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**“Correlation between physical fitness, self-control,
attention and academic achievement in socially
disadvantaged schoolchildren aged 9-12 from Port
Elizabeth, South Africa”**

Masterarbeit

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Abstract

Background

Current literature has linked the parameters physical fitness, self-control, attention, socio-economic status and academic achievement in various combinations and has provided evidence for physical and psychological health improvements. The purpose of this study is to assess the relations between the above-mentioned five parameters within the frame of the DASH-study.

Methods

Cross-sectional data including the academic achievement, 20-m shuttle run, a psychosocial questionnaire including questions about the socio-economic status (SES), the brief self-control-scale and the d2-test of attention were collected within the frame of the longitudinal DASH-study taking place in Port Elizabeth, South Africa. Participants (N=945) are aged 9-12 and divided approximately equally across gender (50.5% are female and 49.5% male).

Results

The correlation analysis revealed no significant relation between physical fitness and academic achievement. There was a small positive correlation between physical fitness and attention. No significant relations could be found neither between self-control and academic achievement nor between self-control and attention. Further, the results did not indicate a relation between physical fitness and self-control. But the results show a substantial positive correlation between SES and academic achievement and a small positive relation between SES and attention.

Discussion

The two key findings of the present study are that attention is associated with cardiorespiratory fitness and that SES is related to academic achievement and attention. All other parameters do not correlate significantly, thereby deviating from results of contemporary research.

List of abbreviations

ANA	Annual National Assessment
ADHD	Attention Deficit Hyperactivity Disorder
BMI	Body Mass Index
CRF	Cardiorespiratory Fitness
CP	Concentration Performance
DASH	Disease and Activity in Schoolchildren's Health
EC	Effortful Control
EF	Executive Function
EOY	End of the Year Results
M	Mean
N	Sample Size
NMMU	Nelson Mandela Metropolitan University
PFC	Prefrontal Cortex
SAT	Scholastic Assessment Test
SC	Self-Control
SD	Standard Deviation
SES	Socio-Economic Status

1. Introduction

"PHYSICAL FITNESS IS NOT ONLY ONE OF THE MOST IMPORTANT KEYS TO A HEALTHY BODY, IT IS THE BASIS OF DYNAMIC AND CREATIVE INTELLECTUAL ACTIVITY." - JOHN F. KENNEDY

A vast amount of research looks into how various factors, such as physical fitness, self-control, attention, socio-economic status and academic achievement, influence one another. The idea that healthy children learn better is empirically supported and well accepted (Basch, 2011). Multiple studies have confirmed that health benefits are associated with physical activity, including cardiovascular and muscular fitness, bone health, psychosocial outcomes, and cognitive and brain health (Strong et al., 2005). In spite of the already existing results it seems additional research is needed in order to gain further insight. Thus, this study will explore, within the frame of the DASH-study, in what ways the above-mentioned factors interact and with what consequences.

Choosing South Africa as the setting for this study is justified because of several reasons. In a third world country such as South Africa the education and health sector exist in parallel. The public systems are chronically underfunded and understaffed, whereas the private sector serves the wealthiest and are far better served than the majority of the population (Ataguba & Akazili, 2010). Furthermore, after a first-hand experience in Cape Town, during a 4-week internship at Streetwise Soccer where much-needed sports coaching for homeless and neglected children was provided, it became apparent that research in that area is much needed. Research to better understand the relationship between our health, our direct environment and cognitive processes that facilitate learning. Therefore, the opportunity to participate in a joint research project between South Africa and Switzerland was much appreciated. Especially working and interacting with children as well as investigating the relationship between cognitive processes, cardiorespiratory fitness and academic achievement, in a socio-economically low status environment in primary school children in South Africa.

In the context of the present study, five parameters were chosen to be prime measures. Cross-sectional data including the academic achievement, 20-m shuttle run, a psychosocial questionnaire including questions about the socio-economic status (SES), the brief self-control-scale and the d2-test of attention will serve as basis for my analysis. Before looking at the results, however, it is pivotal to provide an overview of the *status quo* of the research and explain which definitions are relevant for the study at hand.

2. Theoretical background and definitions

This chapter provides an overview of the five parameters included in the present study; e.g. physical fitness, self-control, academic achievement, attention and socio-economic status. Within the following section, parameters will be defined and their theoretical background will be illustrated.

2.1. Physical activity and physical fitness

Physical activity has been associated with multiple health benefits in both adults and children. Being physically fit reduces the risk of cardiovascular disease, type II diabetes, helps to control body weight and improves mental variables such as stress, depression and anxiety. Physical activity also assists in social development by providing opportunities for self-expression and social interaction (WHO, 2010). Childhood and adolescence are crucial periods in life where lifestyle as well as healthy/unhealthy behaviours are established. Multiple health benefits occur when children and adolescents participate in regular physical activity. Active children have stronger muscles and bones, sleep well and are able to handle physical and emotional challenges better (Eveland-Sayers & Farley, 2009). Physical activity has also beneficial effects on several mental health outcomes, including improved mood states and health-related quality of life (Penedo & Dahn, 2005). A study examining the effects of aerobic physical activity on the psychological well-being in low-income Hispanic children indicates that cardiorespiratory fitness positively affects depression and self-esteem (Crews, Lochbaum, & Landers, 2004). One possible explanation for the positive effect of physical fitness on psychological well-being is that increased fitness may have a direct effect on neurochemicals in the brain that function to elevate mood (Ortega, Ruiz, Castillo, & Sjöström, 2008). Physical fitness has also been associated with cognitive performance and a growing body of literature indicates that physical fitness and activity can benefit both health and academic performance for children (Castelli et al., 2014).

2.1.1. Definitions

The following definitions of physical activity, physical fitness and cardiorespiratory fitness will serve as the basis of this paper:

“Physical activity is any body movement produced by muscle action that increases energy expenditure” (Ortega et al., 2008).

“Physical fitness is the capacity to perform physical activity and makes reference to a full range of physiological and psychological qualities” (Ortega et al., 2008).

“Cardiorespiratory fitness is a health-related component of physical fitness defined as the ability of the circulatory, respiratory, and muscular systems to supply oxygen during sustained physical activity. CRF is usually expressed in metabolic equivalents (METs) or maximal oxygen uptake (VO₂max) measured by exercise tests such as treadmill or cycle ergometer” (Lee, Artero, Sui, & Blair, 2010).

For the purpose of this paper, the term physical fitness refers to the test results from the 20-m shuttle run which measures cardiorespiratory fitness.

2.1.2. Physical activity/fitness and its social status in developing countries

In spite of the evidence that physical activity has various health benefits and can help improve academic achievement, physical education classes are increasingly being cut to a minimum while more time is being invested in other academic purposes. As a result, young people barely engage in the recommended daily 60 minutes of moderate-to-vigorous physical activity (Strong et al., 2005). This is even more drastic in South Africa’s disadvantaged schools and township areas where basic sport and recreation facilities and resources are lacking. According to McVeigh (2004) physical activity levels found in children from the lowest socio-economic quartile were low whereas television watching time was rather high. In contrast, white children were found to be more active than black children, more likely to participate in physical education classes at school and they watched less television than their black peers (McVeigh, Norris, & de Wet, 2004). Limited opportunity for physical activity, inadequate facilities and low curriculum status are not only peculiar to South Africa, but are typical of disadvantaged schools in developing countries (Walter, 2014). The second worldwide survey of school physical education by Hardman (2008) found that in economically developing and under-developed regions of Africa, Asia and South America, physical education appears to be under threat as a result of insufficient curriculum time allocation, inadequately trained teachers, inferior subject status as well as an insufficient provision of facilities and equipment. This is aggravated by the fact that community programmes and facilities outside of schools are poor. Physical fitness/activity has not only a low social status but is also compromised due to lacking resources and insufficiently qualified teachers (Chappell, 2001; Hardman, 2008).

2.2. Self-control

“The human capacity to exert self-control is arguably one of the most powerful and beneficial adaptations of the human psyche. People are happiest and healthiest when there is an optimal fit between self and environment, and this fit can be substantially improved by altering the self to fit the world” (Rothbaum, Weisz, & Snyder, 1982).

Self-control is among the most widely studied constructs in social science. Many theories and models incorporate the concept of self-control. Thus, there is a confusing diversity of both terminology and definitions for self-control in the existing literature; self-regulation, self-discipline, willpower, effortful control, ego strength and inhibitory control, to mention only a few (Duckworth, Gendler, & Gross, 2014). Concerning terminology, this paper will stick to the term *self-control*. However, the next section will shed light on what definitions seem most valuable in the context of this paper.

2.2.1. Defining self-control

Out of the vast variety of definitions, two will represent an increasingly consensual description of self-control and serve as the base of this paper. Both stem from Duckworth et al. (2014) and fit the concept of self-control within this study best. Further, they represent self-control resonating with diverse psychological traditions. The first definition integrates the idea of effortful regulation of the self by the self.

“Self-control has to be self-initiated, and the term “self” as a prefix to the term “control” specifies that it is the individual, rather than an authority figure, who instigates the process of regulation” (Duckworth et al., 2014).

The second definition is based on the idea of exercising self-control in terms of doing what we know to be best in the long run:

“Self-control is the voluntary regulation of attentional, emotional, and behavioural impulses when immediate temptations conflict with more enduringly valued goals.” (Duckworth et al., 2014).

After choosing two definitions that represent self-control the present paper, the next section will elaborate where self-control is governed and what factors can influence it.

2.2.2. The development of self-control

The ability to delay gratification, control impulses and modulate emotional expressions is an omnipresent expectation that society places on children. Even at a young age, children are expected to suppress emotional impulses such as not

hitting a peer despite feeling angry (Tarullo et al., 2009). The mastery of self-control plays a pivotal role throughout all life domains and is associated with predicting school readiness, academic achievement, social competence and appropriate conduct (Eisenberg, Hofer, & Vaughan, 2007).

Modern empirical research has confirmed that the capacity of self-control strengthens over the life course, well beyond childhood, possibly into middle and late adulthood (Roberts, Walton, & Viechtbauer, 2006; Rothbart & Rueda, 2005). Although, self-control increases with age, there are marked differences among children the same age. When presenting a piece of candy to 4-year-olds and telling them not to eat it and to wait for a certain period of time in order to receive more candy. One child might grab the candy immediately, whilst the other child might wait patiently for the bigger reward (Nerlove, Mischel, & Mischel, 2008). This fact poses the question if some children are just better at exhibiting self-control and if so, why. Looking at individual differences in environmental and genetic contributions and their effects on the brain can shed some light on the raised questions. Brain development is not exclusively based on the passage of time. The child's experiences play an active role in shaping the brain as it develops and connections between different parts of the brain are formed (Tarullo et al., 2009).

Self-control underlies a coordinated system in the human brain that directs higher-order cognitive processes and are generally referred to as executive functions (EF). EFs are mental processes that are activated when individuals concentrate, make decisions, plan, regulate emotions and inhibit impulses (Black, Semple, & Grenard, 2011; Suchy, 2009). There is a general agreement that there are three core EFs; inhibition, working memory and cognitive flexibility (Lehto et al., 2003; Miyake et al., 2000). Inhibition includes self-control and involves control over one's behaviour and one's emotions. Self-control is about resisting temptations and not acting impulsively (Diamond, 2013). For an effective use of self-control, several brain regions need to be interconnected. EFs are located in the prefrontal cortex, which develops gradually from infancy through adolescence. The orbitofrontal cortex is involved in decision making, especially when the decision involves reward, as in the example waiting for candy. The part of the brain that is responsible for balancing out logical thought and emotional impulse is the anterior cingulate. This part of the brain becomes more active from ages three to six years, exactly when children become better at suppressing impulsive behaviours. One of the hardest parts of self-control is resisting an emotional impulse – for example refraining from grabbing the candy despite wanting it. Children may know the rule, but just knowing it is not enough because the emotional impulse still wins. The older children get, the more active the anterior cingulate gets and the better they become in waiting for rewards by suppressing impulsive behaviours. Therefore, with age, the logical part of the brain

becomes more capable of exerting control over the emotional, impulsive part of the brain, at least in some situations (Zelazo, Carlson, & Kesek, 2008). In a study where brain-wave patterns were made visible, it became evident that children recruit a widespread area of the brain when trying to resist an impulse. Interestingly, the change in the recorded brain waves of adults when resisting temptation was focused on a much smaller area of the brain. This indicates that the brain gets more efficient at exerting self-control over the course of development (Rueda, Posner, & Rothbart, 2005). In summary, a child's behaviour is determined by different parts of the brain working together and this, in turn, depends on the environmental contributions. It follows that family and culture play an important role in the development of self-control. The home environment, physical and social resources and the quality of the relationship between caregiver and child predict self-control abilities (National Institute of Child Health and Human Development (NICHD) Early Child Care Research Network, 2005). Sensitive parenting in early childhood, that supports autonomy, helps children to develop self-control strategies, whereas negative parenting typically relates to poor child self-control strategies (Tarullo et al., 2009). Additionally, children growing up in cultures that emphasize on the importance of self-control tend to develop self-control abilities faster. Both, Korean and Chinese preschool children, perform better than their American peers on self-control tasks (Sabbagh et al., 2006).

The development of the brain is, as mentioned earlier, not exclusively based on the passage of time but on positive experiences. Negative experiences have a damaging impact on brain development and behaviour. Prenatal exposure to alcohol and drugs, as well as sleep disruption, maltreatment and neglect during childhood are examples of negative effects on the developing brain and put children at risk for various cognitive processes and performances (Tarullo et al., 2009). Prenatal alcohol exposure has been linked to impulsivity, self-control deficits and increased rates of an Attention Deficit Hyperactivity Disorder (ADHD) diagnosis (Niccols, 2007). Maltreatment and neglect are related to self-control problems in children because they lack the opportunity to learn self-control strategies they would learn from interacting with caregivers (Shackman et al., 2008). Families with low socio-economic status (SES) may experience sleep disruption because of an overcrowded household, chronic stress, hunger and poor regulation of temperature (Buckhalt et al., 2007).

2.2.3. Self-control as a predictive factor

Delaying gratification and controlling impulses in favour of long-term goals predict individual, societal, and economical success. Walter Mischel, one of the most

influential modern psychologists, explored self-control and its predictive power in children using the Marshmallow Test. He measured how long a child can resist settling for a small, immediately available reward (one marshmallow) in order to get a larger reward later (two marshmallows) (Mischel et al., 2011). This test has revealed remarkable predictive validity in pre-schoolers for social, cognitive and mental health outcomes in later life domains. The more seconds the children waited for their “bigger” reward at age four or five, the higher their SAT-scores (scholastic assessment test) and the better their rated social and cognitive functioning in adolescence. At age 27-32, those, who had waited longer during the Marshmallow Test in preschool, had a better sense of self-worth, a lower body mass index, pursued their goals more effectively and coped more adaptively with frustration and stress (Mischel, Shoda, & Rodriguez, 1989). Moffitt et al. (2011) found similar results in a longitudinal study, where participants were tested from birth to the age of 32 with an observational and correlational study design. Their major finding was that childhood self-control has a predictive potential regarding physical and mental health, income, savings behaviour, financial security, occupational prestige, substance use as well as lack of criminal convictions in adulthood. The predictive power of self-control is comparable to that of either general intelligence or family socio-economic status (Moffitt et al., 2011).

A study by Fergusson et al. (2013) attempted to replicate the findings reported by Moffitt et al. (2011) and adjusted the results found with the confounding influence of childhood conduct problems. The longitudinal study followed participants from birth to the age of 30. Self-control was measured during ages 6 to 12 years analogously to Moffitt et al. (2011) using parent-, teacher-, and self-report methods. Associations between self-control and outcomes were adjusted for possible confounding by gender, intelligence, socioeconomic status (SES) and childhood conduct problems (ages 6-10). The results showed that adjustment for gender, SES and intelligence reduced to some extent the magnitude of the associations, thereby suggesting that the observed linkages between a measure of childhood self-control and outcomes in adulthood were largely explained by the correlated effects of childhood conduct problems, IQ, SES and gender (Fergusson et al., 2013).

These results relativize the findings of previously mentioned studies and show that childhood self-control is not the only factor that predicts behaviours in adulthood.

2.3. Academic achievement

The third parameter, academic achievement, is usually measured by tests that assess knowledge formally taught in school. Schneider & McGrew (2012) compare academic achievement with crystallized intelligence – which is defined as “depth

and breadth of knowledge that are valued by one's culture"(Schneider & McGrew, 2012). Related definitions can be found in a study about the predicting power of intelligence on academic achievement in future teachers by Čavojová & Mikušková (2015). They define school achievement in two ways: "as demonstrated knowledge required for fulfilment of content of educational standards" and as "consent between requirements of school and performance, personality and development of the student" (Čavojová & Mikušková, 2015). The first definition reflects the academic achievement in various standardised didactic tests such as SAT, ANA etc. or the average score from the school subject at the end of the year. The second definition reflects that school success as a student needs not only the fulfilment of passing tests, but also being able to use and present knowledge adequately, build relationships with teachers and classmates and engage in activities that would compensate for underperformance, etc. (Čavojová & Mikušková, 2015). The second definition of academic achievement sounds similar to Sternberg's conception of successful intelligence which consists of three components: academic, creative and practical intelligence (Sternberg, 2005). The relation of intelligence and academic achievement has been debated and results are inconclusive. This is mainly due to the fact that there are different aspects of intelligence that can be considered. Hence, depending on what aspect is being focused on, result may differ.

2.3.1. Defining academic achievement

For the purpose of this study, academic achievement is measured on the average grade of four different subjects and does not represent intelligence. It represents the ability or degree of competence in school measured by tests and expressed in a grade based on the student's performance. The terms academic achievement and academic performance have the same meaning in the present paper. The following definition will serve as the basis of this paper:

"Academic achievement is the knowledge obtained or skills developed in the school subjects usually designed by test scores or marks assigned by the teacher" (Good, 1959).

2.4. Attention

"Attention is the cognitive process of selective concentration on a distinct aspect of information whilst ignoring other stimuli" (Anderson, 2010). Attention is thought to gate learning and academic outcomes in adults, children and infants, in auditory and visual processing and in cognitive domains such as language, number and space. There are multiple constructs of attention. They are all related but they are also separable processes which include sustained attention or vigilance, selective

attention, and executive attention or attention shifting and divided attention (Steele et al., 2012).

As mentioned before, attention is thought to gate learning and is therefore a main component of academic success. The ability to control and sustain attention as well as participate in classroom activities is linked to test scores and grades during preschool and the early elementary years (Alexander, Entwisle, & Dauber, 1993; Raver, 2004). In their study, Checa and Rueda (2011) describe that effortful control (EC), which includes the ability to voluntarily manage attention and inhibit or activate behaviours as needed, appears to be a key mediator in children's social adjustment to school and academic achievement. Multiple other studies have shown that executive attention has a beneficial effect on learning in school, especially for subjects such as literacy and numeracy, through its involvement on cognitive flexibility and regulation (Blair & Razza, 2007; Bull & Scerif, 2001; Checa et al., 2008).

Another factor that links attention and academic achievement is the attention-deficit hyperactivity disorder (ADHD). ADHD is a behavioural condition that makes focusing on everyday tasks a challenge and can lead to inattention, hyperactivity and impulsivity. ADHD has also been described as executive function deficit (EFD) (Barkley, 1997). In a study by Barry et al. (2002), 66 children aged 9-14, of which 33 diagnosed with ADHD, were tested in four different EF-tests, in one IQ test and in one academic achievement test. Children with ADHD did not exhibit significant impairments in EF, but were clearly impaired behaviourally and they were significantly more impaired academically (Barkley, 1997). The findings of underachievement in ADHD replicate findings of previous researchers (e.g. Frick et al., 1991). These findings are all indicative that attention is a prerequisite of academic achievement and therefore both concepts, academic achievement and attention, are used as parameters in this paper.

2.4.1. Defining attention

The different detailed sub classifications of attention are not of relevance for the study at hand and will be treated as one concept. Hence, the following definition will serve as the basis for the term attention in this paper:

“Attention is the cognitive process of selective concentration on a distinct aspect of information whilst ignoring other stimuli” (Anderson, 2010).

2.5. Socio-economic status

The influence of a child's socioeconomic background is among the most widely studied concepts in social science. Several ways of measuring SES have been

proposed, most of them including some quantification of family income, occupational status and parental education. Research shows that SES is associated with a wide array of cognitive, health and socio-emotional outcomes in children, with effects beginning even before birth and continuing into adulthood. SES impacts children's well-being in more than one level, including both family and neighbourhood. Its effects are moderated by family characteristics, children's own characteristics and the/an external support system (Bradley & Corwyn, 2002).

Studies have shown that family factors such as SES, specifically the parents' education and income, as well as environmental factors such as school facilities and school practices, influence children's academic achievement (Caro, McDonald, & Douglas Willms, 2009; Davis-Kean, 2005; M. Schneider, 2002; Toutkoushian, 2002).

2.5.1. Defining socio-economic status

The following definition will serve as the basis for the term socio-economic status in the present paper:

“**Socio-economic status** is commonly conceptualized as the social standing or class of an individual or group. It is often measured as a combination of education, income and occupation. Examinations of socio-economic status often reveal inequities in access to resources, plus issues related to privilege, power and control” (American Psychological Association, 2007)

After having discussed the five parameters in detail, the next two sections provide background information on the specific setting of the study and sets the socio-economic situation in South Africa in its historical context.

2.6. Historical Background

South Africa is a developing country battling with the after-effects of post-apartheid and its consequences. During Apartheid millions of black and coloured people were forcefully removed from their homes and put into homelands according to their skin colour. They had to live in so called townships and were exploited for decades. Due to the lack of education and oppression, the gap between poverty and wealth became insurmountable. The division of Black and White is still rearing its ugly head even after the abolishment of apartheid. Since colonisation, South Africa has been highly influenced by western culture, especially in urban areas. The social divide between poor and rich seems to only get larger and securing a successful future is still an unreachable aspiration for many. The after-effects of apartheid are clearly visible today with high unemployment rates, high criminal statistics, a lack of educational institution and a poor healthcare system (Toit, Pienaar, & Truter, 2011).

2.6.1. South Africa today

The laterality of poverty and wealth is becoming more evident in health parameters, not only in South Africa, but all over the world (Toit et al., 2011). Compared to 1990, we live longer, but with poorer health. According to the World Health Organization, an estimation of 1.9 million deaths globally are attributed to physical inactivity (WHO, 2004). This is particularly alarming in low to middle income countries that are facing multiple challenges on already overburdened health care systems (J. McVeigh & Meiring, 2014). In accordance with international developments (Katzmarzyk et al., 2008), studies show that urban South African children are growing increasingly unfit, sedentary and overweight (Hurter & Pienaar, 2007). A recent research project, investigating the in-school physical activity patterns of primary schoolchildren at disadvantaged schools in South Africa, confirmed that the level of physical activity is insufficient in disadvantaged areas in South Africa (Walter, 2011). A review of literature showed that roughly 50 percent or more of children and adolescents were not meeting recommended physical activity levels (C. Draper & Basset, 2014). The need for primary prevention of obesity and physical inactivity has become an imperative. A country such as South Africa is already battling the double burden of communicable disease (tuberculosis and HIV epidemics), and this coupled with problems arising from diseases of lifestyle associated with low physical activity levels, may cripple an already overburdened health care system (J. McVeigh & Meiring, 2014).

3. Parameters and their relations in the current field of research

This chapter exemplifies the parameters and their investigated relations within the current body of literature. Not every possible combination of the five parameters is presented, only those relevant to the research questions.

3.1. Academic achievement and physical activity/ physical fitness

There is a growing body of research indicating that physical activity and fitness can benefit children's health and academic achievement. In the last 40 years the number of research that examined the relationship between physical activity, physical fitness and academic achievement among children has significantly increased and most of the outcomes indicate either a positive or a null association (Castelli et al., 2014; Castelli, D.M., Hillman, H., Buck S.M., 2007; Chaddock, Erickson, & Prakash, 2010; Donnelly & Lambourne, 2011; Dwyer, Sallis, Blizzard, Lazzarus, & Dean, 2001).

Rarely is a negative association reported (Ahamed et al., 2007; Sallis et al., 1999; Tremblay, Inman, & Willms, 2000).

Cross-sectional studies have demonstrated small to moderate positive or null associations between physical fitness, particularly aerobic fitness and academic performance. Chomitz et al. (2009) used a fitness variable consisting of five fitness tests: cardiovascular endurance, abdominal strength, flexibility, upper body strength and agility. They found significant relationships between fitness, Maths and English academic achievement, whereby Maths achievement was more strongly associated with aerobic fitness than English scores. Van Dusen et al. (2011) compared the results from the fitnessgram test battery, consisting of muscle fitness, aerobic capacity and body composition, with test results of the Texas Assessment of Knowledge and Skills. All fitness variables showed significant positive association with academic performance, especially cardiovascular fitness. Castelli et al. (2007) examined the relationship of primary schoolchildren's test scores on the Illinois Standards Achievement Test and the fitnessgram test battery. The results showed positive association between aerobic fitness, reading performance and Mathematics. Dwyer et al. (2001) found significant correlations between self-rating and teacher-rating of academic performance and the one-mile run, timed sit-up, timed push-up test, 50-meter sprint and standing long jump. Eveland-Sayers et al. (2009) found partial associations between muscular fitness and Maths and positive associations between the one-mile run and Maths.

Several studies show that regular participation in physical activity is beneficial for academic achievement. A research project called *Physical Activity across the Curriculum* (PAAC) which was conducted with 24 elementary schools added physical activity sessions to the school curriculum. Over the course of three years, standardized test scores were compared and the schools that were randomly assigned to receive physically active lessons did 6 percent better than their peers who had received the same lessons in a seated, inactive manner (Donnelly & Lambourne, 2011). Fedewa & Ahn (2011) reviewed 39 studies on mental and intellectual benefits associated with school-based physical activity programs and found that the greatest effect could be seen when children engaged in aerobic physical activity rather than resistance activities. Sibley & Etnier (2003) agree with these findings and conclude from a meta-analysis that physical fitness and physical activity have been shown to have positive effects on cognition and concentration. By analysing multiple studies, they found that children (ages 4-18) who are physically active score higher on IQ tests, verbal ability, Math ability, perceptual skills and academic readiness (Sibley & Etnier, 2003). Summarising these results, evidence suggests that particularly Mathematics and reading are most influenced by physical activity. Both these subjects depend on efficient and effective executive

function, which has been linked to physical fitness and activity (Tomprowski et al., 2008). Executive function and brain health are vital for academic performance. The basic cognitive functions, attention and memory, facilitate learning, and these functions are enhanced by physical activity and higher aerobic fitness. Hillman et al. (2005) as well as Chomitz et al. (2009) found aerobic fitness to be positively associated with working memory and attention in preadolescent children.

Overall, the findings across the body of literature in this area indicate that increases in aerobic fitness, derived from physical activity, are related to improvements in the integrity of brain structures and functions that underlie academic performance. Conclusively, the benefits of additional time spent on physical activity before, during, and after school outweigh the benefits of only using school time for academic learning, since opportunities for physical activities offered in the school curriculum do not hinder academic performance (Committee on Physical Activity and Physical Education in the School Environment).

3.2. Self-Control and Physical Fitness

Self-control has been associated with multiple benefits such as prediction of success and a healthier lifestyle (Tangney et al., 2004). A healthy lifestyle involves regular physical activity amongst other things. Fitness and self-control show positive correlations in a study by Chaddock, Erickson & Prakash (2010). The study used magnetic resonance imaging to investigate if higher-fit and lower-fit nine- and ten-year-old children show different activations of brain regions, specifically the basal ganglia involved in attentional control. Results showed that fit nine- and ten-year-old children have substantially stronger cognitive control in a demanding attention task than children whose fitness level was in the lowest 30 percent (Chaddock et al., 2010). In a study from Dombrowski and Luszczynska (2009), 13- to 17-year-old adolescents completed a questionnaire on self-regulation and physical activity. The results indicate that students with strong self-control exercise more than students with weak self-control. Similar results were found by Junger and Van Kampen (2010) who examined whether self-control mediates the relationship between cognitive ability and health behaviour. These findings match a description of self-control by Diamond (2013), claiming that self-control is responsible for the discipline to stay on task despite distractions or temptations. For example people with high self-control will be more likely to exercise on a continuous basis because they know it has a health benefit. And they do so even though they might rather want to sit on the couch and watch TV. This is related to the core concept of self-control; delaying gratification for a greater reward later on (Mischel et al., 1989).

When searching for self-control and physical fitness, we are presented with very little results indicating that only few researchers have looked at self-control and fitness. Yet, it has to be considered that self-control is part of a cognitive process called inhibition. Inhibition is one of three core concepts of executive functions. Inhibitory control involves being able to control one's attention, behaviour, thoughts and emotions to override a strong internal predisposition and instead do what is needed or more appropriate. Executive functions develop in childhood and are crucial for adaptive behaviour and development. Especially, the capacity to regulate one's behaviour (inhibiting, delaying gratification) is important for a child to succeed in elementary school (Blair & Razza, 2007). Research with older adults has clearly indicated that aerobic exercise selectively improves older adult's performance on executive function tasks and leads to corresponding increases in prefrontal cortex activity (Colcombe & Kramer, 2003). Similar results are shown in a study on sedentary, overweight seven to eleven year old children, who performed a three months aerobic exercise program. The results show specific improvements on executive function and brain activation due to exercises (Davis et al., 2011). Overall, these studies indicate a positive correlation between regular aerobic fitness and executive function, but made no clear distinction on self-control. A study from Chaddock et al. (2010) showed that fit nine- and ten-year-old children have substantially stronger cognitive control in a demanding attention task than children whose fitness level was in the lowest 30 percent. Fit children seem to have a greater volume in the dorsal stratum, which is a brain region that involves cognitive control and the resolution of conflicts among competing potential response.

Research that focuses specifically on self-control and physical fitness/activity involves mainly studies that see exercise as a means of strengthening self-control. Muraven, Baumeister & Tice (1999) found that repeated exercises in self-control leads to an improvement in the capacity for self-control tasks. Over time, exercise strengthens self-control and increases its power and stamina. In a study by Oaten & Cheng (2006), participants were tested on whether the repeated practice of self-control could improve regulatory strength over time. Results indicate that self-control is operating like a "muscle" and shows improvements in a wide range of regulatory behaviours. This means that long-term training will also promote self-control and increase the capacity to regulate self-control behaviour, provided they are introduced gradually (Oaten & Cheng, 2006). The concept of self-control acting as a muscle was established by Baumeister, Vohs, & Tice (2007) and is based on the idea that self-control depends on a limited energy resource. They observed that self-control appeared to be vulnerable to deterioration over time from repeated exertions, resembling a muscle that gets tired (M Muraven et al., 1999). Muraven & Slessareva (2003) found that self-control is never completely exhausted and that people can

exert self-control despite ego-depletion if the stakes are high enough. For example, when Muraven & Slessareva told participants that they were either paid for their efforts, or that their efforts would benefit others (such as helping to find a cure for Alzheimer's disease), participants were able to overcome weakened self-control and ego-depletion. This indicates that the effect of ego-depletion can be moderated by motivation (Mark Muraven & Slessareva, 2003).

3.3. Academic achievement and Self-Control

Central to the idea of self-control is the ability to change or interrupt undesired behavioural tendencies and refrain from acting on them in favour of more valued long-term goals. Based on this definition, people with high self-control should achieve better grades in the long run, because they should be better at getting tasks done on time, preventing leisure activities from interfering with work, using study time effectively, choosing appropriate courses, and keeping emotional distractions from impairing performance (Tangney et al., 2004).

Studies have provided some evidence that self-control indeed facilitates academic achievement. Feldman et al. (1995) found that eight-grade students with higher self-regulation received better grades in a computer course. Flynn (1985) found that improvements in delay of gratification were correlated with improvements in school achievement among four-year-old African American migrant boys, but not girls. Walter Mischel conducted experiments, also known as the Marshmallow test, on children's capacity to delay gratification at age four in the 1960s and then followed the participants up as they completed high school and entered college. In that same experiment Mischel et al. (1988) and Shoda et al. (1990) showed that the children who were most successful at delaying gratification went on to become adults with higher SAT scores, indicating better academic performance. Since delay of gratification is part of the behavioural index of self-control, these results point towards lasting and long-term benefits of good self-control (Tangney et al., 2004). Wolfe and Johnson (1995) found self-discipline to be the only one among 32 measured personality variables that predicted college grade point average (GPA) more robustly than SAT scores did. Further, study results of Tangney et al. (2004) suggest that people with higher self-reported self-control had better grades than those reporting low self-control. These findings are consistent with the idea that self-control marks a significant contribution to academic success. In a longitudinal study by Duckworth & Seligman (2005), students with a strong sense of self-discipline significantly outperformed their less-disciplined peers on a range of academic indicators, including grades, achievement test scores and attendance. Additionally,

self-discipline appears to be a better predictor of academic gain than is intelligence, as measured by an IQ test (Duckworth & Seligman, 2005).

3.4. Socio-economic status and academic achievement

Research has revealed a consistent and long-lasting relationship between socio-economic status and academic achievement, specifically, a high SES is associated with greater academic achievement (Milne & Plourde, 2006). There is also growing evidence that low SES correlates with multiple risk factors resulting in inequalities in children's early development and educational achievement. These factors include child health, family characteristics, emotional and behavioural development, cognitive and academic attainment, home and school environment and country income to name a few (Carlisle & Murray, 2015). The following section will elaborate on risk factors relevant for this paper.

Child health has a profound influence on child development and school progress. A low SES has been shown to be associated with a poor health status, specifically higher blood levels, stunting, iron deficiency, dental caries and sensory impairment (Cohen, 1999). Children from low SES families, when compared to middle class SES families, have a higher chance of being born premature, to be low in birth weight, to be born with asphyxia, a birth defect, fetal alcohol syndrome, or AIDS. These children are also more likely to have learning difficulties because their parents tend to live or work in unhealthy environmental conditions, smoke, drink alcohol, exercise less and use drugs during pregnancy (Bradley & Corwyn, 2002). Additionally, malnutrition has been related with poor cognitive development resulting in low IQ, cognitive delays and problems with motor development (Anthony et al., 2011). This can cause problems with the ability to concentrate, process information and to focus on academic work (Chung, 2015). Furthermore, low SES families tend to have less access to health care and medical insurance which leads to an increased risk of illness (Bloom et al., 2006). Research has shown that low SES children are almost three times less likely to attend school regularly compared to their middle SES peers. Low school attendance correlates strongly with poor academic achievement (Ready, 2010). As a result of school absences, students receive fewer hours of classroom instruction and consequently have a lower academic performance.

Family characteristics and parenting practice play a vital part in child development. Learning takes place in the early years when the family provides support, nurture and stimulation. The available resources of the family influence the ability to provide a rich, responsive and safe learning environment. Low SES single parenting can lead to negative impact on children due to financial strain, less involvement, less

support and emotional stress. Single parents with low SES tend to work longer hours and it is possible that they are less involved, less sensitive and responsive to their children, less supportive and less warm (Chung, 2015). Irrespective of single parenting or family parenting, families with low income tend to put most resources into their basic family needs. Consequently, they provide less learning stimuli which affects child development and academic achievement (Bradley & Corwyn, 2002). SES also influences the school environment. Children from low SES families usually live in disadvantaged neighbourhoods characterised by high levels of unemployment and crime, absence of adult supervision and lack of opportunities for building social networks (Brooks-Gunn & Duncan, 1997). The majority of schools located in low SES neighbourhoods appear to be under-resourced and have a less supportive school climate with less qualified teachers. Concurrently, living in poor neighbourhoods can lead to decreased positive opportunities and is highly correlated with social and emotional problems (Suarez-Orozco et al., 2008). Consequently, living in poor neighbourhoods with high crime rates and elevated levels of unemployment may result in a weakened sense of security and ability to attain academic success in school.

The cognitive development of children and SES are frequently found to be highly correlated (Duncan et al., 2012). Children from low SES families tend to perform worse on measures of cognitive ability such as attention, inhibitory or cognitive control and working memory in contrast to their wealthier peers. Brooks-Gunn and Duncan (1997) found low SES children to be 1.3 times more likely to experience cognitive developmental delays than middle SES children. A series of research studies conducted by Noble, Farah and colleagues (Hackman et al., 2010; Noble et al., 2007) has shown that children from low SES families tend to have poor working memory and attention and less inhibitory control in contrast to their middle SES peers. Overall it can be said that low SES has an impact on cognitive processes that are needed to succeed at school and in life.

4. Research Question and Hypotheses

The focus of this thesis is on the relation of the five components; self-control, academic achievement, attention, fitness and SES. SES was measured with housing and ownership questions and self-control was assessed with six questions from the brief self-control-scale within a psychosocial health questionnaire. Academic achievement comprises the end of the year results and the d2-concentration test measures attention. The 20-m shuttle run test was used to assess cardiorespiratory fitness in children. Hillman et al. (2008), Chaddock et al. (2010) and Kinnunen et al. (2012) all found a positive correlation between self-control and physical fitness. Also, multiple studies show a positive correlation between academic achievement and physical fitness such as Du Toit et al. (2011), Dwyer et al. (2001), Castelli et al. (2007) and Eveland-Sayers & Farley (2009) to only name a few. Research also shows that SES is associated with a wide array of health, cognitive, and socio-emotional outcomes in children (Bradley & Corwyn, 2002). The present study was conducted in a low socio economic environment. Hence, the factor of SES will be included in the analysis. On the basis of current research it is hypothesised that a positive correlation can be found between self-control, academic achievement, cardiorespiratory fitness and socio economic status.

4.1. Hypothesis 1

Physical fitness correlates positively with academic achievement (H1a) and attention (H1b).

4.2. Hypothesis 2

Physical fitness correlates positively with self-control (H2).

4.3. Hypothesis 3

Self-control correlates positively with academic achievement (H3a) and attention (H3b).

4.4. Hypothesis 4

SES correlates positively with academic achievement (H4a) and attention (H4b).

5. Methods

The following chapter will describe the study participants, the location, the time frame, the procedure, the instruments and the statistical analysis. Also the DASH-study “Impact of disease burden and setting-specific interventions on schoolchildren’s cardiorespiratory physical fitness and psychosocial health in Port Elizabeth, South Africa” will be outlined in Section 5.3 and 5.4. This paper uses the conducted results from the baseline testing T1.

5.1. Participants

Data was collected from 1009 fourth-grade children aged nine to twelve. Due to absence and incomplete data, 11 children were excluded. For the purpose of this paper, additional 54 children were excluded due to age restriction. Summing up, the sample size of this paper counts 945 children, of which 50.5% are female and 49.5% male. The ethnic distribution is 62% Black, 36.5% Coloured, 0.8% Mixed, 0.5% White and 0.2% Indian. The main ethnicity is Black and Coloured due to the location of the 8 schools. 62% of the children speak Xhosa, 36% Afrikaans and 3% English and other languages.

5.2. Location and selected schools

The study was conducted in eight historically black and coloured primary schools from various townships of Port Elizabeth, in the southeast of South Africa (Figure 1). These townships are characterised by extreme poverty and high rates of unemployment. Due to past colonial and Apartheid policies insufficient public health is provided, partly due economic challenges faced by the country (Walter, du Randt, & Venter, 2011).

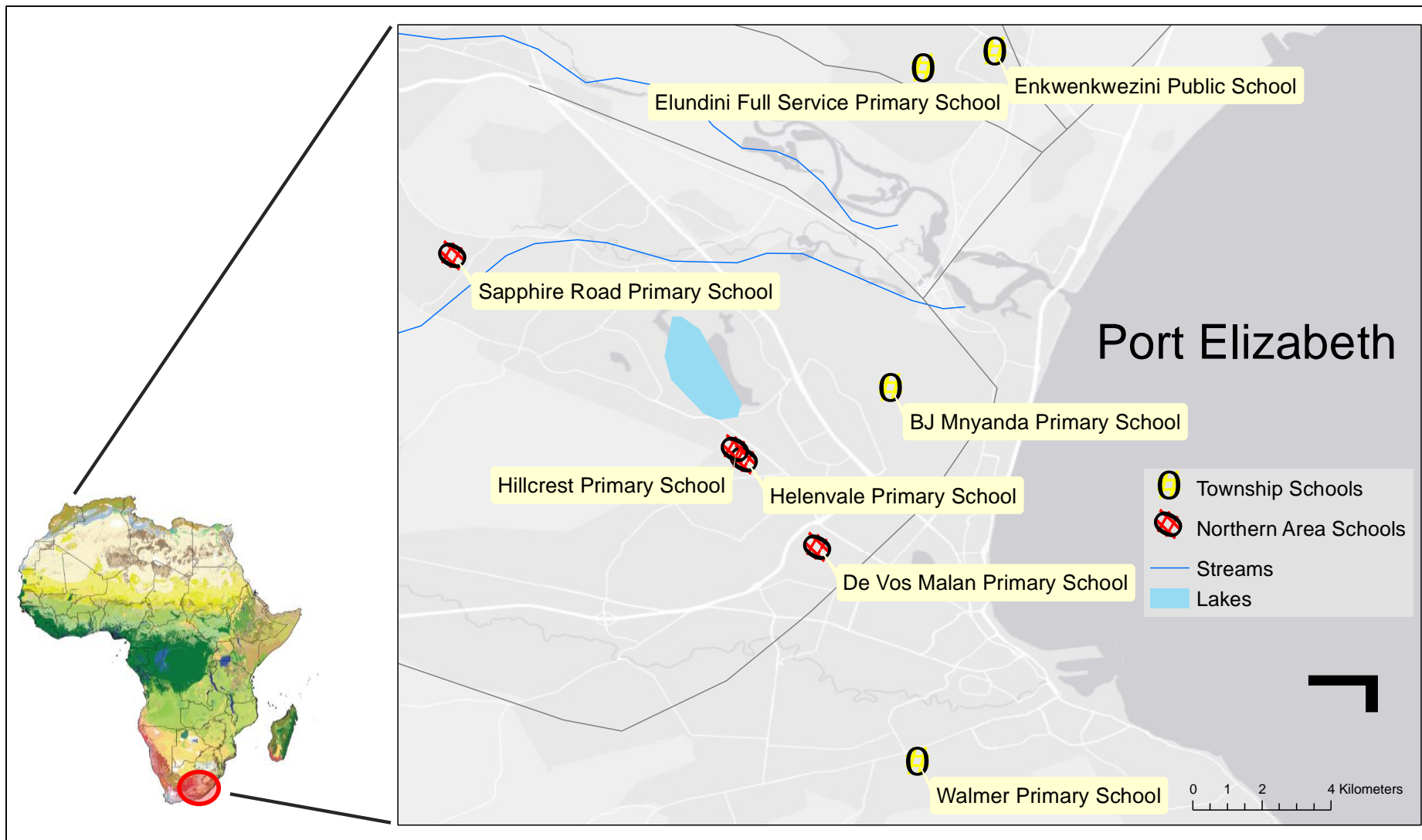


Figure 1: Study area and location of schools participating in the DASH-study, figure (from the DASH protocol)

5.3. DASH-study – Disease Activity and Schoolchildren’s Health

The DASH-study aims to assess the burden and distribution of communicable diseases and non-communicable chronic conditions among school-aged children in selected, historically black township primary schools near Port Elizabeth, and to assess their impact on children’s physical fitness, cognitive performance and psychosocial health. The study is a collaborative project between the Swiss TPH, the Swiss DSGB from the University of Basel and the Nelson Metropolitan University of Port Elizabeth. It is a long-term study over a period of 3 years where schoolchildren aged nine to twelve years are tested. In the first cross sectional appraisal, approximately 1000 fourth grade children from eight underprivileged schools were tested on infections, fitness, physical and psychosocial health. According to the findings of the baseline testing, specific interventions were tailored and will be applied on four intervention schools and four control schools. The intervention package includes physical activity, health and hygiene education and nutrition. Staff and children will be educated on how to eat healthy and all school ground toilets will be repaired and kept in good conditions.

The data of the present paper is based only on the baseline testing from February 2015 until March 2015 and is therefore a cross-sectional survey.

5.4. DASH-study design

The study lasts from February 2015 to June 2017 (Figure 2). The longitudinal study consists of four cross-sectional surveys (baseline, first, second and final follow-ups). At each survey time point, disease status, anthropometry and levels of cardio-respiratory physical fitness, cognitive performance and psychosocial health are measured. After each survey, infected individuals are either treated and/or referred to local clinics. Based on results from the baseline survey, a package of setting-specific interventions is designed together with local students, teachers, school volunteers and parents. The intervention package consists of three main components:

- (i) Physical fitness: Regular physical activity opportunities will be incorporated into the main school curriculum and a physical activity friendly school environment will be created. Weekly dancing-to-music classes will be implemented. These approaches could help improve children’s health and positively affect self-control (Baumeister et al., 2006; Draper et al., 2010; Gailliot et al., 2007; Hürlimann et al., 2014; Kriemler et al., 2010; Muraven et al., 1999; Oaten & Cheng, 2006).

- (ii) **Health education:** This will help increase the awareness for intestinal parasitic infections among the pupils and educate them on treatment and prevention methods, such as proper hygiene and sanitation habits and the importance of consuming clean water and food. It is also planned that schoolchildren will produce a theatre play to convey key messages they have learnt through the health education (Bieri et al., 2012).
- (iii) **Nutritional interventions:** Nutritional intervention will be introduced in the form of multi-micronutrient supplementation (RUSF). The cooks in the schools will also be trained on nutrition and hygiene in food preparation for the school meals.

The interventions will be embedded within the longitudinal study and be implemented in half of the schools (n=4), while the remaining four schools will serve as controls. Implementation of the interventions will take place twice; in July-September 2015, after the baseline survey, and in January-February 2016, after the first follow-up. The first follow-up will allow the implementation feasibility of the designed interventions to be determined, while the subsequent surveys will allow assessing their impact on the measured health parameters.

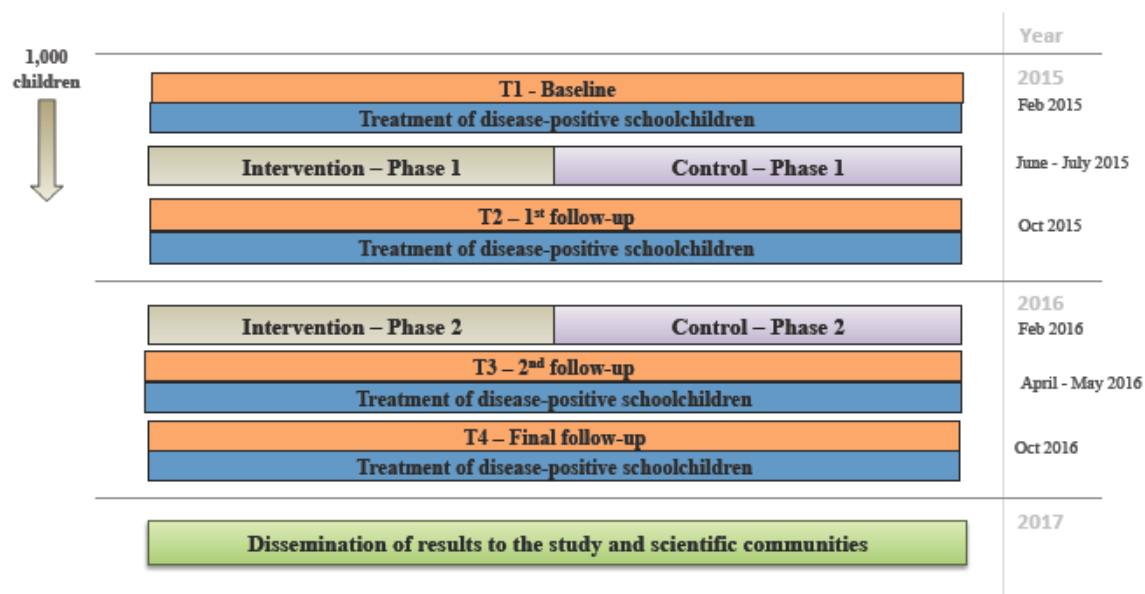


Figure 2: A pictorial display of the design and timeline of the DASH-study (from the DASH protocol)

5.5. Timeframe of baseline testing

The baseline testing started in the 6th week of 2015 on Monday 2nd February. Initially, the plan was to test 2 schools within one week and therefore finish the testing within 4 weeks. Due to time management and unforeseeable events at the schools, such as sports day or shootings, we decided to spend more time at each school so that we could test all the children and conduct all tests with accuracy. The

following table gives an overview of the adapted timeframe of our testing including the outline of the schools tested.

Table 1: Overview of the fieldwork phase

Week 6	Week 7	Week 8	Week 9	Week 10	Week 11
Sapphire Sapphire Hillcrest Hillcrest Hillcrest	Helenvale Helenvale Sapphire Sapphire	Enkwenkwezeni Enkwenkwezeni Elulndini Elulndini	BJ Mnyanda BJ Mnyanda Hillcrest Hillcrest	Walmer Walmer Walmer	De Vos Malan De Vos Malan De Vos Malan

5.6. Procedure

5.6.1. Information, Inclusion and exclusion criteria

School authorities, directors, teachers and parents were informed about the objectives, procedures and potential risks and benefits. A patient information sheet designed for the schoolchildren and parents/guardians was given to all participants. Schoolchildren meeting the following criteria were invited to participate: (i) willing to participate in the study; (ii) having a written informed consent by a parent/guardian; (iii) not participating in other clinical trials during the study period; (iv) not suffer from medical conditions, which will prevent participation in the study, as determined by qualified medical personnel and (v) being a primary school child aged 9-12 years, male or female.

5.6.2. Baseline testing

The testing days were conducted during school hours in classrooms or any facilities that were provided by the school. Depending on class and school size, the testing took between two and four days. On the first day, (Figure 3) medical examination, stool and urine container distribution and a questionnaire (to be found in the appendix) on cognitive performance and health were conducted. Two nurses, who examined each child, thoroughly led the medical examination. An additional researcher took blood to measure insulin, asked questions about functional signs and measured skinfolds, height, weight, blood pressure and temperature. The nurses determined the physical health of each child and decided upon its inclusion. If a child was excluded for health reasons, it was directly referred to a hospital to be treated for the illness or the suspected disease. The cognitive performance and psychosocial health questionnaire was conducted in another class with the help of community members, a translator and the class teacher as well as one researcher. The questionnaires had been translated in Afrikaans and Xhosa. The teachers

decided for each class what language would be most suitable. The questions were explained in English, Afrikaans and Xhosa so that each child was able to understand the questions fully. Each child was given a pencil, a rubber and the questionnaire. Part A of the questionnaire was the d2-test of attention. The test was thoroughly explained and depicted on the blackboard for the children to see. One line on the blackboard was solved with the whole class and then each child had the opportunity to practice on the exercise line. The researcher then started the test and indicated after every 20 seconds to start a new line. The test lasted 4 minutes and 40 seconds. After the test of attention, children filled 70 questions for the psychosocial health questionnaire. The completion of the questionnaire takes two to three hours. Because of the length and intensity, and also due to the interference of the medical examination that was taking place at the same day, the questionnaire was split into sections and was completed within one to three days. On the second day, the questionnaire was continued and physical fitness tests were conducted. Each class was divided into four groups and assigned to one of the four stations; jump sideways, broad jump, sit and reach and grip strength. After completion of all tests, the class returned to their classrooms and the next class was called. If time allowed, the 20 meter shuttle run test was held on the same day as the fitness tests. Otherwise, the test was conducted on the third day. The procedure of the test was the following: A researcher went into the classroom with bibs numbered 1-50. The physical fitness test sheets had been divided into a pile of girls only and boys only previously. The researcher called out the names and distributed the numbers. The children were made to stand in a line according to numbers and then followed the researcher towards the test site. On site the test was demonstrated by a researcher and explained by native-speakers thoroughly. Depending on class size, each test was held with 15 to 20 children and a researcher was always running with the kids to set the right pace. Three to five children were assigned to one kids-coach who monitored them during the test and noted down their score. Children gave back their bibs after completing the test and received a glass of juice. This was the last test and children returned to their classrooms.

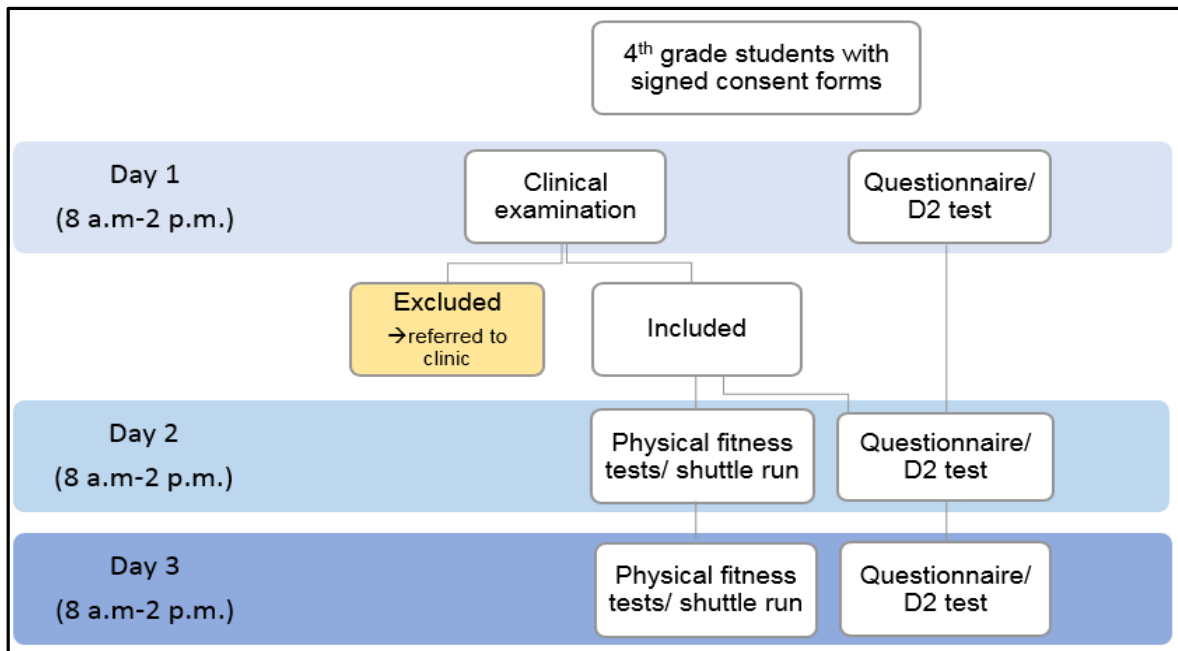


Figure 3: Baseline testing procedure

5.6.3. Ethical Clearance

Ethical clearance for the study was sought from the Ethics Committee Northwest and Central Switzerland (EKNZ) in Basel, Switzerland and from the following ethics committees in South Africa:

- (i) NMMU Health Sciences Faculty Research Committee;
- (ii) NMMU Human Ethics Committee;
- (iii) Eastern Cape Department of Education (for research done at schools); and
- (iv) Eastern Cape Department of Health.

The research conforms to international ethical and scientific standards as they are established in the Declaration of Helsinki, and promoted by the World Health Organization (WHO) and International Conference on Harmonization (ICH) Guidelines. The cluster-randomised trial presented here was registered in the current control trials register (<http://www.controlled-trials.com/>). The investigators ensured the accuracy and completeness of the data reported in the study and submitted the required progress and final reports.

5.6.4. Confidentiality

One meeting per school was organized with the parents/guardians, in which the study was explained in detail and questions were answered. Consent forms were signed for the participation in the study by the parents/guardians beforehand and children gave oral consent at the beginning of the testing. Withdrawal from the study

is possible at any stage but parents and their children are encouraged to participate for the full duration of the study. Personal data of the children is anonymized by means of ID-Numbers and all data is exclusively used for scientific research. Records of the study remain confidential and personal information is stored in lockers. After 5 years these records will be destroyed. Data entered into computerized files will be accessible only by authorized investigators or medical personnel directly involved in the study.

5.7. Instruments

For the purpose of this paper, only the relevant instruments will be explained in detail.

5.7.1. Psychosocial health questionnaire

The questionnaire was created in collaboration with the Swiss TPH, the Swiss Department of Sports, Movement and Health and the Nelson Mandela Metropolitan University. A setting specific questionnaire was compiled and divided into 6 different sections; d2 test of attention, socio-economic and demographic profile, brief self-control scale (SCS), school burnout inventory (SBI), KIDSCREEN-27 a health questionnaire for children and young people and health behaviours in school age children survey. The questionnaire was translated into English, Afrikaans and Xhosa to ensure transparency and comprehensibility. The questionnaire was conducted in the classroom with a translator, two to three community members, a researcher and the teacher. It was completed over the course of two days and worked on in sections with multiple breaks in between. For the purpose of this paper only section one, d2 test of attention, section two SES/ demographic profile and part 3 SCS were used for the data analysis.

5.7.2. Collection of socio-economic status

The socio-economic-status was measured with 22 questions and included the following segments: ethnicity, ownership, housing questions and family questions. The questions were developed by the Swiss Tropical- and Public Health-Institute (SwissTPH), more specifically by Jürg Utzinger, Peter Steinmann and Peiling Yap. The questions were further adapted according to recommendations from the EKNZ (Ethische Kommission Nordwest- und Zentralschweiz) and the final adjustments were made by our South African partners Cheryl Walter, Rosa du Randt and Bruce Peter Damons. For the purpose of this study, nine ownership questions and three housing questions were used to define the socio-economic-status. The ownership

questions cover a mixture of basic needs and luxury goods such as washing machine, fridge, freezer, radio, house phone, television, parent's cell phone, car and computer. The housing questions comprise the size of the house, basic hygiene and existence of electricity access. The questions were recoded and z-transformed relative to the mean standard deviation observed in the entire sample. The sample size of the present data is drawn from a low-socio-economic setting and differences in status were expected to be low. The initial questionnaire did not contain questions on parental income and education that are generally used in questions concerning SES (Kristiansson et al., 2009).

5.7.3. 20 meter shuttle run test

Cardiovascular endurance was tested with the 20-m shuttle run test (Leger, 1988). In multiple studies, the 20-m shuttle run is used to measure fitness. The test was validated by Ruiz et al. (2011) and is considered both valid and reliable to assess cardiorespiratory fitness in children and adolescents.

An 80m rope was used to mark the 20m x 20m demarcated area. The 80m long rope was premeasured at each 20m point and tent pegs were used to mark an exact square of 20m. At each corner, one beacon was placed three meters from the turn-line which is used as a control measure (adaptation from original test description which states 2 meters). Forty coloured cones were placed along each 20m turn-line. There were 20 cones per line which were colour coordinated to ensure the children run in a straight line. Each child was assigned to a coloured cone before the test started. The children ran between the two lines in time to the recorded audio signals. The running speed was controlled by intervals of recorded sound signals, also known as "beeps". The test started with the children standing behind one of the turn-lines facing the direction of the other turn-line and started running when instructed by the audio. The running speed started at 8.5 km/h, and was gradually increased every minute by 0.5 km/h. The children had to run continuously between the two turn-lines and turn only when they reached the 20m turning line. Each child had to touch the line with its foot and turn as quickly as possible. Children ran at a uniform pace meaning they did not run faster or slower than the speed specified by the sound signals. A researcher ran as a pace setter with the children at every test. Volunteers kept records of the number of completed lengths with a scoreboard. The test is terminated if children stop by themselves due to exhaustion or if children do not reach the 3m-line twice in a row after a warning. The test administrators determine whether the child has reached the 3m-line or not.

5.7.4. Cognitive performance: D2 test

The d2 test was employed to measure attention and cognitive performance (Brickenkamp & Zillmer, 1998). This test of attention is one of the most widely used measures of attention, particularly visual attention, in Europe and the USA (Bates & Lemay, 2004). The standard version of the d2 Test is a one-page paper-and-pencil cancellation test, consisting of 14 rows (trials), each with 47 interspersed “p” and “d” characters (Brickenkamp & Zillmer, 1998). The characters have one to four dashes that are configured individually or in pairs above and or below each letter. The target symbol is a “d” with two dashes (hence “d2”), regardless of whether the dashes appear both below the “d”, both above the “d”, or one above and one below the “d”. Thus, a “d” with more or less than two dashes and a “p” with one or two dashes are distracters. The participants’ task was to cancel out as many target symbols as possible, moving from left to right, with a time limit of 20 seconds per trial. No pauses are allowed between trials (Bates & Lemay, 2004). The total test time is 4 minutes and 40 seconds. The d2 paper-and-pencil version can be performed in a group setting and assesses several dimensions of cognitive performance and attention:

- i) E (total errors): sum of all errors of omission and commission.
- ii) O (errors of omission): sum of number of target symbols not cancelled.
- iii) C (errors of commission): sum of non-target symbols cancelled.
- iv) E% (percent of errors): total number of errors divided by the total number of characters processed.
- v) TN (total number of characters processed): sum of number of characters processed before the final cancellation of each trial.
- vi) TN-E (total correctly processed): total characters processed minus total errors made.
- vii) CP (concentration performance): total number of correctly cancelled minus total number incorrectly cancelled.

Criterion, construct and predictive validity of the d2-test among children from the age of 9 years and older are well documented (Bates & Lemay, 2004; Gallotta et al., 2012; Wassenberg et al., 2008). Moreover, the test offers an extensive list of norms, according to age, sex and education. For the purpose of this study only the concentration performance (CP), which was z-transformed, will be used to measure attention.

5.7.5. Self-Control

The dispositional capacity of self-control was measured with a brief form of the self-control scale (SCS) from Tangney et al. (2004). The original SCS measures

dispositional self-regulatory behaviours using 13 items rated on a 5-point-scale, ranging from 1 (never) to 5 (always). The human capacity of self-control has been described as one of the most powerful and beneficial adaptations of the human psyche (Tangney et al., 2004). In this study, the version has been adapted to a 6-item self-control scale. Questions were simplified and adapted for children to understand. The brief self-control questions can be found in the appendix.

5.7.6. Academic Achievement

For the purpose of this study, the end of the year results and the Annual National Assessments (ANA's) in Maths and Home Language have been collected.

South Africa's grading system ranges from 1 (very poor) to 7 (excellent) with the grade or level 4 marking the passing rate. The average of the end-of-the-year academic marks, as recorded in school schedules and children's report cards according to the recommendations of the National Department of Education for learners in the intermediate Phase (grades 4, 5, 6), was used as a measure of academic achievement. This mark represents the average of the level achieved by the learner in each of the four subjects. Namely Home Language, Additional Language, Mathematics and Life Skills with grades or levels ranging from 1 to 7. The end of the year results from the 4th grade learners were collected in the beginning of the year. Therefore the results of their 3rd grade year were received.

The Annual National Assessments are standardised national assessments for literacy and numeracy for the foundation phase (grades 1 – 3) and languages and Mathematics in the intermediate phase (grades 4 – 6). The question papers and marking memoranda (exemplars) are supplied by the National Department of Basic Education and the schools manage the conduct of the tests as well as the marking and internal moderation. The maximum of achievable points is 40, which equals a Level 7 or 80-100% of achievement. The average of both Mathematics and Home Language ANA test level scores were used as measure of academic achievement. The type of assessments used by the schools is unknown and could be diverging amongst different classes and different schools. Thus, the tests which make up the final grade of each subject were not standardised and could therefore implicate divergent scaling. Assigning grades is a complex issue and can be subject to partiality and subjectivity. The representation of academic achievement by the mean of the four school subjects has to be considered in light of these facts. Due to the large amount of missing data from the ANA's (n=478) (one school was on strike and did not do this test at all), the end of the year results (n=674) represent academic performance in this paper.

5.8. Statistical Analysis

The statistical analysis was conducted with SPSS (IBS SPSS Statistics Version 22). The data set was screened beforehand and errors were minimised through a double-entry. The conducted tests were the 20-m shuttle run, the d2-test of attention and a psychosocial questionnaire with parts on socio-economic-status and on the brief self-control scale. The end of the year results from last year (grade 3) were collected from the schools. The investigated parameters were cardiorespiratory fitness (CRF), socio-economic status (SES), self-control (SC), the end of the year results (EOY) and attention (CP).

In a first step, all participants were filtered according to the age restriction (9-12 years) and analysed by descriptive statistical methods, irrespective of sex. In a second step, the z-score for each data point was calculated in order to standardize the raw units. To exclude task irrelevant responses, data points more than 3 standard deviations from the mean were considered as outliers and therefore excluded. In a third step, a basic reliability analysis was run, to assure the reliability of each scale. Therefore, Cronbach's α values were calculated. According to Field (2009), Cronbach's α values between .7 and .8 prove of good reliability. Finally, in a fourth step, Pearson correlations between the investigated parameters were calculated to examine the present hypotheses.

Before reporting the results, the constitution of each scale, its corresponding parameters and the reliability will be described briefly.

5.8.1. Socio-economic status

The SES score is composed of nine ownership and three housing questions. Five questions had to be recoded so that they were compatible to the 0=no and 1=yes scale. The reliability for the SES score was high ($\alpha=.742$).

5.8.2. Academic achievement

The score for academic achievement was calculated from the end of the year results from four different subjects: Home Language, Additional Language, Life Skills and Mathematics. Scores ranging from 1-7; 1 being the weakest score, 4 being the passing score and 7 being the highest score. The mean of the sum score of the four subjects forms the parameter for academic achievement.

5.8.3. Physical fitness

Physical fitness was assessed with the 20-m shuttle run and stands for cardiorespiratory fitness. The achieved laps represent the cardiorespiratory fitness

performance. The more laps the children ran, the better their cardiorespiratory fitness.

5.8.4. Attention

Attention was measured with the d2-test of attention on the basis of concentration performance (CP) which measures the total number of correctly cancelled minus the total number incorrectly cancelled. It is an index with respect to the accuracy of performance and the coordination of speed (Bates & Lemay, 2004).

5.8.5. Self-control

Self-control was assessed through six questions from the brief self-control-scale and was adapted for children. The reliability for the self-control scale was very low ($\alpha = .094$). Because of the low reliability, the mean of the six questions could not be formed and question six was used as the only item to represent self-control. This item was chosen due to the fact that it contains the main aspect of what self-control entails: "I can't stop myself from doing something, even if I know it is wrong".

6. Results

6.1. Descriptive Statistic

Table 2 provides the descriptive statistics for all assessed parameters.

Table 2: Mean, SD and N of all assessed parameters

	Mean	SD	N
EOY	.0000	1.00000	752
SES	.0220	.96480	924
CP	.0040	.97187	919
SC	.0068	.99914	930
CRF	-.0278	.96527	847

To examine the relation among the investigated parameters, Pearson correlations were calculated. The subsequent correlation matrix (Table 3) displays all the possible inter-correlations.

Table 3: Inter-correlation matrix

		EOY	CP	SC	SES
CRF	Pearson Correlation	-.065	.080*	-.006	-.089*
	N	670	831	840	835
SC	Pearson Correlation	-.027	.057		-.003
	N	737	917		922
SES	Pearson Correlation	.296**	.069*	-.003	
	N	733	912	922	
CP	Pearson Correlation	.384**		.057	.069*
	N	729		917	912

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

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

6.2. Results Hypotheses

In the following section, the posed hypotheses 1 – 4 will be recalled and set into context with the results established. Thereby assigning whether the assumption have remained true.

Hypothesis 1

Physical fitness correlates positively with academic achievement (H1a) and attention (H1b).

Results

The correlation analysis revealed no significant relation between physical fitness and academic achievement ($r = .065$, $p = 0.092$).

There was a small positive correlation between physical fitness and attention ($r = .080$, $p = .022$).

Hypothesis 2

Physical fitness correlates positively with self-control (H2).

Results

No relation could be found between physical fitness and self-control. ($r = -.006$, $p = .857$).

Hypothesis 3

Self-control correlates positively with academic achievement (H3a) and attention (H3b).

Results

No significant relations could be found; neither between self-control and academic achievement ($r = -.027$, $p = .472$) nor between self-control and attention ($r = -.057$, $p = .087$).

Hypothesis 4

SES correlates positively with academic achievement (H4a) and attention (H4b).

Results

There was a substantial positive correlation between SES and academic achievement ($r = .296$, $p = .000$) and a small positive correlation between SES and attention ($r = .069$, $p = .038$).

7. Discussion

Key findings

The two key findings of the present study are that attention is associated with cardiorespiratory fitness and that SES is related to academic achievement and attention. All other parameters do not correlate significantly and deviate from the results of contemporary research.

7.1. Hypothesis 1

H1: Physical fitness correlates positively with academic achievement (H1a) and attention (H1b).

The correlation analysis revealed no significant relation between the results of the 20-m shuttle run and the end of the year results. This outcome does not correspond with findings in previous research (Castelli et al., 2007; Chomitz et al., 2009; Eveland-Sayers & Farley, 2009; Fedewa & Ahn, 2011) and raises the question as to why not. However, there are several distinguishable differences between the studies claiming a significant relation between the two parameters and the study that is subject of the present paper. These include the measurement of academic achievement, the non-randomisation of subjects in certain studies and the differences in the study design. In the current study, academic achievement was measured using the mean of the four school subjects: Maths, Home Language, Additional Language and Life Skills. Distinctions between the individual subjects were not made. School results could have been subject to partiality, as they are subjective estimates and also could have differed in terms of difficulty of assessments. The use of a standardised achievement test has the advantage of greater comparability and validity, as it is an objective estimate of the performance. Most studies used a standardised achievement test and correlations between fitness and academic achievement were mostly found in particular subjects, such as Mathematics and reading performance (Castelli et al., 2007), Mathematics (Eveland-Sayers et al., 2009) as well as Mathematics and English (Chomitz et al., 2009). Additionally, Castelli et al. (2007) found positive associations between aerobic fitness, reading performance and Mathematics. The findings of these studies align with the conclusions presented in a meta-analytic review by Fedewa and Ahn (2011). They found the strongest relationship between aerobic fitness and achievements in Mathematics, followed by IQ and reading performance. A possible answer to the initial question why no significant correlations between physical fitness and academic achievement were found in the present study could be that the

measurement of academic achievement was too broad. Furthermore, the cross-sectional design of the present study clearly limits the conclusion that can be drawn, and one cannot attribute causation to any of the observed relationships.

Also, success in both, athletic and academic fields, can be influenced by genetic features, cultural factors and developmental experiences, which are encouraged by supportive parents (Tremblay et al., 2000). The examined study participants were categorised as low SES due to their place of residence. According to McVeigh (2004), children from the lowest socio-economic quartile have low activity levels and high television watching time. The social status of physical education is low and can explain low activity levels amongst participants of the study. Moreover, the living environment has a high crime rate and violence is common. Thus, giving extra assumptions why some of the children might not run and play freely in their neighbourhood because it is too dangerous.

While no relation between physical fitness and academic achievement was evident, a small positive correlation between physical fitness and attention was found. This result coincides with the meta-analysis of Sibley and Etnier (2003) who found a positive relationship between physical activity as well as physical fitness and eight categories of cognitive performance (perceptual skills, IQ, achievement, verbal tests, Mathematics tests, memory, developmental level/ academic readiness). Similar results, indicating robust relationships between aerobic fitness and different aspects of memory and attention in children, were found by Chaddock et al. (2010) and Kammijo et al. (2011). Working memory and attention, which underlie EFs, are all vital for academic performance. The basic cognitive functions, attention and memory, facilitate learning, and these functions are enhanced by physical activity and higher aerobic fitness. Moreover, Hillman et al. (2005) found aerobic fitness to be positively associated with working memory and attention in preadolescent children. A potential relationship between physical fitness/activity and cognition may be explained by both psychological and physiological mechanisms (Chomitz et al., 2009). Motor skills and cognitive skills appear to develop through dynamic interaction. Results from animal studies show that physical activity stimulates neural development including a greater density of neuronal synapses and higher capillary volume as well as differences in regional brain structure and function (Chaddock et al., 2010; Sibley & Etnier, 2003). Research has shown that physical movement can affect the brain's physiology by increasing cerebral capillary growth, blood flow, oxygenation, production of neurotrophins, growth of nerve cells in the hippocampus (centre of learning and memory), neurotransmitter levels, development of nerve connections, density of neural network and brain tissue volume (Hillman et al., 2008).

Even though no significant correlation between physical fitness and academic achievement could be found, it is important to consider that attention and academic achievement correlate significantly. Attention facilitates learning and is a basic skill needed for academic achievement (Checa & Rueda, 2011; Steele et al., 2012). The fact that physical fitness in the present study correlates significantly with attention but not with academic achievement is another indication that the use of school grades for academic achievement might not be the best measurement; whereas using standardised achievement tests could have confirmed a correlation between physical fitness and academic achievement.

7.2. Hypothesis 2

H2: Physical fitness correlates positively with self-control (H2).

No significant correlation could be found between physical fitness and self-control even though a positive association was reported from studies described in the current literature (Chaddock et al., 2010; Diamond, 2013; Dombrowski & Luszczynska, 2009; Junger & van Kampen, 2010; M Muraven et al., 1999; Oaten & Cheng, 2006). There is for example a study by Dombrowski & Luszczynska (2009) that shows students with strong self-control exercising more than students with weak self-control. Likewise, Junger and Van Kampen (2010) found that adolescents with higher self-control are more physically active and have a lower BMI (Body Mass Index). Though, important to consider that in both of the two studies, the parameter physical activity was self-rated and therefore serves solely as a subjective estimate. As mentioned in the introduction under 1.2, self-control is part of the executive functions and research indicates (Chaddock et al., 2010; Colcombe & Kramer, 2003; Davis et al., 2011) that regular aerobic exercise correlates positively with executive functions such as inhibition. One study from Chaddock et al. (2010) showed that fit nine- and ten-year-old children have stronger cognitive control in a demanding attention task when compared to the children whose fitness level was in the lowest 30 percent. Fit children (highest 30 percent) seem to have a greater volume in the dorsal stratum, which is a brain region that involves cognitive control. Research also indicates that regular exercise can be seen as a mean of strengthening self-control (Muraven et al., 1999) and that it operates like a 'muscle' and shows improvements in a wide range of regulatory behaviours (Oaten & Cheng, 2006).

In summary, research clearly supports the idea that physical activity and physical fitness correlate positively with self-control but foremost with regular exercise over a period of time. A main reason why this does not coincide with what was found for the present study may lie in the fact that measurements of self-control and physical

activity/fitness were significantly different. Added to that, a variety in age group provides further impairment to the issue. Thus, a direct comparison between findings of current literature and the ones out of the present study must be judged and interpreted with certain caution as will be outlined more clearly in the following sections.

For self-control some studies used measures such as magnetic resonance (Chaddock et al., 2010), general efficacy-scale (Oaten & Cheng, 2006), self-control exercises (Muraven et al., 1999), questionnaires on planning, lack of awareness and intention (Dombrowski & Luszczynska, 2009) and a Dutch version of 36-item of a self-control questionnaire (Junger & van Kampen, 2010). Also, the ways to measure physical fitness/activity differed considerably. Dombrowski and Luszczynska (2009) as well as Junger and Van Kampen (2010) used a physical activity questionnaire rating the last 7 days of how vigorous participants physical activity was, Oaten and Cheng (2006) used a regular cardiovascular exercise program over a period of 2 months and Muraven et al. (1999) used the handgrip test.

Research on physical fitness and self-control is a study field that has not yet been explored fully and when interpreting the research results it has to be considered that none of the described studies can be directly compared with the results of the present study due to the differences in study design, participants and methods. There are two possible explanations as to why self-control did not correlate significantly with physical fitness in the present data. First, the measurement of self-control might not have been clearly understood by the schoolchildren. In the psychosocial health questionnaire, self-control was assessed through a shortened version of the self-control-scale (Tangney et al., 2004). Six items were used and adapted in a way that children could easily understand what was meant. Due to lack of concentration, minimal reading and writing skills, language barrier and subsequent misunderstandings, the truthful answering of the questionnaire was compromised. A low validity was measured among the six self-control questions and only one question (question 6, see appendix) was used to measure self-control. This fact further compromises the method of measuring and could explain why no significant correlation could be found. Second, the cross-sectional design of the present study clearly limits the conclusion that can be drawn and different results might be found at a later stage, e.g. after the intervention, when regular physical activity was implemented (Kinnunen et al., 2012; Oaten & Cheng, 2006).

7.3. Hypothesis 3

H3: Self-control correlates positively with academic achievement (H3a) and attention (H3b).

No significant relations could be found neither between self-control and academic achievement nor between self-control and attention. These results deviate from the initial assumptions based on existing literature (Duckworth & Seligman, 2005; Feldmann et al., 1995; Mischel et al., 1988; Shoda et al., 1990; Tangney et al., 2004; Wolfe & Johnson, 1995), arguing that self-control facilitates concentration and learning and consequently academic achievement. Compared to issues discussed in the previous section, research designs from Feldmann et al. (1995) and Wolfe & Johnson (1995) are comparable to our parameters. The measurement of academic achievement was also based on the average grades from school assessments, and self-control was measured with self-, and teacher-reports. Nevertheless, there were differences in age group, sample size and randomisation. Contemporary studies also show positive correlations between the parameters self-control and academic achievement; Tangney et al. (2004) report that students with higher self-reported self-control had better grades than those reporting low self-control. Likewise, in a longitudinal study by Duckworth and Seligman (2005), students with a strong sense of self-discipline significantly outperformed their less-disciplined peers. These studies all link self-control with academic achievement.

Self-control and attention are linked through cognitive processes called EF. EF are associated with success in school, both in middle and late childhood (Best, Miller, & Naglieri, 2011; Blair & Razza, 2007). Effortful and voluntary control of behaviour is particularly important for success in school, whereas the attentional control is particularly important to focus on what is being discussed in the classroom despite interfering stimuli (Checa & Rueda, 2011).

It is interesting to see that there is no significant correlation in our set of data despite strong indication that the three components self-control, attention and academic achievement are interlinked with one another. The reason for this could be the malfunctioning of the shortened self-control-scale, which influences the results and leads to no significant correlations. Furthermore, as mentioned in H1, the use of school grades for academic achievement might not be the best measurement, whereas using standardised achievement tests could have shown different results. However, with the malfunctioning of the self-control scale, it is unlikely that significant correlations were to be found.

7.4. Hypothesis 4

H4: SES correlates positively with academic achievement (H4a) and attention (H4b).

The results show a substantial positive correlation between SES and academic achievement and a small positive relation between SES and attention. Both results are consistent with current literature and indicate that risk factors such as family characteristics, child health, emotional and behaviour development and home and school environment have an impact on cognitive and academic achievement (Carlisle & Murray, 2015). Learning takes place in the early years when the family unit provides support, nurture and stimulation. Growing up in an environment where alcohol, drugs, violence and gun fights are predominant, can have a negative impact on children in many ways (Chung, 2015). Living in poor neighbourhoods with high crime rates and elevated levels of unemployment may result in a weakened sense of security and ability to attain academic success in school (Suarez-Orozco et al., 2008).

Literature also emphasises that the cognitive development of children and SES are highly correlated (Duncan et al., 2012). Children from low SES families tend to perform worse on measures of cognitive ability such as attention, inhibitory or cognitive control and working memory in contrast to their wealthier peers. Brooks-Gunn and Duncan (1997) found low SES children to be 1.3 times more likely to experience cognitive developmental delays than middle SES children. The reasoning behind this is again connected to poor parental nurture or to a cognitively impoverished environment. The low cognitive stimulation may have a negative effect on children's normal brain development, particularly on the prefrontal cortex (PFC). The PFC is responsible for executive control processes (attention, decision-making, planning etc.) and has a prolonged period of postnatal development. A series of research studies conducted by Noble, Farah and colleagues (Hackman et al., 2010; Noble et al., 2007) has shown that children from low SES families tend to have poor working memory in contrast to their middle SES peers. These results suggest that low SES children are more at risk to disrupt or reduce their PFC than their middleclass counterparts. Altogether it can be said that children with a low SES may develop different neural systems than children with a middle or high SES. This may further restrict the ability to attend and remember relevant information, filter irrelevant information and, therefore, lead to delays in cognitive development and low academic performance (Chung, 2015).

The study took place in a low SES setting, so when comparing the differences in SES, it has to be considered that the ratio between high and low SES takes place

in the lower part of the SES sector. The immediate surroundings of a child has a profound impact on cognitive, mental and behavioural traits and the proposed hypothesis that SES correlates positively with academic achievement (H4a) and attention (H4b) was confirmed with the results of the present study.

7.5. Additional Correlations

Apart from the correlations discussed in H1-H4, there are two other findings worth mentioning. Firstly, there is the fact that self-control did not correlate significantly with SES, which deviates from contemporary literature that links these two parameters (Tarullo et al., 2009). The data set was collected in a low SES setting, where children are exposed to crime, violence, drugs, alcohol and gunfights, suggesting that the parental nurture was poorer than in a high SES setting. Low nurture and low cognitive stimulation may have a negative effect on children's normal brain development, particularly on the prefrontal cortex (PFC) (Duncan & Brooks-gunn, 2010). A series of research studies conducted by Noble, Farah and colleagues (Hackman et al., 2010; Noble et al., 2007) has shown that children from low SES families tend to have less inhibitory control in contrast to their middle SES peers.

Secondly, there is the fact of academic achievement and attention correlating significantly. This finding is concurrent with current literature saying that attention is a basic skill needed for academic achievement and facilitates learning (Checa & Rueda, 2011; Steele et al., 2012).

8. Study limitations and strengths

The results of this study should be interpreted with a series of factors kept in mind. e.g., participants were all drawn from the Eastern Cape and the results are therefore not nationally representative. The sample size was randomised but the cross-sectional nature of the present study does not indicate causality.

One of the strengths of this study is the big sample size ($n=998$) and the equal distribution of gender ($m=50.5\%$ $f=49.5\%$). All methods are standardised and comparisons to other studies are possible. Also, the standardisation ensures the quality and uniformity of the tests and can be repeated at a later stage with similar conditions. Measurements were made by a small team of researchers to minimize discrepancies of testing at different schools. Another strength of the study is the double-entry of all data which ensures clean data.

One limiting factor of the study is the length and difficulty of the psychosocial health questionnaire. It covered multiple aspects of the children's psychological well-being and was eight pages long. Most children struggled to read and were only able to focus for a short period of time. These factors weaken the reliability of the questionnaire significantly. Further, the parameter self-control was assessed with a shortened version of the self-control scale that was further modified to suit the children's understanding. They had to rate themselves within 5 options between always and never. One of the questions had a double negation which led to further confusion. The language barrier, disability to read, the use of different translators, instructors and helpers restrict the evaluation of the psychosocial health questionnaire. In South Africa, the schools in impoverished areas lack teachers, facilities and basic school materials. Additionally, there is no division between students with learning difficulties and regular students, which hinders the study progress of both.

There is also the fact that the utilisation of field-test measures of physical fitness, although administered by researchers, have a restricted evaluation of fitness in children. Other laboratory procedures, such as maximum oxygen consumption (e.g. VO_2 max), are more valid and reliable measures of aerobic fitness.

Then, academic achievement was composed of the d2- test of attention and the average grade of the end of the year results. The d2-test of attention is a standardised test and has criterion, construct and predictive validity among children from the age of 9 years and older (Bates & Lemay, 2004) (Gallotta et al., 2012) (Wassenberg et al., 2008). Yet, the usage of the concentration performance as the only parameter for attention could be a limiting factor. In other studies the measure of performance includes total number of items processed, percentage of errors and fluctuation rate across trials.

The SES was measured with 22 questions including ethnicity, ownership, housing questions, family questions and financial questions such as receiving a government grant. SES is one of the most widely studied constructs in social sciences and several ways of measuring SES have been proposed, but most include some quantification of family income, parental education, and occupational status (Bradley & Corwyn, 2002). The omission of parental education and occupational status hinders a comparison to other studies.

9. Outlook

The data used in the present paper was conducted within the ongoing longitudinal study *Impact of disease burden and setting-specific interventions on schoolchildren's cardio-respiratory physical fitness and psychosocial health in Port Elizabeth, South Africa*. The project is using setting specific interventions and will retest all participants at a later stage. The cross-sectional nature of this paper limits the ability to draw conclusions on the long-term interaction of the parameters at hand. This will be taken up and can be done with the data of the second round of testing. Furthermore, the aspect of academic achievement could be looked at in different learning areas or subjects instead of one overall academic mark (EOY). Several studies found that physical fitness shows stronger associations with some subjects than others (Chomitz et al., 2009; Eveland-Sayers & Farley, 2009) and therefore, more prominent results might be obtained if additional measures of academic performance are used, which could be the topic of further investigations in future research.

The current research shows that physical exercise leads to evident changes in brain structure and function and thereby has a positive effect on neuronal growth (Hillman et al., 2008). Further research is needed to explain the correlation of physical fitness/activity and/cognitive performance especially in a low SES setting.

It would be interesting to see if there are overall differences amongst the eight schools in terms of academic achievement, attention, SES, self-control and physical fitness.

10. Conclusion

Results of the present study show a link between SES, academic achievement, attention and physical fitness. However, no positive correlations between self-control and any other parameter were found.

Evidence of the link between the cognitive processes self-control and attention to physical fitness were found partially. Even though physical activity has long been seen as important for cognitive processes (Chaddock et al., 2010; Hillman et al., 2008), in the present study only attention correlated positively with physical fitness. This may have been due to methods used for the measuring of scholastic achievement, which was too broad and not standardised. The parameter self-control has shown no association to any other parameter and this could be explained due to the malfunctioning self-control-scale which was used within the psychosocial questionnaire. It is very likely that the used method has failed to measure self-control accurately and has therefore affected the results negatively. There is a lack of research examining the correlation of self-control and aerobic fitness and in order to find conclusive answers, further studies are needed. Self-control is seen as a highly predictive factor, similar to SES, and is related to success in career and in life (Duckworth & Seligman, 2005). Improving self-control in children at risk could be beneficial not only to their current situation but also for the numerous long-term developmental outcomes associated with self-control (Tarullo et al., 2009). Considering the limited resources in disadvantaged communities, actively improving self-control would be a task difficult to prioritise.

Physical activity is an important marker for health and as mentioned earlier, healthy children learn better than unhealthy children (Basch, 2011). Physical activity is not only linked to health, but also to academic achievement and executive functions (Chomitz et al., 2009; Hillman et al., 2008). But the promotion of an active lifestyle in elementary schools, as well as an intervention programme, might potentially enhance academic learning and achievement.

To understand the influence of self-control, physical fitness, attention and SES on academic achievement, further research is essential. In particular, changes in self-control, attention and academic performance resulting from the implementation of physical fitness/activity program should be examined thoroughly in upcoming research.

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14. Appendix

14.1. Declaration of authenticity

I Stefanie Gall declare that all material presented in this paper is my own work or fully and specifically acknowledged wherever adapted from other sources. I confirm that the presented thesis, or parts of it, have not been presented or submitted in a different university, institution of higher education, seminar or project. I understand that if at any time it is shown that I have significantly misrepresented material presented here, any degree or credits awarded to me on the basis of that material may be revoked. I declare that all statements and information contained herein are true, correct and accurate to the best of my knowledge and belief.

Ich versichere hiermit, dass ich die vorgelegte Arbeit selbstständig angefertigt und keine anderen als die in der Arbeit angegebenen Hilfsmittel benutzt habe. Alle Stellen, die wörtlich oder sinngemäss aus Quellen entnommen wurden, habe ich als solche gekennzeichnet. Darüber hinaus bestätige ich, dass die vorgelegte Arbeit nicht an einer anderen Hochschule als Abschluss-, Seminar- oder Projektarbeit oder als Teil solcher Arbeiten eingereicht wurde. Ich bin mir bewusst, dass Plagiate gemäss § 28 der Ordnung für das Masterstudium «Sports Sciences» (Sportwissenschaften) an der Medizinischen Fakultät der Universität Basel vom 30. Januar 2006 als unlauteres Prüfungsverhalten gewertet werden und kenne die Konsequenzen eines solchen Handelns.

Date: 15th October 2015

Signature:

Hiermit bestätige ich, dass die Publikation der vorliegenden Masterarbeit oder Teile des Inhalts – auch in Auszügen bzw. als Zusammenfassungen oder in Rohdatenform – sowie die Abgabe der Autorenrechte (auch unentgeltlich) an Verlage oder Dritte stets eine Einwilligung des Erstbetreuers bedarf.

Date: 15th October 2015

Signature:

20 meter shuttle run

Purpose

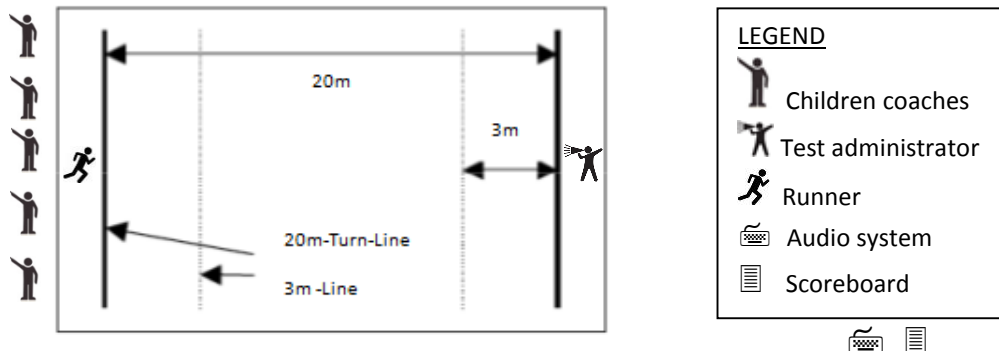
Measurement of cardiovascular endurance

Equipment

- Numbered sports bibs (1 – 50)
- Portable audio system
- USB stick with audio
- Scoreboard (numbered 1-100)
- 50 colour co-ordinated beacons
- 80m rope
- Four tent pegs
- Minimum number of people required to run test: 8
 - 1 runner
 - 1 manager of audio system and scoreboard
 - 1 test administrator ensuring children fulfil test requirements
 - 5 children coaches (4 children per coach, maximum of 20 children per shuttle run)

Site construction

An 80m rope is used to mark the 20m x 20m demarcated area. The 80m rope is premeasured at each 20m point which allows the researcher to mark the area using the four tent pegs. One beacon is placed 3m from each corner of the turn-line which is used as a control measure (Adaptation from original test description which states 2m). Forty coloured cones are placed along each 20m turn-line (20 cones per line which must be colour coordinated). Each child is assigned to a coloured cone to ensure the children run in a straight line. Before the test starts children should know the colour of their cone that they were assigned to.



Procedure

The shuttle run test is administered between two lines 20m apart, the child runs between the two lines in time to the recorded audio signals. The running speed is controlled by intervals of recorded sound signals, also known as “beeps”. The test starts with the child standing behind one of the turn-lines facing the direction of the other turn-line and should begin running when instructed by the audio. At the beginning of the test, the running speed is 8.5 km/h. The child will run continuously between the two turn-lines and turn only when they reach the 20m turning line. The child must touch the line with their foot and turn as quickly as possible. Every minute, the audio will signal an increase in speed by 0.5 km/h in which the beep signals will be closer together. The children run at a uniform pace, this means that they do not run faster or slower than the speed specified by the sound signals.

Instruction to participant

The test administrator explains the procedure in the children's home language afterwards the runner will demonstrate the test prior to the test being conducted.

"The test starts slowly and gets faster and faster. At each 'beep' you have to touch the marked line (which represents the 20m mark) with your foot. You must reach the turn-line on time and you must wait until the signal is heard, only then are you allowed to run. If you are not at the turning line on time, you have to catch up, by running faster to reach the turn-line in time. A 'runner' will run with you, please do not overtake him. Stop only when you are tired or if the test administrator says that the test is completed."

Data collection and error sources

- A volunteer will keep record of the number of the completed lengths with a scoreboard which is displayed during the test.
- Scoring: Record the last completed lap (and not necessarily the lap stopped at)
- The test result is the number of full laps completed.
- If a child has not reached the 20m turning line, they need to catch up and run faster to touch the line with their foot before they can continue.
- If the child runs before the time, the test administrator must ask the child to return to the line.
- If the children stop running, they should leave the field as quickly as possible without disturbing the other children.
- Termination of test:
 - If children stop by themselves due to exhaustion.
 - If children do not reach the 3m-line twice in a row after a warning.
 - The test administrator determines whether the child has reached the 3m- line or not.

DASH Standardization

- The test administrator must ensure that the testing environment has limited noise and distraction. Volunteers will be placed on each side of the 20m line to inform the children to run to their designated cone/ not to run to fast or not to run not to run ahead of the runner.
- Giving instructions before the test is advisable (tying shoelaces, run in a straight line, run faster or slower, wait at the line etc.)
- Encouraging the children is allowed!

Source

- Test-protocol from Léger *et al.* 1984

Table 1: Test Protocol Summary

Levels	Shuttles	Cumulative Shuttles	Speed (km/h)	Shuttle Time (s)	Total level time (s)	Distance (m)	Cumulative Distance (m)	Cumulative Time (mm:ss)
1	7	7	8.5	9.00	63.00	140	140	01:03
2	8	15	9.0	8.00	64.00	160	300	02:07
3	8	23	9.5	7.58	60.63	160	460	03:08
4	9	32	10.0	7.20	64.80	180	640	04:12
5	9	41	10.5	6.86	61.71	180	820	05:14
6	10	51	11.0	6.55	65.50	200	1020	06:20
7	10	61	11.5	6.26	62.61	200	1220	07:22
8	11	72	12.0	6.00	66.00	220	1440	08:28
9	11	83	12.5	5.76	63.36	220	1660	09:31
10	11	94	13.0	5.54	60.92	220	1880	10:32
11	12	106	13.5	5.33	64.00	240	2120	11:36
12	12	118	14.0	5.14	61.71	240	2360	12:38
13	13	131	14.5	4.97	64.55	260	2620	13:43
14	13	144	15.0	4.80	62.40	260	2880	14:45
15	13	157	15.5	4.65	60.39	260	3140	15:46

The 20 m shuttle run test: Prediction of VO₂max according to speed and age

The age of the participating child and the speed at which the child stopped running will be converted into the maximum volume of oxygen that can be utilized within 1 min during exhaustive exercise (VO₂ max). The equation below will be used to calculate the VO₂ max value, the equation is as follows:

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

Y = VO₂max Value

X = reached speed (km/h)

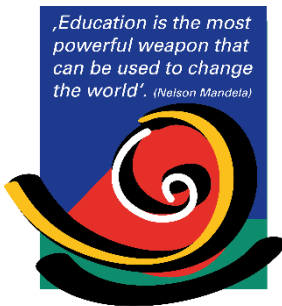
A = rounded lower age

Survey on the impact of disease burden on schoolchildren's physical fitness and psychosocial health in Port Elizabeth, South Africa

Questionnaire

SSAJRP-project

Version 7, 27 January 2015



Hello,

How are you? How do you feel? This is what we would like **you** to tell us and is the reason why we are doing this questionnaire with you. We are not looking for right or wrong answers. We simply want you to write the response that tells us your feelings.

Please read every question carefully. Whatever answer comes to your mind that best reflects your feelings, choose the box that fits that answer best and tick (✓) it. The entire test takes about 2 hours. After 1 hour, you have earned a 15 minute break.

Remember:

- This is not a test.
- There is no mark, and there are no wrong answers.
- Please answer all the questions, as honestly and accurately as you can.
- It is important that you answer all the questions.
- Make sure we can see your marks clearly.
- You do not have to show your answers to anybody.
- All answers remain secret.
- Neither your teacher nor the school principal gets to see the answers.
- Please only tick one box (☐) when answering the questions.
- If you have ticked something wrong, then cross out the field and mark the right place.
- If something is unclear, you can ask one of the investigators of course.

When you are done, please give the questionnaire directly to the investigator. Thank you!

Port Elizabeth and Basel, January 2015; the SSAJRP-team

12. How many bedrooms does your house have?

13. Do you have a bathroom inside your house? Yes No

14. Do you have a toilet inside your house? Yes No

15. What type of toilet does your house have?

- a. Flush toilet
- b. Pit toilet
- c. Bucket
- d. Communal toilet

16. How does your family get water?

- a. Taps inside house
- b. Tap in the yard
- c. Water tank
- d. Communal tap/tap shared with other families

17. Does your house have electricity? Yes No

18. How does your family cook food? With ...

- a. Electricity
- b. Gas
- c. Paraffin stove
- d. Fire

Family questions:

19. How many other people live in your house with you?

20. Who looks after you for the most of the time?

- a. Mother and father
- b. Mother only
- c. Father only
- d. Grandparents
- e. Brothers or sisters
- f. Other adults / guardians

21. Who in your house has a job?

- a. Both parents / guardians
- b. One parent or guardian
- c. None is employed

22. Does any person in your house get a government grant? Yes No Don't know

PART C
BRIEF SELF-CONTROL SCALE (SCS)

Please choose the answer that best describes how you typically are.

	Never	Seldom	Sometimes	Often	Always
23. I am lazy.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
24. I say things that are strange and out of place.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
25. I do certain things that are bad for me, if they are fun.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
26. I refuse things that are bad for me.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
27. I am lacking self-discipline.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
28. I can't stop myself from doing something, even if I know it is wrong.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

PART D
SCHOOL BURNOUT INVENTORY (SBI)

Please choose the answer that best describes your situation at school. Think about the last week...

	Never	Seldom	Sometimes	Often	Always
29. I feel overstressed by my schoolwork.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
30. I feel a lack of motivation in my schoolwork.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
31. I think of giving up in my schoolwork.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
32. I feel that my schoolwork is weak.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
33. I sleep badly because of a matter related to my schoolwork.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
34. I feel that I am losing interest in my schoolwork.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
35. I am wondering whether my schoolwork has any meaning.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
36. I brood over matters related to my schoolwork a lot during my free time.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
37. I am not able to achieve so well in my school work.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
38. I learn things quickly in most school subjects.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

PART E

KIDSCREEN-27: Health Questionnaire for Children and Young People

Think about the last week...

39. In general, how would you say your health is?

- a. Excellent
- b. Very good
- c. Good
- d. Fair
- e. Poor

	Never	Seldom	Sometimes	Often	Always
40. Have you physically felt fit and well?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
41. Have you been physically active (e. g. running, playing)?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
42. Have you been able to run well?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
43. Have you felt full of energy?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
44. Has your life been enjoyable?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
45. Have you been in a good mood?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
46. Have you had fun?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
47. Have you felt sad?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
48. Have you felt so bad that you didn't want to do anything?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
49. Have you felt lonely?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
50. Have you been happy with the way you are?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
51. Have you had enough time for yourself?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
52. Have you been able to do the things that you want to do in your free time?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

	Never	Seldom	Sometimes	Often	Always
53. Have your parent(s)/guardian(s) paid enough attention to you?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
54. Have your parent(s)/guardian(s) treated you fairly?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
55. Have you been able to talk to your parent(s)/guardian(s) when you wanted to?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
56. Have you had enough money to do the same things as your friends?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
57. Have you had enough money for your needs?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
58. Have you spent time with your friends?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
59. Have you had fun with your friends?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
60. Have you and your friends helped each other?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
61. Have you been able to rely on your friends?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
62. Have you been happy at school?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
63. Have you got on well at school?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
64. Have you been able to pay attention?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
65. Have you got along well with your teachers?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

PART F
Health Behaviours in School Age Children Survey

Physical activity can be done in sports, school activities, playing with friends or walking to school.

66. Over the past 7 days (1 week), on how many days were you physically active for a total of at least 60 minutes (1 hour) per day?

- | | | | |
|--------|--------------------------|--------|--------------------------|
| 0 days | <input type="checkbox"/> | 4 days | <input type="checkbox"/> |
| 1 day | <input type="checkbox"/> | 5 days | <input type="checkbox"/> |
| 2 days | <input type="checkbox"/> | 6 days | <input type="checkbox"/> |
| 3 days | <input type="checkbox"/> | 7 days | <input type="checkbox"/> |

67. **OUTSIDE SCHOOL HOURS:** How **OFTEN** do you usually exercise in your free time so much that you get out of breath or sweat?

- | | |
|---------------------------|--------------------------|
| a. Every day | <input type="checkbox"/> |
| b. 4 to 6 times a week | <input type="checkbox"/> |
| c. 2 to 3 times a week | <input type="checkbox"/> |
| d. Once a week | <input type="checkbox"/> |
| e. Once a month | <input type="checkbox"/> |
| f. Less than once a month | <input type="checkbox"/> |
| g. Never | <input type="checkbox"/> |

68. How long does it usually take you to travel to school from your home?

- | | |
|-------------------------|--------------------------|
| a. Less than 5 minutes | <input type="checkbox"/> |
| b. 5-15 minutes | <input type="checkbox"/> |
| c. 15-30 minutes | <input type="checkbox"/> |
| d. 30 minutes to 1 hour | <input type="checkbox"/> |
| e. More than 1 hour | <input type="checkbox"/> |

69. On a typical day is the **MAIN** part of your trip **TO** school made by...? (Please circle one only)

- | | |
|---------------------------|--------------------------|
| a. Walking | <input type="checkbox"/> |
| b. Bicycle | <input type="checkbox"/> |
| c. Bus or train | <input type="checkbox"/> |
| d. Car, taxi or motorbike | <input type="checkbox"/> |
| e. Other means | <input type="checkbox"/> |

70. On a typical day is the **MAIN** part of your trip **FROM** school made by...? (Please circle one only)

- | | |
|---------------------------|--------------------------|
| a. Walking | <input type="checkbox"/> |
| b. Bicycle | <input type="checkbox"/> |
| c. Bus or train | <input type="checkbox"/> |
| d. Car, taxi or motorbike | <input type="checkbox"/> |
| e. Other means | <input type="checkbox"/> |



71. First and last name of the investigator: _____

72. Date of evaluation:

				2	0		
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