In order to assist with determining the significance of the impact of the various interventions, the pre- to post-intervention differences are also indicated.

4.3.2.1 School Comparison: PA Intervention (E1) versus No Intervention (C1)

Tables 4.5 and 4.6 illustrate the inferential statistics for comparing two schools, the experimental school receiving the PA intervention only (E1) and its control school (C1) with no intervention, for pre-intervention (T1), post-intervention (T2) and pre- to post-intervention differences (D2-1), respectively; with regards to all the assessed variables, namely age, attention [percentage of errors (E%), total performance (TN-E) and concentration performance (CP)] and academic performance [end of year results (EoYR)].

Table 4.5: Comparison of the Frequency Distribution of Age for E1 and C1 Schools at Pre-Intervention (T1)

School	Age Category T1				Total	
	8 - 9 Years		10 - 13 Years			
E1	60	69%	27	31%	87	100%
C1	89	86%	14	14%	103	100%
Total	149	78%	41	22%	190	100%
Chi²	**d.f.**	**p**	**V**	**Outcome**		
8.48	1	.004	0.21	Small		

Both E1 and C1 schools involved a larger number of participants in the younger age category (8 – 9 years) as opposed to the older age category (10 – 13 years) in T1. However, the Chi² test reported a statistical and practical significant difference ($p = .004$ and $V = 0.21$) between the distribution of age for E1 and C1, indicating that C1 comprised of a significantly larger percentage of younger participants than E1 at pre-intervention.

Table 4.6: Comparison of Attention and Academic Performance between E1 and C1 Schools for Pre- (T1), Post- (T2), and Pre- to Post-Intervention Differences (D2-1)

Variable	School	Mean	S.D.	Diff.	t	p d.f.=188	Cohen's d
Pre-Intervention (T1)							
E% T1	**E1**	12.84	9.01	-2.85	-1.90	.059	n/a
	C1	15.69	11.26				
TN-E T1	**E1**	184.28	37.37	-5.16	-0.85	.394	n/a
	C1	189.44	44.65				
CP T1	**E1**	61.07	20.15	4.08	1.20	.232	n/a
	C1	56.99	25.72				
EoYR T1	**E1**	4.25	0.78	-1.27	-8.77	**<.0005**	**1.28 Large**
	C1	5.52	1.14				
Post-Intervention (T2)							
E% T2	**E1**	10.57	7.47	1.88	1.50	.135	n/a
	C1	8.69	9.45				
TN-E T2	**E1**	222.33	41.76	-14.10	-2.14	**.033**	**0.31 Small**
	C1	236.44	47.92				
CP T2	**E1**	78.62	20.39	-9.07	-2.58	**.011**	**0.38 Small**
	C1	87.69	26.86				
EoYR T2	**E1**	4.37	0.74	0.79	8.23	**<.0005**	**1.20 Large**
	C1	3.58	0.58				
Pre- to Post-Intervention Differences (D2-1)							
E% D2-1	**E1**	-2.27	8.82	4.73	3.99	**<.0005**	**0.58 Medium**
	C1	-7.00	7.50				
TN-E D2-1	**E1**	38.06	42.41	-8.94	-1.45	.148	n/a
	C1	47.00	42.24				
CP D2-1	**E1**	17.55	19.39	-13.15	-4.88	**<.0005**	**0.71 Medium**
	C1	30.70	17.72				
EoYR D2-1	**E1**	0.12	0.70	2.06	16.34	**<.0005**	**2.38 Large**
	C1	-1.94	0.98				

In T1, of the four variables compared in Table 4.6, only the end of year results (EoYR) showed a statistical and practical significant result ($p < .0005$ and $d = 1.28$), with C1 performing significantly better than E1. At post-intervention (T2), significant differences ($p < .05$ and $d > 0.20$) were observed for all the variables, except for the percentage of errors (E%). A small practical significance in favour of C1 was found for total performance (TN-E) ($d = 0.31$) and concentration performance (CP) ($d = 0.38$). However, a large practical significance ($d = 1.20$) in favour of E1 was found for the end of year results (EoYR).

When comparing E1 and C1 in terms of pre- to post-intervention differences (D2-1) for all attention and AP variables, statistical and practical significant differences ($p < .0005$ and $d > 0.50$) were observed for all variables, except total performance (TN-E). The significant differences were in terms of the percentage of errors (E%) ($p < .0005$ and $d = 0.58$) and concentration performance (CP) ($p < .0005$ and $d = 0.71$) revealing a medium practical significance both in favour of C1; as well as the end of year results (EoYR) ($p < .0005$ and $d = 2.38$), which revealed a large practical significance in favour of E1.

4.3.2.2 School Comparison: PA and Health and Hygiene Education Intervention (E2) versus No Intervention (C2)

Tables 4.7 and 4.8 report on the inferential statistics comparing the experimental school (E2) receiving the PA and Health and Hygiene Education intervention and its control school (C2) with no intervention for pre-intervention (T1), post-intervention (T2) and pre- to post-intervention differences (D2-1), respectively; with regards to all the assessed variables, namely age, attention [percentage of errors (E%), total performance (TN-E) and concentration performance (CP)] and academic performance [end of year results (EoYR)].

Table 4.7: Comparison of the Frequency Distribution of Age for E2 and C2 Schools at Pre-Intervention (T1)

School	Age Category T1				Total	
	8 - 9 Years		10 - 13 Years			
E2	75	74%	26	26%	101	100%
C2	67	83%	14	17%	81	100%
Total	142	78%	40	22%	182	100%
Chi²	**d.f.**	**p**	**V**	**Outcome**		
1.88	1	.171	n/a	n/a		

There was a larger number of participants in the younger age category (8 – 9 years) when compared to the older age category (10 – 13 years) in T1. However, the Chi² test did not reveal a statistical difference ($p = .171$) between the distribution of age for E2 and C2 at pre-intervention.

Table 4.8: Comparison of Attention and Academic Performance between E2 and C2 Schools for Pre- (T1), Post- (T2) and Pre- to Post-Intervention Differences (D2-1)

Variable	School	Mean	S.D.	Diff.	t	p d.f.=180	Cohen's d
Pre-Intervention (T1)							
E% T1	**E2**	17.70	13.25	3.61	1.97	.051	n/a
	C2	14.09	11.01				
TN-E T1	**E2**	196.44	56.16	-0.89	-0.11	.916	n/a
	C2	197.32	56.27				
CP T1	**E2**	56.31	35.40	-5.62	-1.18	.241	n/a
	C2	61.93	27.24				
EoYR T1	**E2**	4.48	1.25	-1.42	-8.33	**<.0005**	**1.24 Large**
	C2	5.90	1.00				
Post Intervention (T2)							
E% T2	**E2**	13.23	11.65	2.57	1.47	.143	n/a
	C2	10.67	11.75				
TN-E T2	**E2**	219.30	55.82	2.36	0.30	.762	n/a
	C2	216.94	47.37				
CP T2	**E2**	73.16	34.46	-4.55	-0.89	.373	n/a
	C2	77.70	33.62				
EoYR T2	**E2**	4.35	0.97	0.57	3.30	**.001**	**0.49 Small**
	C2	3.78	1.34				
Pre- to Post-Intervention Differences (D2-1)							
E% D2-1	**E2**	-4.47	12.23	-1.04	-0.64	.526	n/a
	C2	-3.42	9.23				
TN-E D2-1	**E2**	22.86	56.08	3.24	0.41	.686	n/a
	C2	19.62	50.44				
CP D2-1	**E2**	16.85	32.90	1.07	0.25	.804	n/a
	C2	15.78	23.08				
EoYR D2-1	**E2**	-0.13	0.81	1.99	13.00	**<.0005**	**1.94 Large**
	C2	-2.12	1.25				

A statistical and large practical significant difference ($p < .0005$ and $d = 1.24$) for the end of year results (EoYR) was found at T1, with C2 representing the larger mean value. A small but significant difference ($p = .001$ and $d = 0.49$) was observed for the end of year results (EoYR) between E2 and C2 for T2, with E2 reflecting the larger value in scores. When comparing E2 and C2 in terms of pre- to post-intervention differences (D2-1) for all the attention and AP variables, only the end of year results (EoYR) showed a statistical and practical significant difference ($p < .0005$ and $d = 1.94$) between the two schools in favour of E2.

4.3.2.3 School Comparison: PA, Health and Hygiene Education and Nutrition Intervention (E3) versus No Intervention (C3)

Tables 4.9 and 4.10 display the inferential statistics comparing the experimental school (E3) receiving the PA, Health and Hygiene Education and Nutrition intervention and its control school (C3) with no intervention for pre-intervention (T1), post-intervention (T2) and pre- to post-intervention differences (D2-1), respectively; with regards to all the assessed variables, namely age, attention [percentage of errors (E%), total performance (TN-E) and concentration performance (CP)] and academic performance [end of year results (EoYR)].

Table 4.9: Comparison of the Frequency Distribution of Age for E3 and C3 Schools at Pre-Intervention (T1)

School	Age Category T1				Total	
	8 - 9 Years		10 - 13 Years			
E3	53	31%	120	69%	173	100%
C3	42	49%	43	51%	85	100%
Total	95	37%	163	63%	258	100%
Chi²	**d.f.**	**p**	**V**	**Outcome**		
8.64	1	.003	0.18	Small		

The Chi² test was conducted to compare the frequency distributions of age for the experimental and control schools and a small statistical significant result (p = .003 and V = 0.18) was found between the two schools. For E3, two thirds of the participants fell within the older age category (10 – 13 years); whereas there was a more even split (49% versus 51%) in the age categories for C3.

Table 4.10: Comparison of Attention and Academic Performance between E3 and C3 Schools for Pre- (T1), Post- (T2) and Pre- to Post-Intervention Differences (D2-1)

Variable	School	Mean	S.D.	Diff.	t	p d.f.=256	Cohen's d
Pre-Intervention (T1)							
E% T1	**E3**	20.78	13.35	-3.68	-1.96	.052	n/a
	C3	24.46	15.83				
TN-E T1	**E3**	173.76	69.52	10.66	1.17	.244	n/a
	C3	163.11	67.65				
CP T1	**E3**	42.91	31.60	6.74	1.60	.110	n/a
	C3	36.16	32.15				
EoYR T1	**E3**	2.88	1.11	-0.65	-4.24	**<.0005**	**0.56 Medium**
	C3	3.53	1.26				
Post Intervention (T2)							
E% T2	**E3**	18.14	15.76	0.15	0.07	.941	n/a
	C3	17.99	15.72				
TN-E T2	**E3**	208.17	64.25	10.16	1.17	.242	n/a
	C3	198.01	67.56				
CP T2	**E3**	62.70	42.26	5.90	1.07	.286	n/a
	C3	56.80	40.51				
EoYR T2	**E3**	3.72	1.38	-0.44	-2.56	**.011**	**0.34 Small**
	C3	4.16	1.16				
Pre- to Post-Intervention Differences (D2-1)							
E% D2-1	**E3**	-2.64	12.95	3.83	2.12	**.035**	**0.28 Small**
	C3	-6.47	14.94				
TN-E D2-1	**E3**	34.41	57.51	-0.50	-0.06	.949	n/a
	C3	34.91	61.90				
CP D2-1	**E3**	19.79	28.67	-0.84	-0.22	.829	n/a
	C3	20.64	30.93				
EoYR D2-1	**E3**	0.84	0.70	0.21	1.92	.056	n/a
	C3	0.64	1.02				

There was a statistical and practical significant difference ($p < .0005$ and $d = 0.56$) between E3 and C3 at T1, only for the end of year results (EoYR), with C3 reflecting the larger mean value. A small but significant difference ($p = .011$ and $d = 0.34$) between the experimental and control schools was observed for the end of year results (EoYR) at T2, with C3 reporting the larger mean value. When comparing E3 and C3 in terms of pre- to post-intervention differences (D2-1) for each of the variables measured, only the percentage of errors (E%) showed both a statistical and practical significant difference ($p = .035$ and $d = 0.28$) in favour of C3.

4.3.2.4 School Comparison: Health and Hygiene Education and Nutrition Intervention (E4) versus No Intervention (C4)

Tables 4.11 and 4.12 indicate inferential statistics comparing two schools, the experimental school receiving the Health and Hygiene Education and Nutrition intervention (E4) and its control school (C4) with no intervention for pre-intervention (T1), post-intervention (T2) and pre- to post-intervention differences (D2-1), respectively; with regards to all the assessed variables namely age, attention [percentage of errors (E%), total performance (TN-E) and concentration performance (CP)] and academic performance [end of year results (EoYR)].

Table 4.11: Comparison of the Frequency Distribution of Age for E4 and C4 Schools at Pre-Intervention (T1)

School	Age Category T1				Total	
	8 - 9 Years		10 - 13 Years			
E4	40	47%	45	53%	85	100%
C4	88	62%	54	38%	142	100%
Total	128	56%	99	44%	227	100%
Chi²	**d.f.**	**p**	**V**	**Outcome**		
4.81	1	.028	0.15	Small		

The Chi² test was performed for comparing the age distribution between the experimental and control schools at pre-intervention and is displayed in Table 4.11. A small statistical and practical significant difference ($p = .028$ and $V = 0.15$) was observed between the two schools. Almost half the participants in E4 formed part of the younger age category (8 – 9 years). Similarly, almost two thirds of the participants in C4 were distributed in the same age category.

Table 4.12: Comparison of Attention and Academic Performance between E4 and C4 Schools for Pre- (T1), Post- (T2) and Pre- to Post-Intervention Differences (D2-1)

Variable	School	Mean	S.D.	Diff.	t	p d.f.=225	Cohen's d
Pre-Intervention (T1)							
E% T1	**E4**	12.90	10.68	-2.67	-1.73	.084	n/a
	C4	15.57	11.52				
TN-E T1	**E4**	191.75	52.92	1.91	0.27	.786	n/a
	C4	189.84	50.59				
CP T1	**E4**	61.79	23.54	3.95	1.06	.288	n/a
	C4	57.84	28.94				
EoYR T1	**E4**	4.10	1.28	-0.11	-0.60	.548	n/a
	C4	4.21	1.35				
Post-Intervention (T2)							
E% T2	**E4**	11.87	12.59	-1.06	-0.63	.533	n/a
	C4	12.92	12.16				
TN-E T2	**E4**	222.85	45.07	-1.43	-0.17	.863	n/a
	C4	224.28	68.38				
CP T2	**E4**	76.34	30.65	3.88	0.86	.389	n/a
	C4	72.46	33.98				
EoYR T2	**E4**	3.95	1.25	-0.22	-1.49	.137	n/a
	C4	4.17	0.99				
Pre- to Post-Intervention (D2-1)							
E% D2-1	**E4**	-1.03	12.90	1.61	1.07	.284	n/a
	C4	-2.64	9.57				
TN-E D2-1	**E4**	31.09	53.55	-3.35	-0.42	.672	n/a
	C4	34.44	59.76				
CP D2-1	**E4**	14.55	26.41	-0.07	-0.02	.982	n/a
	C4	14.63	22.97				
EoYR D2-1	**E4**	-0.15	0.91	-0.11	-0.72	.472	n/a
	C4	-0.04	1.28				

There were no statistical and practical significant differences ($p > .05$) between the E4 and C4 results for all the variables measured at T1 and T2, nor in terms of pre- to post-intervention differences (D2-1), as is evident in Table 4.12.

4.3.3 Univariate ANOVA and ANCOVA Comparisons Between Intervention Components Regarding Attention and Academic Performance

The next sub-section describes the ANOVA and ANCOVA results comparing the attention and AP means in respect of each of the three intervention components applied at pre-intervention (T1), post-intervention (T2) and for pre- to post-intervention differences (D2-1), respectively. The results will be discussed relative to pre- and post-intervention to investigate whether they reflect any significant differences.

Table 4.13: Univariate ANOVA Results: Pre-Intervention (T1) Comparison between the Three Intervention Components regarding Attention and Academic Performance

Effect	F-Value (d.f.= 1; 853)	p	Cohen's d	Mean Values	
Attention – Percentage of Errors (E%)					
Intervention:				**No**	**Yes**
PA	0.94	.332	n/a	16.42	18.00
HHE	0.06	.806	n/a	16.39	18.05
N	0.30	.583	n/a	16.61	18.18
Attention – Total Performance (TN-E)					
Intervention:				**No**	**Yes**
PA	3.03	.082	n/a	186.72	182.64
HHE	5.94	.015	0.02	185.44	184.40
N	8.11	.005	0.13	187.29	179.69
Attention – Concentration Performance (CP)					
Intervention:				**No**	**Yes**
PA	2.76	.097	n/a	55.29	51.03
HHE	1.45	.229	n/a	55.19	51.15
N	5.66	.018	0.21	55.38	49.13
Academic Performance (EoYR)					
Intervention:				**No**	**Yes**
PA	47.41	<.0005	0.68	4.62	3.66
HHE	8.28	.004	0.73	4.65	3.62
N	82.97	<.0005	0.98	4.62	3.28

Table 4.13 indicates that there was a significant relationship ($p = .018$ and $d = 0.21$) in relation to the Nutrition component grouping and concentration performance (CP) at pre-intervention, with those participants not receiving the nutrition intervention performing better than those who did. The other two intervention components showed no significant difference. There was also a significant difference ($p < .05$ and $d > 0.50$)

with AP and all three intervention components in favour of the no intervention component grouping for PA, Health and Hygiene Education and Nutrition.

Table 4.14: Univariate ANCOVA Results: Post-Intervention (T2) Comparison between the Three Intervention Components regarding Attention and Academic Performance

Effect	F-Value (d.f.= 1; 853)	p	Cohen's d	Mean Values	
Attention – Percentage of Errors (E%)					
E% T2	491.97	<.0005	n/a		
Intervention:				**No**	**Yes**
PA	1.34	.247	n/a	12.36	14.94
HHE	0.18	.670	n/a	12.14	15.28
N	5.39	.020	0.29	12.32	16.08
Attention – Total Performance (TN-E)					
TN-E T2	376.20	<.0005	n/a		
Intervention:				**No**	**Yes**
PA	0.01	.905	n/a	220.86	214.70
HHE	1.30	.254	n/a	220.78	214.78
N	0.26	.611	n/a	220.53	213.01
Attention – Concentration Performance (CP)					
CP T2	760.51	<.0005	n/a		
Intervention:				**No**	**Yes**
PA	0.00	.985	n/a	74.46	69.46
HHE	0.62	.433	n/a	74.87	68.87
N	0.00	.962	n/a	74.58	67.19
Academic Performance (EoYR)					
EoYR T2	270.93	<.0005	n/a		
Intervention:				**No**	**Yes**
PA	28.38	<.0005	0.10	3.95	4.05
HHE	0.01	.931	n/a	4.02	3.95
N	0.58	.445	n/a	4.08	3.80

Table 4.14 shows that at post-intervention, only those participants that received the PA intervention revealed a significant relationship ($p < .0005$ and $d = 0.10$) with AP. None of the other interventions yielded a statistical significant difference for any of the other variables measured.

Table 4.15: Univariate ANCOVA Results: Pre- to Post-Intervention Differences (D2-1) Comparison between the Three Intervention Components regarding Attention and Academic Performance

Effect	F-Value (d.f.= 1; 853)	p	Cohen's d	Mean Values	
Attention – Percentage of Errors (E%)					
E% D2-1	191.80	<.0005	n/a		
Intervention:				**No**	**Yes**
PA	1.34	.247	n/a	-4.05	-3.06
HHE	0.18	.670	n/a	-4.26	-2.77
N	5.39	.020	0.19	-4.29	-2.11
Attention – Total Performance (TN-E)					
TN-E D2-1	224.47	<.0005	n/a		
Intervention:				**No**	**Yes**
PA	0.01	.905	n/a	34.14	32.06
HHE	1.30	.254	n/a	35.34	30.38
N	0.26	.611	n/a	33.24	33.32
Attention – Concentration Performance (CP)					
CP D2-1	42.95	<.0005	n/a		
Intervention:				**No**	**Yes**
PA	0.00	.985	n/a	19.17	18.43
HHE	0.62	.433	n/a	19.67	17.72
N	0.00	.962	n/a	19.20	18.07
Academic Performance (EoYR)					
EoYR D2-1	550.91	<.0005	n/a		
Intervention:				**No**	**Yes**
PA	28.38	<.0005	0.83	-0.68	0.40
HHE	0.01	.931	n/a	-0.63	0.33
N	0.58	.445	n/a	-0.54	0.51

Table 4.15 indicates that for pre- to post-intervention differences, only the PA intervention had a significant relationship with AP ($p < .0005$ and $d = 0.83$), with those participants receiving PA intervention producing significantly higher end of year results (EoYR).

In summary, this chapter reported on the descriptive statistics regarding the participant demographic information and the comparative results for the intervention components at pre- (T1), post- (T2) and pre- to post-intervention differences (D2-1) for the total sample. Furthermore, inferential statistical analyses on the overall comparisons of the intervention components regarding attention [percentage of errors (E%), total performance (TN-E) and concentration performance (CP)] and academic performance [end of year results (EoYR)]; the comparisons between the experimental and control

schools regarding specific interventions; as well as the univariate ANOVA and ANCOVA comparisons between intervention components regarding all assessed variables at pre- (T1), post- (T2) and pre- to post-intervention differences (D2-1), were also conveyed. The next chapter provides an interpretation and discussion of the results provided above. The results will be discussed according to the objectives of the study to draw relevant conclusions.

CHAPTER 5
DISCUSSION, CONCLUSION AND RECOMMENDATIONS

5.1 INTRODUCTION

The primary aim of this study was to determine the effect of school-based interventions on the attention and AP of primary schoolchildren from lower socioeconomic communities in Port Elizabeth. This study occurred under the auspices of a larger 3-year joint research project funded by the Swiss South African Joint Research Programme (SSAJRP), entitled "Impact of disease burden and setting-specific interventions on school children's cardio-respiratory physical fitness and psychosocial health in Port Elizabeth, South Africa". Phase 1 of the research project, the collection of the baseline data, was completed in March 2015. This study formed part of Phase 2 of the research project, investigating the effect of setting-specific interventions on schoolchildren's cardio-respiratory physical fitness, cognitive performance and psychosocial health.

This chapter discusses the results obtained and reflected in Chapter 4 to achieve the aims and objectives of the study. To describe the participants under investigation, descriptive statistics were employed. Inferential statistics were reflected in accordance with the aims and objectives of the study. This chapter commences with a section comparing the entire sample regarding variables measured at pre-, post- and pre- to

post-intervention differences. Thereafter, an interpretation and possible explanations for the results provided for the pair-wise comparison of schools follows. Evidence-based literature, as was presented in Chapter 2, is used to discuss and compare the findings obtained. Ultimately, a summary of the findings is provided denoting the extent to which the study achieved its aims and objectives, and an overall conclusion is presented. An overview of the limitations and strengths of the study, followed by recommendations for future research, concludes this chapter.

5.2 PARTICIPANT DEMOGRAPHICS

SA encompasses a multicultural and multiethnic diversity that provides a unique platform for exploring health issues across various cultural settings. However, its historic past, particularly the institutionalisation of apartheid by the former government, forcibly segregated majority of the country's socioeconomic groups by perpetuating race, class, gender and ethnic divisions; and emphasized separateness, rather than common citizenship and nationhood (Chappell, 2005:1; du Plessis, 2013:80). As a result, majority of the lower socioeconomic groups consisting of the non-White population (Black African, Coloured and Indian), live in disadvantaged areas that were developed on the remote outskirts of the city (Armstrong *et al.*, 2011:1000). In Port Elizabeth, regions inhabited by Black Africans are commonly termed Townships; whereas regions inhabited by Coloured people are referred to as the Northern Areas. Due to apartheid legislation, schools and communities within these areas have been subjected to adverse conditions of extreme poverty and other social issues (Walter, 2011:787). Often, children living in these disadvantaged communities are limited to public transport or active commuting (walking) to get to school (McVeigh *et al.*, 2004b:986). The reason behind the relevance of the area of residence is because schools in the Northern Areas are comprised of predominantly Coloured learners, sometimes both Black and Coloured learners; whereas schools in the Township Areas comprised of only Black learners. Black parents residing in the Township Areas perceive Northern Areas schools to be better than Township schools (South Africa, 2004:16). Additionally, black learners who are enrolled in Northern Areas schools travel lengthy distances to attend these schools and since these areas have been developed on the remote outskirts of the city, daily travelling expenses can become costly.

Discussions in the sub-sections to follow describe and compare the eight schools participating in the study regarding the study variables. Therefore, it is necessary to reiterate the ethnic and geographical differences of the eight schools, as it was alluded to in Chapter 3. Furthermore, the eight primary schools participating in the study were match-paired, with each school in a pair randomly allocated to either the experimental or control groups. Using the match-pair technique and based on the results from the baseline survey, the eight schools were assigned to each group by means of similar geographical location, medical examination and helminthic infection results, and the social and ethnic composition of schools. Of the eight schools, four schools are in the Northern Areas, namely experimental school 4 (E4) and control school 4 (C4) which are populated mainly by Coloured children only, whereas experimental school 2 (E2) and control school 2 (C2) have a combination of both Black and Coloured learners. The remaining four schools, namely experimental schools 1 and 3 (E1 and E3) and control schools 1 and 3 (C1 and C3), are in urban informal Township Areas and are only attended by Black learners.

The current study encompassed a homogenous population (n = 857) in respect of socioeconomic status, specifically lower socioeconomic communities, but were diverse regarding ethnicity. As was illustrated in table 4.3, descriptive statistics show the ethnic distribution reflected a larger portion of the sample were of Black African descent (61%), residing in the Township Areas of Port Elizabeth, in comparison to those of Coloured ethnicity (39%), residing in the Northern Areas of the city. Table 4.2 displays the descriptive statistics for the target sample group which reflects an almost evenly balanced gender distribution of 434 (51%) males and 423 (49%) females. The distribution of participants according to age categories is presented in table 4.1 and shows that for both the experimental and control schools, the younger age category (8 - 9 years old) represents the highest age frequency and constitutes 60% of the participants; whereas the older age category (10 – 13 years old) represents the lowest age frequency and constitutes 40% of the participants. To successfully achieve the aim of the study, the sub-sections to follow will describe and discuss the effect of the various combinations of the school-based interventions and the pair-wise comparisons between the eight schools in respect of the attention and AP variables measured.

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

Schools E1 and C1 were both Township schools with a similar geographical location and socioeconomic status and was comprised of only Black African children. E1 was an experimental school participating in the PA only intervention and C1 was its control school. In respect of age distribution at pre-intervention (T1), both E1 and C1 schools encompassed a larger number of participants (69% and 86%, respectively) in the younger age category of 8 – 9 years, as opposed to the older age category of 10 – 13 years (31% and 14%, respectively). A statistical and small practical significant difference ($p < .05$ and $V > 0.1$) was observed between E1 and C1, indicating that C1 comprised of a significantly larger percentage of younger participants than E1 at T1. These values are reflected in Chapter 4, specifically table 4.5.

Before the experimental school participated in the ten-week intervention, T1 measurements were obtained to assess attention [percentage of errors (E%), total performance (TN-E) and concentration performance (CP)] and academic performance [end of year results (EoYR)]. As displayed in figure 5.1, results indicated that of the four variables compared in table 4.6, only the EoYR showed a statistical and practical significant result ($p < .05$ and $d > 0.80$), with C1 performing significantly better and having higher mean EoYR (5.52 ± 1.14) than E1 (4.25 ± 0.78).

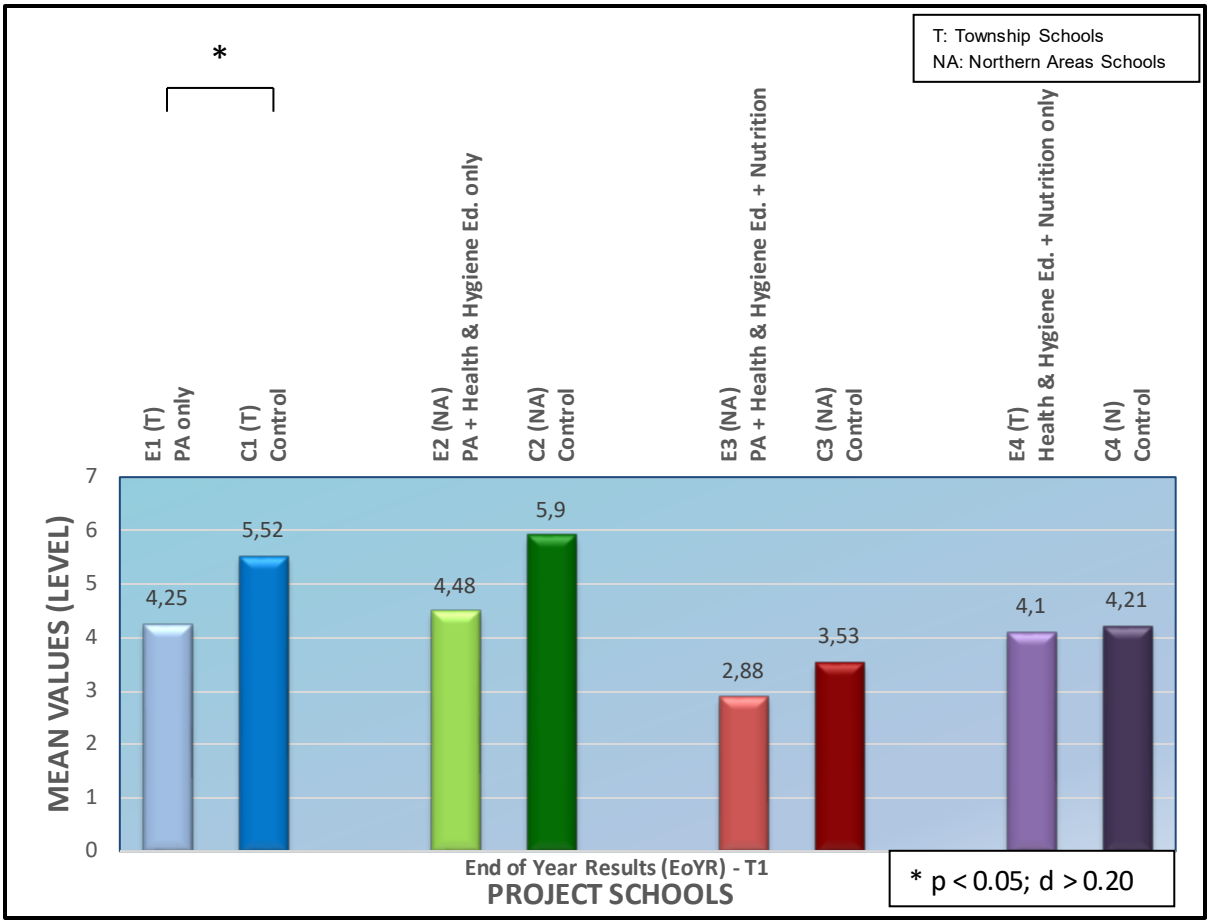

Figure 5.1: Baseline (T1) Differences Between Schools for Academic Performance (EoYR)

Post-intervention (T2) results, as illustrated in table 4.6 and figures 5.2, 5.3 and 5.4, revealed that significant differences ($p < .05$ and $d > 0.20$) were observed for all the variables, except for the percentage of errors (E%). A small practical significance in favour of C1 was found for total performance (TN-E) ($d > 0.20$) and concentration performance (CP) ($d > 0.20$). However, a large practical significance ($d > 0.80$) in favour of E1 was found for the end of year results (EoYR). For TN-E, T2 results indicated that C1 presented a mean value of 236.44 ± 47.92, which differed significantly from E1 (222.33 ± 41.76). The same tendency was observed for CP, where C1 (87.69 ± 26.86) differed significantly from E1 (78.62 ± 20.39). Contrastingly, EoYR increased in E1 (4.37 ± 0.74), while it decreased in C1 (3.58 ± 0.58), resulting in a significant difference.

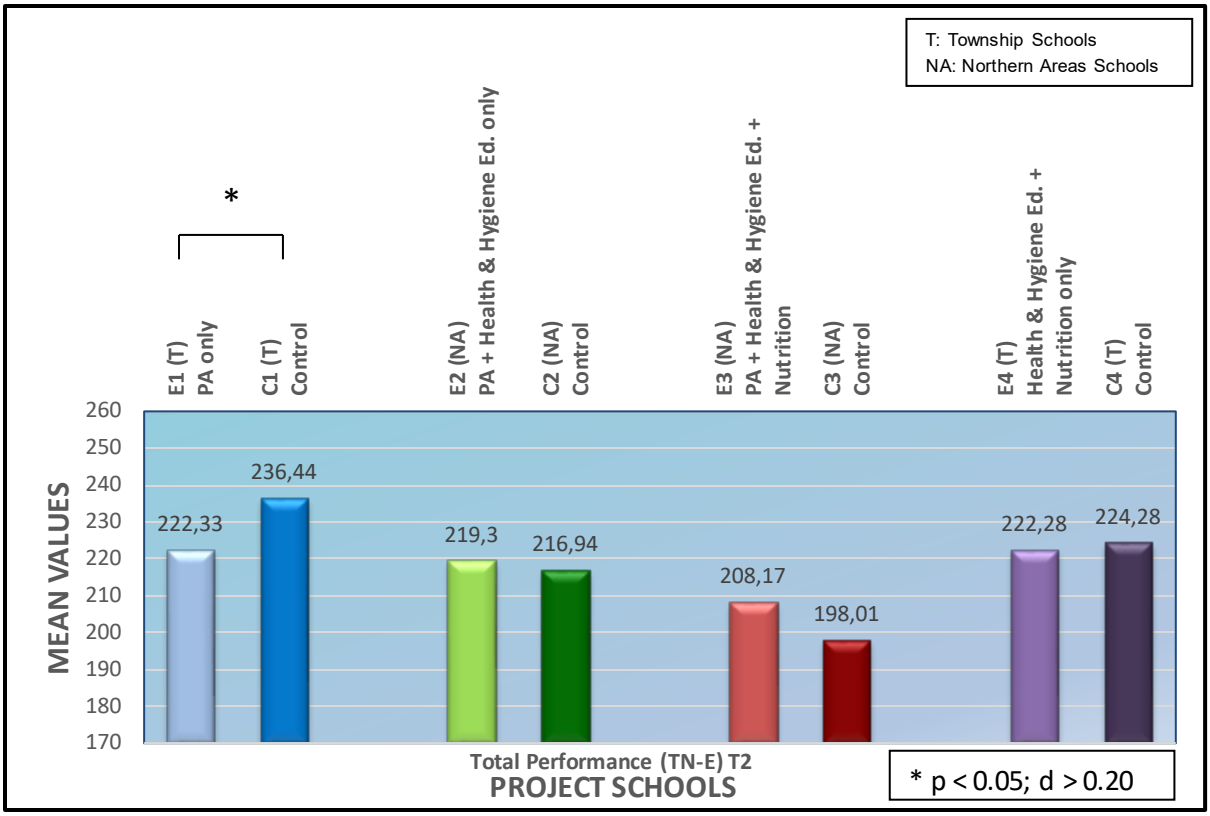

Figure 5.2: Post-Intervention (T2) Differences Between Schools for Total Performance (TN-E)

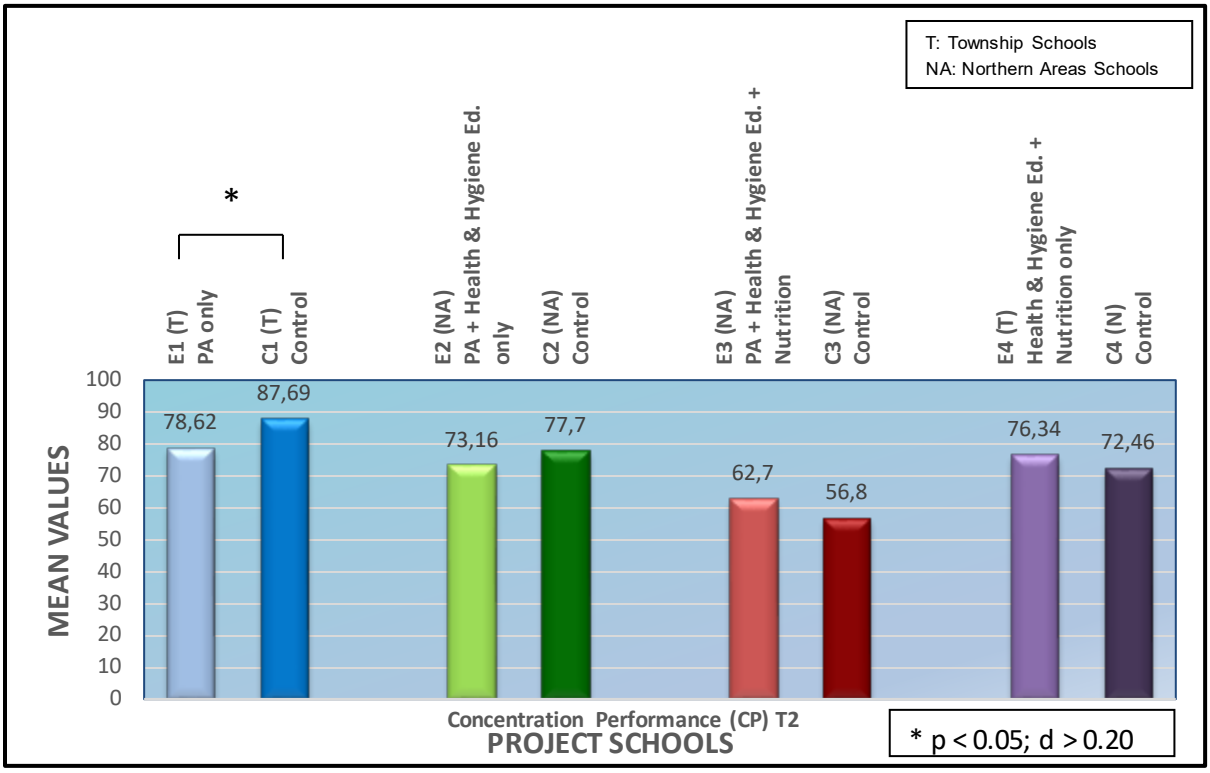

Figure 5.3: Post-intervention (T2) Differences Between Schools for Concentration Performance (CP)

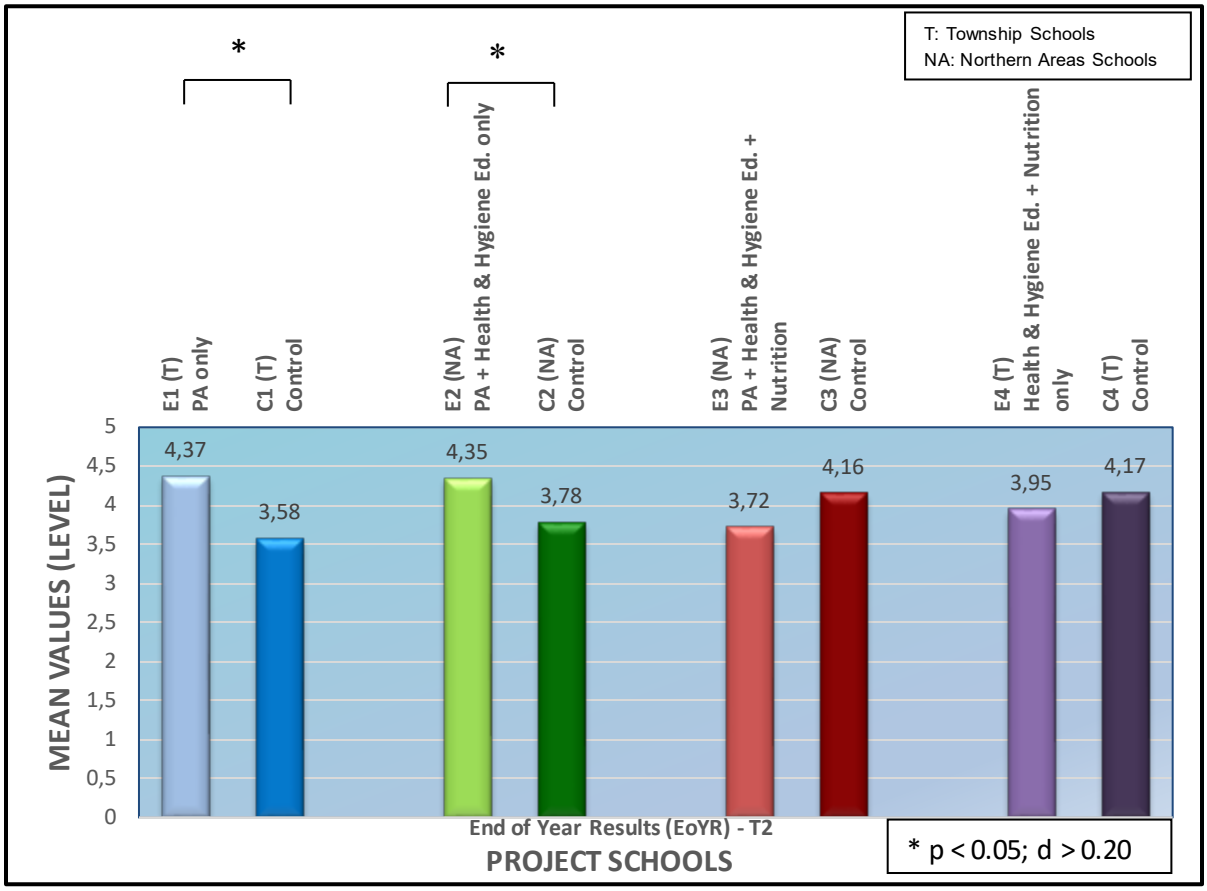

Figure 5.4: Post-Intervention (T2) Differences Between Schools for Academic Performance (EoYR)

As depicted in table 4.6 and figures 5.5, 5.6 and 5.7, when comparing E1 and C1 in terms of pre- to post-intervention differences (D2-1) for all attention and academic performance variables, statistical and practical significant differences ($p < .05$ and $d > 0.50$) were observed for all variables, except total performance (TN-E). The significant differences were in terms of the percentage of errors (E%) ($p < .05$ and $d > 0.50$) and concentration performance (CP) ($p < .05$ and $d > 0.50$), revealing a medium practical significance both in favour of C1; as well as the end of year results (EoYR) ($p < .05$ and $d > 0.80$), which revealed a large practical significance in favour of E1. The results indicated that the percentage of errors (E%) decreased in both schools, with the larger decrease presented by C1 (-7.00 ± 7.50%) differing significantly compared to E1 (-2.27 ± 8.82%). Regarding the percentage of errors, as specified in Chapter 4, section 4.3.1, a lower percentage of errors score reflects better accuracy, quality of work and degree of carefulness (Brickenkamp & Zillmer, 1998:1). Therefore, a decrease in scores translates into an improvement in performance. For concentration performance (CP), there was a significantly larger increase in the mean value (30.70 ± 17.72) for

C1 in comparison to the mean value (17.55 ± 19.39) for E1. However, the EoYR displayed an increase for E1 (0.12 ± 0.70), but a decrease for C1 (-1.94 ± 0.98), indicating a significant difference in favour of E1. The results from this study are supported by previous findings in other studies investigating attention and AP in children. A discussion surrounding the possible reasons for these results is presented below.

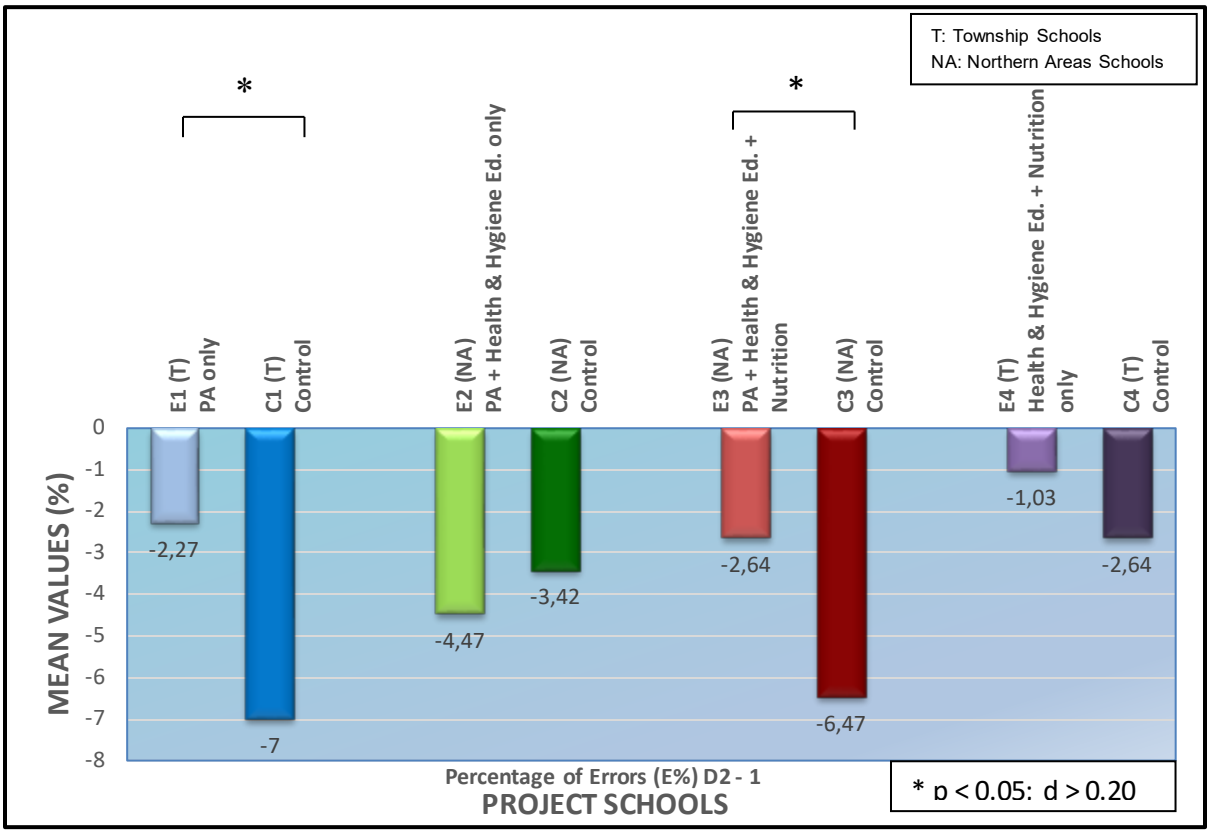

Figure 5.5: Pre- to Post-Intervention Differences Between Schools for Percentage of Errors (E%)

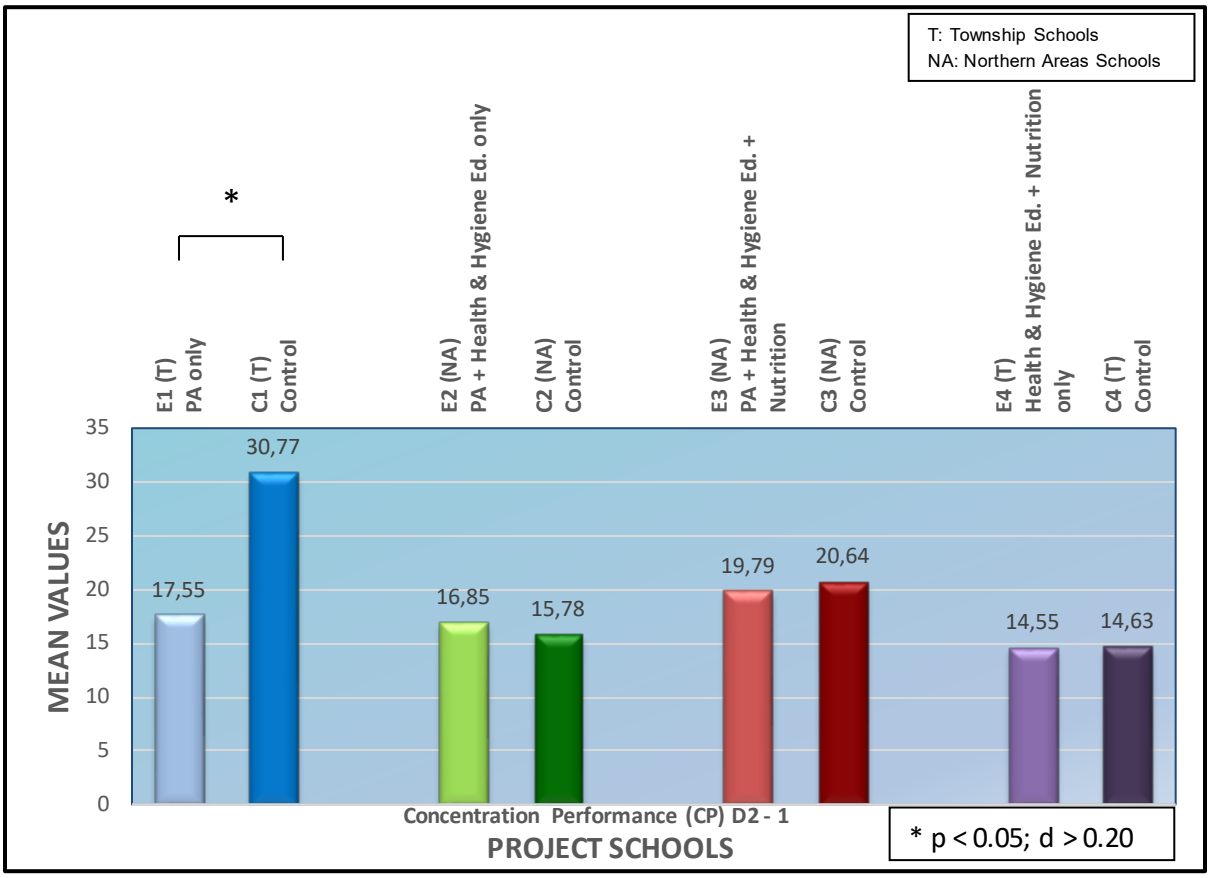

Figure 5.6: Pre- to Post-Intervention Differences (D2-1) Between Schools for Concentration Performance (CP)

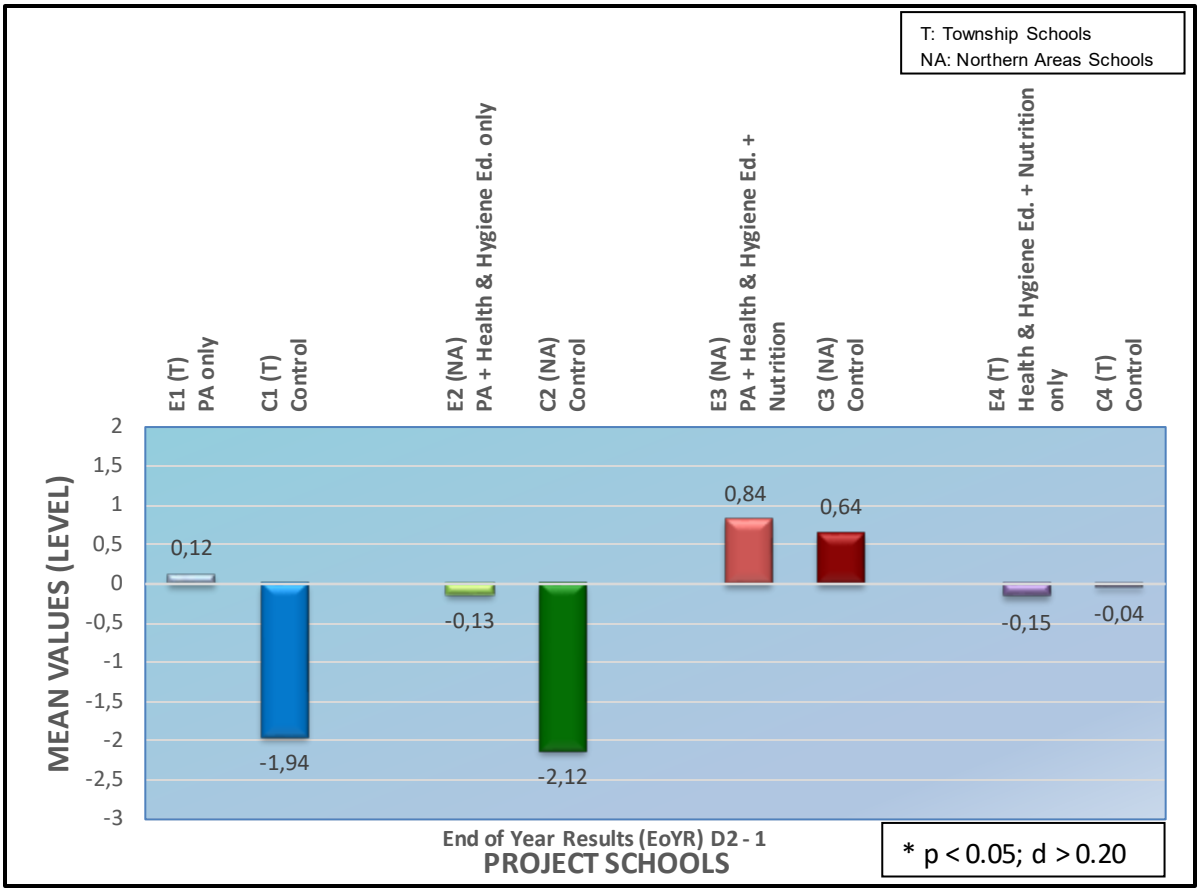

Figure 5.7: Pre- to Post-Intervention Differences Between Schools for Academic Performance (EoYR)

Two international studies (Sallis *et al.*, 1999:131-132; Ahamed *et al.*, 2007:371) were found with similar results to the present study when comparing the baseline AP scores for E1 and C1, whereby C1 performed significantly better than E1. A study conducted in Canada by Ahamed *et al.* (2007:371) evaluated the effectiveness of a 16-month school-based PA intervention for maintaining AP in a multi-ethnic group of elementary schoolchildren (n = 287) and showed that participants attending usual practice schools had significantly higher baseline scores than those attending intervention schools. Reasons attributing to this could include the use of non-standardised, grade-specific academic tests and possible differences in timing of test administration (Ahamed *et al.*, 2007:375). Furthermore, there was no significant sex-by-group interaction for AP scores, however, boys in both the usual practice and intervention group had higher AP scores than girls at baseline. This highlights that gender differences should also be taken into consideration when interpreting results related to AP, however, this did not fall within the scope of the present study.

Another study conducted in the United States (n = 759) by Sallis *et al.* (1999:131-132) assessed the effect of a 2-year health-related school PE programme on children's standardised academic achievement scores and revealed that at baseline, the control condition for Cohort 1 had higher mean academic achievement scores for all the variables measured, namely basic battery, language, and mathematics, when compared to the specialist and trained teacher conditions. Similarly, for Cohort 2, the control condition performed better than the other two conditions at baseline, for all the academic achievement measures, except Language. However, reasons for the significance at baseline between the groups in relation to academic achievement was not reported on. Therefore, the results of this study are supported by the findings reported by Ahamed *et al.* (2007:371) which emphasise the importance of standardised testing protocols, as well as the timing of testing. Gender differences should also be taken into consideration when interpreting results related to AP, however, this did not fall within the scope of the present study.

When comparing E1 and C1 in terms of attention at post-intervention, several incongruent results were reported by three previous international studies investigating the effects of school-based interventions on the EFs of primary schoolchildren (Davis *et al*., 2007:510; Davis *et al*., 2011:95; Tine & Butler, 2012:821). One study revealed significant and favourable effects for the intervention group when compared to the control group (Tine & Butler, 2012:821), one study's results was mixed (Davis *et al*., 2011:95); and one study showed no change (Davis *et al*., 2007:510). Possible explanations could be that learners in the experimental group may have had a lower drive and that learners in the control group were more susceptible to practice effects due to the familiarity and repeating of the d2 Test (Tine & Butler, 2012:829 & 831). Davis *et al.* (2011:96) highlighted that a longer intervention period may result in more benefits for child development; and thus, considering a limitation of the present study that the intervention was relatively short, perhaps an intervention programme of longer duration may have resulted in significant EF gains. Other reasons may be that C1 performed better than E1 at T1, specifically in terms of total performance (TN-E), although not significantly so, indicating that E1 was already at a disadvantage prior to the PA intervention being implemented. A possible reason for this disadvantage may be that the experimental school could have a higher percentage of learners with special education needs attending the school in comparison to the control school,

however, this was not measured or controlled for when assessing these learners. Findings from Frick *et al.* (1991:289) and Barkley (1997:84) suggest that children with attentional, behavioural and academic deficits are most likely to underachieve in comparison with children without any deficits. It is therefore critical to identify children with special educational needs and provide them with the necessary programmes to enhance EF skills. Furthermore, targeted PA intervention programmes over a longer duration, as well as increasing arousal in children may provide significant benefits in enhancing both cognitive and academic skills.

In terms of the AP result between E1 and C1 at post-intervention, six international studies that implemented PA interventions have seen improvements in the AP of the experimental group and have attributed this to increased time spent being active, either during PE classes (Mullender-Wijnsma *et al.*, 2015a:365) or PA breaks in class (Hollar *et al.*, 2010:646), after school PA (Davis *et al.*, 2011:91; Ericsson & Karlsson, 2014:273), as well as meeting recommended vigorous PA guidelines for children (Coe *et al.*, 2006:1515). Additionally, one study showed that increasing the PF levels of the experimental group has an effect on AP (Hansen *et al.*, 2014:2279). Furthermore, in the present study, a possible reason behind the decreased AP in C1 could be the medium of instruction transition, also identified as the "fourth-grade slump" (Sanacore & Palumbo, 2008:67-68). T1 results were obtained from the EoYR of grade three learners and T2 results were the EoYR from grade four. In SA, most schools offer mother-tongue instruction for the first three grades of school, whilst the transition to English as the medium of instruction takes place in grade four (Taylor & von Fintel, 2016:75). In combination with a change in the language of instruction, children undergo a shift from "learning to read" to "reading to learn". Cummins (1992:95) argues that a child will only have the necessary skills to transition to a second language once the first language has been mastered. Therefore, findings from this study are supported by previous studies which show that AP is decreasing in learners progressing from grades three to four (Hirsch, 2003:10; Sanacore & Palumbo, 2008:67). Hence, one interpretation provided by the current study's results could be that increasing PA levels of grade three learners holds promise to counteract a negative tendency of AP as transitioning to English language instruction. Furthermore, the experimental schoolchildren were exposed to the PA intervention and the control

schoolchildren were not. Hence, participation in the PA intervention could have influenced the AP of the experimental schoolchildren.

When interpreting pre- to post-intervention differences (D2-1) between E1 and C1 for the attention variables, the previously discussed findings from numerous other studies provides justification for these results whereby learners in the experimental group may have had a lower drive, learners in the control group were more susceptible to practice effects (Tine & Butler, 2012:829 & 831), an intervention of longer duration is needed to significantly enhance gains in attention (Davis *et al.*, 2011:96), as well as the underachievement tendencies in learners with special education needs (Frick *et al.*, 1991:289; Barkley, 1997:84). Furthermore, a possible reason behind the decreased AP in C1 could be the medium of instruction transition, identified as the "fourth-grade slump" (Sanacore & Palumbo, 2008:67-68). Five international studies proposed that participating in the PA intervention could have influenced the results of the experimental school (Coe *et al.*, 2006:1517; Carlson *et al.*, 2008:4; Hollar *et al.*, 2010:650; Hansen *et al.*, 2014:2282; McClelland *et al.*, 2015:95). Coe *et al.* (2006:1517) suggested that increased activity levels might be related to increased self-esteem, which would improve classroom behaviour as well as performance. Similarly, Carlson *et al.* (2008:4) highlighted that expanding PE programmes may increase the benefit in academic achievement. Hansen *et al.* (2014:2282) noted that increasing aerobic fitness might have a greater effect on academic achievement scores for children below a particular fitness threshold than that for those above. McClelland *et al.* (2015:95) proposed several mechanisms which might explain the positive impact of PA on AP, including increased embodied cognition, improved cognitive arousal, promotion of growth of new neurons and connections between existing neurons through stimulation of the molecular machinery of the brain, increased inter-hemispheric neural connectivity, and improved brain function in magnocellular or cerebellar systems. These findings suggest that well-targeted choices of PA interventions which have a firm grounding in science have led to a viable educational intervention approach.

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

At pre-testing, there were no significant differences ($p > .05$) between E2 and C2 regarding the distribution of age, as illustrated in table 4.7. Both schools were from the Northern Areas and had a mixture of Black African and Coloured children attending the schools. In addition, socioeconomic conditions and the geographic location of the two schools were similar. As illustrated in table 4.8 and figure 5.1, a statistical and large practical significant difference ($p < .05$ and $d > 0.80$) only for the end of year results (EoYR) was found at T1, with C2 representing the larger mean value (5.90 ± 1.00) than E2 (4.48 ± 1.25). Displayed in figure 5.4, a small but significant difference ($p < .05$ and $d > 0.20$) was observed only for the end of year results (EoYR) between E2 and C2 for T2, with E2 reflecting the larger mean score (4.35 ± 0.97) in comparison to C2 (3.78 ± 1.34). Findings indicate that both schools' EoYR decreased from T1 to T2, however, C2 decreased significantly more than E2. When comparing E2 and C2 in terms of pre- to post-intervention differences (D2-1) for all the attention and academic performance variables, figure 5.7 demonstrates that only the end of year results (EoYR) showed a statistical and practical significant difference ($p < .05$ and $d > 0.80$) between the two schools, with E2 (-0.13 ± 0.81) displaying a significantly lesser decrease in scores than C2 (-2.12 ± 1.25). Findings from the present study are supported by data from previous results in other studies investigating attention and AP in children. The possible reasons for the present study's results are discussed below.

Results comparing E2 and C2 were similar to E1 and C1 in terms of the AP baseline scores obtained and could be explained by the observations by Ahamed *et al.* (2007:371) who attributed the possible reasons to the use of non-standardised, grade-specific academic tests and differences in timing of test administration (Ahamed *et al.*, 2007:375). Furthermore, gender differences could possibly also have attributed to the differences in AP baseline scores (Ahamed *et al.*, 2007:375), however, this was not analysed in the present study. Similarly, in the present study where C2 performed significantly better than E2, the afore-mentioned factors may have negatively influenced the intervention group more than the control group. The results of this study therefore support the findings of Ahamed *et al.* (2007:371) which emphasise the importance of standardised testing protocols, as well as the timing of testing. Gender

differences should also be taken into consideration when interpreting results related to AP, however, this did not fall within the scope of the present study.

In terms of the AP result for E2 and C2 at post-intervention in the present study, a possible reason behind the decreased AP in both E2 and C2 could be the medium of instruction transition, which was identified as the "fourth-grade slump" (Sanacore & Palumbo, 2008:67-68), as discussed earlier. Hence, one interpretation provided by the current study's results could be that increasing PA levels of grade three learners holds promise to counteract a negative tendency of AP when transitioning to English language instruction.

When interpreting pre- to post-intervention differences (D2-1) for AP between E2 and C2, a smaller decrease in the experimental school's EoYR was noted, and hence, two international studies suggested that participating in the PA intervention could have had a maintenance effect on the AP results of the experimental school (Keeley & Fox, 2009:198; Mullender-Wijnsma *et al.*, 2015a:365). In the Netherlands, a study by Mullender-Wijnsma *et al.* (2015a:370) reported that the PA programme implementation effects on AP of school-age children ($n = 228$) after one year, presented mixed results, with significantly higher post-test math ($p < .05$) and reading ($p < .05$) scores in third grade experimental children, significantly lower ($p < .05$) post-test math scores in second grade intervention children when compared to second grade control children and no effect in reading ability of second grade children. Findings from this study could be explained by the results of Mullender-Wijnsma *et al.* (2015a:370), that perhaps older children can better focus their attention on the academic content. Although no significant differences were observed between E2 and C2 in terms of age distribution, E2 comprised of a higher percentage of older children than C2. Keeley and Fox (2009:207) performed a systemic review to identify the impact of PA and fitness on academic achievement and cognitive performance in children and found that one study showed significantly smaller declines in four out of eight measures of AP when compared to control schools, indicating that the introduction of more curriculum time PA at the expense of time allocated to academic subjects, does not have a detrimental effect on children's AP. Factors providing explanations for this include level of motivation and aspirations, cognitive skills, clustering of abilities within individuals, parental encouragement and logistic support

(Keeley & Fox, 2009:209). Parents supporting and encouraging their children's academic activities also tend to encourage them to be active. Similarly, children are inclined to emulate their parents' values which might include both sport and academic achievement. Further, there might be a degree of clustering of academic and athletic abilities in children. Academically more capable or driven children may be more motivated to do well on tests. Children with behavioural problems are less likely to be involved in PA. Inactive children may reflect greater illness and school absence, thus, missing out on school work (Keeley & Fox, 2009:210). These findings suggest that the normal maturation and development of cognitive skills; motivational and aspirational levels; academic and athletic ability clustering within individuals; parental encouragement and logistic support all contribute to the maintenance of AP. In the present study, none of the factors mentioned have been controlled for in the statistical analyses. Nevertheless, it is impossible to control for all factors contributing to AP. Therefore, it is difficult to elucidate the specific influences thereof.

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

Schools E3 and C3 were both Northern Areas schools and had only Coloured children attending the schools. In addition, socioeconomic conditions and the geographic location of the two schools were similar. E3 was an experimental school participating in all three intervention components and C3 was its control school. Findings illustrated in table 4.9 indicated that, for the distribution of age at pre-intervention, a statistical and small practical significant result ($p < .05$ and $V > 0.1$) was found between the two schools, denoting that E3 comprised of a significantly larger percentage of older participants than C3. For E3, two thirds of the participants (69%) fell within the older age category (10 – 13 years); whereas there was a more even split (49% versus 51%) in the age categories for C3.

Prior to the ten-week intervention, table 4.10 and figure 5.1 highlights that there was a statistical and practical significant difference ($p < .05$ and $d > 0.50$) between E3 and C3 at T1, only for the end of year results (EoYR), with C3 reflecting the larger mean value (3.53 ± 1.26) when compared to E3 (2.88 ± 1.11). Similarly, as displayed in figure

5.4, a small but significant difference ($p < .05$ and $d > 0.20$) between the experimental and control schools was observed for only the end of year results (EoYR) at T2, with the control school also reporting the larger mean value (4.16 ± 1.16) in comparison to the experimental school (3.72 ± 1.38). A noteworthy observation was that both the experimental and control school improved in EoYR scores, however, the pre- to post-intervention difference was not significant ($p < .05$).

When comparing E3 and C3 in terms of pre- to post-intervention differences (D2-1) for each of the variables measured, figure 5.5 demonstrates that only the percentage of errors (E%) showed both a statistical and practical significant difference ($p < .05$ and $d > 0.20$) in favour of C3 (-6.47 ± 14.94%), as opposed to E3 (-2.64 ± 12.95%). These findings indicate that C3 had a significantly larger decrease in percentage of error scores than E3. At T1, a noteworthy observation revealed that C3 had a higher percentage of errors in comparison to E3 (24.46 ± 15.83% and 20.78 ± 13.35%, respectively). Contrastingly, at T2, C3 displayed a lower percentage of errors when compared to E3 (17.99 ± 15.72% and 18.14 ± 15.76%, respectively), with only a 0.15% difference between the two schools. Both differences between the two schools were of no significance; however, it could explain for the significantly larger pre- to post-intervention decrease in percentage of errors for the control school. The results from this study are supported by previous findings in other studies investigating attention and AP in children. A discussion surrounding the possible reasons for these results is presented below.

Results comparing E3 and C3 were similar to both E1 and C1 and E2 and C2 in terms of the AP baseline scores obtained and could be explained by the observations of Ahamed *et al.* (2007:371) who attributed the possible reasons to the use of non-standardised, grade-specific academic tests and differences in timing of test administration (Ahamed *et al.*, 2007:375) and Sallis *et al.* (1999:131-132), however, these authors did not report on reasons for the significance at baseline between the groups in relation to academic achievement. Gender differences should also be taken into consideration when interpreting results related to AP, however, this did not fall within the scope of the present study. In the present study where C3 performed significantly better than E3, the afore-mentioned factors may have negatively impacted the intervention group more than the control group.

Results between E3 and C3 for AP at post-intervention indicate that C3 performed significantly better than E3. The present study's results are in line with three previous international studies conducted by Keeley and Fox (2009:207), Mullender-Wijnsma *et al.* (2015a:370) and Treu *et al.* (2017:143). Treu *et al.* (2017:143) compared two intensity levels [standard (SI) versus enhanced (EI)] of a nutrition and PA intervention versus a control (usual programmes) on nutrition knowledge, body mass index, fitness, AP, behaviour, and medication use amongst elementary schoolchildren and found mixed results with regard to AP. Test scores for reading fluency improved in the control group significantly more than in either intervention group, and test scores for math concepts and applications increased significantly more in the control group and EI groups than in the SI group. The reason identified is possibly due to phenomena unrelated to the intervention (Treu *et al.*, 2017:149). Findings from Mullender-Wijnsma *et al.* (2015a:370) showed that mathematical outcomes in grade two indicated a significantly lower score in the intervention group in comparison to the control group. The contrary effect in grade two was partly explained by the difference in PA levels, whereby second grade children participated in MVPA significantly more than third grade children. Additionally, Keeley and Fox (2009:207) found that one study showed a closing of baseline difference in AP, which was suggestive of a positive effect for higher levels of curriculum-based PA. Therefore, the results of this study are supported by the findings reported above and can be explained that the experimental group schoolchildren were exposed to the PA intervention and the control schoolchildren were not, and that participation in the PA intervention could have influenced the AP of E3.

Results between E3 and C3 for AP regarding pre- to post-intervention indicate that C3 performed significantly better than E3 at both pre- and post-intervention. However, both schools improved from T1 to T2, although, not significantly so, C3 reported a lesser increase in scores than E3. Szabo-Reed, Willis, Lee, Hillman, Washburn and Donnelly (2017:2346-2347) reported that prior to the PA intervention, the control group was on-task in a higher percentage of academic lessons when compared with the intervention group for year 1 and 2, although there was no significant group difference. Contrastingly, there was a significant group difference in favour of the control group for year 3. These researchers did not report on evidence supporting these results; however, it was concluded that physically active classroom lessons do not have a

negative impact on classroom attention in children and that future studies should continue to investigate the influence of physically active classroom lessons on time spent on-task and its impact on academic achievement to determine the sustainability of PA's effect on classroom behaviour.

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

Schools E4 and C4 were both Township schools with a similar geographical location and socioeconomic status and was comprised of only Black African children. E4 was an experimental school participating in the Health and Hygiene and Nutrition intervention components and C4 was its control school. In respect of age distribution in T1, almost half the participants (47%) in E4 formed part of the younger age category (8 – 9 years). Similarly, almost two thirds of the participants (62%) in C4 were distributed in the same age category. A statistical and small practical significant difference ($p < .05$ and $V > 0.1$) was found between the two schools, indicating that C4 comprised of a significantly larger percentage of younger participants than E4 at pre-intervention. These values are reflected in table 4.11.

There were no statistical and practical significant differences ($p > .05$) between the E4 and C4 results for all the variables measured at T1 and T2, nor in terms of pre- to post-intervention differences (D2-1), as is evident in Table 4.12. This indicates that the experimental and control schools were relatively similar at pre- and post-intervention in terms of attention, as well as academic performance variables. Other studies finding incongruent results to the present study will be discussed and provide possible explanations below.

Two local studies (Taljaard *et al.*, 2013:2271; Graham *et al.*, 2015:35) found contrary results to the present study. Taljaard *et al.* (2013:2271) investigated the effects of micronutrients and sugar, alone and in combination, in a beverage on growth and cognition in schoolchildren (n = 414) from the North West province in SA over a period of eight and a half months and concluded that the beverages with micronutrients or added sugar (in the form of sucrose) alone had a beneficial effect on cognition, which

was attenuated when provided in combination. Results indicated significant ($p < .05$) micronutrient with sugar interaction effects on the scores of Atlantis (test of learning ability and associative memory), Number recall (test of sequential processing), Rover (test of simultaneous processing and visual memory) and Discrimination Index (verbal recognition memory). A previous South African study revealed that provision of a multi-micronutrient-fortified biscuit resulted in improved short-term memory, with more significant intervention effects observed when only the children who were micronutrient deficient at baseline were included (van Stuijvenberg, Kvalsvig, Faber, Kruger, Kenoyer & Spinnler Benadé, 1999:497). In a recent review by Gilsenan, de Bruin and Dye (2009:946), several possible physiological processes have been discussed, including the glucose usage as metabolic fuel for neurons, increased neurotransmitter synthesis due to increased glucose metabolism and potential peripheral action through triggering neural signals and hormones (for example, insulin and cortisol). However, most studies have observed improved cognitive performance following acute intake of breakfast, carbohydrate or glucose. Cognitive development deficits cannot be explained merely by poor micronutrient status. It is well established that cognitive performance is influenced by many factors, including sociodemographic factors such as income, crèche attendance and the education level of the mother. In the present study, none of the factors mentioned have been corrected for in the statistical analyses. Nevertheless, it is impossible to correct for all factors contributing to cognitive function. Therefore, it is difficult to elucidate the specific influence on cognition, specifically attention.

Graham *et al.* (2015:35) evaluated the National School Nutrition Programme (NSNP) and the Tiger Brands Food (TBF) in-school breakfast feeding programme in the Lady Frere and Qumbu districts of the Eastern Cape on school performance in 41 quintile 1 to 3 schools (n = 1390) that were allocated into three groups, namely, the NSNP group - which comprised of a mid-morning meal, the NSNP and TBF group - which composed of a breakfast and mid-morning meal, and the control group. Results indicated that, overall, learners in all groups improved on AP at post-intervention, but not significantly so. The differences between the school types indicate that those receiving some intervention performed better than those receiving none and that those receiving the TBF programme performed better than those that were not (Graham *et al.*, 2015:36). However, the differences between learners in the NSNP only group and

those receiving both TBF and NSNP was of no statistical significance. Learner performance is influenced by numerous variables, of which some are more directly related to performance than nutrition, including teacher performance and learning materials accessibility. Hence, it was surmised that the changes observed in the learner performance results of Graham *et al.* (2015:36) were due to a variety of factors, aside from the nutrition intervention. Furthermore, school performance is affected by several other variables including quality teaching, learning support materials availability, infrastructure functionality, and many other variables in the school and home environment. Additionally, performance improvements due to improved nutrition is a relatively slow process. Contrastingly, better concentration and participation in class are gains that can typically be observed in the short-term and have a direct correlation with nutritional health. As these are measured quantitively, data through qualitative interviews were gathered (Graham *et al.*, 2015:37), revealing that principals, educators and learners felt strongly that the nutrition programmes improved learner performance, with educators and principals indicating that the impact of school feeding on the education of learners extended beyond school performance results at assessment time. Learners receiving the NSNP lunch also reported feeling much better after consuming a meal at school, indicating they had more energy. The TBF breakfast also ensured learners had the ability to concentrate better during the first half of the day, whereas learners struggled to perform prior to the TBF intervention and before receiving the NSNP meal. Majority of the school curriculum during a day is covered before lunch, so it is of utmost importance that learners have enough energy to concentrate during this period. Furthermore, the perception of educators and principals was that school feeding exerted an important and positive impact on behaviour that is integral to school performance, especially concentration in class (Graham *et al.*, 2015:38).

Although the present study revealed similar results of no significance between E4 and C4 for all the assessed variables of attention and AP for T1, T2 and pre- to post-intervention differences, in addition to being contrary to other recent findings, factors such as micronutrient fortification, breakfast consumption versus no breakfast, school feeding programmes, sociodemographic factors such as income, crèche attendance and the education level of the mother could all possibly have an influence on the attention and AP of children. The findings presented here strengthens the need for

further investigation into the effects of a health and hygiene and nutrition intervention on the attention and AP of children, particularly in those from lower socioeconomic communities. In the present study, none of the factors mentioned have been controlled for in the statistical analyses. Nevertheless, it is impossible to control for all factors contributing to attention and AP. Therefore, it is difficult to elucidate the specific influences thereof.

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

Results illustrated in table 4.13 and figure 5.8 indicates that there was a significant relationship ($p < .05$ and $d > 0.20$) between the Nutrition component grouping and concentration performance (CP) at pre-intervention. The other two intervention components showed no significant difference with respect to two of the attention variables, namely percentage of errors (E%) and total performance (TN-E). There was also a significant difference ($p < .05$ and $d > 0.50$) with academic performance (EoYR) and all three intervention components in favour of the no intervention component grouping for PA, Health and Hygiene Education and Nutrition, as can be seen in figure 5.9. It can be concluded that the participants exposed versus those not exposed to the interventions were similar in terms of two of the attention variables, specifically percentage of errors (E%) and total performance (TN-E). Similarly, the participants exposed to the PA and Health and Hygiene interventions were the same in comparison to those not exposed for one of the attention variables, namely concentration performance (CP).

At post-intervention, table 4.14 and figure 5.9 demonstrate that only the PA intervention revealed a significant relationship ($p < .05$ and $d = 0.10$) with academic performance (EoYR), in favour of the children exposed to the PA intervention (the latter reflecting a significant increase in EoYR when compared to those not exposed). None of the interventions yielded a significant difference for any of the other variables measured, which indicates that the participants exposed versus those not exposed to the interventions remained minimally influenced by the interventions in terms of all the attention variables. Similarly, the participants exposed to the Health and Hygiene and Nutrition interventions presented similar EoYR as those not exposed.

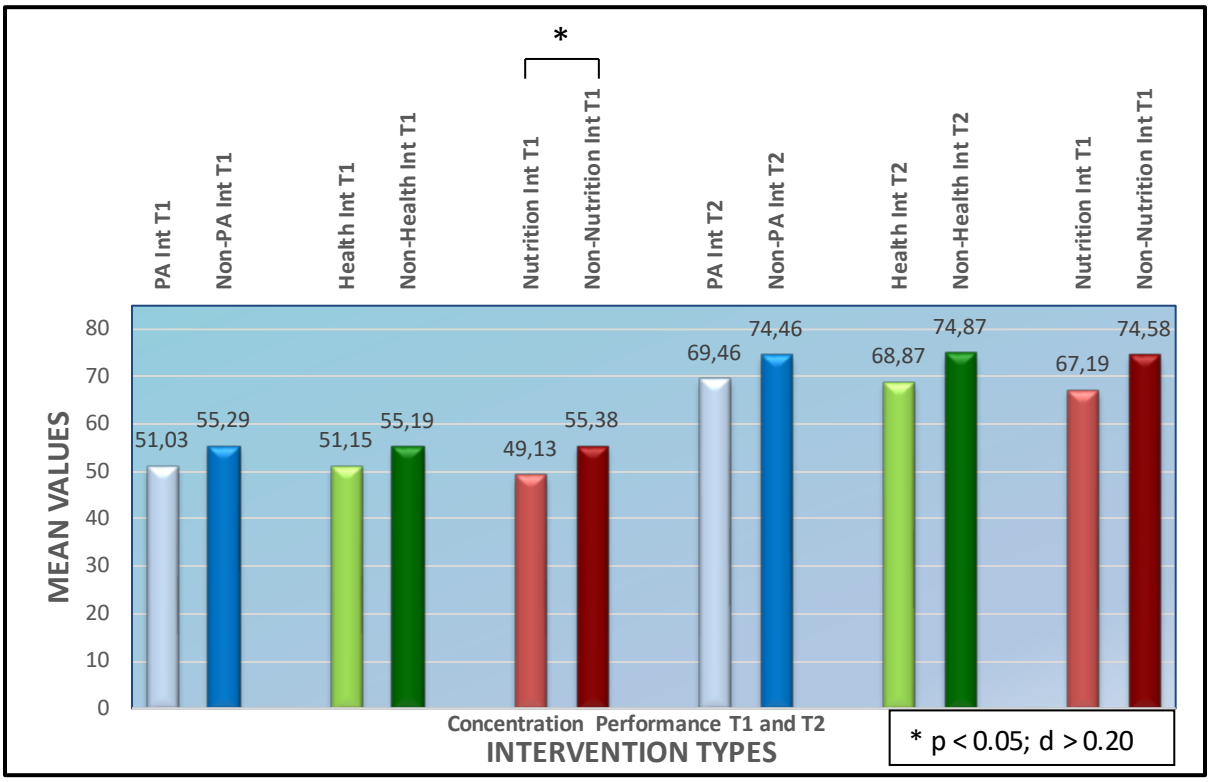

Figure 5.8: Effects of Individual Interventions on Concentration Performance (CP) at Pre-(T1) and Post-(T2) Intervention

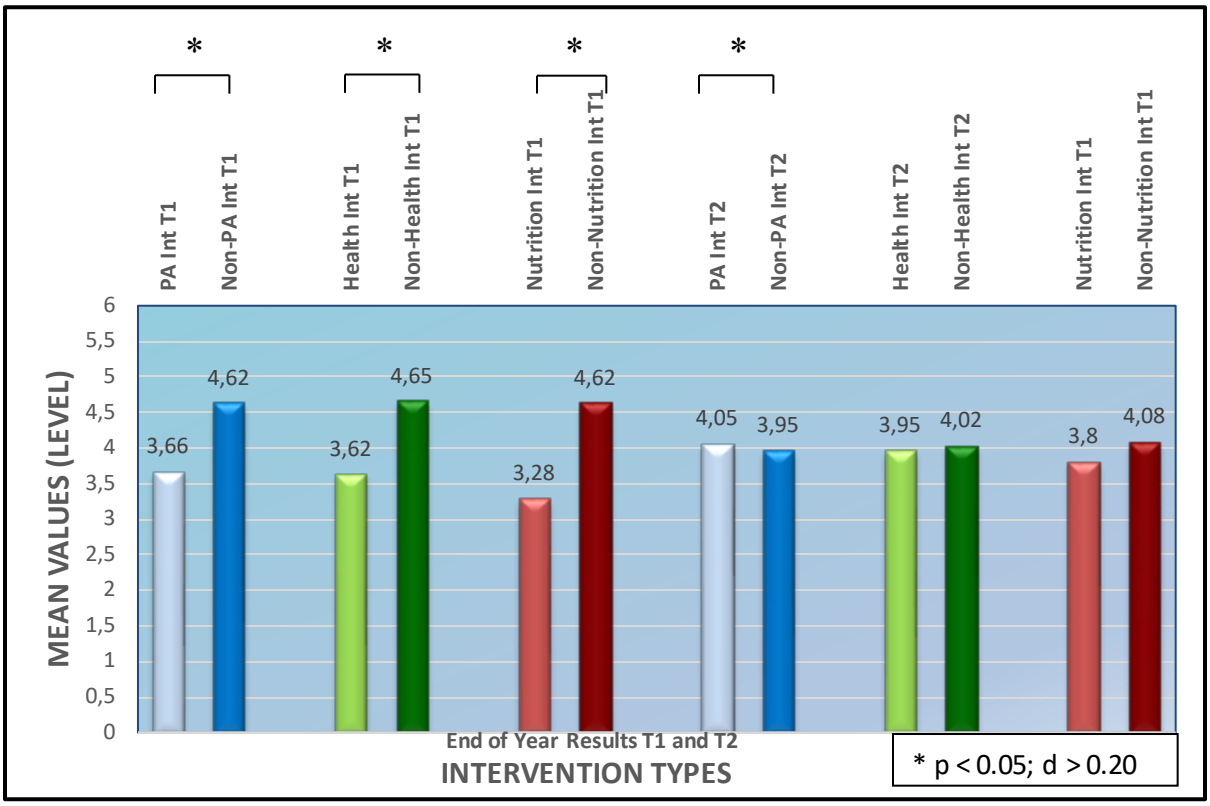

Figure 5.9: Effects of Individual Interventions on Academic Performance (EoYR) at Pre-(T1) and Post-(T2) Intervention

For pre- to post-intervention differences, table 4.15 and figure 5.10 shows that only the PA intervention had a significant relationship with academic performance ($p < .05$ and $d > 0.80$), in favour of the children exposed to the PA intervention who displayed a significant increase in EoYR in comparison to those not exposed. None of the interventions yielded a significant difference for any of the other variables measured, which indicates that the participants exposed versus those not exposed to the interventions remained minimally influenced by the interventions in terms of all the attention variables. Similarly, the participants exposed to the Health and Hygiene and Nutrition interventions were the same as those not exposed for EoYR. The possible reasons for the present study's results are discussed below.

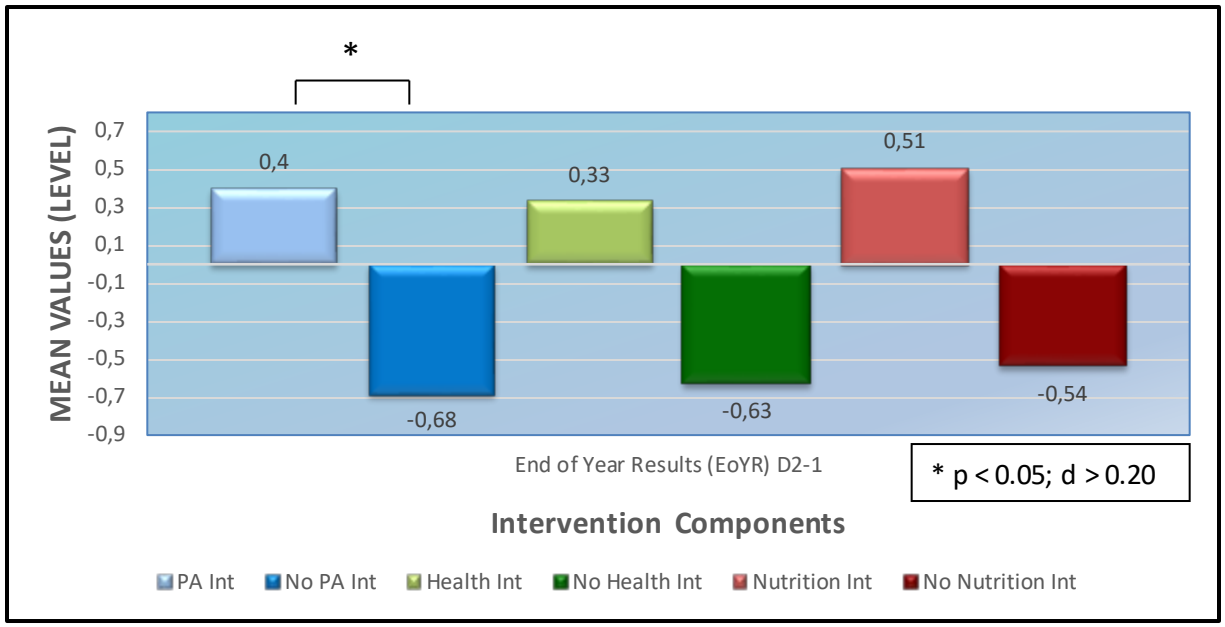

Figure 5.10: Effects of Individual Interventions on Academic Performance (EoYR) for Pre- to Post-Intervention Differences (D2-1)

Results comparing the three intervention components, specifically nutrition, on attention at baseline were incongruent and could be explained by the observations by one international study (Hjorth *et al.*, 2016:398) and one local study (Taljaard *et al.*, 2013:2271). In the study by Taljaard *et al.* (2013:2271), mixed results were observed between all the groups, however, the significance thereof was not reported on. Similarly, Hjorth *et al.* (2016:398) did not report on any baseline differences. Hence, no possible explanation for these baseline findings between the nutrition intervention group and the non-nutrition intervention group for attention could be provided.

Similar results obtained when comparing the three intervention components in terms of the AP baseline scores, whereby the non-intervention groups performed significantly better than the intervention group were found in two international studies and could be explained by the observations of Ahamed *et al.* (2007:371) who attributed the possible reasons for the relevant findings to the use of non-standardised, grade-specific academic tests and differences in timing of test administration (Ahamed *et al.*, 2007:375) and Sallis *et al.* (1999:131-132), however, these authors did not report on reasons for the significance at baseline between the groups in relation to academic achievement. Furthermore, gender differences could possibly also have attributed to the differences in AP baseline scores (Ahamed *et al.*, 2007:375), however, this was not analysed in the present study. Similarly, these results were found in the present study whereby all the control groups performed significantly better than all the intervention groups, and hence, the afore-mentioned factors may have negatively impacted all the intervention groups more than the control groups. Therefore, the results of this study are supported by the findings reported by Ahamed *et al.* (2007:371) which emphasises the importance of standardised testing protocols, as well as the timing of testing. Gender differences should also be taken into consideration when interpreting results related to AP, however this did not fall within the scope of the present study.

In terms of the AP result between the PA intervention and the non-PA intervention at post-intervention, six international studies that implemented PA interventions have seen improvements in the AP of the experimental group and have attributed this to increased time spent being active, either during PE classes (Mullender-Wijnsma *et al.*, 2015a:365), or PA breaks in class (Hollar *et al.*, 2010:646), after school PA (Davis *et al.*, 2011:91; Ericsson & Karlsson, 2014:273), as well as meeting recommended vigorous PA guidelines for children (Coe *et al.*, 2006:1515). Additionally, one study showed that increasing the PF levels of the experimental group has an effect on AP (Hansen *et al.*, 2014:2279). Furthermore, in the present study, a possible reason for the decreased AP in the non-PA group could be the medium of instruction transition, also identified as the “fourth-grade slump” (Sanacore & Palumbo, 2008:67-68). Hence, one interpretation provided by the current study’s results could be that increasing PA levels of grade three learners holds promise to counteract a negative tendency of AP as transitioning to English language instruction. Furthermore, the PA intervention

group was exposed to the PA intervention programme and the non-PA intervention group was not. Hence, participation in the PA intervention could have influenced the AP of the PA intervention group.

When comparing the AP result between the PA intervention and the non-PA intervention for pre- to post-intervention differences, similar results to post-intervention was obtained in that the PA intervention group significantly improved in AP scores, whereas the non-PA group decreased. Therefore, the possible explanations would be similar to the post-intervention justifications. The AP decrease in the non-PA group is attributed to the "fourth-grade slump", whereas the PA intervention group's increase in AP could be due to the participation in the PA intervention programme.

In this section, the findings of present study were discussed in relation to the relevant literature reviewed and presented in Chapter 2. A summary of the findings is provided denoting the extent to which the study achieved its aims and objectives, and an overall conclusion is presented in the sections to follow.

5.8 SUMMARY OF FINDINGS

The following section provides a summary of the findings relevant to this study, indicating the extent to which the five research objectives were met. Summated findings are listed with relevance to each objective that was set for the study.

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

- Significant post-intervention differences ($p < .05$ and $d > 0.20$) were observed for all the variables, except for the percentage of errors (E%).
- A small practical significance in favour of C1 was found for total performance (TN-E) ($d > 0.20$) and concentration performance (CP) ($d > 0.20$).
- A large practical significance ($d > 0.80$) in favour of E1 was found for the end of year results (EoYR).
- When comparing E1 and C1 in terms of pre- to post-intervention differences (D2-1) for all attention and AP variables, statistical and practical significant differences ($p < .05$ and $d > 0.50$) were observed for all variables, except total performance (TN-E).

- The significant differences were in terms of the percentage of errors (E%) ($p < .05$ and $d > 0.50$) and concentration performance (CP) ($p < .05$ and $d > 0.50$), revealing a medium practical significance both in favour of C1.
- The end of year results (EoYR) also exhibited a statistical significance ($p < .05$ and $d > 0.80$) in favour of E1.
- Regarding the attention results, possible explanations could be due to a lower drive in experimental school children, whereas learners in the control school may have been more susceptible to practice effects due to the familiarity and repeating of the d2 Test (Tine & Butler, 2012:829 & 831). Other potential contributing factors include a relatively short intervention period in the experimental schoolchildren (Davis *et al.*, 2011:96), as well as the experimental school possibly having a higher percentage of learners with special educational needs attending the school in comparison to the control school (Frick *et al.*, 1991:289; Barkley, 1997:84). However, this was not measured or controlled for when assessing these learners.
- Additionally, increased time spent being active, either during PE classes (Mullender-Wijnsma *et al.*, 2015a:365) or PA breaks in class (Hollar et al., 2010:646), after school PA (Davis et al., 2011:91; Ericsson & Karlsson, 2014:273), as well as meeting recommended vigorous PA guidelines for children (Coe et al., 2006:1515) was thought to positively influence the AP results for the experimental school. The experimental schoolchildren were exposed to the PA intervention and the control schoolchildren were not. Hence, participation in the PA intervention could have influenced the AP of the experimental schoolchildren.
- Furthermore, a possible reason behind the decreased AP in C1 could be the medium of instruction transition, also identified as the “fourth-grade slump” (Sanacore & Palumbo, 2008:67-68). Hence, increasing PA levels of grade three learners holds promise to counteract a negative tendency of AP as transitioning to English language instruction.

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

- A small but significant difference ($p < .05$ and $d > 0.20$) was observed only for the end of year results (EoYR) between E2 and C2 for T2, with E2 reflecting the larger mean score (4.35 ± 0.97) in comparison to C2 (3.78 ± 1.34).

- When comparing E2 and C2 in terms of pre- to post-intervention differences (D2-1) for all the attention and academic performance variables, only the end of year results (EoYR) showed a statistical and practical significant difference ($p < .05$ and $d > 0.80$) between the two schools, with E2 (-0.13 ± 0.81) displaying a significantly lesser decrease in scores than C2 (-2.12 ± 1.25).
- In terms of the AP result for E2 and C2 at post-intervention in the present study, a possible reason behind the decreased AP in both E2 and C2 could be the medium of instruction transition, which was identified as the "fourth-grade slump" (Sanacore & Palumbo, 2008:67-68). Hence, one interpretation provided by the current study's results could be that increasing PA levels of grade three learners holds promise to counteract a negative tendency of AP as transitioning to English language instruction.
- When interpreting pre- to post-intervention differences (D2-1) for AP between E2 and C2, a smaller decrease in the experimental school's EoYR was noted, and hence, two international studies suggested that participating in the PA intervention could have had a maintenance effect on the AP results of the experimental school (Keeley & Fox, 2009:198; Mullender-Wijnsma *et al.*, 2015a:365).
- These findings suggest that the normal maturation and development of cognitive skills; motivational and aspirational levels; academic and athletic ability clustering within individuals; parental encouragement and logistic support all contribute to the maintenance of AP (Keeley & Fox, 2009:209-210). In the present study, none of the factors mentioned have been controlled for in the statistical analyses. Nevertheless, it is impossible to control for all factors contributing to AP. Therefore, it is difficult to elucidate the specific influences thereof.

5.8.3 The effect of the PA, health and hygiene education and nutrition intervention (E3 versus C3)

- A small but significant difference ($p < .05$ and $d > 0.20$) between the experimental and control schools was observed for only the end of year results (EoYR) at T2, with the control school also reporting the larger mean value (4.16 ± 1.16) in comparison to the experimental school (3.72 ± 1.38). A noteworthy observation was that both the experimental and control school improved in EoYR scores, however, this difference was not significant ($p < .05$).

- When comparing E3 and C3 in terms of pre- to post-intervention differences (D2-1) for each of the variables measured, only the percentage of errors (E%) showed both a statistical and practical significant difference ($p < .05$ and $d > 0.20$) in favour of C3 (-6.47 ± 14.94%), as opposed to E3 (-2.64 ± 12.95%). These findings indicate that C3 had a significantly larger decrease in percentage of error scores than E3.
- The present study's results in AP at post-intervention are in line with three previous international studies conducted by Keeley and Fox (2009:207), Mullender-Wijnsma *et al.* (2015a:370) and Treu *et al.* (2017:143).
- According to Treu *et al.* (2017:149), the reasons identified behind the increase in AP scores is possibly due to phenomena unrelated to the intervention.
- Findings from Mullender-Wijnsma *et al.* (2015a:370) showed that the contrary effect was partly explained by the difference in PA levels, whereby second grade children participated in MVPA significantly more than third grade children.
- Additionally, Keeley and Fox (2009:207) found that one study showed a closing of baseline difference in AP, which was suggestive of a positive effect for higher levels of curriculum-based PA.
- Therefore, the AP results of this study are supported by the findings reported above and can be explained that the experimental group schoolchildren were exposed to the PA intervention and the control schoolchildren were not. Hence, participation in the PA intervention could have influenced the AP of E3.
- Regarding the attention results between E3 and C3 for pre- to post-intervention differences, similar results to the present study were reported by Szabo-Reed et al. (2017:2346-2347), whereby there was a significant group difference in favour of the control group. Evidence supporting these results were not reported on, however, it was concluded that physically active classroom lessons do not have a negative impact on classroom attention in children and that future studies should continue to investigate the influence of physically active classroom lessons on attention and its impact on academic achievement to determine the sustainability of PA's effect on classroom behaviour.

5.8.4 The effect of the health and hygiene education and nutrition intervention (E4 versus C4)

- There were no statistical and practical significant differences ($p > .05$) between the E4 and C4 results for all the variables measured at T1 and T2, nor in terms of pre- to post-intervention differences (D2-1). This indicates that the experimental and control schools were relatively similar at pre- and post-intervention in terms of attention, as well as academic performance variables.
- Although the present study revealed similar results of no significance between E4 and C4 for all the assessed variables of attention and AP for T1, T2 and pre- to post-intervention differences, in addition to being contrary to other recent findings, factors such as micronutrient fortification (Taljaard *et al.*, 2013:2271), breakfast consumption versus no breakfast (Graham *et al.*, 2015:35), school feeding programmes (Graham *et al.*, 2015:35), sociodemographic factors such as income, crèche attendance and the education level of the mother could all possibly have an influence on the attention and AP of children. The findings presented here strengthens the need for further investigation into the effects of a health and hygiene and nutrition intervention on the attention and AP of children, particularly in those from lower socioeconomic communities.
- In the present study, none of the factors mentioned have been controlled for in the statistical analyses. Nevertheless, it is impossible to control for all factors contributing to attention and AP. Therefore, it is difficult to elucidate the specific influences thereof.

5.8.5 The effect of individual intervention components on attention and academic performance

- At post-intervention, only the PA intervention revealed a significant relationship ($p < .05$ and $d = 0.10$) with academic performance (EoYR), in favour of the children exposed to the PA intervention who showed a significant increase in EoYR when compared to those not exposed.
- Similarly, for pre- to post-intervention differences, only the PA intervention had a significant relationship with academic performance ($p < .05$ and $d > 0.80$), in favour of the children exposed to the PA intervention who displayed a significant increase in EoYR in comparison to those not exposed.

- None of the interventions yielded a significant difference for any of the other variables measured, which indicates that the participants exposed versus those not exposed to the interventions remained minimally influenced by the interventions in terms of all the attention variables. Similarly, the participants exposed to the health and hygiene and nutrition interventions were the same as those not exposed for EoYR.
- In terms of the AP result between the PA intervention and the non-PA intervention at post-intervention, the possible causative reasons for the present study's results could be explained by six international studies that implemented PA interventions have seen improvements in the AP of the experimental group and have attributed this to increased time spent being active, either during PE classes (Mullender-Wijnsma *et al*., 2015a:365), or PA breaks in class (Hollar et al., 2010:646), after school PA (Davis et al., 2011:91; Ericsson & Karlsson, 2014:273), as well as meeting recommended vigorous PA guidelines for children (Coe et al., 2006:1515). The PA intervention group was exposed to the PA intervention programme and the non-PA intervention group was not. Hence, participation in the PA intervention could have influenced the AP of the PA intervention group.
- Furthermore, in the present study, a possible reason behind the decreased AP in the non-PA group could be the medium of instruction transition, also identified as the "fourth-grade slump" (Sanacore & Palumbo, 2008:67-68). Hence, one interpretation provided by the current study's results could be that increasing PA levels of grade three learners holds promise to counteract a negative tendency of AP as transitioning to English language instruction.

5.9 CONCLUSION

The results of the study provide insight into the effect of school-based interventions on attention and AP of primary schoolchildren from lower socioeconomic communities in Port Elizabeth. The most important finding emerging from the analysis of the results of this study revealed that, for AP, there was a large statistical and practical significant difference ($p < .05$; $d > 0.80$) between the comparison of the PA intervention group and the non-PA intervention group, in favour of the PA intervention group. Therefore, it can be deduced that the higher an individual's PA level, the more likely that individual is to perform academically. From these results, no statistical or practical significant differences were found for AP in relation to the health and hygiene education and

nutrition intervention groups. Further investigation indicates that inconclusive results in respect of attention (total performance and concentration performance) was observed.

These findings provide evidence that the implementation of school-based interventions, particularly that of PA, can positively affect children's AP; and hence, is recommended as an attractive and feasible method for the improvement thereof. Furthermore, the present results reinforce previous findings indicating that spending more time on PE does not interfere with, nor detrimentally affects AP (Sallis *et al.*, 1999:133-134; Keeley & Fox, 2009:207). In addition, school-based interventions should be of longer duration and higher intensity levels (Davis *et al.*, 2011:96; Gallotta *et al.*, 2015:5). The current study emphasises the critical need for PA and the importance of PE in school curricula; and thus, it is strongly recommended that PE regain its rightful place and be actively taught within the school curriculum because PA confers physical and mental health benefits to learners (Sallis *et al.*, 1999:134). Lastly, further research is required to determine the effect of school-based interventions on the attention of primary schoolchildren in lower socioeconomic communities.

5.10 LIMITATIONS

The results of this study should be interpreted with a series of factors kept in mind. Despite all the efforts made to conduct the study as well as possible, there were limitations that played a role and could have affected the study's outcomes. The factors identified as general and relevant limitations of the study are highlighted as follows:

- Participants involved in the study were not representative of SA's schoolchildren, and therefore, generalisations regarding all primary schoolchildren could not be made.
- Attention was measured by the d2 Test of Attention. This test is a standardised test and criterion, construct and the predictive validity and reliability of the d2 test are well documented amongst children aged 7 years and older (Bates & Lemay, 2004:392; Wassenberg *et al.*, 2008:195; Gallotta *et al.*, 2012:550; Van Dijk *et al.*, 2014:460). However, the use of total performance, concentration performance and percentage

of errors only could serve as a limiting factor. In other studies, an additional measure, the fluctuation rate across trials were also included.

- Although concerted efforts to encourage participation of all children were made, children who were deemed to have apathetic attitudes and who appeared to struggle with factors, such as illiteracy and other social barriers, were not compelled to participate.
- The intervention period was relatively short, lasting only ten weeks. The reason attributed to this was because the study schedule had to consider school holidays, mid-term assessments and end-of-term examinations pertinent to the schools.
- Results of the study did not identify causality, but rather identified association. The study could not confirm that the changes indicated was caused by the intervention, since there were factors that could not be accounted for. These factors include other interventions implemented at the school and activities during break-times and after school.

5.11 STRENGTHS OF THE STUDY

- The sample size of the study was large, with the overall study assessing 1009 children and the current study reporting on 857 children.
- There was an almost even distribution of gender (males = 51% and females = 49%).
- The study included two ethnic groups.
- The socioeconomic status of the participants was low and homogenous, and this is a group that requires further research since they are most affected by conditions associated with poverty and low-income, such as lack of and inadequate structural, material and financial resources.
- All methods were standardised, thus enabling comparisons to other studies. Additionally, this standardisation verifies the quality and uniformity of the tests and repeatability at a later stage, with similar conditions, is ensured.
- Measurements were conducted by a small team of researchers to minimize discrepancies of testing at different schools.
- Attention was measured by the d2 Test of Attention. This test is a standardised test and criterion, construct and the predictive validity and reliability of the d2 test are well

documented amongst children aged 7 years and older (Bates & Lemay, 2004:392; Wassenberg *et al.*, 2008:195; Gallotta *et al.*, 2012:550; Van Dijk *et al.*, 2014:460)

- Double-entry of all data ensured for accurate and clean data.

5.12 RECOMMENDATIONS FOR FUTURE RESEARCH

Despite the limitations of the current study, the information is still useful in terms of the contribution of school-based intervention programmes on attention and AP. The effect of movement on these concepts creates an overall picture of the importance of PA programmes for young, developing children. The present study also emphasises the need for PA programmes (PE) in SA schools. It highlights the important role that PA programmes can play in the school environment, as well as supporting a holistic approach to teaching that leads to an optimal learning environment. With all the information available, it is strongly recommended that the role of PE in schools be reconsidered.

The following are future recommendations for research in, or related to, a similar focus as the present study. The study has not controlled for the wide range of factors that affect attention and AP. There could be biological and environmental factors that were not measured and accounted for. An expanded research project with more measured variables is required to confirm the study's findings. Future research should also consider investigating the effect of the following:

- AP measures which include different learning areas or subjects, as opposed to one overall, averaged academic score (EoYR).
- Gender in respect of the possible influence thereof on measured variables.
- Relevant school-based interventions such as nutrition education and PA at schools, particularly in historically disadvantaged areas, and more specifically in the Northern Areas of Port Elizabeth, on children's health.
- Low-cost, community-based PA programmes to facilitate the provision of extra-curricular PA opportunities within disadvantaged schools.
- PA school interventions implemented in accordance with the daily recommended PA (60 minutes) for children, that could be achieved through PE lessons, activity during break-time and after school extramural activities.

- The current study's school-based intervention programme implemented over a longer time-period.

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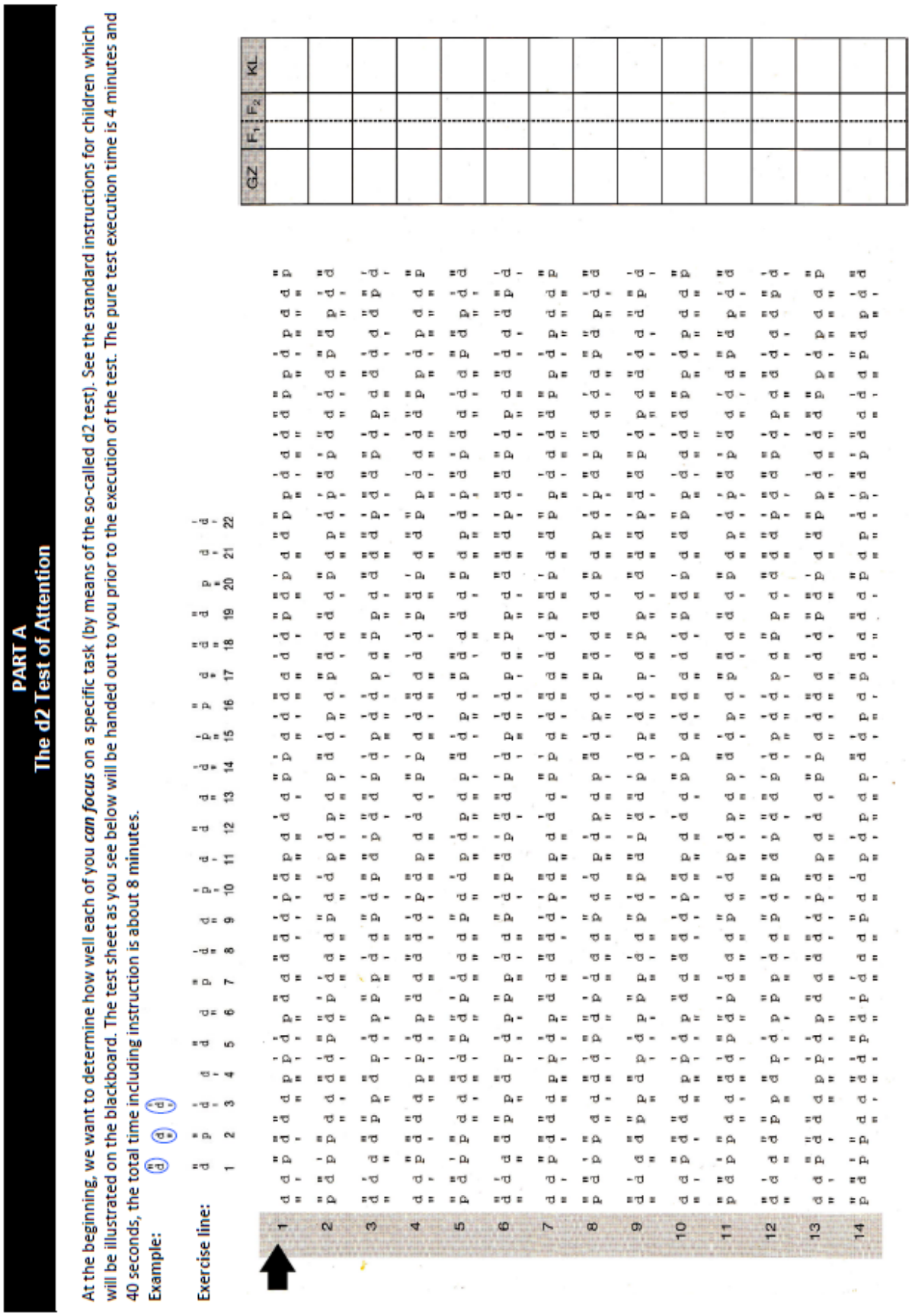
LIST OF APPENDICES

APPENDIX 1: MEASURING INSTRUMENT

a. The d2 Test of Attention



APPENDIX 2: CONSENT, ASSENT AND PROJECT INFORMATION LETTER

a. Informed Consent Form

INFORMED CONSENT FORM

PROJECT TITLE: The Effect of School-Based Physical Activity Interventions on the Cognitive Performance of Grade 4 Children from Lower Socio-Economic Communities in Port Elizabeth

Statement by the researcher/person taking consent:

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

I confirm that the participant Mr/Ms: _____

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

Name of researcher: _____

Place: _____ Date: _____ Signature: _____

Statement by the parent/legal guardian

I have read the letter of information of the study, or it has been read and explained to me in a language that I understand. I had the opportunity to ask questions about it and any questions I have asked, have been answered to my satisfaction. I know the purpose, objectives and procedures, risk and benefits of the study. I understand that I can withdraw my child from the study, at any time, without further consequences. I received a copy of this written informed consent form and an additional letter of information that I keep myself.

Name of schoolchild: _____

Name of parent/legal guardian: _____

Place: _____ Date: _____ Signature: _____

If participant is **illiterate**

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

Name of witness: _____

Place: _____ Date: _____ Signature: _____

Thumb print of participant:

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

If you have any questions about the study, please feel free to contact:
Larissa Adams – 083 395 0345

b. Oral Assent Form

ASSENT FORM TEMPLATE FOR CHILD PARTICIPANTS

PROJECT TITLE: The Effect of School-Based Physical Activity Interventions on the Cognitive Performance of Grade 4 Children from Lower Socio-Economic Communities in Port Elizabeth

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

The purpose of this study is to see how well you concentrate and focus in class after taking part in the programme. You will also need to answer questions about how you feel about school and whether you enjoy school. There are no wrong answers to any of the questions, it is not a test. Please answer the questions as honestly as you can. If you do not understand anything, please ask questions.

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

There are no wrong answers to any of the questions. Nothing bad can happen to you.

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

You may be better able to concentrate and focus in class after taking part in the programme.

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

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

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

Your parents or caregiver have been given information about the study. You should not get hurt in any way.

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

You can contact Larissa Adams on 083 395 0345, if you have any questions about the study.

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

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

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

YES	NO

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

_____ _____

Signature of Child Date

c. Information Sheet

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 malaria) 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 children per school) in the Port Elizabeth area will be selected for participation in a rapid appraisal. Out of these 50 schools, 30 schools (30 children 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 single 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), diabetes and malaria through an RDT, is slightly an uncomfortable procedure, however produces no 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 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 treatment guidelines.
The proposed research will provide a comprehensive update on the status of communicable diseases (e.g. helminth infections and malaria) 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 diseases and provide guidance for further health interventions to be implemented among school children 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 under the following address:

Professor Rosa du Randt (local coordinator)
Department of Human Movement Science
Summerstrand Campus (South)
Nelson Mandela Metropolitan University
Port Elizabeth 6031, South Africa
Tel.: +27 41 504-2499/7
E-Mail: rosa.durandt@mandela.ac.za

APPENDIX 3: ETHICS APPROVAL DOCUMENTATION

a. Department of Education Approval Letter

Province of the
EASTERN CAPE
EDUCATION

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

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

Professor R du Randt

Department of Human Movement Science

Nelson Mandela Metropolitan University

P.O. Box 77000

Port Elizabeth

6031

Dear Prof Du Randt

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

1. Thank you for your application to conduct research.
2. Your application to conduct the above mentioned research in 50 Primary Schools under the jurisdiction of Port Elizabeth District of the Eastern Cape Department of Education (ECDoE) is hereby approved on condition that:
    a. there will be no financial implications for the Department;
    b. institutions and respondents must not be identifiable in any way from the results of the investigation;
    c. you present a copy of the written approval letter of the Eastern Cape Department of Education (ECDoE) to the Cluster and District Directors before any research is undertaken at any institutions within that particular district;
    d. you will make all the arrangements concerning your research;
    e. the research may not be conducted during official contact time, as educators' programmes should not be interrupted;

PGDP EASTERN CAPE
Ikamva eliqaqambileyo!

building blocks for growth

Page 1 of 2

b. Department of Health Approval Letter

From: To:0866114682 07/11/2014 22:14 #177 P.001/001

Eastern Cape Department of Health

Enquiries:	Zonwabele Mafile	Tel No:	040 608 0630
Date:	07th November 2014	Fax No:	043 642 1409
e-mail address:	zonwabele.mafile@impilo.ecprov.gov.za		

Dear Prof Rosa du Randt 0866114682

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

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

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

Your compliance in this regard will be highly appreciated.

DEPUTY DIRECTOR: EPIDEMIOLOGICAL RESEARCH & SURVEILLANCE MANAGEMENT

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

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

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

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

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

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

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

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

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

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

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

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

GF MAC MASTER
CHIEF DIRECTOR: STRATEGIC MANAGEMENT MONITORING AND EVALUATION

FOR SUPERINTENDENT-GENERAL: EDUCATION

c. NMMU Research Ethics Committee Approval Letter

• 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

CB Cilliers

Prof CB Cilliers
Chairperson: Research Ethics Committee (Human)

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

d. Ethics Committee Northwest and Central Switzerland (EKZN) Approval Letter

Ethikkommission Nordwest- und Zentralschweiz EKNZ

Prof. Dr. U. Pühse
DSBG University of Basel
Birsstrasse 320 B
4052 Basel

Basel, 01st 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 Northwestern 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 have to 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. In particular, 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.) with regard to the best possible protection of the study subjects;
- Professional qualification of the non-Swiss research personnel.

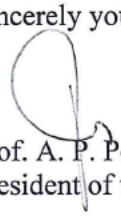
The points listed above should be assessed by the responsible ethical research committee(s) of the place(s) where the project is carried out.

./.

Geschäftsführerin: Frau Irene Oberli, Hebelstrasse 53, 4056 Basel, Telefon 061 268 13 50, Fax 061 268 13 51, eknz@bs.ch. www.eknz.ch

The Ethics Committee of Northwestern 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



Prof. A. P. Perruchoud
President of the EKNZ

e. NMMU Faculty of Postgraduate Studies Committee Approval Letter

FPGSC reference number: **H15-HEA-HMS-009**.

Please be informed that this is a summary of deliberations that you must discuss with your Supervisors.

Please forward a final electronic copy of your appendices, proposal and REC-H form to the FPGSC secretariat.

We wish you well with the project.

Kind regards,

Marilyn Afrikaner
FPGSC Secretariat
Faculty of Health Sciences

Student number: 211106852

Contact person: Ms M Afrikaner

1 September 2015

MS LA ADAMS
32 GAMBIT CRESCENT
PALMRIDGE
PORT ELIZABETH
6059

RE: OUTCOME OF PROPOSAL SUBMISSION

QUALIFICATION: MA (Human Movement Sciences: Research)

FINAL RESEARCH/PROJECT PROPOSAL:
THE EFFECT OF SCHOOL-BASED PHYSICAL ACTIVITY INTERVENTIONS ON THE COGNITIVE PERFORMANCE OF GRADE 4 CHILDREN FROM LOWER SOCIO-ECONOMIC COMMUNITIES IN THE NELSON MANDELA BAY MUNICIPALITY, 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 Supervisors:

COMMENTS/RECOMMENDATIONS

1. The proposal already has ethics and institutional approval as part of a joint study.
2. Title
   - The title was very long. "The" in the beginning of the title could be removed.
   - Delete the words "the NMBM", or "Port Elizabeth" in the title.
   Same as the above for 2.2.
   Same as the above for 2.4.
3. Throughout the proposal the researcher refers to the aim of the study, namely "… to determine the effect of a school based physical activity intervention, on its own, or in combination with health education and / or nutrition on the cognitive performance of Grade 4 children …" Should it not be "…to determine the effect of a school based physical activity intervention, on its own, and in combination with health education and nutrition on the cognitive performance of Grade 4 children …"
4. Supportive literature
   Add "lack of physical activity" to 1. Contectualisation L9.
5. Participants and sampling method
   Although the population and the sampling of the schools are included, the researcher needs to add sampling of the children, or will it include all children in the age group giving assent?
6. Reliability of data collection procedure
   Is the researcher controlling for FAS in children?
7. Budget
   The researcher did not add the budget for data collection. This needs to be included or explained that it was already covered by the joint research project as stated on the REC-H form 1l).

APPENDIX 4: DASH STUDY INTERVENTION MATERIAL

a. Physical Activity Lesson Example

PE LESSON 3

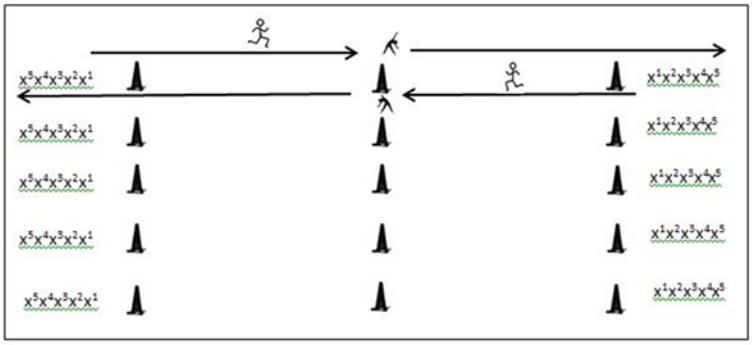
LESSON NO: 3	EQUIPMENT
Lesson Focus: Cardiovascular endurance, agility, strength, flexibility	**35 Cones**
	10 Hula Hoops
	5 Soccer Balls
	5 Netballs

ACTIVITY
Introduction (5min-10Min) **Whistle Freeze:** Teacher asks the children to walk, jog, or skip. Children follow instructions but on hearing teacher blow the whistle, each child must freeze. If they move then, they must do five jumps. Teacher may ask them to freeze in a balance or to perform a stretch after each whistle. **Traffic Lights** Students run freely around the activity area: when RED is called – everyone stops; YELLOW – walk; GREEN – run. Add to the game by having students perform balances or stretches for RED, funny movements (hands over head waving, knees high, etc.) for YELLOW, and zigzag movements for GREEN. This is a good warm-up activity.
Fitness Component (10min-15min) **Team Relay: 6 children in a team:** **Learners perform the following activities in relay context** - Running, Skipping, Monkey Walk, Crabby Walk, Bunny Hop, Running Backwards, High Knees, Spiderman
Modified Invasion Game (10min-15min) **Piggy in the middle** Learners stand in a circle with two learners in the middle. Learners must pass the ball to each other and those in the middle must try to intercept the ball. Learners may not pass to the person directly next to them. If a learner in the middle intercepts the ball, the one who passed it goes in the middle. Alternatively, the coach can swap learners after a certain number of passes, regardless of interception. The coach can also add a second ball into the circle. Equipment: Enough beacons for the number of learners, and two or more soccer balls.
Cool Down Stretch (5min-10min) **Stretching 1** – 8 Figure, Straddle, Long Seat, and Arm Stretch. Reflection: Ask children what they enjoyed, what they learnt while stretching and cooling down.

PE LESSON 3

ACTIVITY

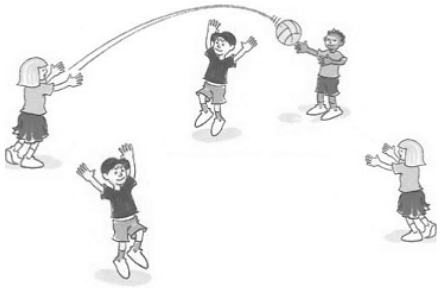
Fitness Component (10min-15min)



Exercise - Running, Skipping, Monkey Walk, Crabby Walk, Bunny Hop, Running Backwards, High Knees, Spiderman

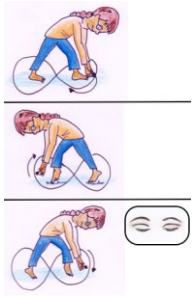
Modified Invasion Game (10min-15min)

Piggy in the Middle



Cool Down Stretch (5min-10min)

8 Figure

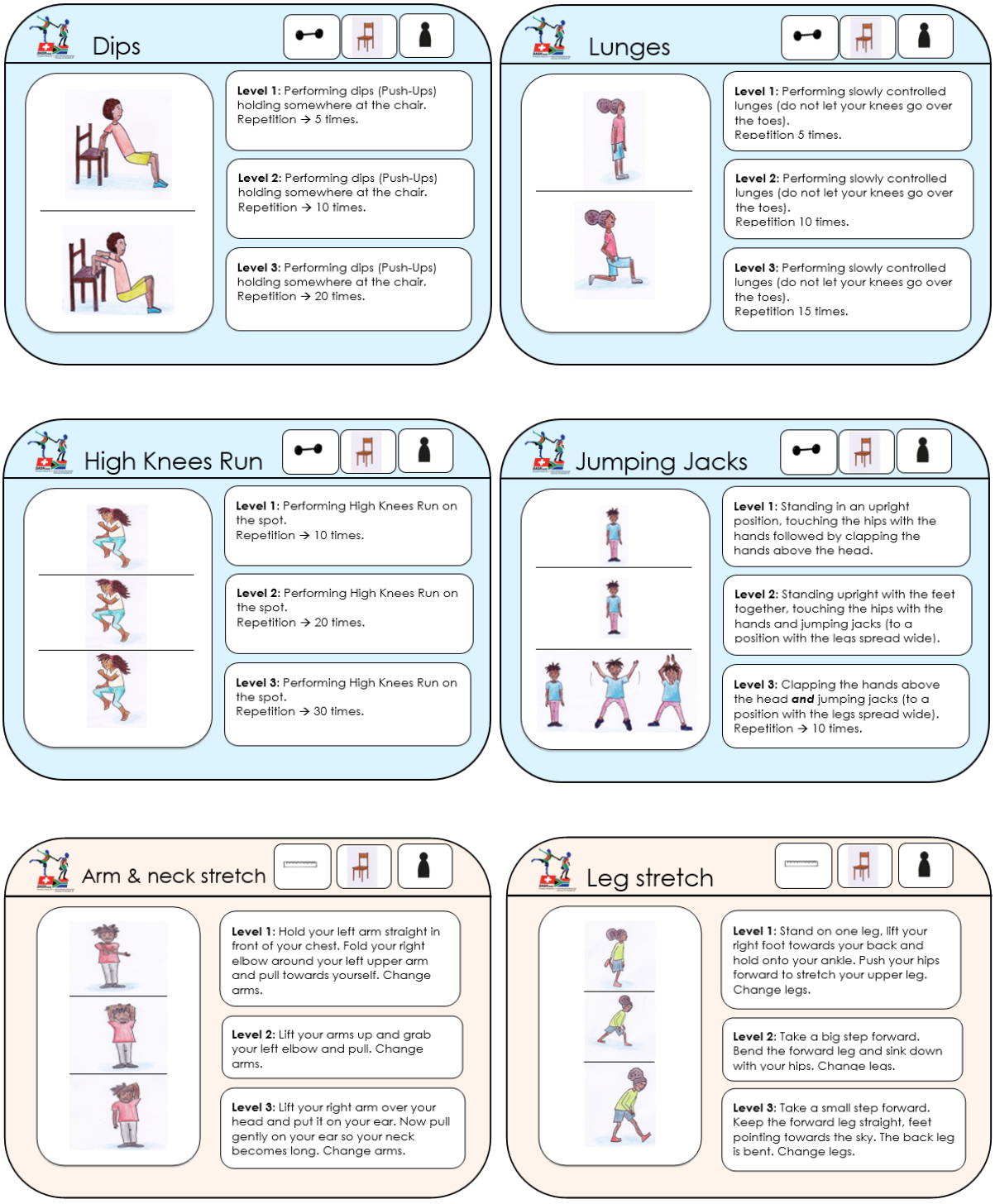


Straddle

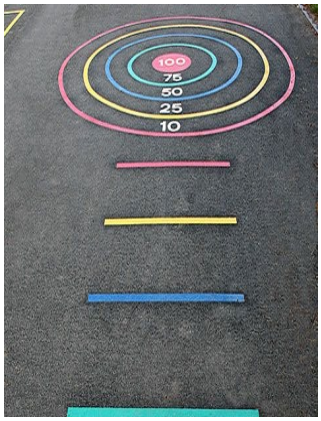
Long Seat

Arm Stretch

b. Physical Activity Classroom Poster Examples



c. Playground Structures and Murals Examples



d. Health and Hygiene Education Lesson Example

DASH Study: Health Education Module 3 (Teachers' Guidelines)

Handwashing

Length of session: 45 minutes

Module materials: Let's wash our hands poster, soap and water

Goal of session: To show the children how and when to properly wash their hands clean.

Guidelines:

1) Explanation of the poster: a) Get the children to put their hands out in front and as you read through the steps on how to wash their hands, get them to practice the different rubbing motions. b) Go through the different times to wash their hands. Remind them of what they have learnt in module 2 on why they have parasites in their stomach and how to prevent them. c) Remind them to wash the areas on their hands colored with red as shown in picture.
2) Demonstration in the toilet or any open sink: Please demonstrate the hand washing steps with soap and water for the children. After the demonstration, get around 4 children to try washing their hands according to the steps and see if the whole class is clear with how to wash their hands.
3) Setting up of a buddy system: Divide the children up in groups of 4 or 6. Boys and girls should have separate groups. Within the group, the children should remind each other to wash their hands before eating, after toilet use, after sports or playing outside, after sneezing or coughing and after playing with pets.

End of the module:

- Encourage the children to ask questions about what they have learnt in this module. If there is any question, which the teacher is not able to answer, he/she can check with the DASH study team and get back to the children later.
- Encourage the children to share what they have learnt with their parents and friends in the community. Interested parents are most welcomed to sit in for the next sessions.
- **Teachers to discuss with the school management how to ensure that soap is provided in the toilet for the children.**

e. Health and Hygiene Education Classroom Poster Example

f. Health and Hygiene Education Activity Task Example

DASH Study: Health Education Module 4

Little Toilet Experts – Part 1

Task to do in class: Classify your school toilet

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

Is there a bad smell?		
Are there any flies?		
Is there sufficient toilet paper available?		
Is there a door to the toilet/latrine?		
If there is a door: can it be locked from inside?		
For outdoor toilets: is there a properly working light on the path to the toilet?		
For outdoor toilets: Is there a path to the toilet which can be conveniently used in any weather and season?		
Is there a hand washing station close by?		
Is there a permanent water supply (pipe) at the hand washing station?		
Is there soap at the hand washing station?		

g. Nutrition Education Lesson Example

Session 2 : Carbohydrates
Length of session: 15 minutes

Module materials: Slideshow
Additional materials: Copies of the activity sheet where children draw a line between the food item and the picture to match them. Fill in the missing words in the second box.

Goal of session: To teach children about carbohydrates and its role in the body (functions). To teach children about good sources of carbohydrates.

Guidelines:

1) Slide 1: Tell children about the goal of today's session.
2) Slide 2: What are carbohydrates? Teach them that starches in another name for carbohydrates. Pictures on the slide of foods rich in carbohydrate.
3) Slide 3: Children must understand that carbohydrates form the basis of most meals and that they could have it at every meal.
4) Slide 4: What are good sources of carbohydrates? Children must look at the two columns and choose in class (they can vote) whether column1 or column 2 is the healthiest.
   Then explain that the high fiber column (column 2) is healthier because high fiber is good for digestion, to help protect our hearts against unhealthy fat and it has less sugar.
5) Slide 5: What are the functions of carbohydrates? It serves as a source of fuel for the brain and the body to help you think and be able to be active.
6) Slide 6: Over the next weeks, children will learn about other food groups as protein, fruit and vegetables and fat

End of the module:

- Encourage the children to ask questions about what they have learnt in this module. If there is any question, which the teacher is not able to answer, he/she can check with the DASH study team and get back to the children later.
- Encourage the children to share what they have learnt with their parents and friends in the community.
- Ideally, slide nr 5 could be printed and hanged up on the walls in the classroom for at least one week.

h. Nutrition Education Classroom Poster Example

Carbohydrates – The basis for all meals

Carbohydrates provide **energy** at every meal. They are a fuel for:

1. Your brain: helping you think, concentrate and learn;

2. Your whole body: helping you exercise and play.

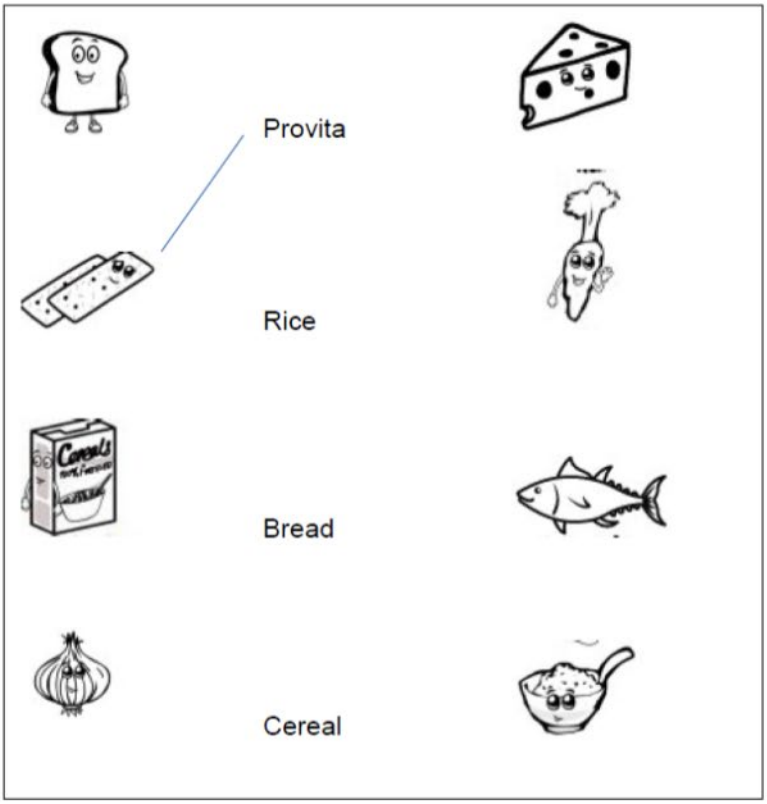
Bread, potatoes, pasta, rice, cereal and porridge are all carbohydrates.

The fibre in carbohydrates is good for digestion and keeps you fuller for longer. Whole-wheat and brown bread has more fibre than white bread – and contain less sugar.

i. Nutrition Education Activity Task Example

Activity:

Children match the food item with the picture by drawing a line to the right item. Tip: only use the carbohydrates. Fill in the missing words in the next box.



Carbohydrates give me _____ that helps my _____ to _____, concentrate and learn

It also gives me energy to _____ and exercise