PHYSICAL ACTIVITY AND GROSS MOTOR SKILLS IN RURAL SOUTH AFRICAN PRESCHOOL CHILDREN

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Abstract

Background:
Global levels of overweight and obesity in preschool-aged children have increased dramatically in the last two decades, with most overweight and obese children younger than five years living in low- and middle-income countries (LMICs). Statistics from the 2013 South African National Health and Nutrition Examination Survey (SANHANES-1) confirm that levels of overweight and obesity are high in South African preschool-aged children, with prevalence rates of overweight and obesity up to 18.2% and 4.7%, respectively. This increasing problem of overweight and obesity in South African preschool-aged children highlights the need for intervening in this age group. Overweight and obesity interventions in preschool children typically include one or more of the following behaviours: physical activity, sedentary behaviour and screen time.

Aim and objectives: The aim of this study was to characterise the preschool environment in rural South Africa, and to explore physical activity, gross motor skill proficiency, sedentary behaviour and screen time in rural South African preschool-aged children. Additionally, aims of this study were to explore the associations between gross motor skills, body composition and physical activity; and to assess compliance with current physical activity and sedentary behaviour guidelines.

Methods: Preschool-aged children (3-5 years old, n=131) were recruited from three Preschools and two Grade R (reception year) settings in Agincourt, a rural village in north eastern South Africa. In order to gain an understanding of the Preschool and Grade R settings, an observation of the preschool environments was conducted using a tool adapted from the Outdoor Play Environmental Categories scoring tool, Environmental and Policy Assessment and Observation instrument, and the Early Learning Environments for Physical Activity and Nutrition Environments Telephone Survey. Each child's height and weight was measured. Physical activity and sedentary behaviour were measured objectively using a hip-worn ActiGraph GT3X+ accelerometer for 7 days (24 hours, only removed for water-based activities). Gross motor skills were assessed using the Test of Gross Motor Development–Version 2 (TGMD-2). Physical activity and sedentary behaviour, including the contextual information for these behaviours, during the preschool day (08h00 until ±12h00) were measured using the Observational System for Recording Physical Activity in Children (Preschool Version). A separate sample of parents/caregivers were recruited (n=143) to complete a questionnaire that was adapted from the Healthy Active Preschool Years questionnaire and Preschool Physical Activity Questionnaire. Parents reported on their child's screen time, and on factors within the home and community contexts in which physical activity and sedentary behaviours occur.

Results: In terms of the environment, the Preschools and Grade R settings differed in that fixed play equipment only featured in the Preschool settings. Grade R settings had more open space in which to play. All Preschool and Grade R settings provided children with limited portable play equipment, and none of the schools had access to screens. Although all children

recruited for the study were preschool-aged, the Grade R children were significantly older than the Preschool children (5.6±0.3years vs. 4.4±0.4 years, $p<0.05$). According to IOTF cut-offs, the prevalence of overweight/obesity was low (5.0%) in the sample, and 68.1% of children were classified as normal weight. On average, children spent 477.2±77.3 minutes in light- to vigorous-intensity physical activity (LMVPA) per day, and 93.7±52.3 minutes in moderate- to vigorous-intensity physical activity (MVPA). In terms of the new current guidelines (180min/day LMVPA, including 60min of MVPA, described as 'energetic play'), and using average daily average of LMVPA and MVPA, 78.2% met current guidelines. Observed and objectively measured sedentary behaviour results revealed that children were more sedentary during preschool time (between 08:00 to 12:00) compared to the afternoons. Overall, boys were significantly more physically active than girls; and Preschool children did more physical activity during preschool time than Grade R children (all $p<0.05$). Over 90% of the sample achieved an 'average' or better ranking for gross motor skill proficiency. The Grade R children were significantly more proficient than the Preschool children for all gross motor skill components (raw scores and standardised scores). Overall, boys achieved significantly better object control raw scores than the girls, and displayed greater proficiency than the girls in the strike ($p=0.003$), stationary dribble ($p<0.001$) and kick ($p<0.001$). None of the preschool or Grade R settings had access to screens such as televisions or iPads, and parent-reported screen time was low for the total sample (0.5±0.3hr/day). The majority of the sample (97.9%) met current screen time guidelines (<1 hour per day). Parents (82.5%) reported that they believed that their child did sufficient PA for their health, but 81.8% also reported believing that television time would not affect their child's health. Parent responses revealed neighbourhood safety as a potential barrier to being physically active in the community.

Conclusions: Rural preschool-aged children in South Africa appear to be engaged in adequate amounts of physical activity, particularly LMVPA, and are adequately proficient in gross motor skills. The children did not engage in excessive amounts of screen time. Overweight and obesity were not prevalent in this sample of rural preschool-aged children, and therefore it would appear that an intervention to reduce or prevent obesity by increasing physical activity, improving gross motor skills and reducing screen time is unnecessary. Rather, interventions that facilitate the increase in levels of MVPA in order to meet current physical activity guidelines are warranted. Additionally, it is essential that the high levels of physical activity (LMVPA) and good foundation of gross motor skills observed in this sample are promoted in an effort to maintain them throughout childhood. Future research may want to determine whether these activities (high levels of LMVPA, low levels of screen time) track throughout childhood and into adolescence.

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List of Abbreviations

Abbreviation	Meaning
95% CI	95% confidence interval
AAP	American Academy of Pediatrics
BAZ	BMI-for-age z-score
BMI	Body mass index
cpm	Counts per minute
ECD	Early childhood development
GMQ	Gross motor quotient
GMS	Gross motor skills
GPAQ	Global Physical Activity Questionnaire
Grade R	Reception year before Grade One
HAKSA	Healthy Active Kids South Africa
HAZ	Height-for-age z-score
HICs	High-income countries
IOTF	International Obesity Task Force
IQR	Inter-quartile range
LINC	Learning, Information and Dissemination and Networking with the Community
LMICs	Low- and middle-income countries
LMVPA	Light- to vigorous-intensity physical activity (total physical activity)
LPA	Light-intensity physical activity
MPA	Moderate-intensity physical activity
MVPA	Moderate- to vigorous-intensity physical activity
OSRAC-P	Observational System for Recording Physical Activity – Preschool version
PA	Physical activity
rrr	Relative risk ratio
SANHANES	South African National Health and Nutrition Examination Survey
SD	Standard deviation
TGMD-2	Test of Gross Motor Development – Version 2
VPA	Vigorous-intensity physical activity
WAZ	Weight-for-age z-score
WHO	World Health Organization
ZAR	South African Rand (currency)

Chapter One: Introduction

Global levels of overweight and obesity in early childhood have increased dramatically in the last two decades [1]. Overweight in childhood has been shown to track into adolescence [2] and adulthood [3], emphasising the importance of intervening in young children in order to reverse anticipated trends in obesity [1].

Although the prevalence of overweight and obesity is reportedly higher in high-income countries (HICs) in comparison to low- and middle-income countries (LMICs, 11.7% versus 6.1%, respectively)[1], most overweight and obese children younger than five years are living in LMICs (34.7 million versus 8.1 million in HICs) [1]. Statistics from the 2013 South African National Health and Nutrition Examination Survey (SANHANES-1) [3] confirm that levels of overweight and obesity are at alarmingly high levels in young South African children. The prevalence of overweight and obesity among 2-5-year-old children is 18.2% and 4.7%, respectively.

The 2016 Healthy Active Kids South Africa (HAKSA) Report Card [4] (as part of the Global Matrix 2.0 on Physical Activity for Children and Youth initiative [5]) provided grades for different indicators for children of school-going age; including overall physical activity, sedentary behaviour and nutrition. The grades range from an 'A', indicative of success for a particular indictor with a large majority of children; to an 'F', indicating that very few children are succeeding for a particular indicator. The 2016 HAKSA team introduced early childhood physical activity and nutrition sub-sections for the HAKSA 2016 Report Card. The Report Card identified several gaps in the literature for 3-5 year olds, specifically research investigating physical activity, gross motor skills, sedentary behaviour and screen time, and therefore early childhood physical activity could not be assigned a grade [4]. However, overall physical activity levels for older (school-going) children received a 'C' grade on the basis that 50% of South African children are meeting physical activity recommendations. South African children's screen time and sedentary behaviour levels were concerning, and graded 'F' [6].

This evidence of an ever-increasing overweight and obesity problem in South African preschool-aged children deserves attention, and highlights the need for intervening in this age group. Overweight and obesity interventions in preschool children tend to include one or more of the following behaviours [7]: physical activity, sedentary behaviour and screen time. These behaviours are explored in greater detail in Chapter 2.

To date, no evidence- and theory-based obesity prevention interventions (including a physical activity, sedentary behaviour, screen time and/or gross motor skill component) for South African preschool children has been developed and rigorously evaluated. The majority of evidence- and theory-based interventions in preschool children are from HICs [8-10], including interventions that include a home component, preschool component or both. Although most interventions have been developed in HICs, several of them have been

included a comparison of low-income settings within the HIC. For example, the Toy Box study [11] developed in Europe has reported some intervention effects, although the effects are somewhat limited to boys in high-income settings [12]. Another example is the Jump Start programme developed in Australia for disadvantaged communities [13]; as well as Head Start [14], an educational programme developed in the United States that has reported some success in reducing obesity in preschool-aged children [15].

This project intended to explore rural South African preschool children's levels of physical activity, gross motor skills, sedentary behaviour and screen time. No published studies report on levels of these behaviours/variables in preschool children from rural, low-income South African settings. This project also sought to gain insight into the preschool and home contexts within which these behaviours occur. Substantial evidence of the levels of these behaviours [16,17] and skills [18] exists for preschool-aged children in HICs, along with numerous studies of the correlates of those behaviours [18,19]. However, those data may not be applicable to the South African context, where physical, social, political and cultural environments vary. Thus, it is necessary to explore these behaviours and skills in depth in the South African context to gain insight which may provide guidance for future interventions to support health behaviours in pre-schoolers.

The next chapter (Chapter 2) explores existing evidence pertaining to preschool children's physical activity, sedentary behaviour, gross motor skills and screen time. Throughout the literature review, research from HICs is differentiated from that in LMICs, and from South Africa (as a LMIC) in particular. The review also focuses on the preschool and home environments as contexts of physical activity and sedentary behaviour in the preschool years.

Chapter 3 provides a detailed description of the methodology used to collect data for this study. Data on physical activity, sedentary behaviour, gross motor skill proficiency, and screen time were collected. The preschool and home environments were also observed for contextual information. Chapters 4 to 8 present the results. The characteristics of the preschool environments are presented in Chapter 4. Chapter 5 reports on objectively measured physical activity and sedentary behaviour. Chapter 6 reports on the results of the gross motor skill test, as well as associations between objectively measured physical activity and gross motor skill proficiency. Results of physical activity and sedentary behaviour taking place in the preschool contexts are reported in Chapter 7; and Chapter 8 presents the results of the parent's questionnaire, including questions pertaining to the home environment, and pre-schooler's parent-reported screen time. Finally, Chapter 9 summarises and provides an interpretation of all five of the results chapters. The discussion (Chapter 9) includes recommendations and presents avenues for further research.

Chapter Two:
Literature Review

2.1 Introduction

This literature review begins with an overview of the current prevalence of overweight and obesity in South African preschool children (three to five years of age), as well as the health outcomes of overweight and obesity in this age group. Four contributory behaviours and factors (physical activity, gross motor skills, sedentary behaviour, and screen time) and contextual factors (home and school) associated with overweight and obesity among young children are investigated. The review emphasises research from African (particularly sub-Saharan) and other LMICs, with a focus on South African data in particular. Every country in the sub-Saharan region is classified as a LMIC [20]. South Africa is currently classified as an upper middle-income country, which falls in the category of LMIC [20], and is geographically a sub-Saharan country. LMICs are defined as having a per capita gross national income of less than US$12,476. Where there are gaps in the literature for a given topic in LMICs, literature from low-income settings in HICs is reviewed to provide additional context and illustration.

2.1.1 Search strategy for the literature review

The literature search was performed using five electronic databases: PubMed, Google Scholar, Scopus, The Cochrane Database of Systematic Reviews and Web of Science. Search terms included in the search strategy were: 1) 'preschool', 'early childhood', and 'kindergarten'; in combination with 2) 'Africa', 'South Africa', and 3) 'overweight', 'obesity', 'adiposity', 'physical activity', 'gross motor skill', 'gross motor skill', 'sedentary behaviour', 'screen time', 'parent', 'home', and 'environment'. Grey literature from the South African government and reports pertaining to early childhood development in South Africa were searched for relevant statistics and publications.

2.1.2 Body composition definitions for children

The International Obesity Task Force (IOTF) defines overweight, obesity and morbid obesity according to age- and sex-specific body mass index (BMI) values [21], and therefore the cut-off for each differs depending on the child's age and sex. The World Health Organization (WHO) defines overweight and obesity as having a weight-for-height above the median of WHO Child Growth Standards by >2 standard deviations (SD) and >3SD, respectively [22]. The WHO also defines stunting as a height-for-age z-score (HAZ) below the median by >2SD, and severe stunting as >3SD [22]. This is relevant because in sub-Saharan populations in particular, stunting is more prevalent than in HICs [23] and children under five years of age who are stunted are more likely to be overweight or obese than children who are not stunted, due to having a compromised height [24]. Although stunting is recognised as a contributor to overweight and obesity prevalence in sub-Saharan populations [24-26], it will not be discussed in detail as it is beyond the scope of this thesis.

2.2 Prevalence of overweight/obesity in African preschool children

The concern of overweight and obesity in the preschool years has increased globally in the last two decades [1,27]. The prevalence rates for 1990, 2010, 2015 and projected prevalence for 2020 are shown in Table 2.1. Although the estimated prevalence of overweight/obesity in HICs in 2020 is similar to that in Africa, the projected relative increase in overweight/obesity from 2010 to 2020 is substantially higher in Africa than in HICs [1].

Table 2.1 Prevalence of overweight and obesity in preschool children, 2010 – 2020

	Prevalence: 1990	Prevalence: 2010	Prevalence: 2015 *	Projected prevalence: 2020 **	Projected rate of increase: 2010 - 2020
Africa	3.9%	8.5%	10.4%	12.7%	49.4%
LMICs	3.3%	6.1%	7.2%	8.6%	41.0%
HICs	n/a	11.7%	12.9%	14.1%	20.5%

*Estimated prevalence
**Calculated as a relative rate of increase (as a %)
1990 rates from [27]; 2010, 2015 and 2020 rates from [1]

More recently, the overweight/obesity prevalence rates from 26 sub-Saharan African countries were assessed using data from demographic and health surveys completed between 2010 and 2014 [28]. South African specific-data were not included in this report as data in South Africa were being collected for the National Health and Nutrition Examination Survey (SANHANES-1) [3] during this same time frame. According to this cross-sectional study, there were over 10 million overweight/obese children aged younger than six years (6.8%) in the sub-Saharan region [28]. Among the 26 included countries, the highest estimated overweight/obesity rate was in Sierra Leone (16.9%), followed by Comoros (16.2%) and Malawi (14.5%). The three countries with the lowest estimated overweight/obesity were Ethiopia (3.0%), Togo (2.6%) and Senegal (2.0). However, in Ethiopia specifically, overweight/obesity prevalence has more than doubled (to 6.9%) according to a recent study [29]. These findings indicate that overweight/obesity is a persistent problem in African countries, although data reporting on the prevalence of overweight/obesity in early childhood is limited.

Overall, there is a paucity of nationally representative data from many of the countries in Africa and most prevalence data has been collected more than 10 years ago (for example, [24,30]). Thus, while these reviews are valuable to examine trends, they may not be representative of the current situation.

2.3 The prevalence of overweight/obesity in South African preschool children

Although South Africa is classified as an upper middle-income country, according to the World Bank it is one of the most unequal societies in the world [31]. The uppermost decile of the South African population accounts for almost 60% of South Africa's income, while the lowest decile accounts for less than 1% [31]. The World Bank has described the South African

economy as a 'dual economy', defined as an economy where technically-advanced and primitive sectors exist [31]. This type of economy is theorised to perpetuate inequality. It is therefore important to understand the different settings and settlement types as overweight/obesity are different according to income level and geographical location [3].

In South Africa, there are four broad settlement types: urban formal, urban informal, rural formal and rural tribal [32].

- Urban formal areas are characterised by structured, organised and permanent buildings, which have land plots (areas of land or property that are formally owned), and are controlled by a local or district council. Water, electricity and refuse removal are supplied and the council maintains the roads. Historically, urban formal areas were reserved for white people.
- Urban informal areas are typically referred to as 'townships', informal settlements or 'squatter camps'. Service delivery tends to be poor, although these areas are controlled by a local or district council. Many residents in these areas live in non-permanent 'shacks' made of materials such as wooden planks and corrugated iron. Historically, these areas were created outside of the city limits for the black migrant labour force.
- Rural formal areas are referred to as 'semi-towns' that lack a local authority and are mostly mining or industrial towns where housing is often provided by employers.
- Rural tribal areas are villages that are governed by a tribal authority (a chief). They are typically characterised by pockets or clusters of houses or huts with large areas of open land between areas. There are seldom tarred or asphalt roads in any rural area, and many of the rural areas do not have water or electricity supplied to the houses within the villages. South Africa still has a sizeable rural population (approximately 35% of the total population in 2015) according to the World Bank [33].

These terms are important to note throughout comparisons within the South African setting, as they are indicative of the vast differences between living situations within South Africa [32]. From this point onwards, the term 'rural' refers to rural tribal areas.

Similar to prevalence data across Africa, prevalence data specific for South Africa is also limited. In 2015, a systematic review by Monyeki and colleagues reported provincial trends of under- and over-nutrition (from 1990) in South Africans younger than 20 years old [34]. Sixteen studies were reviewed, however only three studies examined preschool-aged children [3,35,36]. These studies are summarised in Table 2.2. The 2013 South African National Health and Nutrition Examination Survey (SANHANES-1) [3] is the most current nationally representative data for under- and over-nutrition in preschool children. According to the SANHANES-1, 22.9% of two- to five-year-old children were overweight or obese in South Africa. This rate of overweight/obesity is higher than all overweight/obesity rates for nationally representative samples reported for sub-Saharan Africa (22.9% vs. an average of 6.8%, range 2.0% - 16.9%) [28].

Table 2.2 South African overweight/obesity prevalence data, 2010 – 2014

First author, year and reference	Participants and sample size	Study setting* and settlement type	Main findings including definition of overweight/obesity used
Mamabolo, 2005 [36]	3-year olds. Boys and girls not specified, n=162.	Central Limpopo Province Rural	46% of sample presented as overweight/obese (IOTF cut-offs used [21]). Differences between boys and girls not assessed. The co-existence of stunting and overweight was observed in 19% of children measured.
Kimani-Murage, 2010 [35]	3- to 5-year olds. Boys n=272; girls n=275.	Agincourt, Mpumalanga Rural	Prevalence of 3% to 11%, with similar rates for overweight/obesity in boys and girls aged 3 to 5 years (IOTF cut-offs used [21]). Overweight/obesity more prevalent in 3-year olds compared to 4- and 5-year-old children. The co-existence of stunting and overweight was observed in 18% of children 4 years of age and younger.
Shisana, 2013 (SANHANES) [3]	2- to 5-year olds. Boys n=651; girls n=640. All results reported by sex.	National representation. All provincial and setting data pooled for children aged 2-14y.	Boys 17.5% and 4.4% of boys aged 2-5y overweight and obese, respectively. Obesity (2-14y) was the most prevalent in Mpumalanga (6.1%) and Kwa-Zulu Natal (6.1%). Overweight/obesity rates highest in urban informal areas (25.2%). Girls 18.9% and 4.9% of girls aged 2-5y overweight and obese, respectively. Obesity (2-14y) the most prevalent in Gauteng (10.0%) and Kwa-Zulu Natal (8.5%). Overweight/obesity rates highest in urban informal areas (30.1%). Girls had greater overweight/obesity prevalence rates than the boys for all age groups (WHO growth standards used [22]).

*Map of South Africa is included (Appendix A1)

Based on the literature available, overweight/obesity is prevalent among children five years of age and younger across all income levels in South Africa. Additionally, within the South African context, preschool children from rural areas appear to have the additional burden of associated stunting with overweight/obesity.

2.4 Health and economic outcomes of overweight/obesity

There are several health complications associated with overweight/obesity among children [37-39]. Particular conditions that have been described in preschool-aged children include asthma [40], obstructive sleep apnoea syndrome [41], and various orthopaedic conditions, including flat feet which may cause pain in pre-schoolers [42]. The metabolic consequences of obesity in childhood are more pronounced [39]. Obesity has been shown to increase risk for metabolic syndrome (the combination of visceral obesity, dyslipidaemia, hyperglycaemia and hypertension [43]) in children aged one to 17 years [44]. Metabolic syndrome is a growing problem in LMICs [45]. For example, data from South Africa shows that obesity at five years of age and weight velocity (described as weight gained per year, in kilograms) between one and seven years of age correlates with insulin resistance and poor glucose tolerance [46] which are key indicators of metabolic syndrome and precursors for developing diabetes [47].

Furthermore, obesity in the preschool years persists in adolescence and adulthood [48-52]. The Birth to Twenty Cohort study in South Africa [53], showed that girls who were obese at four to eight years were 42.3 times more likely to be obese at 16-18 years. In this study, the overweight and obesity prevalence rates were lower in boys, and boys who were obese at four to eight years were 19.7 times more likely to be obese at 16-18 years [54]. The consequences of obesity during adolescence include hypertension, type 2 diabetes, asthma, musculoskeletal pain and obstructive sleep apnoea syndrome [55]. The same co-morbidities are related to obesity in adulthood, as well as osteoarthritis, lower back pain, gall bladder disease as well as several different types of cancer [56]. In South African adults specifically, obese adults are more likely to be diagnosed with arthritis, diabetes and heart disease than their non-obese counterparts [57].

In addition to the health implications of overweight and obesity during early childhood and in the preschool years in particular, there are several neurocognitive and developmental consequences. In particular, obesity in boys aged four to eight years old is negatively associated with gross motor skill development, and obese girls in the same age group have reduced ability to focus attention [58]. In older children, several cognitive outcomes have been linked to childhood overweight/obesity, including poorer executive function (described as self-regulatory cognitive processes associated with monitoring and controlling both thought and goal-directed behaviours) and attention [59,60].

Several psychological consequences of obesity in early childhood have been identified [38,39,61]. Preschool children tend to perceive obese children negatively, a phenomenon referred to as “anti-fat attitudes” that is believed to begin as early as three years of age [62]. Some research has shown that healthy-weight and overweight/obese children aged four to six years believe that overweight/obese children have negative personality and behaviour traits [62,63]. It is possible that this stigmatisation results in overweight/obese preschool children struggling to make friends with their peers, as it has been shown that preschool children are more likely to choose a “thin” child, as opposed to a “chubby” child, to be their (best) friend [62,63]. Overweight/obesity in five year olds has also been associated with low self-esteem and eating disorders [64]. In primary school-aged children, obesity has been associated with anxiety, depression and psychiatric disorders [65].

Overweight/obesity and associated health conditions have a detrimental economic impact on households [66], especially in LMICs [67] including South Africa [68], and have a significant economic burden globally [69,70]. Obese individuals tend to have higher health care costs than their healthy-weight counterparts [69]. In South Africa, in comparison to healthy-weight individuals, 'moderately obese' adults (described as having a BMI ≥30kg/m^2) experience an increase in healthcare expenditure of 10-21% (ZAR2238, equivalent US$175), and 'severely obese' adults (BMI ≥35kg/m^2) an increase of 22-51% per annum (ZAR4425, equivalent US$346) [68]. Obese individuals also tend to be less productive in the workplace through increased absenteeism due to mortality and morbidity [71]. This creates a situation whereby an obese person is contributing less to the economy due to absence from work, while requiring more from the economy in terms of their health care requirements. The impact of obesity and related diseases has been estimated to cost the South African economy over ZAR25 billion between 2006 and 2015 (equivalent US$1.88 billion) [72]. It is therefore necessary to try to prevent overweight/obesity as early as possible to ensure a healthy South African adult population, as well as a less compromised South African economy, in the future.

Overweight/obesity are clearly relevant issues in South African preschool children. This has been highlighted in the relatively recent SANHANES-1 report, which states that nearly one-quarter of preschool children across South Africa are overweight/obese, and children from rural settings are at risk of stunting and overweight/obesity [3]. This section emphasised the detrimental effects of overweight/obesity during the preschool years, and the likelihood of obesity tracking through to adulthood. Thus, the preschool years are a crucial period in which to intervene to support children in achieving and maintaining a healthy weight. In order to intervene effectively, it is necessary to understand the factors and behaviours that contribute to overweight/obesity.

2.5 Behaviours that influence overweight/obesity during the preschool years

Four specific behaviours (sleep, dietary behaviours, physical activity, and sedentary behaviours [73]) have been identified as being critical in the early years (0-5 years). The contributions of sleep and dietary behaviours to early childhood overweight/obesity have been comprehensively described [74,75]. Evidence suggests that late time to bed and/or too little sleep are associated with obesity in preschool children [74,76], and recent 24-hour movement guidelines have emphasised that preschool-aged children need for 10-13 hours of good quality sleep to be healthy [77,78]. To date, there are no studies from African countries that have described sleep in preschool-aged children, nor studies that have investigated the relationship between overweight/obesity and sleep. This gap is noted, but will not be addressed in this thesis.

Poorer dietary behaviours including the consumption of sugar-sweetened beverages and over-consumption of fatty foods [75] are also associated with overweight/obesity in young children. There is a wealth of evidence describing nutrition and dietary behaviours of young South African children [4]. However, the research from South Africa tends to place greater emphasis on under-nutrition, rather than on overweight/obesity [4]. Given the existing data

linking dietary behaviours with under-nutrition and overweight/obesity in South Africa, this study focused on the other two behaviours, namely physical activity and sedentary behaviours, during the preschool years.

2.5.1 Physical activity and overweight/obesity

Physical activity encompasses any bodily movement produced by the skeletal muscles that results in energy expenditure [79] and is inclusive of a wide variety of activities, including running, walking or cycling, working in the garden, or doing water-based activities such as swimming. Physical activities that are more relevant in the preschool years include playing outdoor games, riding a tricycle or jumping on a trampoline.

During the early years, physical activity can be classified as either structured or unstructured. Structured physical activity is guided or facilitated by an adult, teacher or a coach [80]. In South Africa, examples of structured physical activities for preschool-aged children include participating in games such as 'mini' (or modified) cricket, rugby, or netball, or participation in franchised programmes or extra-mural activities such as Playball© [81], Sporting Chance [82] or gymnastics [83]. Unstructured physical activity includes 'free play' [80], which is defined as spontaneous activity, usually characterised in this age group by short bouts of activities that children engage in to entertain themselves [84,85]. Examples of physical activities that would be deemed as 'free play' include playing games like tag, skipping or jumping on a trampoline, but in the absence of an adult or older person leading the activity.

A number of correlated and intervention studies have investigated the relationship between overweight and obesity, and physical activity. Bingham and colleagues reviewed the correlates of total physical activity (referred to as light- to vigorous-intensity physical activity in this thesis, LMVPA) and moderate- to vigorous-intensity physical activity (MVPA) in children aged six years and younger [19]. BMI was reported to have an inconsistent association with LMVPA: six of 37 studies showed a negative association, 26 studies showed no association and five studies showed a positive association. Of the 30 studies that reported on the relationship between BMI and MVPA, four studies showed a positive association [19]. This systematic review did not deliberately exclude studies from LMICs, although all of the studies reviewed came from HICs, highlighting the paucity of literature pertaining to this topic from LMICs.

A recent review [9] assessed the success of obesity interventions in early childhood between 2010 and 2015. A number of different anthropometric indices were reported in the 24 studies reviewed, with 10 (42%) studies reporting a minimum of one significant intervention effect. The studies were predominantly from HICs, although several studies included preschool-aged children from low-income settings within these HICs, including Belgium [86], Chile [87], Switzerland [88,89], Germany [90] and the United States [91,92]. In these studies, physical activity interventions were not consistently effective in reducing BMI or reducing overweight/obesity in preschool children. A number of reasons have been suggested for this including the multi component nature of the interventions. Several studies had included a nutrition or dietary behaviour component ([86-89,91]), or a gross motor skill development

component ([90,92,93]), in addition to the physical activity intervention, thus these may have enhanced or inhibited changes in BMI.

There are a few studies that have investigated the relationship between physical activity and obesity in preschool children in African countries. In a review of childhood obesity in LMICs [94], reduced physical activity was described as a key determinant of childhood obesity (in the absence of data). This review reported on prevalence of obesity in pre-schoolers and provided suggestions to alleviate the obesity problem, but there was no emphasis on physical activity and obesity in preschool-aged children specifically [94]. The review made recommendations for obesity prevention for teachers, and for national health authorities and legislation, with greater emphasis on nutrition and dietary behaviours. The recommendations for school-aged children included an emphasis on the importance of physical activity in the school setting and mandating parents to supervise 45-60 minutes of physical activity daily, but no mention was made of younger children. This may be due to the paucity of physical activity data during early childhood in LMICs, or the lack of clear guidelines for physical activity in early childhood at the time of publication. It is also possible that the authors felt that under-nutrition in young children is of greater concern in this age group in LMICs, a point that has been previously emphasised based on older evidence showing trends of overweight/obesity in LMICs [27]. Therefore, authors are less likely to promote or prescribe increasing physical activity for the purpose of overweight/obesity prevention (in particular) in preschool children from LMICs.

A study from Cameroon, not included in the above-mentioned review, compared physical activity in preschool-aged children who were stunted, stunted and overweight, overweight, and not stunted or overweight [26]. Overall, the overweight children were significantly more physically active than the other three groups of children, particularly at a light intensity of physical activity, although MVPA in the overweight (only) children was similar to that of the non-stunted, non-overweight children [26]. The findings from Cameroon affirms the relevance of concern pertaining to under-nutrition, particularly stunting, in African countries (described earlier); but also highlights the need for more research to confirm whether overweight preschool-aged children in Africa are more active than children of a healthier body weight.

More recently, a cross-sectional study from South Africa used direct observation to assess physical activity in children during the preschool day, and showed that obese children were significantly less likely to engage in light-intensity physical activity (LPA) than their healthy-weight peers [95]. This is the only study to date to describe physical activity, as well as show differences between healthy-weight and overweight/obese children, in preschool-aged children in South Africa.

To summarise, the evidence is inconclusive about the direct relationship of physical activity and overweight/obesity in young children. However, there is a severe paucity of data from South Africa and LMICs with only one study from South Africa describing the relationship between physical activity and overweight/obese preschool children [95]. Given that the prevalence of overweight/obesity is increasing in young South African children (discussed in

section 2.3), and is predicted to continue rising, further understanding of levels of physical activity levels in South African preschool children is needed. A greater understanding of the levels of physical activity may then offer a mechanism of slowing the rates of overweight and obesity among young South African children. A key component of young children's physical activity is their ability to master gross motor skills, thus, the next section discusses the association between gross motor skills and overweight/obesity in pre-schoolers.

2.5.2 Gross motor skills and overweight/obesity

Gross motor skills are an integral part of physical activity in early childhood, as the preschool years are a crucial period for motor development [96,97]. Gross motor skills (known also as fundamental motor skills or fundamental movement skills), refer to locomotor, object control (or manipulative), and stability (or balance) skills [98]. Locomotor skills are those that include body projection skills such as running or leaping. Object control skills are sometimes referred to as ball skills, and include throwing, kicking or striking a ball. Stability skills include balancing and are occasionally called non-locomotor stability skills. These skills are the 'building blocks' to developing sport-specific skills that may be used later in life [97,98]. Although a recently published review of terminology has recommended the use of the terms 'fundamental movement skills' and/or 'fundamental motor skills' [99], the term 'gross motor skills' tends to be the more commonly used term in South African practice and research [4,100-103]. Additionally, the Test of Gross Motor Development (version 2) [104] and the Observational System for Recording Physical Activity (Preschool version) [105] were used as assessment tools (for gross motor skills and physical activity, respectively) for this thesis. Both of these tools refer to 'gross motor skills' and/or 'gross motor activities', and so for consistency, the term 'gross motor skills' will be used throughout this thesis.

The relationship between gross motor skills and overweight/obesity has been well studied in preschool-aged children from HICs, including the United States [106-108] and Germany [109,110]. For example, a study from the United States (n= 9800) showed that jumping and hopping were negatively associated with BMI [108]. The two studies from Germany both reported that overweight/obese children fared significantly worse on all tested gross motor skills components in comparison to their healthy-weight peers [109,110]. The gross motor skills that were tested in these studies included balancing, jumping, hopping, running, as well as hanging. These relationships were apparent independently of income (and immigration) status.

A review by Lubans and colleagues assessed the health benefits of gross motor skills in children and adolescents and found that overall, there was a negative association between gross motor skills and weight status (i.e. children with poorer gross motor skills had less favourable weight status). This review included children and adolescents aged between three and 18 years [111]. Four of the included studies in this review focused on preschool-aged children [106,107,112,113], with only one reporting specifically on the association between gross motor skills and BMI [107]. Williams and colleagues found in a sample (n=198) of three- and four-year old children that there was no association between BMI-for-age z-score (BAZ) and gross motor skills [107]. The other studies reported positive relationships between gross

motor skills and fitness [106] and physical activity [112,113]. Differences in findings may be attributable to how gross motor skills were tested and reported, for example Williams et al and Cliff et al reported composite gross motor skills scores while Fisher and colleagues reported individual skill scores; and tests used differed across all studies discussed.

Three of the physical activity interventions reported in the review conducted by Ward and colleagues (2017, referred to in section 2.5.1) [9] included a gross motor skill component [90,92,93]. Of these three, all were inclusive of children from lower income settings and one was successful in reducing BMI [92], one was successful in reducing skinfold measures [90] and the third study reporting slower rates of weight gain in the intervention sample [93]. The two successful interventions (with respect to adiposity) were substantially longer in length than the study that reported trends in the right direction (nine and 12 months versus 18 weeks), which may explain the difference in findings.

To date, one study from South Africa that has investigated the relationship between gross motor skills and overweight/obesity in preschool-aged children [114]. This cross-sectional study reported no significant differences between healthy-weight and overweight/obese groups at age three, but reported an inverse relationship between gross motor skills and overweight/obesity at four years of age [114]. The healthy-weight four year old children performed significantly better in the catch and balance skills in comparison to their overweight/obese peers [114]. However, the results should be interpreted with caution as the sample sizes between the groups differed substantially. (n=101 healthy-weight children, n=19 overweight/obese). A similar inverse association between gross motor skills and overweight/obesity has been shown in a study in other LMIC [115]. The study from Iran showed that obese preschool children had poorer object control and locomotor skills than their healthy-weight peers [115].

The evidence suggests that overweight/obesity is negatively associated with gross motor skills, particularly skills that are body weight-dependant, such as jumping. Furthermore, this association has been shown to be independent of income status (within a high-income setting). As is the case with physical activity, there is a paucity of literature assessing the relationship between gross motor skill proficiency and overweight/obesity in preschool-aged children from LMICs, and in particular South Africa.

2.5.3 Sedentary behaviour and overweight/obesity

Sedentary behaviours are waking behaviours that are characterised by an energy expenditure ≤1.5 METs and which are undertaken while in a reclining or sitting position [116]. Sedentary behaviour is not the same as physical inactivity (which refers specifically to not meeting physical activity guidelines) [117] or the absence of physical activity [118]. Higher levels of sedentary behaviour result in lower levels of energy expenditure, which increases the likelihood of attaining a positive energy balance [8,119]. Typical sedentary behaviours include watching television, reading, or travelling in a motorised vehicle [117]. Sedentary behaviours that are more relevant in the preschool years include building puzzles, playing with LEGO®, being read to or playing screen-based games. Screen time is a prevalent and highly reported

type of sedentary behaviour, and so it will be addressed separately in the next section in relation to obesity. The focus of this section is on objectively measured sedentary behaviour. Although objectively measured sedentary behaviour may include screen time, it is necessary that in the context of association with overweight/obesity, they be addressed separately.

One study from Africa has assessed objectively measured sedentary behaviour (and physical activity, detailed in section 2.5.1) and weight status in children aged two- to six-years old from Cameroon [26]. Overweight preschool children were significantly less sedentary than the stunted, and stunted and overweight children, and were similarly sedentary to the non-stunted, non-overweight children [26]. This is contrasted with evidence from HICs, where higher levels of sedentary behaviour has been shown to be associated with overweight/obesity: Biddle and colleagues recently published a systematic review of reviews to assess evidence for causal association between sedentary behaviour and adiposity in youth (children aged two to 18 years) [17]. This review of nine systematic reviews highlighted a dose-response relationship between sedentary behaviour and adiposity, i.e. higher sedentary behaviour levels led to higher levels of adiposity, although there was not enough evidence to establish a causal association. Even less evidence exists with respect to sedentary behaviour and overweight/obesity in children and preschool children. A systematic review and meta-analysis reported associations between objectively measured sedentary behaviour and health outcomes in children and adolescents [120]. Only three of the 50 included studies were in preschool-aged children [121-123]. All three studies were from the United States and all reported a negative association between objectively measured sedentary behaviour and BAZ. These finding are consistent with a more recent study which reported a similar relationship between objectively measured sedentary behaviour and overweight/obesity in pre-schoolers in Canada [124].

The evidence available suggests that higher levels of sedentary behaviour is associated with adiposity, but there are currently no data describing the relationship between obesity and objectively measured sedentary behaviour in preschool-aged children from South Africa, and only one study from Cameroon that found that overweight children had similar sedentary behaviour levels to their healthy weight counterparts. Thus, it necessary to explore the relationship between sedentary behaviour and overweight/obesity in South African children.

2.5.4 Screen time and overweight/obesity

As mentioned in section 2.5.3, screen time is a prevalent and highly reported type of sedentary behaviour. Screen time is described as a sedentary behaviour that includes the use of an electronic screen, such as television, digital tablets, computers or mobile phones [117]. Screen time is becoming increasingly popular in young children as the prominence of these devices in the home environment is increasing [125]. Television viewing is the most common form of screen time reported in pre-schoolers from HICs [75,118]. Other relevant screen-based behaviours in the preschool years include playing games on a tablet or video-chatting.

The review by Biddle and colleagues reported a dose-response relationship between screen time and adiposity [17]. This might be due to the volume of literature describing this

association, as there are substantially more studies that have measured screen time as a proxy measure of sedentary behaviour, than studies that have objectively measured sedentary behaviour [75,118]. To date, the majority of studies pertaining to screen time and overweight/obesity in pre-schoolers are from HICs, with some studies incorporating data on children in low-income settings [75]. Le Blanc and colleagues reviewed intervention studies looking at the association of sedentary behaviours in young children on several health indicators, including adiposity [126]. Based on the seven studies of preschool-aged children from HICs, the evidence suggests that increased television time is associated with higher levels of adiposity [126]. Two of the seven studies reported a dose-response relationship between television viewing time and BMI or body fatness [127,128]. Additionally, a cohort study from the United Kingdom reported a positive linear relationship between obesity and screen time, revealing that the odds of being obese at seven years were 1.55 times higher when three year olds had eight hours of (parent-reported) weekly television time compared to children with less than four hours per week [129]. Another study in pre-schoolers from the United States reporting NHANES data, with low-income pre-schoolers included, showed that more than two hours of television viewing per day was associated with overweight as well as higher adiposity levels, independent of age, sex, ethnicity and income status [130]. All of the studies included for review for sedentary behaviour and adiposity were from HICs. One study conducted in India reported that more television time led to a higher body weight in children aged 3-10 years [131]. The study found that 19.6% of the children gained weight over a nine-month period but did not report any increase in screen time. The study was an observational study and only reported on exposure to television time (21.2 hours per week for children three to five years of age) and health outcomes, and so no dose-response relationship between television viewing and adiposity was described [131]. Therefore, it was not possible to determine if the changes in weight were attributable to screen time exclusively.

More recently, studies reporting on screen time and overweight/obesity have provided mixed results compared with previous research describing television viewing and overweight/obesity [126]. A study from Australia reported no association between screen time compliance and overweight/obesity in preschool children [132]. A large study in children aged two to 13 years from Portugal reported on three different types of screen time, including television time, computer time and electronic game time [133]. Television viewing was positively associated with overweight/obesity. The children who viewed more than one hour of television per day had higher BMI values and body fatness, compared to the children who had less than an hour of daily television viewing [133]. Time spent playing electronic games was not associated with BMI or body fatness, while time playing on the computer was weakly associated with BMI only [133]. This study in particular highlights that different types of screen time and the use of only one marker of overweight/obesity may explain the inconsistency in some results reporting associations between screen time and overweight/obesity.

While the evidence from HICs suggests that screen time may be associated with obesity during early childhood, there are no studies from South Africa investigating screen time and overweight/obesity in preschool-aged children. Differences in time spent in screen time between preschool children from different income settings have been reported in other

countries such as Canada [134]. However, it is unknown whether these findings would be consistent in South African populations.

In summary, the contribution of physical activity, gross motor skills, and sedentary behaviour and screen time to overweight/obesity in preschool children are poorly examined in LMICs, particularly in the South African context. The prevalence of overweight/obesity among South African preschool children is high, warranting interventions in the early years. Physical activity and gross motor skill interventions developed in HICs show limited promise in improving overweight/obesity in preschool children. However, the majority of the literature is from HICs. While there is evidence from low-income settings within these HICs, the evidence is limited and it may not be appropriate to assume that physical activity, gross motor skills, sedentary behaviour and screen time influence obesity in these settings in the same respect as in HICs. It is therefore necessary to obtain data on factors that contribute to overweight/obesity in South African pre-schoolers. These data would be integral to inform the development of interventions and public health programmes which aim to minimise overweight/obesity in South African preschool-aged children. In light of the paucity of data describing physical activity, gross motor skills, and sedentary behaviour and screen time in relation to overweight/obesity in South African preschool children in particular, these topics are the focus of this study.

The following section will use the epidemiological framework [135] to further investigate four of the key behaviours that are associated with overweight/obesity: physical activity, gross motor skills, sedentary behaviour and screen time. Although gross motor skills are not a behaviour per se, but rather an important contributor to physical activity (as the 'building blocks' of physical activity and complex movements [98], it is referred to as a behaviour throughout this thesis for ease of reference, as it is grouped with three other behaviours, namely physical activity, sedentary behaviour and screen time. For each of these four behaviours, the measurement, contextual factors and prevalence will be discussed.

2.6 Physical activity in the preschool years

2.6.1 The importance of physical activity in preschool children

Based on the evidence presented earlier in this literature review, the relationship between physical activity and overweight/obesity in preschool children is unclear. However, it is worth noting that there is substantial evidence that describes a clear relationship between physical activity and overweight/obesity in children (older than six years) and adolescents [136-138]. This highlights the importance of addressing physical activity in the preschool years, as physical activity tracks from the preschool years, through childhood and adolescence [139]). Although the benefit on overweight/obesity is not clear, physical activity is critically important for preschool-aged children, as it is associated with a number of other health and developmental benefits [140,141]). Positive associations between physical activity and adiposity, bone health, cardio-metabolic indicators, psychosocial health, cognitive development and motor skill development have been reported [140,141].

A study involving pre-schoolers across eight European countries showed that increasing MVPA, particularly vigorous-intensity physical activity (VPA) by 10 minutes daily had a significant effect on bone strength [142]. The Iowa bone study group [143] also reported that physical activity in preschool children (parent-report and objectively measured) was positively associated with bone mineral content and that MVPA, during the preschool years predicts bone mineral content at ages eight and 11 in boys [144].

Findings from a three-year longitudinal study found that physical activity (using a four-day recall completed by parents) in four year olds improved high-density lipoprotein (HDL) cholesterol levels, reduced triglyceride and total cholesterol levels, and improved blood pressure readings [145]. In particular, high-intensity physical activity and playing outdoors was strongly linked to these health outcomes [145]. It has been reported that this cardio-metabolic health benefit is sex-specific, with girls requiring less physical activity to experience similar cardio-metabolic benefits [140,145,146]. Furthermore, weekend physical activity in three- and four-year-olds, reported by parents, has been shown to be weakly associated with lower total cholesterol [147].

Physical activity has been described as a contributor to the cognitive, social, emotional, [85] and brain development [80] of young children. A recent systematic review investigated the relationship between physical activity and cognitive development [148] in children aged younger than five years. A paucity of literature in this field was highlighted, however the limited evidence, mostly from HICs (Canada, Germany, Switzerland and the United States), provided preliminary evidence for a positive relationship between physical activity and cognitive development in preschool-aged children [148]. One study from the United States found that the children who spent more time in active play, i.e. MVPA, scored better in a task of self-regulation, one of the elements of cognitive development [149]. Furthermore, the children who had better self-regulation also had better mathematics and literacy outcomes [149]. Children who engage in play more frequently have been found to perform better in school (kindergarten) readiness assessments, supporting the link between cognitive development and physical activity [150].

Children who are more physically active display greater gross motor skill proficiency, particularly in locomotor skills [107]. In particular, children who accumulate more VPA tend to display greater proficiency for locomotor activities [107]. A number of physical activity interventions have resulted in an increase in gross motor skills, and have been reported in a recent updated systematic review of seven RCTs in preschool-aged children, all from HICs [151]. Six of the seven studies reviewed showed an improvement in gross motor skill proficiency [152-157], with one showing that the intervention and control group were similar post-programme [158]. One of the reasons mentioned in the review for one RCT finding no improvement was the lack of report on physical activity, thus there was uncertainty around the type and intensity of physical activity. The six RCTs that found improvements in gross motor skills were variable in terms of the type (physical activity and/or nutrition), frequency (twice to five times weekly), time allocated (15 to 40 minutes per session) to the programme and length of intervention (nine weeks to six months). Therefore, it is evident that physical

activity programmes have potential to improve gross motor skills, with longer interventions seemingly showing the most promise for greater effectiveness [151].

To summarise, preschool children who are more physically active experience greater health and developmental benefits than physically inactive preschool children. It is clear that the benefits of physical activity in preschool children surpass the prevention and management of overweight/obesity. The health benefits of physical activity are well established, although within the South African context, additional studies are needed to further understand the levels of physical activity among preschool children.

2.6.2 Measurement of physical activity in preschool children

Physical activity in early childhood is measured using subjective and objective instruments, of which the most common methods used for preschool children are described.

Subjective methods of physical activity measurement in preschool children

Subjective methods generally include interviews or self-report instruments, such as report logs (diaries), surveys or recall. However, due to the cognitive ability of preschool children [159,160] parents or caregivers usually complete these as a proxy measure, on behalf of the preschool child [160]. Subjective instruments usually require parents or caregivers to report on the frequency, intensity and duration of physical activity in a given time period (for example, in the past 24 hours or on the previous day or in a given block of time) [160]. A limitation of subjective methods is that they rely on the memory of the parent/caregiver or parents/caregivers being aware of the activity that they are reporting. This is often difficult for parents/caregivers as they cannot accurately report on physical activity that takes place in out-of-home settings or other contexts where the parent is not present. These limitations result in recall bias with parents and caregivers, typically over-reporting physical activity [161] or incorrectly reporting the intensity and type of activity [162]. In South Africa another challenge that may contribute to self-report issues is adult literacy levels where adult illiteracy rates are close to 10% in several provinces [163].

Strengths of using self-report measures include low participant burden, low cost and easy administration particularly in studies where the sample size is large [164]. Furthermore, subjective measures allow researchers to capture characteristic and contextual information which may aid in understanding of the behaviours being examined [165].

Objective methods of physical activity measurement in preschool children

Objective methods include direct observation, accelerometry, pedometry, and heart rate monitoring. The most common methods in the preschool years include direct observation, pedometry and accelerometry [164]. These are described in detail below.

Direct observation usually entails children being observed by a researcher who records physical activities, including the type, intensity and duration. The observer may video-record the observations for later coding and data entry, or record data during the observation period. Direct observation is often laborious and can potentially be influenced by the

observer's subjectivity and bias, particularly when coding physical activities [164]. However, direct observation is useful as it provides data on the context in which physical activity takes place [84], with some tools including characteristics of the setting and social interactions within which physical activity occurs [105]. The data that these tools provide is very detailed, making it easier to characterise activities [160].

Pedometers are devices that are usually hip-mounted and measure step counts. There are two kinds of pedometers, namely mechanical and piezoelectric. During ambulation, mechanical pedometers count the number of times a certain acceleration threshold is exceeded, while piezoelectric pedometers count number of zero crossings in the acceleration waveform and sum this to give an overall estimate of steps taken [166]. Pedometers primarily provide an indication of volume of physical activity in the form of a step count [160,166]. Newer models of pedometers offer better precision and measurement capabilities as they are time-sampled, and therefore it is possible to measure volume of steps taken in a given time period, such as steps per minute [166]. This provides an estimate of intensity (or pace of steps), as an increased number of steps in a minute means that the person wearing the pedometer has walked faster (which could be attributable to brisk walking or running). However, this is not a reliable indication of overall intensity of physical activity, as other intense activities that involve stepping, such as walking uphill or walking while carrying something, are not differentiated from other walking-based activities. Pedometers are relatively inexpensive, but are unable to capture the context in which physical activity takes place. By design, a pedometer can only capture walking or running-based activities [166], thus many of the activities in which young children participate, such as climbing or jumping, are not able to be captured.

Accelerometers are monitors that measure acceleration to quantify the intensity of movement, and are the most common method for physical activity measurement in preschool-aged children [164]. The accelerometer works by recording counts from accelerations within a predetermined epoch length or time interval (in seconds). The summed value of movement counts across each epoch is recorded. An epoch length of 15 seconds is the most widely used epoch length of choice for preschool-aged children to accurately capture the spontaneous and sporadic nature of their physical activity [167]. Limitations of using accelerometers include high unit cost, the inability to capture the context in which physical activity takes place or the actual type of physical activity the child is engaged in. Additionally, most accelerometers are not completely waterproof, and therefore cannot capture water-based activity [167] and an accelerometer cannot differentiate between activities that have a greater energy cost, as would be the case when pushing something heavy (like a trolley), or walking on a flat surface versus stair climbing [164]. Furthermore, depending on where the device is worn, it cannot capture the movement (accelerations) of a body part to which it is not attached [168], so hip-worn devices cannot account for strenuous upper body activity, for example [164]. Strengths of using accelerometers are the avoidance of bias [169], the devices are non-invasive, the device can measure intensity of physical activity and the participant burden is minimal.

In summary, each instrument has limitations and there is no single instrument that is capable of capturing all elements of physical activity, such as duration, intensity and context. Accelerometers are arguably better for objective physical activity measurement in preschool-aged children, as accelerometers are the most widely validated and used instruments for the preschool age group [168]. However, it is advantageous to use more than one method (objective and subjective) to get an accurate measure of preschool children's physical activity. This allows researchers to quantify the intensity of movement and determine the context and type of physical activity the child is engaged in at the same time [170].

2.6.3 Physical activity guidelines for preschool-aged children

To date, several countries have developed guidelines for physical activity for preschool children. The most recent guidelines were released concurrently in 2017 by Australia [78] and Canada [77], and place emphasis on the spectrum of movement behaviours (physical activity, sedentary behaviour and sleep) over the course of a 24-hour day. The physical activity component of the new movement guidelines states that a healthy 24-hour day for a preschool-aged child includes a minimum of 180 minutes of physical activity spread throughout the day, of which at least 60 minutes is 'energetic play', and more is better. 'Energetic play' is operationalised and measured as moderate- to vigorous-intensity physical activity (MVPA) [77,78].

Physical activity guidelines have somewhat evolved over the years, and the most recent guidelines released by Australia and Canada have replaced previous guidelines [171] [172]. The previous guidelines stated that pre-schoolers should be active at any intensity for at least 180 minutes, spread out throughout the day, every day. Other guidelines have also been developed in the United Kingdom [173] and the United States (by the National Association for Sport and Physical Education – NASPE [174] and the Institute of Medicine – IOM [175]. The current NASPE guidelines state the preschool-aged children should engage in 120 minutes of daily physical activity, including at least 60 minutes of MVPA [174]. The IOM recommends that preschool children should be active for at least 15 minutes per hour whilst in formal out-of-home care [175].

To date, there are no physical activity guidelines specifically for preschool children in Africa. Furthermore, there is a limited number of studies describing prevalence of physical activity and compliance with any physical activity guidelines for African preschool-aged children. This will be discussed in the following sub-section.

2.6.4 Levels of physical activity and compliance with guidelines in preschool children

The prevalence reported of objectively measured physical activity for preschool children varies considerably. Some studies, conducted in HICs, have reported low levels of physical activity in pre-schoolers [174,176-179]. In these studies preschool children spent between 15.3% to 19.1% of their day in light- to vigorous-intensity physical activity (LMVPA). However, this is contrasted with other studies from high income countries having reported much higher prevalence rates [180-182]. For example, Hinkley and colleagues [182] found that approximately 99% of their sample of preschool children met the IOM guideline [175], while

Vale and colleagues reported compliance rates of 97.3% and 99.4% (to the guidelines stipulating three hours per day of physical activity [171-173]) in Portuguese girls and boys, respectively. The differences between studies could be due to the use of different cut points and devices (details of which have been covered in section 2.6.1), as the compliance with the guidelines also varies between studies. Beets and colleagues describe estimated differences in reported compliance based on different criteria in detail with reference to the NASPE guidelines for pre-schoolers. Depending on the criteria used, estimated compliance ranged from 13.5% to 99.5%, depending on the cut point used [174].

In the study from Cameroon that compared physical activity in preschool-aged children who were stunted and/or overweight to non-stunted and/or normal weight children, the physical activity levels were also reported [26]. Total physical activity levels ranged from 194.6 minutes per day to 263.9 minutes per day [26]. Although the authors did not address compliance to guidelines specifically, and despite differences between stunted and non-stunted children, on average the children meet physical activity guidelines [171-173].

To date, there are no studies from South Africa that have investigated habitual physical activity of preschool children, and only one study (referred to in section 2.5.1) has assessed physical activity in South African preschool children during the preschool day. Physical activity was measured using direct observation (the Observational System for Recording Physical Activity – OSRAC-P) and activity levels were compared between preschool children from low- and high-income settings. Children spent 9% and 17% of their preschool hours in MVPA and LPA, respectively [95]. Children in low-income preschool settings spent a significant percentage of preschool time in MVPA than their high-income peers (11% vs. 8%, $p=0.018$), despite children in high-income preschool settings spending more time outdoors (19% vs. 7%, $p<0.001$). LPA did not differ between children in the high- and low-income settings (18% and 16%, respectively) [95].

Currently, there are no studies reporting compliance with any physical activity guidelines in South African preschool children. In LMICs or low-income settings within HICs, results for prevalence of physical activity and/or compliance with early childhood physical activity guidelines are varied, although the trend is towards poor physical activity levels and compliance. There is clearly a paucity of data pertaining to early childhood physical activity in African countries, with physical activity levels and compliance with physical activity guidelines in South African preschool children remaining unknown.

2.6.5 Contextual factors of preschool children's physical activity environments

A first step to understanding the physical activity levels of South African preschool children is to briefly examine some of the key correlates and contextual factors of physical activity in this age group. This section will briefly explore, using the ecological model [135], some of these factors. Ecological models have previously been used to explore potential correlates and contexts of energy balance-related behaviours in children [183,184]. The ecological model described by Bronfenbrenner [135] includes different levels or systems, namely the individual (for example, age and sex), microsystem (for example, parents and home), the mesosystem

(for example, school and community) and the exosystem (for example, policy). Factors that influence physical activity occur across these four levels, with the microsystem and the mesosystem being the most pertinent for preschool children [19,185,186].

This section will focus on physical activity as the behaviour, and selected contextual factors that are relevant to the scope of this thesis. By no means are the contextual factors that are described exhaustive, but rather specific factors have been chosen which align with this thesis. The specific contextual factors that will be investigated include:

I. The child (individual): sex, age, and gross motor skills
II. The role of parents and siblings (microsystem)
III. The role of the preschool and outdoor environment (mesosystem)
IV. Other contextual factors (that would not otherwise fit into a classic ecological model)

I. The Individual Level – The child

At the individual level, age, sex and gross motor skills will be discussed. Sex is one of the most-studied factors associated with physical activity. Boys have consistently been shown to be more physically active than girls in the early years, with boys spending more time in MPA and VPA than girls [181,185,187-190]. Additionally, boys are likely to be more physically active if there are other children to play with [190], whether in the home or school environment, compared to girls [191]. However, recent data from a South African study suggests that girls spend significantly more time in MVPA than boys during the preschool day [95]. This finding is inconsistent with other studies, which may be partially explained by the instruments used to measure physical activity. In this study, the direct observational tool involved the observation of a single child as a representative for a group of children in the preschool setting. Therefore, it is possible that at the times that the preschool children were engaged in MVPA, girls just happened to be observed [95]. No other research has been done in South Africa to support or contest these findings.

In preschool children, age is inconsistently associated with physical activity [19]. A review of physical activity (and sedentary behaviour) in early childhood education and care settings found age to be a strong correlate of physical activity (eight of 11 studies showing a positive association), with older children being more physically active than the younger preschool children [188]. A Swiss cohort study identified age as the strongest correlate (among 12 other correlates) of total and MVPA, in that children participated in higher volumes of physical activity as they grew older [181]. In contrast, an Australian study showed a reduction of approximately 10% in physical activity during the week and weekend for every additional year of age [186]. Other studies have reported no association between physical activity and age [190,192]. These differences may be influenced by the tools used to measure physical activity, the different cut-points applied to the data and the environment in which physical activity was measured (i.e. at preschool or at home in the afternoon).

Gross motor skills have been shown to be positively associated with physical activity in young children [151,181,188,193]. Schmutz et al recently identified gross motor skills as positively and significantly correlated with LMVPA and MVPA [181]. Locomotor skills were identified in

rural areas in the United States as a significant predictor of preschool-day physical activity (objectively measured steps per minute used as the physical activity indicator) [193].

II. The microsystem - The role of parents and siblings

The specific roles of the parents that will be explored include parental physical activity, parental rules, support or encouragement provided by the parent, parental reports of the home and perceptions of the community environment. Research reporting on the role of mothers and fathers in preschool children's physical activity has yielded inconsistent findings. Hnatiuk and colleagues assessed correlates in the home environment and found that parent self-reported physical activity were negatively associated with the preschool children's (three- and four-year olds) MVPA and LPA [194]. This is contrasted with findings from a recent review, where four out of five studies showed that self-reported parental physical activity was positively associated with LMVPA [19]. These differences in findings could be linked to the self-report measure used. For example, Hnatiuk and colleagues reported using a self-report instrument that captures physical activity across domains, which could result in higher values of physical activity reported in comparison to instruments that don't compartmentalise physical activity into domains [194].

A recent review of qualitative literature reported parents' perceptions of physical activity of children less than six years of age [195]. Facilitators and barriers to young children's physical activity were identified, with facilitators including: the parents being active role models for their children, co-participation and support, and the parents imparting the value of physical activity to their young children [195]. Barriers included: constraints due to employment, lack of time, juggling family schedules and monetary costs associated with out-of-home activities [195]. Maternal full-time employment has been positively associated with girls' weekend physical activity [186], but has also been shown to be negatively associated with preschool children's LPA [194]. Bingham and colleagues reported on many parent-related correlates of physical activity in preschool children [19]. The correlates that were shown to be most consistent with LMVPA in pre-schoolers included parents' self-reported physical activity (80%), subjectively measured parental support (100%), and spending time playing (parent with the child, 75%) [19].

With regards to the home environment, the factors that have been assessed include the access/availability of play equipment and space. Generally, greater access to toys and space has been associated with higher levels of physical activity [189,194,196]. In particular, a study on 3- to 4-year old children identified that having play equipment at home positively correlated with MVPA, but was negatively associated with LPA [194]. Qualitative findings support this, with parents reporting that homes with 'active toys' and ample space for play allow for young children to be more physically active [196]. Neighbourhood (or community) safety appears to be a common concern for parents, although parents generally agree that outdoor play is beneficial for children and their development [196]. In some studies, the presence of older siblings in the home has been identified as a positive correlate of physical activity in young children [189,190,196], however, in other studies no association between the presence of older siblings and physical activity has been reported [19].

III. The mesosystem - The role of the preschool and outdoor environment

The preschool environment has been identified as a key environment for the facilitation of physical activity in young children [182,188] with preschool teachers/care providers playing an important role in encouraging physical activity [196]. A study from South Africa reported that children spent 17% of their school day (observed between 08h00 and 12h00) in LPA, and approximately 10% in MVPA [95]. Although in this study, the preschool teacher initiated 69% of the physical activities, the teachers did not often prompt the children to increase or maintain their physical activity (11%) and did not arrange many outdoor gross motor (physical) activities, particularly in the low-income settings [95]. When the predictors of physical activity were assessed in this sample, teacher-initiation of activity was found to be a significant predicator of LPA as well as MVPA [95].

Time spent outdoors has been positively associated with preschool children's physical activity in multiple studies [19,181,186,192,197], as well as in the study from South Africa [95]. In this study, time spent outdoors was the strongest predictor of LMVPA, irrespective of low- or high-income settings [95]. A recent review of physical activity (and sedentary behaviour) in early childhood education and care settings identified that the outdoor environment, including the size of the outdoor environment and opportunities to be active (such as recess periods), were the strongest positive environmental correlates of physical activity [188].

IV. Other contextual factors

Other contextual factors relating to physical activity that do not specifically align with the 'classic' ecological model are important to address. For example, patterns of physical activity over a typical day and understanding differences between weekday and weekend day physical activity for preschool children are important to consider. It is particularly important to discuss patterns of physical activity as preschool children accumulate activity through small intense bouts of physical activity throughout the day, and these bouts of activity vary each day. Data from Chile, Denmark and Australia suggest that preschool children are more active during the afternoons (or after preschool) [198-200]. Research from United Kingdom found children's physical activity patterns are dependent on their enrolment status (full time vs. part time) in an early childhood education and care setting. Children enrolled part-time accumulated significantly more MVPA during preschool hours, as well as after preschool, than those enrolled full-time [191].

It has been widely accepted in physical activity research that weekdays and weekend days differ substantially for children. However, this has more recently be contested for preschool children with some researchers suggesting that there is no variation between weekdays and weekend days [201]. For example, a study from the United States reported significant differences between weekday and weekend day objectively measured physical activity, with children spending approximately 70 minutes more in outdoor play per day on weekend days compared with weekdays [202]. This finding is consistent with research from Australia [200,203], but conflicts with research from Scotland [204], which showed no difference between week and weekend day physical activity. It is also in contrast with the studies assessing patterns mentioned earlier [191,199], both of which showed that children were less physically active over the weekend. It remains unknown if differences between weekday and

weekend days exist for preschool children within the South African context, thus this is an important contextual factor to investigate further.

To summarise, many factors associated with physical activity in preschool-aged children have been studied including sex, age, gross motor skill proficiency, the role of the parents, as well as factors within preschool and home environments. To date, few studies have investigated the influence of contextual factors in relation to physical activity in the South African setting. It is therefore necessary to not only explore the prevalence and compliance of physical activity levels of South African preschool children, but to further understand some of the contextual factors that may influence physical activity within the South African context.

2.7 Gross motor skills in preschool children

Similar to section 2.6 where physical activity was discussed, the importance of gross motor skills proficiency in relation to developmental outcomes, the methods for measuring gross motor skills and some key correlates of gross motor skills are discussed in this section.

2.7.1 Importance of gross motor skill proficiency during the preschool years

Evidence suggests that gross motor skill proficiency at a young age is a determinant of physical activity participation later in life [205]. There is evidence suggesting that gross motor skill proficiency is directly related to physical activity (i.e. those with better gross motor skill proficiency have higher physical activity levels) [193]. There is also some research that suggests that those with higher levels of physical activity have better gross motor skills [107]. These studies describing the association between physical activity and gross motor skills have been discussed in section 2.6.1 and 2.6.5. Independent of the direction of causality, they are undoubtedly linked and it is clear that the preschool years are a critical time for the development and teaching of gross motor skills [96,154].

The importance of teaching gross motor skill development is supported by a number of theories including the 'Mountain of Motor Development' [206]. The 'Mountain of Motor Development' theory suggests that typically developing children learn fundamental movement patterns between the ages of one and seven years, and during this period the focus is the process or quality of performance [206,207]. It is theorised that at age seven there is a 'proficiency barrier' for motor skills, as after this age children learn to develop skills that are context-specific [206,207]. From age seven, the focus shifts from the process of performance to the product or outcome of performance. For example, during the early years a child will learn how (process) to kick a ball correctly, but will refine these skills by putting them into practice when they aim for goals during a soccer match (outcome), assuming that sport participation commences around the age of seven. At roughly age eleven and thereafter, children reach a stage of 'skilfulness', at which point the child is expected to have the developmental ability to be fully proficient at a skill in a particular context [206]. For this reason, teaching correct technique of gross motor skills is essential from a young age, as such skills are the foundation on which lifetime participation in physical activity and sport are built [208].

Based on the evidence presented above, it is understood that physical activity and gross motor skills are very closely linked, and there is evidence that supports that this relationship between physical activity and gross motor skills is bi-directional. Given that physical activity and gross motor skills are so closely linked, it is possible that the many benefits of increased physical activity in preschool-aged children (described in section 2.6.1) would be observed in children with better gross motor skills. Although fully exploring this bi-directional relationship is beyond the scope of this thesis, more evidence is needed to explore gross motor skill proficiency and physical activity in children from low-income settings, to determine whether gross motor skill proficiency is associated with physical activity in these settings.

2.7.2 Measuring gross motor skills in preschool children

During the early years, gross motor skill tests typically assess the process or quality of performance exclusively. When assessing the process, gross motor skill proficiency is graded or scored according to selected performance criteria. Some gross motor skill tests include both the process and outcome. Whether assessing process and/or outcome, gross motor skills are most commonly measured by observation following a thorough explanation and correct demonstration. It is recommended that the observation is video-recorded to allow for greater scrutiny [209].

There are several instruments used to test gross motor skill proficiency. In South Africa, the Kinderkinetics assessment is an assessment tool primarily used for Kinderkinetics practitioners in South Africa. The tool was developed for use in children aged younger than 12 years, and has not yet been validated for research purposes, although it is regularly used in practice [210]. The Test of Gross Motor Development-version 2 (TGMD-2) [104], Bruininks-Oseretsky Test of Motor Proficiency (BOT-2) [211], Movement Assessment Battery for Children (Movement ABC-2) [212], Körperkoordinationtest für Kinder (KTK) [213], Motoriktest für Vier- bis Sechjärige Kinder (MOT 4-6) [214] and Maastrichtse Motoriek Test (MMT) [215] and Peabody Developmental Motor Scales (PDMS-2) [216] are examples of instruments that are used to assess gross motor skills in preschool-aged children.

The TGMD-2, Movement Assessment Battery for Children (Movement ABC-2) [212], Körperkoordinationtest für Kinder (KTK) [213] and Peabody Developmental Motor Scales (PDMS-2) [216] are tests with 12 or fewer items (particularly for children of a preschool age) and are therefore less laborious to administer than the Bruininks-Oseretsky Test of Motor Proficiency (BOT-2) [211], Motoriktest für Vier- bis Sechjärige Kinder (MOT 4-6) [214] and Maastrichtse Motoriek Test (MMT) [215]. A limitation for the KTK, MOT4-6 and MMT assessment tools is that all three have been developed for use in European countries and the manuals are not readily available in English. Furthermore, the TGMD-2, M-ABC-2 and PDMS-2 were developed (as first editions) as research tools in addition to having diagnostic or intervention properties [217]. All gross motor skill assessment tools detailed above provide raw scores that convert to percentile rank scores, although a strength of the TGMD-2, BOT-2 and PDMS-2 is that they provide additional outcomes such as age equivalents and quotient scores that are arguably more meaningful [217]. A more detailed description of each gross motor skill assessment tool is provided in Table 3.3 in Chapter 3 (the Methods Chapter).

In summary, different gross motor skill assessment tools serve different purposes based on the age of child being tested and how they are designed to measure gross motor skill proficiency. Of the assessment tools available, most have been developed and validated in North American and European countries, with only one assessment tool being developed in South Africa to date.

2.7.3 Gross motor skill proficiency in preschool children

To date, there are three published studies that have described gross motor skill proficiency in South African preschool-aged children [102,114,210], and these studies describe gross motor skill proficiency of children from a range of income settings. In 2003, du Toit and colleagues assessed three gross motor skills (hopping, catching, single-leg balancing), using process and outcome measures from the Kinderkinetics assessment tool in relation to adiposity in three- and four-year-olds [114]. On average, the three-year-olds were in the 'initial phase' of development for all three tests. As expected in a test that is not age-standardised, the four-year-olds performed better (in the 'elementary phase') for the catch and balance tests than the three-year-olds, although the significance of this was not reported. One of the outcome components of the assessment showed that the three- and four-year-olds caught the ball 3.6 times out of four possible throws [114].

Another study by Draper and colleagues assessed the gross motor skills of pre-schoolers enrolled in Little Champs [218], a community outreach gross motor programme [102]. Children were enrolled into the intervention group, which participated in the Little Champs programme, or the control group. The TGMD-2 [104] was used to assess gross motor skills. The gross motor skills of children in the intervention group improved more than those in the control group, however both groups were adequately proficient in gross motor skills (according to the TGMD-2 norms and scoring method) at baseline [102]. More recently, a study in a South African sample of six-year-old children from low- and middle-income preschools aimed to establish sex differences in gross motor skills [210]. The study reported good mastery of locomotor skills such as running and hopping (84% achieved a level of 'mature mastery') in boys and girls. In terms of object control skills, a significantly higher percentage of the boys displayed mastery in catching, kicking and throwing a ball than girls (75% vs. 66%, respectively) [210]. These sex differences are comparable to other international studies [97,219-222], and have prompted studies that have aimed to improve proficiency in young girls' gross motor skills [223].

Based on the limited body of evidence available, South African preschool-aged children from middle- and low-income settings seem to display adequate gross motor skill proficiency. This is consistent with results from a recent study conducted in five-year-olds from Myanmar (a LMIC) [224], and in contrast to studies from disadvantaged (or low-income) settings from HICs [225-228]. In these HIC studies, children from areas of disadvantaged or low-income settings show poorer gross motor skills. However, given the small number of studies from South Africa, additional studies are needed to further substantiate these differences and to determine the gross motor skill proficiency of South African children.

To summarise, there is some data from South Africa that shows that South African pre-schoolers display adequate gross motor skills, and that gross motor skill programmes are effective in improving gross motor skill proficiency and cognitive outcomes; however more evidence is needed to confirm these findings.

2.7.4 Contextual factors linked to gross motor skills in preschool children

Similar to section 2.6, some of the key correlates of gross motor skills in preschool children are discussed. A review of 20 studies of preschool children's correlates of gross motor skills was recently published by Barnett and colleagues [18]. None of the studies reviewed were from LMICs, although there were three studies (two studies from the United States [228,229] and one study from Australia [220]) that included pre-schoolers from low-income settings. Similar to physical activity, the correlates of gross motor skill and development will be detailed using the ecological model.

I. The Individual level - The child

The most widely reported individual correlates of gross motor skills in young children include sex and age. Sex is the most consistently studied correlate of gross motor skills in preschool children [18]. Boys have been shown to be more proficient in object control skills than girls [97,219-222], more frequently than girls have been shown to be or similar in object control proficiency [230,231]. Findings from South Africa show in terms of object control skills, boys are more proficient than girls for ball kicking, but for no other object control skills (catching and throwing) [210]. In terms of locomotor skills, some studies have reported no difference between boys and girls [221,222,232], and one showing that preschool girls perform better than preschool boys [97]. One study from South Africa has reported that boys and girls are similar in locomotor skills, with the exception of girls being superior at rope skipping [210]. With reference to balance and stability skills, preschool-aged girls have been shown to be similar to preschool-aged boys [230], as well as better than boys [219,233], which is consistent with one study from South Africa [210]. This indicates that sex differences in gross motor skills differ depending on the instrument used, the target age (within the preschool years) as well as between different populations.

Age has been shown to be a positive correlate of gross motor skills, with older children being more proficient than young children [18]. However, given that many gross motor skill tests provide norms allowing for the standardisation of test scores according to age, these differences are already accounted for and one would be less likely to observe age-related differences. Tests that only evaluate process may also have a ceiling effect as they have fewer assessment criteria than those designed for older children, which evaluate process and outcome [18]. This will result in less variance in a sample of preschool children, which may influence the likelihood of showing any associations between age and gross motor skills, although it is expected that older children will perform better than younger children.

II. The microsystem - The role of parents and siblings

Several aspects of parenting and the home have been assessed with reference to preschool children's gross motor skills. Play equipment in the home, paternal physical activity and

parent education have been shown to be positively associated with gross motor skill proficiency in a study conducted in Belgian pre-schoolers [234]. Correlates for object control skills and locomotor skills have also been found to differ [220]. With reference to object control skills, parental confidence in their own skills, number of pieces of play equipment in the home, and not participating in dance lessons have been found to be positively associated with greater object control competence in Australian preschool children [220]. In terms of locomotor skills, the same study reported fewer significant associations, although having a greater number of pieces of play equipment was also positively associated with locomotor skills.

To date, few studies have investigated the contextual factors influencing gross motor skills in the South African setting. More research is needed to first establish the level of proficiency among South African preschool children, and to determine the factors that may influence the levels of proficiency.

2.8 Sedentary behaviour and screen time in preschool children

As previously mentioned in Section 2.5, screen time is often used as a proxy measure for sedentary behaviour. Although screen time is a distinct behaviour, this section will describe sedentary behaviour and screen time together, as the health and developmental outcomes are believed to be similar, as are the measurement tools and the related contextual factors. Additionally, guidelines for sedentary behaviour (discussed in section 2.8.2) are inclusive of screen time recommendations. For these reasons, this section of this literature review will combine sedentary behaviour and screen time.

This section will describe the health and developmental outcomes of sedentary behaviour and screen time, tools used to measure sedentary behaviour and screen time, guidelines, prevalence of sedentary behaviour and screen time, as well as contextual factors linked to sedentary behaviour in early childhood.

2.8.1 The consequences of excessive sedentary behaviour and screen time in preschool children

The association between sedentary behaviour and health during early childhood has been described in a review published in 2012 [126]. None of the studies included in this review reported on the relationship between sedentary behaviour and bone health, gross motor skill development or cardio-metabolic health indicators [126]. The relationship between sedentary behaviour and screen time with adiposity has been discussed in section 2.5: there may be a dose-response relationship between sedentary behaviour and adiposity, but there is not enough evidence to establish a causal association [17]. This section will address the remaining health and developmental outcomes.

There is a growing body of literature describing the relationship between screen time and psychosocial health. Higher levels of screen time have been weakly associated with young children being at risk for poorer well-being, including emotional problems and poorer family functioning [235]. The Le Blanc review reported on three studies in preschool-aged children

[126], with one study reporting a dose-response relationship between television viewing time and poor psychosocial health outcomes, especially when the viewing material is characteristically non-educational [236]. Carson and colleagues reviewed the effect of sedentary behaviour on cognitive outcomes and reported mixed findings for preschool-aged children [237]. Educational television programmes or cartoons were associated with higher cognitive development and vocabulary scores, but there is also evidence that there is a detrimental effect of cognitive development, particularly executive function [238]. It has been shown that preschool children who accumulate more television viewing time have poorer executive function than children who watch less television [238]. Additionally, the age of onset for television viewing has also been found to have detrimental effects on executive function. Children who reportedly began watching television at a younger age had weaker executive function than children who began watching television at a later age [238].

Although Le Blanc and colleagues [126] did not report on any bone, gross motor skill or cardio-metabolic health outcomes related to sedentary behaviour, a potential issue with sedentary behaviour (as well as screen time) is that it may displace time that a preschool child would otherwise be spending playing, or engaged in physical activity or gross motor skill - based activities. There is evidence that screen time displaces sleep in preschool children [239], and a lack of sleep is associated with other negative outcomes for young children [240], including obesity [74,76].

2.8.2 Measurement of sedentary behaviour and screen time in preschool children

As is the case with physical activity, sedentary behaviour in children is measured using subjective and objective methods [241]. There is some overlap between the features of sedentary behaviour and physical activity measurement, and so this section will build on some aspects of measurement discussed in section 2.6.1.

Subjective methods of sedentary behaviour and screen time measurement in preschool children

Subjective methods include interviews or self-report instruments, such as report logs (diaries), surveys or recall. As mentioned in section 2.6.1.1, self-report of activities in preschool children is not feasible as young children lack the cognitive ability to accurately recall activities [160]. Parents or caregivers would therefore usually complete these as a proxy measure, on behalf of the preschool child [160]. The strengths and limitations discussed in section 2.6.1.1 (pertaining to subjective physical activity measurement) are very similar in sedentary behaviour [242].

Objective methods of sedentary behaviour and screen time measurement in preschool children

Objective methods of sedentary behaviour measurement include direct observation and accelerometry, and the strengths and limitations of direct observation and accelerometry discussed in section 2.6.1.2 (regarding objective physical activity measurement) also apply to objective sedentary behaviour measurement.

When using accelerometry as an objective measurement tool to assess sedentary behaviour, low levels of energy expenditure are captured, and not different sedentary behaviours.

Therefore an additional limitation with objectively measured sedentary behaviour using accelerometers is that there is a risk of misclassification of sedentary behaviour as sleep time, or non-wear time [243,244]. This is particularly problematic in preschool-aged children as they are likely to take daytime naps [245]. Misclassifying naptime as sedentary time is probable, because when motionless, an accelerometer will register zero counts [243]. Depending on the wear time rule applied, for example 20 minutes versus 60 minutes of consecutive zeroes, to accelerometer data, this misclassification can be minimised [246]. Much like physical activity, objective sedentary behaviour measurement using accelerometers cannot determine the context in which sedentary behaviour is taking place, or the type of sedentary behaviour the child is engaged in [241]. This is challenging because not all sedentary behaviours are unhealthy. There are sedentary behaviours that are beneficial and necessary for young children [125] such as reading, craft activities and drawing. These types of sedentary behaviours facilitate the development of important skills, including fine motor skills, picture perception and social skills.

The ActivPAL (PAL technologies Ltd., Glasgow, Scotland) is another tool that was initially designed to measure free-living activity. The ActivPAL is capable of differentiating postures and classifying an individual's activity into time sitting, standing and stepping. This device has been validated in laboratory settings, achieving an accuracy of 100% for measuring sitting, standing and stepping [247], and is considered a superior tool for sedentary behaviour measurement. This tool has been used in pre-schoolers recently [179,198], despite having been described as having little promise for measuring sedentary behaviour in preschool-aged children [248].

Much like physical activity, there is not one single instrument that is capable of capturing all elements of young children's sedentary behaviour. To do so, it is necessary to use more than one method to get an accurate measure and to gain an understanding of preschool children's sedentary behaviour, and screen time. To date, few studies have assessed contextual factors linked to sedentary behaviour in South African preschool children.

To date, there are no instruments that are capable of measuring screen time objectively, thus screen time is measured using proxy-report by parents and caregivers. Advances in this area are currently underway with possible objective measures of television viewing time being tested, although the progress on this development is currently unknown.

2.8.3 Sedentary behaviour and screen time guidelines for preschool-aged children

Similar to physical activity guidelines, several countries have established sedentary behaviour guidelines for preschool-aged children. The most recent sedentary behaviour guidelines, as described in section 2.6.3 for physical activity, are a component of 24-hour movement guidelines released by Australia [78] and Canada [77]. In a 24-hour day, it is recommended that preschool-aged children should not be restrained for more than one hour at a time, and that engagement in sedentary screen time should be limited to less than one hour (less is better) [77,78].

Sedentary behaviour guidelines do not age as far back as physical activity guidelines, and much like physical activity guidelines, the latest guidelines released by Australia and Canada replace previous guidelines [249,250]. Previous guidelines from Australia state that preschool children should not be "sedentary, restrained, or kept inactive, for more than one hour at a time, with the exception of sleeping" [249], which is consistent with current sedentary behaviour guidelines from the United Kingdom [173]. The American Academy of Paediatrics (AAP) guidelines [251] state that preschool children should spend less than one hour on screen time per day. Specifically, the content of programming should be of a high quality, and that parents should co-view media with children to help them understand what they are seeing and apply it to the world around them. The AAP also recommends that families designate media-free times together (such as dinner or driving) and media-free locations or 'zones' at home (such as the bedroom) for all age groups [251].

To date, there are no sedentary behaviour guidelines for preschool children in South Africa. The next section will explore prevalence data for sedentary behaviour and screen time in preschool children.

2.8.4 Prevalence of sedentary behaviour and screen time and compliance with guidelines in preschool children

Reports of compliance with sedentary behaviour guidelines by children in HICs are mixed, with several studies reporting poor compliance in countries including Canada [134,252,253] and Australia [132]. Reported compliance (with sedentary behaviour guidelines) rates in preschool-aged children range from 36% [252] to 58.9% [132]. However, it is worth noting that compliance rates may differ based on the guidelines used as a comparison [132]. This was addressed by Hinkley and colleagues [132], where compliance rates differed substantially in Australian pre-schoolers depending on whether compliance with AAP guidelines (58.9%) or Australian guidelines (21.8%) were reported.

Several studies have reported on time spent in sedentary behaviour in pre-schoolers in preschool settings. Jones et al, in their observational study of South African pre-schoolers, reported that children spent 73% of their time in sedentary behaviours during the preschool day [95], with time spent in sedentary behaviour being similar between in high- and low-income preschools [95]. This is contrasted with a study from Australia that showed that preschool children spent 48% of their preschool day sitting, with sitting time being measured using the ActivPAL [179].

2.8.5 Contextual factors of sedentary behaviour/screen time in preschool children

The ecological model [135] that has been used earlier to describe the contextual factors pertaining to physical activity (section 2.6.5) and gross motor skills (section 2.7.4) will now be used to explore the contexts of sedentary behaviour/screen time. The following contextual factors will be discussed:

I. The child (individual): sex and age
II. The role of parents and the home environment (microsystem)
III. The role of the preschool and outdoor environment (mesosystem)

I. The individual level (The child)

Evidence, including evidence from South Africa [95], consistently suggests that there is no association between sex and sedentary behaviour in preschool children [189,254]. Evidence that age is associated with sedentary behaviour is inconsistent [254]. Of the 23 studies reviewed by Hinkley and colleagues, three studies reported a positive association, one study reported a negative association and two studies no association with age specifically. However, this may be due to the narrow age range within the preschool years, as described earlier [185]. Additionally, the inconsistencies may be due to different instruments used to measure sedentary behaviour and the general complexity of sedentary behaviour measurement, particularly in an age group where self-report is not always feasible.

II. The microsystem (The role of parents and the home environment)

Parents of pre-schoolers play a pivotal role in the amount of time a child spends in sedentary behaviours. Findings from a study of pre-schoolers in the United Kingdom suggest that people who spend time with a child and who influence their behaviours, particularly in the home environment, have the greatest influence on time spent in sedentary behaviours [194]. Screens in particular are becoming increasingly ubiquitous, and parents are being increasingly reliant on the 'electronic babysitter' [237]. Similarly, a large study of children aged four to eight years old from the Netherlands found that parents play a pivotal role in children's television viewing. Parents are responsible for the rule-making, and the number of television sets in the home as well as a television in the child's bedroom, all of which will determine high screen time (defined as >90 minutes in the study) in young children [239]. This is congruent with findings from Australia [132], where the children (boys) of parents who limited the child's screen time were more likely to meet Australian screen time guidelines.

Parental perception of neighbourhood safety is linked to time spent in sedentary behaviour. A study from the United States reported that children who lived in the least safe tertile (as perceived by the parent) had approximately 10% more television viewing time than children in safer neighbourhoods, after adjusting for SES [202]. Before adjustment for SES, children in the less safe neighbourhoods were more likely to watch more than two hours of television per day [202]. This finding has been echoed in a qualitative review by Barbosa and colleagues, who reported that some parents report safety as an important barrier to children's physical activity and thus having a preference for being indoors, versus being in danger outdoors [196].

III. The mesosystem (The role of the preschool environment)

While the preschool context can be viewed as a context where children are potentially more physically active, there are studies that have shown that children are less active during their time spent at preschools in comparison to time spent elsewhere [182,198,255]. For example, in Chile, preschool children were significantly more sedentary during 'in class' periods compared to times that they were not in class. It is relevant to note that sedentary time in the preschool context is linked to the availability of screens at the preschool. This has been described in a review by Vanderloo [256], who also identified two key correlates of screen-based behaviour in early childhood education and care settings: high staff education was found to be negatively associated with screen time, while home-based childcare (compared to centre-based childcare facilities) were positively associated.

To summarize, several factors associated with sedentary behaviour in preschool children have been studied. Based on the literature presented, some of the key correlates to consider when examining preschool children's sedentary behaviour include sex, the role of the parents as well as factors within the preschool and home environment. To date, only a limited number of studies have described contextual factors with respect to sedentary behaviour and screen time in the South African setting.

2.9 Summary

The prevalence of overweight/obesity among South African preschool aged children is of concern. There are some studies that have described prevalence rates of overweight/obesity in South African preschool-aged children, but there is little evidence describing factors that may be affecting these rates among preschool children, particularly with reference to physical activity, gross motor skills, sedentary behaviour and screen time. There are no published studies to date that have objectively measured physical activity or sedentary behaviour in South African preschool children. There is some, albeit limited, evidence that shows that gross motor skill proficiency is satisfactory in South African preschool children. A few of these studies have not made use of valid and reliable gross motor skill measurement tools, and the study samples are largely localised to two geographical areas in South Africa. There is only one study that has observed and described physical activity and sedentary behaviour in the preschool environment. Lastly, there are no studies that have described the home environment and parental influences on physical activity and sedentary behaviour in preschool children. This information is necessary to develop effective interventions to combat overweight/obesity in South African preschool children.

2.10 An introduction to the early childhood sector in South Africa

Data in this study are collected from five early childhood settings which fall under the early childhood development (ECD) sector. The ECD sector in South Africa has multiple challenges that will be highlighted in this section to provide an understanding of the broader ECD context, and therefore the preschool system, in South Africa.

In South Africa, preschool-aged children (three to five years) attend both preschools and primary schools, as Grade R (the 'Reception' year) programmes are provided through three different models, namely those within the public primary school system, those within community-based centres, and the independent provision of Reception year programmes [257]. It is legislated that children start Grade R in the year that they turn six [258]. However, the South African Schools Act [258] states that admission for Grade R immediately prior to Grade One is permissible at four years old if they are turning five years old before the 30th of June of the admission year. Therefore, when conducting research in preschool-aged children in South Africa, it is likely that children in the targeted age group (three to five years) could be recruited from a preschool or primary school (as a Grade R, i.e. the first grade of primary school but not Grade One).

Primary schools in South Africa, and hence Grade R facilities at these primary schools, come under the authority of the National Department of Basic Education; they receive government funding and have qualified teachers in their employ (although it is estimated that up to two-thirds of Grade R teachers across South Africa are under-qualified or need to upgrade their skills [259]). However, Grade R teacher training, qualifications and remuneration are yet to be professionalised.

Independent preschools (or ECD centres) in South Africa are often opened or established based on the needs of a community, and continue to grow as the demand for ECD facilities increases. For example, an ECD centre may have started as a home in which a few children were initially cared for by a neighbour or relative, or a community identified a need and started a centre, or a primary school established an ECD centre to cater for the younger children of the communities they serve. Independent preschools, unlike primary schools, fall under the jurisdiction of the Department of Social Development, and the quality of service provided by a preschool can vary between preschools that are fully registered, conditionally registered or unregistered. Registered preschools are fully compliant with requirements for registration and receive funding from government. They are therefore better able to provide for the developmental needs of children. Conditionally registered and unregistered preschools are mostly community-based centres. The three most common reasons cited for conditional registration include inadequate infrastructure (52%), inadequate equipment (41%), and inadequate staff training (34%) [257]. These reasons provide insight into the magnitude of the challenges faced by ECD centres in South Africa, particularly in poorer and disadvantaged communities. For example, in both Mpumalanga and KwaZulu-Natal, almost 60% of centres reported that inadequate equipment was a reason for their conditional registration, which is 20% higher than the national average [257]. Furthermore, 45% of all audited ECD centres in South Africa have obtained a Health and Environment certificate. This certificate states the requirements for, among other things, the acceptable capacity for a structure based on the size of the ECD centre [257].

Teachers at preschools in rural or urban informal areas across South Africa are largely not trained in ECD and are often lacking in tertiary and in some cases, even secondary education; and so, by definition, are not 'teachers'. The 'teachers' tend to be members of the community who are paid a minimal stipend to supervise the children. Therefore, there are adults (mostly women) who hold no qualification in ECD, or who are poorly educated, supervising many children in preschools across South Africa, particularly in the urban informal and rural settings [257].

Due to a lack of governmental funding, preschools in South Africa are generally run as independent organisations that largely rely on fees paid by parents/caregivers [259]. In rural or urban informal areas, preschools may also receive donations or rely on a limited government subsidy (mainly to cover food) to function [259], as parents are seldom able to afford fees. Preschool children from poorer families do qualify for a subsidy to attend registered ECD centres (including preschools). It is estimated that more than one million children under four years of age are in some form of out-of-home care or programme, although fewer than half receive subsidies [259]. Due to the registration requirements

discussed briefly earlier, children from disadvantaged areas are often inadvertently excluded as their parents often cannot afford to pay fees, and due to the challenges of registration, they are more likely to live in an area that does not have an ECD centre that is registered or subsidised. Thus, it is vital that differences between preschool and Grade R children (from primary schools) are accounted for, as these settings are likely to be different.

In light of all the challenges faced by the ECD sector in South Africa, it is not unexpected that physical activity, sedentary behaviour, screen time, gross motor skill development and overweight/obesity are not prioritised. Key ECD strategies, outlined in a diagnostic review of the ECD sector in South Africa [259] make no reference to any one of these four behaviours. The key ECD strategies are: "1) To deliver comprehensive services to young children, using all opportunities of contact with families; to extend early child care and education through home- and community-based programmes, beginning with the poorest communities not reached by current services; 2) To ensure food security and adequate daily nutrition for the youngest children to avert the life-long damaging effects of stunting; 3) To launch well-designed high-profile parent support programmes through media campaigns, community activities and services that acknowledge and reinforce the importance of positive parenting for young children" [259].

While it is clear that the poorest communities (which are often rural) need to be prioritised and served, the key ECD strategies do not emphasize physical activity, gross motor skills, sedentary behaviour and screen time in young children. This literature review has presented evidence that suggests that by improving these four behaviours and investigating contributing factors of these behaviours, the benefits are not limited to the improvement of overweight/obesity, but also to healthy development of preschool children. However, to intervene effectively, it is vital to measure and describe these behaviours and factors, as well as to gain an understanding of the contexts in which they take place.

2.11 Aim of this PhD project

This PhD thesis aimed to describe the following in a sample of preschool-aged children from a rural, low-income setting in South Africa:

1. Characteristics of the preschool/school environment;
2. Objectively measured physical activity (levels, compliance and daily patterns);
3. Objectively measured sedentary behaviour (levels, compliance and daily patterns);
4. Directly observed physical activity and sedentary behaviour within the preschool setting, as well as contextual and individual-level factors of physical activity;
5. Gross motor skill proficiency;
6. Associations between gross motor skills, body composition and physical activity objectively measured and directly observed);
7. Parent and/or caregiver perceptions of home and community factors that influence physical activity and sedentary behaviour;
8. Parent-reported child screen time (levels and compliance).

Chapter Three: Methods

The PhD candidate performed all data collection unless otherwise stated. This includes health measurements taken during the recruitment of parents and caregivers.

3.1 Study setting

The study took place in Agincourt, a rural (tribal) village in the Bushbuckridge area in the province of Mpumalanga. This province is in the northeast part of South Africa (see map in Appendix A1). The Medical Research Council (MRC)/University of the Witwatersrand (Wits) Rural Public Health and Health Transitions Research Unit (Agincourt) leads a health and socio-demographic surveillance system (HDSS) in the Agincourt sub-district of Bushbuckridge. This system was developed in 1992 in an effort to support the post-apartheid health ministry with sub-district health centre networks and referral systems, and the training of clinically-oriented nurses [260]. More recently, the HDSS in Bushbuckridge provides a platform for research programmes and projects that aim to explain causal pathways and test interventions across the life course [260]. Considering the permissions required from local traditional authorities to conduct research in villages within the site, it was decided that it would be better to conduct the study in one village to facilitate efficient community entry. In the HDSS site, all recruitment is coordinated through the Learning, Information and Dissemination and Networking with the Community (LINC) team in the MRC/Wits Research Unit.

This area has a population of 5,157 people, and a population density of approximately ±607 persons per km^2 [261]. The majority of the people in this area are Xitsonga-speaking (97.4%), black African people (99.7%) [261]. The village has been characterised by a slow rate of infrastructure development, with few tarred roads [260]. Sanitation is limited, with few houses having piped water: 85.3% of households use a pit toilet and only 1.5% use flush toilets [261]. While electricity is available in Agincourt, the cost allows only 51.2% of households to use electricity to prepare meals [261]. Other methods of cooking include the use of wood (48.4%) and gas/paraffin (0.3%) [261]. There is access to one health centre (clinic) in Agincourt village, and the nearest district hospital is approximately 25 kilometres away [260]. The most recent national census took place in South Africa in 2011, and so the degree of poverty in Agincourt will be explained using the 2011 census report and markers of poverty from a similar time period. The minimum wage in South Africa (across all sectors) between 2011 and 2012 was ±ZAR1500 (±US$216) [262], and the poverty line was ZAR604 (±US$87) [263]. A common metric used to assess food prices is the 'basic food basket'. In 2011, the 'basic food basket' cost ±ZAR383 (±US$30), and consisted of 1kg each of: apples, bananas, stewing steak, cabbage, fresh chicken portions, frozen chicken portions, onions, oranges, potatoes and tomatoes; 1 can each of: baked beans and pilchards; as well as a 500g brick of margarine, a box of Ceylon tea, 18 chicken eggs, 1 litre of full cream milk, a 750g tin of instant coffee, a 700g loaf of brown and white bread, a 5kg bag of maize meal, a 400g jar

of peanut butter, a 2kg bag of rice and a 750ml bottle of sunflower oil [264]. These foods listed above represent typical monthly food baskets of low-income households, as described by women in low-income areas in South Africa [265].

The 2011 South African census reported that 16.8% of households in Agincourt earn no income, and 46.4% of those who were employed were earning less than ZAR1650 (±US$237, in 2011) per month [261]. As a result of this, the South African government's social grant system (including pension and child support grants) is an important source of income for many households in the HDSS site in Agincourt, although in many cases adults still need to migrate to bigger towns and cities for greater earning capacities [266]. It was reported that less than 30% of children in the province of Mpumalanga live in a household with an employed adult [263]. Furthermore, [267] a recent qualitative study found that many households report poverty as a barrier to healthy eating and can only affording to do grocery shopping after receiving money from migrated family members. Thus, Agincourt represents an impoverished rural area in South Africa.

There has been a substantial amount of research conducted in primary- and high- school aged children and adolescents, particularly focussing on HIV/AIDs, non-communicable diseases, metabolic risk and aging in the HDSS site [260], yet there has been no research in preschool-aged children in Agincourt. Given that there are limited data on physical activity, gross motor skills, sedentary behaviour and screen time in South African preschool children, and rural South African children in particular, the Agincourt HDSS site provided an appropriate setting to conduct this novel research study. This study was the first in Agincourt to measure physical activity, gross motor skills, sedentary behaviour and screen time in preschool children. Furthermore, it is the first study to use accelerometry as a physical activity measure in South African preschool children, as well as the first to assess gross motor skills in any age group in Agincourt.

There are three independent preschools, two primary schools and three secondary schools in Agincourt. None of the preschools or primary schools have flush toilets, and electricity is not supplied to all rooms in the buildings (for example, preschools usually only have electricity in the kitchen). Despite having access to electricity, most of the schools prepare the meals using an open fire. Many of the classrooms are incomplete buildings and missing a ceiling or windows. In section 2.10 of the literature review the South African Schools Act [258] describing the ages for admission into Grade R was discussed. Feedback from the LINC community engagement officer, after making initial contact with the three preschools in Agincourt, indicated that children in the targeted age group for the study (three to five years) were also in Grade R (i.e. the first grade of primary school). In an effort to recruit as many children of preschool age as possible, children were recruited from all three preschools and from the Grade R classes at the two primary schools in Agincourt. No data pertaining to the education of the teachers were formally collected, but discussions with the teachers during the recruitment and data collection process revealed that most teachers at the preschools were not trained in early childhood development, and were lacking in tertiary and, for a few teachers, secondary education. Most teachers were parents or community members that had

children or grandchildren at the preschools. There were infants and toddlers (aged two years) enrolled at all three preschools in Agincourt.

The operating hours for the preschools and primary schools differed. The observational component of this research study includes the daily schedules of each setting in greater detail (see Table 7.3 in results section). The start of the school day varied between 07h30 and 08h15. There is an educational component in both settings, although the Grade R activities are specifically referred to as 'teacher-guided activities', whereas the preschools have allocated time for story time, biblical instruction and art (as examples). The Grade R children finished school at approximately 12h30 daily, while the children in the preschool settings finished at varying times. An allocated time for lunch is unique to the preschools (the Grade R children have refreshment/recess periods). Afternoons in the preschools operate much like an aftercare facility, including a nap/rest time and a refreshment period/snacking.

3.2 Sample details

3.2.1 Recruitment of preschools and primary schools

As per standard LINC procedures for recruitment, supervisor CD (as Principal Investigator of the broader research study) met with the principals at each preschool and primary school (Grade R settings are based at primary schools) to explain the research study in March 2014. A LINC community engagement officer arranged and was present at these meetings, and assisted with translation. The support and buy-in from the school principals were seen as a crucial part of the research process. The school principals were provided with an opportunity to ask questions about the study, and were given information about the timeline for the study. All of the principals were willing for their school to be included in the study and were accommodating of the research process.

3.2.2 Recruitment of preschool and Grade R children

In June 2014, parents and caregivers from the preschools and primary schools were invited to an information meeting at the school to give written, informed consent for their child to participate in the accelerometry, gross motor skill and observational components of the study. All information sheets and consent forms were translated from English into Xitsonga with the assistance of a community engagement officer from the LINC team at the MRC/Wits Research Unit. The information sheets and consent forms are provided in English in Appendices B1 and B2. Teachers and school principals were invited to be present at this meeting. The information sheet and consent form were explained to parents in Xitsonga, with the assistance of a local fieldworker. This meeting provided an opportunity for parents and caregivers (referred to as parents from now on) to ask questions about the study. The children of the parents who did not attend the meeting were provided with information sheets and consent forms to take home to their parents. Teachers collected completed consent forms when they were returned and passed them on to the fieldworker for supervisor CD.

3.2.3 Recruitment of parents

In March 2015, parents from the same preschools and primary schools were invited to a meeting at the school to give their informed consent to participate in the questionnaire component of the study. The information sheet and consent form were explained to parents in Xitsonga, with the assistance of a local fieldworker. The information sheets and consent forms are provided in English in Appendices B3 and B4. The parents recruited in March 2015 were not the same parents that were recruited for the children's participation in the accelerometry, gross motor skill and observational component of the study. The questionnaire was an additional component to the study to provide insight into the home context of physical activity and sedentary behaviours of preschool-aged children in Agincourt. Initially, the aim of the study was only to determine physical activity and gross motor skills in the preschool-aged children. After testing in 2014, it became clear that more contextual information was required. Therefore, we were not able to match the parents to the children who participated in 2014 as some of those children had been promoted from Grade R to Grade One, or were no longer in the target age group (three to five years of age). Despite not being able to match these data, the contextual information was deemed important as it would contribute to a greater understanding of physical activity, gross motor skill development, sedentary behaviour and screen time of South African preschool children.

In an effort to recruit as many parents as possible for the parent questionnaire, free basic health checks including height and weight, used to calculate BMI, waist circumference and blood pressure were offered to parents. Parents were given a report card following their health check (Appendix B5), and were offered a referral to their local health facility if they presented with hypertension and/or obesity. The definitions published by American College of Sports Medicine (ACSM) were used as a reference to define hypertension (having a resting systolic blood pressure ≥140mmHg and/or diastolic blood pressure ≥90mmHg) and obesity (having a BMI ≥30 kg/m^2) [268]. Furthermore, parents that had other health-related questions were free to ask the PhD candidate for recommendations to achieve better health.

The PhD candidate is a registered biokineticist, a profession that is similar to that of a clinical exercise physiologist or exercise (physical) therapist, and was therefore qualified to make these referrals and answer questions relating to the health check. The Biokinetics Association of South Africa [269] defines a biokineticist as a professional that "functions within professional alliance to health and medicine, and is recognised by and registered with the Health Professions Council of South Africa." A biokineticist "improves a person's physical wellbeing and quality of life through individualised scientific assessment and the prescription of exercise in rehabilitative treatment to prevent or intervene with certain ailments and the enhancement of performance… evaluates and measures: body posture, body composition, blood pressure, glucose levels, lung function, heart rate, fitness, muscle strength, endurance, power, flexibility and other health screenings... is a health professional who through health promotion and wellness create a better quality of life for people they work with."

3.3 Data collection tools and procedures

The following measurements were taken (where appropriate, the instrument used is specified):

1. An observation of the physical activity environment,
2. Anthropometric measures including height and weight,
3. Objectively measured physical activity and sedentary behaviour using accelerometry,
4. Gross motor skill proficiency using the Test of Gross Motor Development – Version 2 (TGMD-2),
5. Direct observations of physical activity and sedentary behaviour in the preschool settings using the Observational System for Recording Physical Activity in Children – Preschool version (OSRAC-P).
6. Parent-report of pre-schooler's screen time, included in a questionnaire administered to parents.

Due to limited time, resource constraints (i.e. having a limited number of accelerometers and fieldwork costs in Agincourt) and school holidays, it was not possible to complete the accelerometry and TGMD-2 components of the study concurrently at every school recruited for the study. Therefore, anthropometry measurements were taken directly before the accelerometers were fitted, and again directly before the TGMD-2 was conducted to ensure accurate body composition measures in each instance. Testing took place over 10 weeks, however the three-week long school holiday fell within these ten weeks. Accelerometry data collection for all three preschools took place before the school holiday. Four weeks later (after the holidays), the TGMD-2 was conducted in all five schools, and accelerometry data collection for children in the primary schools. In the objectively measured physical activity results section (Table 5.1, Chapter 5), anthropometry measures taken at the point of accelerometer fitting are reported. In the gross motor skill proficiency results section (Table 6.1, Chapter 6), anthropometry measures at the time that the TGMD-2 was conducted are reported. For the results that include analyses for accelerometry and TGMD-2, the TGMD-2 anthropometry results were used (Table 6.3, Chapter 6). It was deemed appropriate to use the height and weight measures that were taking immediately before the other measures as the data presented is cross-sectional.

3.3.1 Physical activity environment observation tool

Characteristics of the preschool environment are important to measure to provide a context for understanding physical activity levels and patterns. There are a number of observational instruments that are available to measure environments. Table 3.1 provides an overview of those instruments.

Table 3.1 Environment observational instrument available for use in preschool settings

Instrument name and reference	Description of the tool
Outdoor Play Environmental Categories scoring tool (OPEC) [270]	Measures variables in relation to exposure to the sun exposure and other health indicators: - total outdoor area, - number of trees, shrubbery and hilly terrain, integration between vegetation, - open areas and play structures.
Environmental and Policy Assessment and Observation instrument (EPAO) [271]	Direct observation tool expanded from the NAP SACC (Nutrition and Physical Activity Self-Assessment for Child Care; an intervention tool using self-assessment) {Ammerman 2007}. Assessment includes: - observations of nutrition-specific variables, - play opportunities (in- and outdoors) - playground equipment. Includes an evaluation of safety, lesson plans and PA/nutrition policies.
Early Learning Environments for Physical Activity and Nutrition Environments Telephone Survey (ELEPhANTS) [272]	Telephone-administered, inclusive of elements of the NAP SACC/EPAO. Additional environment measures include: - playground size and quality, - topography, - access, - surface, - shade provided.
Other items used in instruments:	Directly observe the environment to: - Count equipment [182,273,274] - Identify different types of equipment (fixed or portable) [273,274] - Physically measure the size (area) of the playground [273,274]

An observational assessment of the environment was adapted from the tools listed in table 3.1 (Appendix C) to document characteristics of the environment. The revised tool was split into four different sections:

1. Outdoor area
2. Equipment (indoor and outdoor)
3. Indoor play space
4. Policy practices

Characteristics assessed in the outdoor environment included:

- The size of the playground, measured manually by the researcher using a tape measure;
- The surface of the playground (including the options of rubber mats, gravel, concrete, tar, bricks, grass, dirt, sand or wood chips);
- Whether or not the playground was shared and the nature of the vegetation around the playground;
- Questions pertaining to the presence of shade, gradient (described as flatness); and
- The cleanliness of the playground.

The equipment section involved counting and describing different pieces of equipment (fixed and portable). Fixed play equipment included structures for balancing, aiming, climbing and hanging; as well as merry-go-rounds, a pool, sandbox, a seesaw, slides, swings, track and tunnels. The descriptive section requires details of the material (metal, plastic or wood) and general condition of the equipment. Portable play equipment listed in the observation tool include balls, climbing structures, toys for playing on the floor and jumping, parachutes, push/pull toys, riding toys, rocking toys, water toys, slides, twirling equipment (such as ribbons) and stacking structures (such as blocks).

The section on indoor play evaluates the suitability of the indoor space for play (in terms of space available), and the presence of screens (TV/DVD/video players/computer/tablets). The number of chairs and tables in the classroom was not recorded.

The last section on policies includes questions on the structure/schedule of the school day, including the allocation of time to free, outdoor and structured play. The presence of any physical activity policy (in a spoken/written format), and compliance with physical activity policy was assessed. Lastly, there are questions pertaining to the barriers to promoting a health childcare environment, including the lack of support (from administration, teachers, family), the lack of training, and lack of resources.

This observation took place during school time, and took approximately 20 minutes to complete.

3.3.2 Anthropometry

Height and weight measurements were conducted with the children's shoes and heavy clothing removed. A portable stadiometer (Leicester 214 Transportable Stadiometer; Seca GmbH & Co, Hamburg, Germany) was used to measure height to the nearest millimetre. The children were instructed to stand up straight, face forwards and have their heels against the back of the stadiometer plate. Height was measured twice and reported as an average of the two measures. A third height measurement was taken if there was a discrepancy of more than five millimetres between the first two measurements, in which case the two closest measurements were averaged and reported. To measure body weight, the children stood centred on a calibrated scale (Soehnle 7840 Mediscale Digital; Soehnle Industrial Solutions GmbH, Backnang, Germany). Weight was measured twice and reported as an average of the two measures. If the measures differed by more than 0.5 kilograms, the child was measured for a third time, with the average of the two closest measures reported. Supervisor CD conducted all height and weight measurements to ensure consistency. Supervisor CD was trained by an anthropometrist based at the Division of Exercise Science and Sports Medicine at the University of Cape Town.

Anthropometry data management

The World Health Organization (WHO) AnthroPlus software [275] was used to calculate BMI (weight in kilograms divided by height in metres, squared), BAZ, WAZ and HAZ. The International Obesity Task Force (IOTF) [21] cut-offs were applied to determine whether children were categorized as level 1, 2 or 3 for thinness (combined and referred to as 'thinness' in Results Chapters 5, 6 and 7), normal weight, overweight, obese (combined with morbidly obese and referred to as 'obese').

3.3.3 Objectively measured physical activity and sedentary behaviour

Accelerometers are a valid and reliable instrument for assessing physical activity and sedentary behaviour in preschool children [167]. They have been described in detail in sections 2.6.1 and 2.8.1, for physical activity and sedentary behaviour measurement, respectively. Formative research conducted by supervisor CD in preschool-aged children in South African urban low-income settings showed high levels of compliance with wearing accelerometers and that the devices were not a hindrance to the children [101,276]. Accelerometry was therefore believed to be the most feasible method of physical activity and sedentary behaviour measurement.

The most common brand of accelerometers used in research is the ActiGraph (ActiGraph, LLC, Fort Walton Beach, FL) and has been shown to be a valid measure of physical activity and sedentary behaviour in preschool-aged children [164,167,203,277]. ActiGraph accelerometers have progressed from the initial ActiGraph model 7164 (uniaxial device, used in the 1990s), to the newer models including the ActiGraph GT1M, GT3X and GT3X+. The GT3X and GT3X+ are tri-axial accelerometers, and are capable of measuring accelerations in three directions, namely the x-, y- and z-axes. These axes correspond with the planes of movement in the body, namely: frontal, vertical and transverse planes, respectively. The

ActiGraph models of accelerometers have been used extensively in research of preschool-aged children in other countries [278].

The Actigraph GT3X+ accelerometer (Actigraph LLC, Pensacola, FL; USA) was chosen to objectively measure physical activity and sedentary behaviour for this study. The GT3X+ is a small and light, red monitor (3.8cm×3.7cm×1.8 cm) that is not much bigger than a wrist-worn watch. The validity and reliability of the ActiGraph GT3X+ accelerometer has been established in young children [279]. The device was fitted to each child's right hip using an elasticated belt. Children were asked to wear the monitors for 24 hours each day over a seven-day period and to remove the monitors during activities involving water (such as swimming or bathing). A 'gold star' sticker was stuck onto the device to remind the children how to orientate the device (the star was to be facing the sky or 'up'). An instruction sheet (translated into Xitsonga; shown in English in Appendix D1) explaining what the device was, how it should be worn, where it should be worn, and when it should be worn (and not worn) was distributed to teachers and parents. The fieldworker also followed up telephonically with the parent of each child to make sure that they understood the instructions. If a child arrived at school without their accelerometer, the teachers would notify the fieldworker, who would then follow up with the parent of the child.

Accelerometry data management

Data were recorded in 15-second epochs [167]. ActiLife version 6 (ActiLife software; Pensacola, FL; USA) was used to clean and manage the accelerometry data. Two different methods were initially compared to determine time to bed and wake up time, thus determining the waking wear time for each participant. This was performed to maximise the amount of data that could be included in the analyses. The details of the two different methods are explained in Appendix D2.

A previous study in preschool children has chosen time points for patterns analysis on the basis that 75% of the sample had valid wear time for that time period [200]. The hours between 07h00 and 18h00 were therefore included for analysis as 78.2% of the sample had valid wear time for that time period, on each of three weekdays and one weekend day [167]. Using ActiLife, a time filter was applied to exclude the hours outside 07h00 and 18h00. Non-wear time within the time period (where a child may have taken the device off for a water-based activity, or if the child had a nap) was defined as 20 minutes of consecutive zeroes and was removed [246].

There are several validated cut points that identify sedentary behaviour and the different intensities of physical activity (from light- to vigorous-intensity) for the ActiGraph data [277,280-283]. Table 3.5 summarizes the different cut points used in preschool-aged children.

Table 3.2 Common accelerometry cut points used in preschool-aged children

Cut point name and reference	Specific age-range	Epoch used	Sedentary behaviour cut points (counts)	Physical activity cut points
Pate [280]	3-5 year olds	15s	≤37 counts.15s-1	LPA: 37-419 counts.15s-1 MPA: ≥420-841 counts.15s-1 VPA: ≥842 counts.15s-1
Sirard [283]	3-5 year olds (cut-point per age year differs)	15s	≤301 (3yo), counts.15s-1 ≤363 (4yo), counts.15s-1 ≤398 (5yo) counts.15s-1	LPA: 302-614 (3yo), 364-811 (4yo), 399-890 (5yo) counts.15s-1 MPA: 615-1230 (3yo), 812-1234 (4yo), 891-1254 (5yo) counts.15s-1 VPA: ≥1231 (3yo), ≥ 1235 (4yo), ≥ 1255 (5yo) counts.15s-1
Evenson [282]	5-8 year olds	15s	≤25 counts.15s-1	LPA: 26-573 counts.15s-1 MPA: 574-1002 counts.15s-1 VPA: ≥1003 counts.15s-1
Reilly [277]	3-4 year olds	60s	≤1099 (≤274 per 15s epochs)	n/a
Van Cauwenberge [281]	4-6 year olds	15s	≤372 counts.15s-1	LPA: 372-584 counts.15s-1 MVPA: ≥585 counts.15s-1

LPA: light-intensity physical activity; MPA: moderate-intensity physical activity; VPA: vigorous-intensity physical activity; MVPA: moderate- to vigorous-intensity physical activity; s: seconds; yo: years old

The cut points chosen to identify sedentary behaviour and MVPA in this thesis were ≤25 counts.15s^{-1} [282] and ≥420 counts.15s^{-1} [280], respectively. These cut points have recently been shown to accurately classify sedentary behaviour and physical activity in preschool-aged children [284]. LPA is therefore activity that is between 25 and 419 counts.15s^{-1}. To determine low LPA and high LPA, a median split of the light intensity cut points was applied. Low LPA was therefore activity between the sedentary behaviour cut point and 222 counts.15s^{-1}, and high LPA between 223 counts.15s^{-1} and the cut point for MPA. Total physical activity therefore encompasses all activity above the sedentary behaviour threshold.

3.3.4 Gross motor skill proficiency

Gross motor skill proficiency can be assessed using instruments evaluating process and/or outcome, as discussed in section 2.7.1 of the literature review. Tests that have been used to assess gross motor skills in preschool-aged children are shown in Table 3.3.

Table 3.3 Gross motor skill assessment instruments used in preschool-aged children:

GMS instrument	Age group (in years)	Number of items	GMS variables measured *	Cost	Time required (per child, in minutes)
Test of Gross Motor Development (TGMD-2) [104]	3-10	n=12	1. Locomotor skills (n=6): run, hop, gallop, horizontal jump, leap, slide 2. Object control skills (n=6): strike, kick, overarm throw, catch, underarm roll, stationery dribble	US$126 (±ZAR1700)	15-20
Kinderkinetics assessment [210,285]	3-6	n=23	1. Locomotor skills (n=8), 2. Object manipulation (n=3), 3. Balancing (n=6), 4. Overall body coordination (n=3) 5. Body awareness and spatial orientation as perceptual-motor skills (n=3).	Not specified	10-15
Bruininks-Oseretsky Test of Motor Proficiency (BOT-2) [211]	4-21	n=20 (long version; includes fine motor control)	1. Bilateral coordination (n=7): jumping, pivoting etc. 2. Upper limb coordination (n=7): dribbling, catching, throwing balls 3. Strength and agility (n=5): hopping, running and sideways stepping	£898 (±ZAR16000)	45-60 (long version)
Movement Assessment Battery for Children (Movement ABC-2) [212]	3-16	n=32 (only 8 for children aged 3-6-years; includes manual dexterity)	1. Aiming and catching (n=2): catching and throwing bean bags 2. Balance (static and dynamic, n=3): one-leg balance, tip-toe walking, jumping	£868.50 (±ZAR15000)	20-30
Peabody Developmental Motor Scales (PDMS-2) [216]	0-17	n=170 (gross and fine motor; 10 items per age level)	Number of items dependant on age of child being tested: 1. Reflexes: only for children <11months old 2. Balance: standing on one foot, standing on tip-toes, push ups, trunk stabilisation etc. 3. Locomotor: includes walking, running, jumping, rolling, scooting, creeping etc. 4. Receipt and propulsion of objects: catching, kicking, rolling and bouncing balls etc.	US$435 (±ZAR6000)	45-60

*Fine motor skills for tools that assess fine motor skill proficiency have been excluded from the table.

Table 3.3 continued Gross motor skill assessment instruments used in preschool-aged children:

GMS instrument	Age group (in years)	Number of items	GMS variables measured *	Cost	Time required (per child, in minutes)
Körperkoordinationstest für Kinder (KTK) [213]	5-14	n=4	1. Gross motor coordination (n=4): walking backwards on a balance beam, moving sideways, hopping and jumping sideways	€524 (±ZAR8500)	20
Motoriktest für Vier- bis Sechjärige Kinder (MOT4-6) [214]	4-6	n=18 (some items assess more than one skill, includes fine motor skills)	1. Locomotion (n=10): including jumping, skipping, rolling, sit-to-standing 2. Stability (n=7): including balancing and tackling 3. Object control (n=5): including catching and throwing	€418 (±ZAR7000)	15-20
Maastrichtse Motoriek Test (MMT) [215]	5-6	n=70 (34 quantitative, 36 qualitative)	1. Static motor skills (n=7 quantitative, 7 qualitative) 2. Dynamic motor skills (n=9 quantitative, n=11 qualitative) 3. Balance skills (n=4 quantitative, n=4 qualitative)	€447 (±ZAR7300)	20-25

*Fine motor skills for tools that assess fine motor skill proficiency have been excluded from the table.

The Kinderkinetics assessment is an assessment tool primarily used for Kinderkinetics practitioners in South Africa. The South African Professional Institute for Kinderkinetics describes the profession of Kinderkinetics as "a profession that aims to promote and optimise the neuro-motoric development of young children (0-12 years), through scientifically-based physical activity. It has the following goals: Promote functional growth and development, focus on certain movement activities to promote/facilitate sport specific activities; and implement appropriate rehabilitation programmes for children with growth and/or developmental disabilities." [286]. The Kinderkinetics assessment has not yet been validated for research purposes, although it is used in practice in South Africa [210]. However, the Kinderkinetics assessment is not accessible to practitioners or researchers that are not Kinderkinetics practitioners, as the training for the assessment tool is provided exclusively by the developers of the tool, to students pursuing an honours-level degree in Kinderkinetics.

As shown in Table 3.3, the BOT-2, M-ABC and PDMS-2 are relatively expensive (as are the KTK, MOT4-6 and MMT assessment tools), as they require several pieces of specialised equipment and particular testing kits, whereas the TGMD-2 is less expensive to obtain and administer. It was not financially feasible to use the BOT-2, M-ABC and PDMS-2; and given that the Kinderkinetics Assessment is not accessible to practitioners or researchers lacking a Kinderkinetics degree, the TGMD-2 [104] was chosen as the test that suited the requirements of this thesis. The TGMD-2 is a criterion-norm referenced test that is designed and validated to assess gross motor skills in children aged 3 to 10 years [104]. This test has been used extensively for gross motor skill assessment in preschool-aged children across the world, including in LMICs [115] and low-income settings in HICs [97,112,152,221]. Furthermore, the TGMD-2 has been used in the South African setting, in urban low- and high-income areas of Cape Town [102,287] and in Johannesburg [276]. Therefore, this instrument was deemed appropriate for use in the Agincourt sample.

The TGMD-2 involves the qualitative (process) assessment of six locomotor skills (run, gallop, hop, leap, horizontal jump and slide) and six object control skills (catch, roll, throw, strike, stationary dribble, kick). Each skill is graded according to a set of performance criteria represented by specific components of the motor skill. For example, when performing the hop, the child is required to meet the following five performance criteria:

1. Non-support leg swings forward in pendular fashion to produce force
2. Foot of non-support leg remains behind the body
3. Arms flexed and swing forward to produce force
4. Takes off and lands three consecutive times on preferred foot
5. Takes off and lands three consecutive times on non-preferred foot [104]

These performance components represent the pattern of the skill. Components of skills (referred to as performance criteria for each skill) performed correctly are scored as 1 and skill components that are performed incorrectly or only partially are scored as 0. For example, the first performance criterion for the hop is 'non-support leg swings forward in pendular fashion to produce force'. The child would not score '1' if their non-support leg did not produce any force, or if the leg didn't swing correctly (as a pendulum). There are no half-

marks awarded as grading is not permissible for partial achievement of the performance criteria [104]. The other skills used in TGMD-2 (taken as an extract from the TGMD-2 manual) and their performance criteria can be viewed in Appendix E.

In the week leading up to the TGMD-2 testing at the schools, the PhD candidate explained the TGMD-2 to the fieldworker, and did thorough demonstrations with explanations for each skill, according to the TGMD-2 manual [104]. The PhD candidate and fieldworker then practised the TGMD-2 administration at a preschool in a neighbouring village. For the testing, the children were divided into groups of four to seven. The PhD candidate demonstrated the skill to the group with the assistance of the local fieldworker, who explained the demonstration in Xitsonga. The children attempted to repeat the skill. Following a child that displayed the skill incorrectly, the skill was demonstrated again to ensure that subsequent children in the group did not replicate the incorrect technique. Children were given two opportunities to perform each skill, and were encouraged to perform at their best throughout the testing procedure. The testing was video-recorded to allow the PhD candidate more time to score the data after testing was complete, and to allow for greater scrutiny [209].

TGMD-2 data management

Using the TGMD-2 manual and scoring sheets [104], the raw scores, standard scores and gross motor quotient (GMQ) scores were determined for each child. Using the raw score, proficiency for each skill was calculated as a percentage to establish mastery in each individual skill. For example, the horizontal jump has four performance criteria points. Each skill is attempted twice and therefore they will have a score out of 8. Scoring 6 out of 8 is therefore equal to 75% proficiency. The GMQ score is a combined score for all tests that is age- and sex-normed, and provides a reliable numeric score for gross motor proficiency.

The GMQ score is further used to rank children according to descriptive categories of gross motor development as follows:

- Greater than 130 is very superior,
- Between 121 and 130 is superior,
- Between 111 and 120 is above average,
- Between 90 and 110 is average,
- Between 80 and 89 is below average,
- Between 70 and 79 is poor,
- Below 70 is very poor.

These descriptive categories are referred to as ‘GMQ rankings’ throughout this thesis. Norms for the TGMD-2 are based on American children [104]. There are no TGMD-2 norms for South African children (or for previous versions of the TGMD), but the TGMD-2 has been accepted for use in other countries [288].

3.3.5 Direct observation of physical activity and sedentary behaviour

Table 3.4 summarises observational tools used to assess physical activity and sedentary behaviours of preschool children in the preschool setting.

Table 3.4 Observational tools used to measure physical activity and sedentary behaviour in children

Tool name and reference	Age group (years)	Intensities of activities coded	Description of tool
Observational System for Recording Physical Activity in Children, Preschool Version (OSRAC-P) [105]	Preschool-aged	1. Stationary/motionless (SB) 2. Stationary with limbs (SB) 3. Slow-easy (LPA) 4. Moderate movement (MPA) 5. Fast movement (VPA)	Intensity and type of PA contextualized by location, topography and the social setting. Tool was designed for use in preschool settings (and thus preschool-aged children)
Children's Activity Rating Scale (CARS) [289]	3-4	1. Resting (SB) 2. Low (LPA) 3. Medium (MPA) 4. Medium to High (MVPA) 5. High and Very High (VPA)	The tool was designed for PA measurement.
System for Observing Play and Leisure Activity in Youth (SOPLAY) [290]	Primary school-aged	1. Sedentary 2. Walking 3. Vigorous	Tool designed to observe PA according to environmental characteristics in the context of free play. Boys and girls are observed separately.
Behaviours of Eating and Activity for Children's Health Evaluation System (BEACHES) [291]	4-8	1. Lying down 2. Sitting 3. Standing 4. Walking 5. Very active	Tool designed to evaluate dietary and PA behaviours. Is applicable for home or school.

SB: sedentary behaviour; PA: physical activity; LPA: light-intensity physical activity; MPA: moderate-intensity physical activity; VPA: vigorous-intensity physical activity; MVPA: moderate- to vigorous-intensity physical activity.

The OSRAC-P [105] was selected for this thesis to observe physical activity and sedentary behaviour. Although the SOPLAY tool [290] has been used previously in an observational study of South African primary school children [292], a distinguishing feature of the OSRAC-P is that it is tailored to the preschool setting, and includes an extensive list of activities of pre-schoolers that are specific to the preschool environment. This is particularly beneficial, as the CARS [289], SOPLAY and BEACHES [291] tools only record the intensity of a physical activity, and not the actual activity. Thus, OSRAC-P provides additional insight into the different behaviours that the preschool child may be engaged in [105]. The OSRAC-P is also a more recently developed tool that incorporates the strengths and accounts for some of the features that appear missing from the CARS, SOPLAY and BEACHES tools.

The OSRAC-P observation entails a timed observation lasting 5 seconds, followed by a record (or capturing) interval that lasts 25 seconds, making a single observation interval last a total of 30 seconds (detailed in Figure 3.1). This cycle is repeated 30 times per child, after which a different child becomes the focal point for 30 observations. It takes approximately 15 minutes to completely observe one child. Before OSRAC-P testing commenced, the PhD candidate identified children for whom there was consent, and selected children on arrival at the setting. Therefore, the sample for this thesis included the first 10-15 children who arrived at the Preschool and Grade R setting (for whom we had consent), and the children were tested in that order. The time block of 08h00 until 12h00 was selected for data collection and measurement, and observation was a continuous process for the full 4-hour period. The observational period at Grade R setting 2 was cut short due to a departmental meeting.

Prior to testing, the PhD candidate was familiarized with the OSRAC-P manual and Open Data Kit (ODK) application on the tablet. Prior to testing, practice sessions at a primary school in Cape Town, and in Agincourt, took place. There is an element of subjectivity when using the OSRAC-P tool, but familiarity helps to alleviate potential bias [105]. The practice sessions allowed the observer to become familiar with the behaviours and how these would be coded correctly on the tablet (described in the data management section below). Figure 3.1 illustrates the order in which the coding takes place on the tablet. As far as possible, attempts were made to minimise the observer effect on the behaviours of the children by remaining discreet. For the duration of the observation, teachers were requested to continue with the usual daily schedule. For observations that took place during class time (indoors), the observer remained unobtrusive in the corner of the classroom. When the observed child moved outdoors, which usually occurred with the remainder of the class as a collective to play outside for recess or to go to the toilet (for example), the observer moved in a manner that would not make the child aware of the observation.

OSRAC-P data management

The ODK Collect application [293] was used to electronically capture the data for the OSRAC-P on a Google Nexus 7 tablet. Data from the ODK Collect application were automatically uploaded to ODK Aggregate and then exported as an Excel spreadsheet to be cleaned.

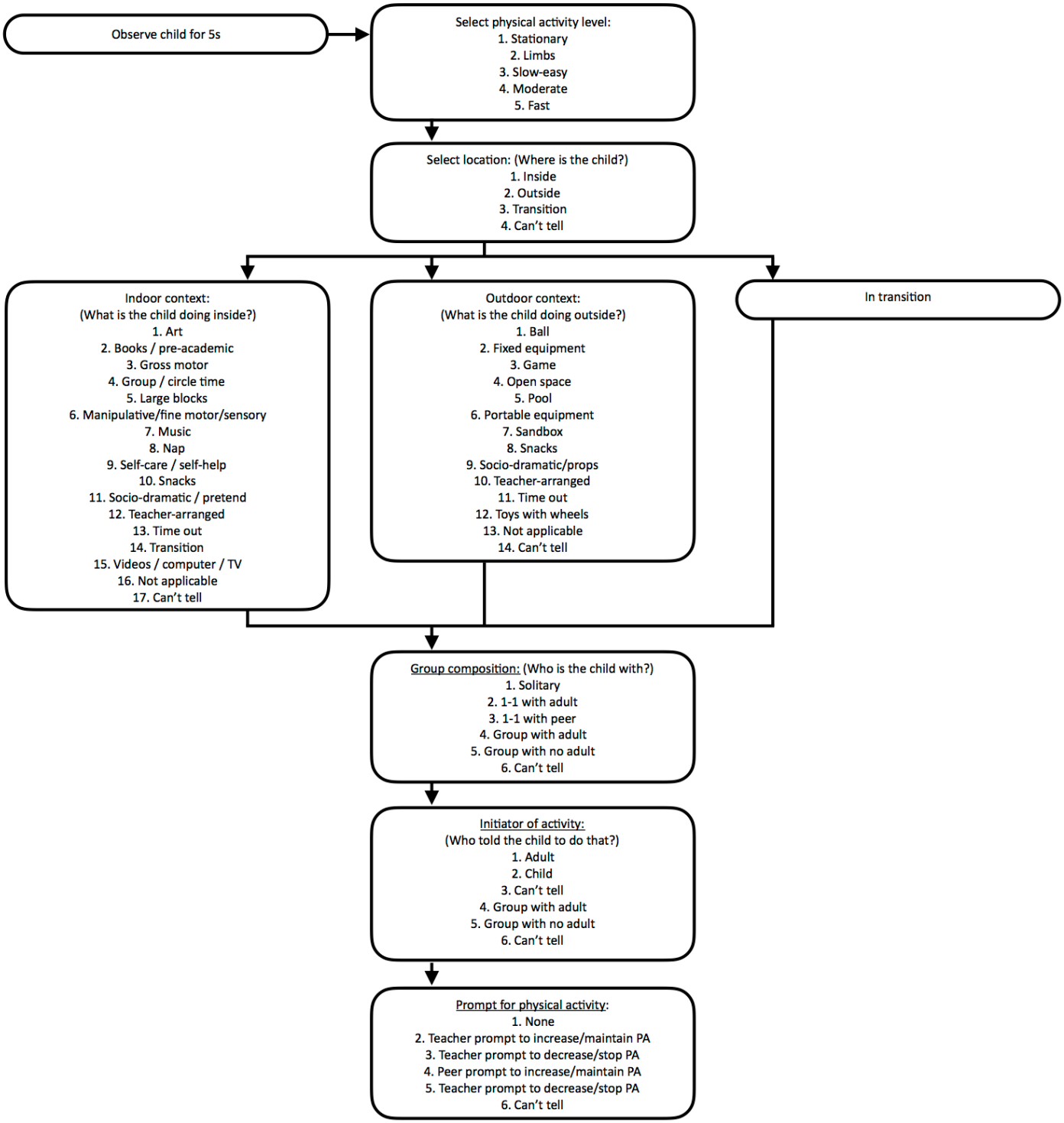


Figure 3.1 Flow diagram illustrating the order of coding of activity using the OSRAC-P

3.3.6 Parent perceptions

Parent questionnaires provide a method for understanding physical activity and sedentary behaviours in the home context. A questionnaire (Appendix F1) was used to assess the context of children's physical activity outside of the preschool, and to measure physical activity taking place in the home. This questionnaire was adapted from components of the Healthy Active Preschool Years (HAPPY) parent questionnaire [294] and the Preschool-age Children's Physical Activity Questionnaire (Pre-PAQ) [295]. The HAPPY and Pre-PAQ were designed for the purpose of identifying characteristics of the home and neighbourhood environments which may be associated with preschool children's physical activity. Additionally, the HAPPY measures potential correlates of physical activity across three domains of the ecological model: individual (for example, age and sex), microsystem (for example, parents and home), the mesosystem (for example, school and community) [135]. HAPPY and Pre-PAQ have previously been assessed for reliability [294,295]. The Pre-PAQ and HAPPY questionnaires have not yet been validated in South Africa, but relevant sections were adapted for use in this context, as outlined in Table 3.5. These adaptions were intended to improve the relevance of the questionnaires for the South African context, and reduce participant burden, considering the general literacy levels of parents in Agincourt. The questionnaire also included the Global Physical Activity Questionnaire (GPAQ) [296] to establish the self-reported physical activity levels of the parents. The GPAQ has been validated for use [297], and used in several studies, in South African adults [298-300].

Table 3.5 Adaptation of the parent questionnaire for relevance to the South African setting

Section (ordered as per the questionnaire)	Source of questions / section	Modifications (for relevance to the setting)	Description of questions asked
About you and your family	Pre-PAQ: Section 1: General Information	Addition of relationships (to the child), education levels modified as per South African school grades.	Questions regarding the relationship to the child, marital status, educational level, home language, car ownership and details of other children living in the home comprised items 1-7 in this section.
Your physical activity levels	GPAQ (and Section 2 of the Pre-PAQ, as questions are similar)	No modifications made to the GPAQ.	The GPAQ divides physical activity into MPA and VPA three different domains: occupational, transport (only MPA) and leisure domain. The GPAQ includes one question pertaining to sedentary behaviour.
Your preschool child and what they do at home	HAPPY: Section B: Your preschool child Pre-PAQ: Section 4: Your child	Structured activities modified: Kindy gym/kindagym, callisthenics, football and soccer replaced with ballet, traditional dancing, monkeynastics and Play Ball©.	Questions 1-3 in this section addressed the details of the child's sleeping habits. Questions 4 and 6 used a 5-point scale: 1= Strongly disagree; 2= Disagree; 3= Neither agree/disagree; 4= Agree; and 5= Strongly agree. Some items included a "not applicable" response option where appropriate. Question 4 asked parents to report on their child's activity when on his/her own. For question 6, parents reported on children's barriers to being physically active. Question 5 used a 5-point scale: 1= Never; 2= Rarely; 3= Sometimes; 4= A lot or most of the time; and 5= Always, where parents reported on the likelihood of a child being active versus sedentary behaviours including, but not limited to, screen time and crafts. Parents reported on frequency of activities during a typical week in question 7, using a 6-point scale: 1= Never/rarely; 2= Less than once a week; 3= 1-2 times a week; 4= 3-4 times a week; 5= 5-6 times a week; and 6=Daily. Two items asked about playing with and walking a dog, for which a 7th option was provided: 7= We don't have a dog. For question 8, parents reported on participation in organised sports and for question 9, parents reported on leisure activities including, but not limited to, playing TV games, imaginary games or quiet play. Parents answered yes or no to the options provided, and then indicated times per week, weekday and weekend day.

Table 3.5 continued, Adaptation of the parent questionnaire for relevance to the South African setting

Section (ordered as per the questionnaire)	Source of questions / section	Modifications (for relevance to the setting)	Description of questions asked
Being a parent/caregiver to your preschool child	HAPPY: Section C: Being a parent	Question C1 and C3 removed (pertaining to parent concerns and preferences)	For question 1, parents reported on their constraints to supporting their child's activity, such as energy levels and housework. This question used a 5-point scale: 1= Strongly disagree; 2= Disagree; 3= Neither agree/disagree; 4= Agree; and 5= Strongly agree. Question 2 explored parental confidence in encouraging their child to be physically active, and was scored on a 3-point scale: 1= Not at all confident; 2= Moderately confident; 3= Extremely confident.
Your beliefs and behaviours as a parent/caregiver	HAPPY: Section C: Your beliefs and behaviours	Question C7 removed (regarding parents switching off electronic devices)	This section focused on parental correlates, used a 5-point scale: 1= Strongly disagree to 5= Strongly agree. Parents reported on concerns about the volume of physical activity and screen time, rules and limiting screen time as well as safety inside and outside the house.
Your friends, family and home	HAPPY: Section D: Friends and family and Section E: Your home	Questions D1, D2 and D4 removed. Toys and home equipment modified: Billy cart, sand pit and cubby house removed.	Question 1 of this section explored the frequency of how often other people are active with the child, including siblings, grandparents and other children. This question used a 6-point scale (1= Never/rarely; 2= Less than once a week; 3= 1-2 times a week; 4= 3-4 times a week; 5= 5-6 times a week; and 6=Daily), with a 7th option provided for when the answer was not applicable. For example, if a grandmother was completing the questionnaire for the question where the parent, or in this case the caregiver, is the grandmother, the 7th option was "I am the grandparent". Questions 2 and 3 were checklists where the parent allocated the toys (Q2) and electronic devices (Q3) available to the child in the home.
Your community	HAPPY: Section F: Your local neighbourhood	No modifications made.	Questions 1 and 2 assessed the accessibility and suitability of places for their child to be active within their community. Both questions used a 5-point scale: 1= Strongly Disagree to 5= Strongly agree. Question 3 assessed the frequency that children visited specific locations where they may be physically active, including playgrounds and restaurants with play areas. A 7-point scale was used for this question: 1= Never, 2= Once a month or less, 3= Twice a month, 4= Once a week, 5= Twice a week, 6= 3-4 times a week, and 7= 5 or more times a week.

The questionnaire was translated into Xitsonga. Following translation, a staff member from the LINC team at the MRC/Wits Research Unit checked the questionnaire to ensure that the translation maintained the intended meanings of the original questionnaire items. Although the content of the questionnaires was identical, there were many English words that were not translatable into Xitsonga. In these instances, the English words were used and explained as necessary.

Parent questionnaire data management

At the meeting where the parents were recruited, parents were invited to remain at the venue for the fieldworker to administer the questionnaire to them in Xitsonga, if needed. Parents and caregivers who felt confident completing the questionnaire at home could do so. The questionnaire took approximately 20 minutes to complete, and for parents who were not confident completing the questionnaire on their own, the questionnaire was administered with the assistance of the fieldworker in groups of three to six parents. The local fieldworker followed up with the parents that did not attend the meeting and met with them at their homes to complete the questionnaire. Administration of the questionnaire at participants' homes was a more effective strategy as parents were reluctant to come to the schools for meetings. Completing the questionnaire at home with the fieldworker helped to reduce the participant burden.

Questions throughout the questionnaire that required parents to report agreement on a 5-point scale from 'strongly disagree' to 'strongly agree' are dichotomised as 'agree' (inclusive of 'strongly agree' and 'agree') and 'disagree', with the 'agree' scores reported. For questions that required parents to answer on the 5-point scale described as 1= Never; 2= Rarely; 3= Sometimes; 4= A lot or most of the time; and 5= Always, the scores for 'Never' and 'Rarely' were combined, and scores for 'A lot or most of the time' and 'Always' were combined. Questions that required parents to report on frequency of activities using either a 6- or 7-point scale were reported on the same scale. Lastly, there is one question under the heading 'Being a parent/caregiver to your preschool child', where parents report confidence in encouraging their child to be physically active. Scoring on this scale remained unchanged, and was scored on a 3-point scale: 1= Not at all confident; 2= Moderately confident; 3= Extremely confident. Statements in the questionnaire that require the parents to recall frequency of activities are reported independently.

The questions pertaining to time spent sedentary behaviours, including screen time, were calculated as weekly and daily averages of time spent watching television, playing video game and watching DVD's. Three parents reported having a Wii/Eye toy at home, and seven parents reported having an Xbox or PlayStation. However, the responses given between the sections tended to be contradictory of each other. For example, there were parents that reported not owning a television, but did report having a PlayStation or a Wii™. Therefore, the categories including PlayStation, Wii™, computer and smart phone were not included in the analysis of screen time.

3.4 Statistical methodology

Stata 13 for Mac (StataCorp, Texas, USA) was used to perform all statistical analyses. Descriptive data (including anthropometry) in each section are stratified by sex and school setting. The level for statistical significance was set at $p<0.05$.

3.4.1 Physical activity environment observation tool

Data are presented as descriptive tables comparing each of the five schools. Differences between the three preschools and two primary schools (Grade R classes) are also described throughout the section. Each item in the observation was assessed individually, and is described individually.

3.4.2 Anthropometry

The samples for each results chapter differ and therefore anthropometric sample characteristics are presented in each chapter, for the applicable sample. Descriptive statistics were used to describe age and the body composition of each valid sample, per chapter. Data are presented as mean (SD) for parametric, or median (IQR) for non-parametric data. The IOTF categories for weight status are presented as number (%). The three degrees of 'thinness' (one, two and three) were collapsed into one category named 'thinness'. The three degrees of overweight/obesity (overweight, obesity and morbid obesity) were collapsed into one category named 'overweight/obese'. All variables were stratified by sex and setting, and the differences were assessed using unpaired t-tests for parametric data, and Mann-Whitney U tests for non-parametric data.

3.4.3 Accelerometry

Levels of objectively measured physical activity and sedentary behaviour

Data representing time spent in physical activity and sedentary behaviour are presented as mean (SD) and median (IQR). All physical activity and sedentary behaviour data were categorised as either weekday (Monday to Friday) or weekend day (Saturday and Sunday). Descriptive statistics were produced first to determine the time spent in sedentary behaviour, and low LPA, high LPA, MPA and VPA. Total physical activity refers to all physical activity above the sedentary behaviour threshold and is referred to as light- to vigorous-intensity physical activity (LMVPA) throughout this thesis. Mann-Whitney U tests were performed to determine differences between sex and setting as the data were non-parametric. Time spent in LMVPA and MVPA was used to establish children's compliance with the new physical activity guidelines for preschool-aged children [77,78].

Objectively measured patterns of physical activity and sedentary behaviour

The descriptive data management is the same as that described above. The distinguishing feature of this analysis of physical activity and sedentary behaviour is that hourly patterns were established using the proportions of time spent per hour in sedentary behaviour and physical activity, according to the same cut points described earlier (section 3.3.3). Weekday and weekend day patterns were separated for analysis. Differences in hourly sedentary

behaviour and physical activity (per hour, LMVPA and MVPA) between sex and setting were determined using Mann-Whitney-U tests.

3.4.4 Test of Gross Motor Development – Version 2

Descriptive statistics were produced first to determine gross motor skill proficiency in the sample using the locomotor and object control raw scores, the locomotor and object control standard scores, and the GMQ. Data are presented as mean (SD) for parametric, or median (IQR) for non-parametric variables. Differences between sex and setting were assessed using unpaired t-tests and Mann-Whitney U tests for variables that were normally and not normally distributed, respectively. The data reporting on the proportion of children per TGMD-2 ranking, based on their proficiency, are reported as percentage per ranking and are stratified by sex and setting.

For children who completed the TGMD-2 and who had valid accelerometry data, linear regression models were used to determine the association of physical activity with gross motor skill proficiency. Variables included in the regression were determined *a priori*, and included age, sex, body composition and varying intensities of physical activity.

3.4.5 Observational System for Recording Physical Activity in Children – Preschool version

OSRAC-P data are presented as proportions of time (%) spent in different physical activity intensities. For some of the data analyses, the OSRAC-P physical activity categories were combined; 'stationary' and 'limb movement' is referred to as sedentary behaviour, 'slow easy' was referred to as light PA, and 'moderate' and 'fast' were referred to as MVPA which is similar to that done in other studies [95,301]. Proportions of time spent per physical activity intensity were compared between sex and setting. Pearson's chi-squared analyses were used to determine differences between the settings for the OSRAC-P categories, including type of activity, group setting, initiator and prompts for physical activity and location. OSRAC-P data are time-series, and it is therefore possible to produce a pattern to visualise the pattern of physical activity throughout the preschool day. A multinomial logistic regression analysis was performed to determine factors within the preschool environment (assessed by the OSRAC-P) that are associated with physical activity levels. Variables included in the regression were sex, body composition, setting, location and initiator of physical activity.

3.4.6 Parent questionnaire

The primary objective of including the questionnaire was for descriptive purposes, therefore the results are presented as frequencies and percentages. All results are stratified by child sex and setting (Preschool and Grade R). Results were not stratified by parent sex as the majority of parents were female. Chi-squared analysis was used to determine the differences between parents of boys and girls, as well as between parents of Preschool and Grade R children.

The physical activity GPAQ data (for parents self-reported physical activity levels) are presented as time spent in MVPA per domain (in minutes), as well as total MVPA per week.

Like the physical activity data, sedentary behaviour and screen time data are reported as minutes per day. Differences between boys and girls and Preschool and Grade R children for time spent engaged in screen time were determined using Mann-Whitney-U tests.

3.5 Ethics

The University of Cape Town Human Research Ethics Committee (Ref: 237/2012), the Human Research Ethics Committee (Medical) at the University of the Witwatersrand (Ref: M140250), as well as the Mpumalanga Departments of Health, and Education granted approval for this study. This study adheres to the guidelines explained in the Declaration of Helsinki Ethical Principles for Medical Research Involving Human Subjects. Parents provided written informed consent for each participating child, including specific permission for their child to be video-recorded for the TGMD-2 testing. Parents also gave written informed consent for their participation in the parent component of the study. All information sheets and consent forms were available in Xitsonga and English (Appendix B). At any point in the study, children and parents were allowed to withdraw from the study.

3.6 Overview of results chapters

The five results chapters are as follows:

1. Physical activity environment observations (Chapter 4)
2. Objectively measured physical activity and sedentary behaviour (Chapter 5)
3. Gross motor skill proficiency (Chapter 6)
4. Direct observation of physical activity (Chapter 7)
5. Parent perceptions of home and community factors influencing preschool children's physical activity (Chapter 8)

In total, 131 preschool-aged children from three Preschools (n=76 out of a potential n=129, 59.7%) and Grade R classes from two primary schools (n=55 out of a potential n=162, 34.0%) were recruited. The descriptive results for the total sample are shown in Table 3.6. The samples for each results chapter (Chapters 5-7) differ and therefore sample characteristics and demographic data are also presented in each chapter. An overview of the recruitment of the samples for each chapter is shown in Figure 3.2.

Table 3.6 Descriptive results: Total sample of children measured

	Total (n=131)	Boys (n=57)	Girls (n=74)	Preschool (n=76)	Grade R (n=55)
Age (y)	5.0± 0.6	5.0± 0.7	4.9± 0.6	4.5± 0.4	5.6± 0.3*
BMI (kg.m^{-2})	15.2± 1.4	15.6± 1.4	14.9± 1.4 #	15.3± 1.5	15.2± 1.4
BAZ	-0.9± 1.0	0.2± 1.0	-0.3± 0.9 #	-0.1± 1.0	-0.1± 1.0
WAZ	-0.3± 0.9	-0.1± 0.9	-0.3± 0.9 #	-0.4± 0.9	-0.2± 0.9*
HAZ	-0.4± 1.0	-0.4± 1.0	-0.4± 1.0	-0.6± 1.1	-0.2± 0.8*
IOTF weight status (%)					
Thinness	23.7	14.0	31.1	23.7	23.6
Normal weight	71.8	79.0	66.2	72.4	70.9
Overweight/obese	4.6	7.0	2.7	3.9	5.5

Data are presented as mean±SD

BAZ- BMI-for-age z-score, WAZ=weight-for-age z-score, HAZ=height-for-age z-score

#Indicates a significant difference between boys and girls ($p<0.05$)

*Indicates a significant difference between the preschool and grade R children ($p<0.05$)

Thinness includes thinness categories 1,2 and 3; obese category includes morbidly obese category

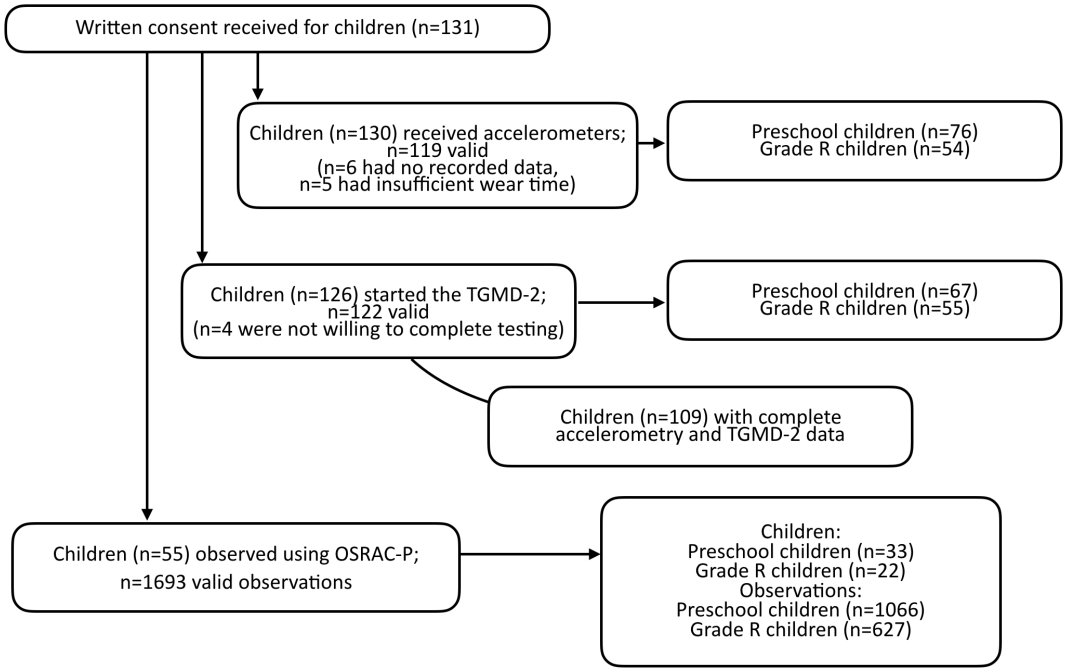


Figure 3.2 Recruitment and sample sizes

Chapter Four:
Physical activity environment observations

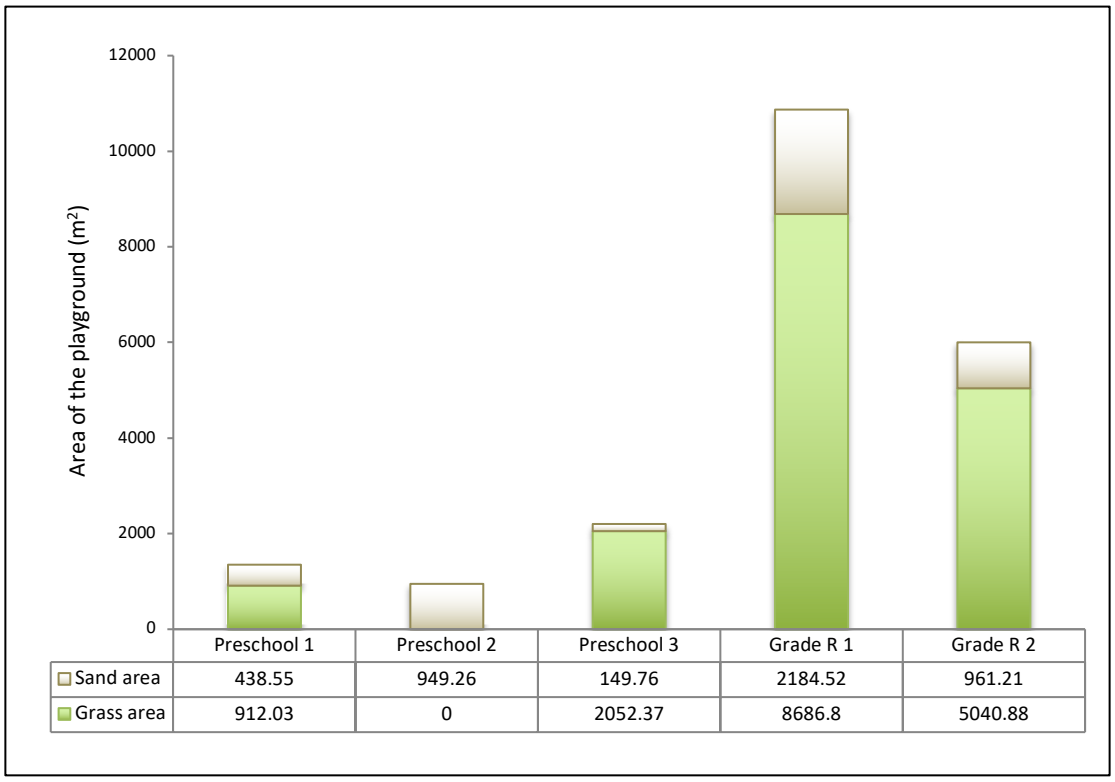
This chapter aimed to describe the following in a sample of preschool-aged children from a rural, low-income setting in South Africa:

1. Characteristics of the preschool/school environment

Specific objectives within this aim included the description of the Preschool and Grade R settings, in terms of the outdoor and indoor characteristics.

4.1 Outdoor (playground) characteristics

The playground sizes and compositions of each setting are presented in Figure 4.2; the characteristics of the outdoor settings are highlighted in Table 4.1. The outdoor space varied between settings. On average, the Grade R settings had more playground space than the Preschool settings. In both settings, the playground space was shared with all children, irrespective of age. For the Preschools, this meant that space was shared with younger children. For the Grade R settings, the space was shared between the preschool-aged children and children in Grade Seven (up until the age of 13 years). Two of the three Preschools had grassed areas and both Grade R settings had grassed areas. All three Preschools had fixed play equipment (for example, one jungle gym, eight to 18 swings, and four to five slides, per Preschool). Despite having more playground space, the Grade R settings had no, or minimal fixed play equipment. Both Preschool and Grade R settings had some portable play equipment, although availability in each setting of such resources was limited. For example, one of the Preschools (preschool 2) had only three soccer balls and one of the Grade R settings (Grade R setting 2) had two soccer balls. All Preschool and Grade R settings had a vegetable garden. No setting had clean and safe drinkable water, and none of the settings had flushable toilets. Figures 4.2 and 4.3 provide pictorial examples of one Preschool and one Grade R setting, respectively.



	Preschool 1	Preschool 2	Preschool 3	Grade R 1	Grade R 2
Sand area	438.55	949.26	149.76	2184.52	961.21
Grass area	912.03	0	2052.37	8686.8	5040.88

Figure 4.1 Outdoor playground size and composition, by individual Preschool and Grade R settings

Table 4.1 Characteristics of the outdoor playground, by setting

	Preschool 1	Preschool 2	Preschool 3	Grade R setting 1	Grade R setting 2
Exclusivity of playground	Preschool children and younger			Entire school makes use of the fields, up to grade 7 (aged 13 years)	
Shade available and proportion shaded	Natural trees covering <⅓ of the playground	Nearby building shaded <⅓ of the playground, no trees	Natural trees and building covering <⅓ of the playground	Natural trees covering <⅓ of the playground	Natural trees and building covering <⅓ of the playground
Vegetation	Every setting had a vegetable garden				
Availability of water	Clean, safe water was not available to drink at any of the setting*				
Playground flatness	Some incline/decline	Some incline/decline	Completely flat	Some incline/decline	Completely flat
Overall cleanliness of the outdoor area	Equal mix of poorly and well-maintained elements			Very unclean and poorly maintained	Outdoor area in good condition
Fixed play equipment available	8 swings 1 jungle gym 40 tyres (fixed/dug into the ground) 5 slides 3 tunnels	18 swings 1 jungle gym 2 see-saws 25 tyres (fixed/dug into the ground) 4 slides 4 tunnels	14 swings 1 jungle gym 1 merry-go-round 40 tyres (fixed/dug into the ground) 5 slides 2 tunnels	n/a	1 see-saw (made using a tyre that was fixed/dug into the ground, and a loose pole)
Material and condition of fixed play equipment	Metal and wood, in fair condition and function	Metal and wood, in excellent condition and function	Metal and wood, some in excellent condition, some non-functional	n/a	n/a
Portable play equipment	34 hula hoops	3 soccer balls	1 hula hoop 1 plastic slide 20 loose tyres	8 hula hoops 2 soccer balls	2 soccer balls

*Water collected and stored in JoJo vertical storage water tanks (http://www.jojotanks.co.za/product/storage-tanks/vertical-storage-tanks)

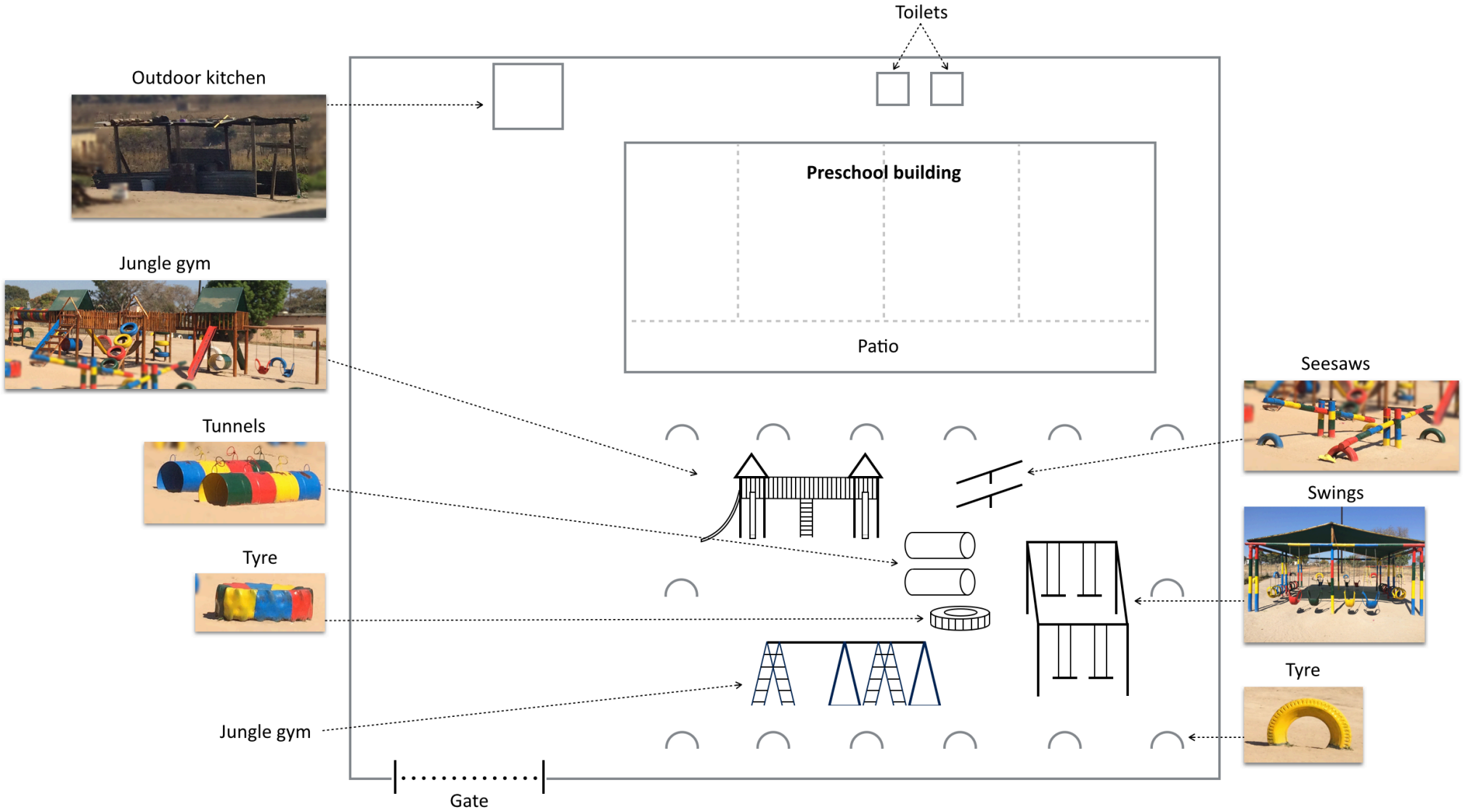


Figure 4.2 Configuration of the playground: Preschool setting 2

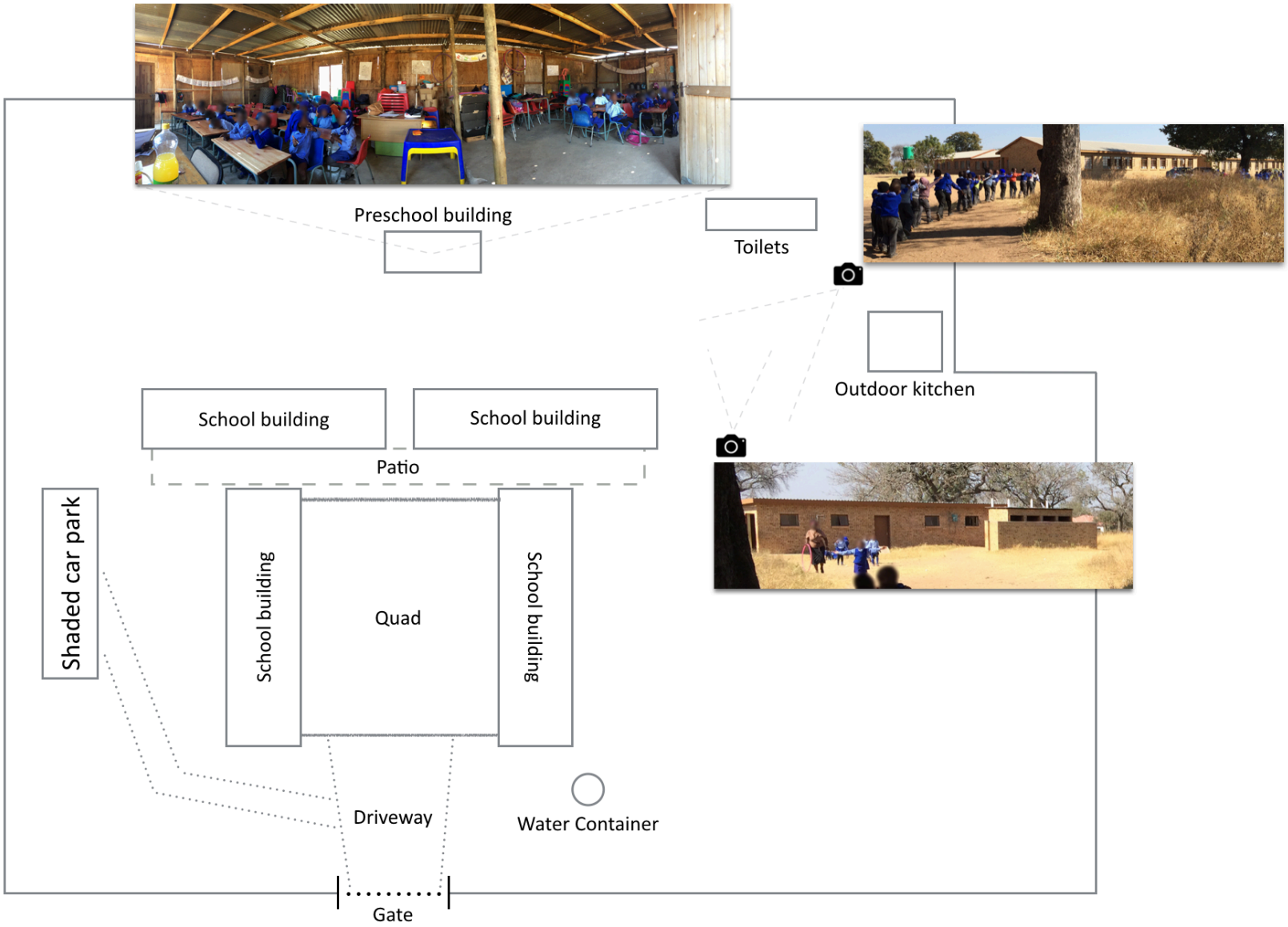


Figure 4.3 Configuration of Grade R setting 1

4.2 Indoor (classroom) characteristics

Indoor and classroom characteristics are presented in Table 4.2. None of the settings had classrooms that were big enough for indoor play, and none of the settings had any screens or electronic equipment. Most of the indoor space in both settings was taken up by tables and chairs. Although all of the settings had time allocated in the daily schedules to play (shown in Table 4.3, photographs of original schedules provided in Appendix C2), be it indoors or outdoors, there was no evidence (in the classrooms) of physical activity and/or gross motor skill lesson plans or policies. The three main barriers identified by teachers included lack of staff training on physical education, insufficient funds and a lack of physical education resources.

Each school had a daily schedule (in poster form) on the classroom wall (Table 4.3). The curriculum requirements for Grade R children (both in primary school settings and in independent preschools) based on the South African Department of Basic Education stipulates that they should have a minimum of twenty-three hours of instruction per week [302]:

1. Ten hours should be allocated to instruction to teach the home language (in this case, Xitsonga),
2. Seven hours of mathematics instruction, and
3. Six hours of life skills, which includes instruction on 'beginning knowledge', creative arts, physical education and 'personal and social wellbeing'.

On the day of observation (detailed further in Chapter 7), 'pre-academic activities and instructional time' (including activities involving books, writing, listening, science and math) was monitored in order to understand determine if these settings met the basic requirements stipulated by their governing body. In both settings (i.e. the Preschool and Grade R setting) the time spent in pre-academic activities and instructional activities was very low, and differed between the preschool and Grade R settings (1.9% vs. 8.1%, p=0.000). The observational period was approximately four hours for each setting, meaning that the Preschool children received less than three minutes and the Grade R's less than 20 minutes, of pre-academic/instructional activities per day. Time spent in 'group or circle time' activities also differed between the Preschool and Grade R children (39.4% and 46.2%, respectively, p=0.000). For the period of observation, this equates to approximately 96 minutes and 110 minutes in 'group or circle time' for the children in the Preschool and Grade R settings, respectively. None of the schools had scheduled time for physical education or gross motor skill instruction; although every school allocated time for free play. Chapter 7 reports on the complete results of the direct observation of physical activity and sedentary behaviours within a typical preschool day.

Table 4.2 Characteristics of the classrooms and indoors, by setting

	Preschool 1	Preschool 2	Preschool 3	Grade R setting 1	Grade R setting 2
Indoor play space	Limited space for movement and active play			Limited space for movement and active play (when desks and chairs are moved)	Limited space for movement and active play
TV/DVD/video player/video game	None of the schools had any electronic games or equipment				
Time allocated to structured, outdoor and free play.	Free play (including outdoor): ¼ hour	Free play: 1¼ hour	Free play: ¾ hour	Free play (including outdoor): 1 hour	Outdoor play: 1 hour
Lesson plans for PA and GMS	None of the schools had lesson plans for PA				
Written policies pertaining to PA	None of the schools had a written PA policy				
Training for staff on PA and GMS	None of the teachers at the schools had received PA or GMS training				
Material about PA and GMS	None of the teachers or schools had material explaining PA or GMS				
Extra-mural PA	No schools provided extra-mural activities for the preschool-aged children				

Table 4.3 Daily schedules as shown in each classroom, by setting

Preschool 1		Preschool 2		Preschool 3		Grade R setting 1		Grade R setting 2	
Time	Activity	Time	Activity	Time	Activity	Time	Activity	Time	Activity
07:30-08:15	Arrive/free play	07:00-08:15	Arrive	07:00	Welcome	07:20-07:30	Arrive/free play	07:30-08:00	Morning circle
08:00- 08:15	Health check	08:15-08:30	Morning routine	08:00	Assembly	07:30-08:05	Morning ring (teacher-guided)	08:00-08:30	Teacher-guided activity
08:15-08:45	Bible stories and prayer	08:30-08:45	Toilet routine	08:10	Biblical instruction	08:05-08:55	Art activity/free play	08:30-08:40	Toilet routine
08:45-09:00	Breakfast	08:45-09:00	Breakfast	09:00	Breakfast	08:55-09:25	Teacher-guided activity	08:40-09:30	Indoor play
09:00-09:55	Art/make believe	09:00-10:00	Creative/art	09:30	Arts and Culture	09:25-09:55	Teacher-guided activity	09:30-10:30	Refreshment
09:55-10:15	Cleaning	10:00-10:15	Cleaning	10:15	Toilet routine	09:55-10:00	Toilet routine	10:30-11:00	Teacher-guided activity*
10:15-10:45	Toilet routine	10:15-11:30	Free play	10:30	Refreshment	10:00-10:30	Refreshment	11:00-11:10	Toilet routine
10:45-11:00	Free play/outdoor play	11:30-12:00	Snack time	10:45	Music	10:30-11:30	Outside free play	11:10-11:40	Teacher-guided activity
11:00-11:15	Story time/singing	12:00-12:15	Lunch	11:15	Free play	11:30-11:50	Toilet routine	11:40-12:00	Story time/reading
11:15-12:15	Bed time/rest	12:15-13:00	Rest	12:00	Lunch	11:50-12:20	Story time	12:00-12:30	Depart
12:15-13:15	Lunch	13:00-14:00	Toilet routine	12:30	Story time	12:20-12:30	Depart		
13:15-14:15	Toilet routine/ snacks/play time	14:00-15:00	Depart	12:45	Rest				
14:15-15:30	Depart			14:15	Refreshment				
				14:30	Departure				
*Schedule listed outdoor play as an alternative from 10:30-11:30									

4.3 Summary

In summary, this chapter identified several differences between the Preschool and Grade R settings in terms of the physical environment. The most prominent differences between the settings in terms of the outdoor environment was the amount of open space and availability of fixed equipment. The Preschool settings were better equipped with fixed play equipment, although there was less open space available to the children in comparison with Grade R setting. Both settings provided minimal portable play equipment. The indoor characteristics were similar across the settings. All of the classrooms were small and had limited space for indoor play, and there was no electronic equipment. Minimal time in either setting was allocated to pre-academic activities or instructional activities. Substantially more time was allocated to circle time in both settings. There was no evidence of physical activity lesson plans or policies.

Chapter Five:
Objectively measured physical activity and sedentary behaviour

This chapter aimed to describe the following in a sample of preschool-aged children from a rural, low-income setting in South Africa:

1. Objectively measured physical activity
2. Objectively measured sedentary behaviour

Specific objectives within this aim were to:

i. Identify levels of physical activity,
ii. Identify levels of sedentary behaviour,
iii. Determine the level of compliance with current physical activity guidelines
iv. Investigate differences between boys and girls,
v. Investigate differences between children in Preschool and Grade R settings,
vi. Identify patterns of physical activity,
vii. Identify patterns of sedentary behaviour,
viii. Investigate the relationship between weight status and physical activity levels.

Accelerometers were placed on 130 children. Six participants were excluded due to children not wearing the device at all or having no recorded data (due to a fault in the device). Five participants were excluded due to insufficient wear time (detailed in the Methods Chapter); thus 119 children had valid data. For the whole sample, there were 817 valid days (weekday and weekend day), therefore the average number of days of wear time was 6.9 (n=109 had seven valid days, n=8 had six valid days and n=2 had 5 valid days).

5.1 Descriptive characteristics

Sample characteristics and differences between sexes and settings for the children that had valid accelerometry data are shown in Table 5.1. More than two-thirds of the sample were classified as normal weight (n=81, 68.1%), with 'thinness' being more prevalent than overweight and obesity combined (26.9% vs. 5.1%). Girls had significantly lower BMI values, BAZ and WAZ than boys (all $p<0.05$) and there were significantly more girls represented in the 'thinness' IOTF category (shown in Table 5.1) in comparison to boys. The Grade R children were significantly older than the preschool children and had significantly higher WAZ and HAZ (all $p<0.05$).

Table 5.1 Descriptive results: Children with valid accelerometry data, stratified by sex and setting

	Total (n=119)	Boys (n=52)	Girls (n=67)	Preschool (n=68)	Grade R (n=51)
Age (y)	4.9± 0.7	4.9± 0.7	4.9± 0.7	4.4± 0.4	5.6± 0.3*
BMI (kg.m^{-2})	15.1± 1.4	15.5± 1.4	14.7± 1.3 #	15.0± 1.4	15.2± 1.4
BAZ	-0.2± 1.0	0.1± 1.0	-0.4± 1.0 #	-0.2± 1.0	-0.1± 1.0
WAZ	-0.4± 1.0	-0.2± 0.9	-0.5± 1.0 #	-0.6± 1.0	-0.2± 0.9*
HAZ	-0.4± 1.0	-0.4± 1.0	-0.4± 1.0	-0.6± 1.1	-0.2± 0.8*
IOTF weight status (%)					
Thinness	26.9	15.4	35.8	29.4	23.5
Normal weight	68.1	76.9	61.2	66.2	70.6
Overweight/obese	5.0	7.7	3.0	4.4	5.9

Data are presented as mean±SD
#Indicates a significant difference between boys and girls (p<0.05)
*Indicates a significant difference between the preschool and grade R children (p<0.05)
BAZ=BMI-for-age z-score, WAZ=weight-for-age z-score, HAZ=height-for-age z-score.
Thinness includes thinness categories 1,2 and 3; obese category includes morbidly obese category

5.2 Levels of physical activity and sedentary behaviour

Accelerometers were worn for 24 hours; waking time was extracted for analysis as described in section 3.3.3 of Chapter 3. Accelerometry results from this point forward are reported as times within an 11-hour period, between 07:00 and 18:00.

Table 5.2 Average time spent in physical activity and sedentary behaviour for the total sample

	Time spent per day in each intensity
Sedentary (<100cpm)	157.3± 57.2 (153, 114-193)
Low light (101 to 890cpm)	261.4± 47.3 (262, 232-293)
High light (891 to 1679cpm)	122.2± 35.2 (123, 100-146)
Moderate (1680 to 3367cpm)	79.1± 40.5 (75, 50-105)
Vigorous (>3368cpm)	14.6± 15.9 (9, 4-20)
MVPA (>1680cpm)	93.7± 52.3 (85, 56-125)
LMVPA (>100cpm)	477.3± 77.3 (489, 437-534)

Data are presented as mean±SD (median, IQR)
cpm=counts per minute, MVPA=moderate- to vigorous-intensity physical activity, LMVPA=light- to vigorous-intensity physical activity

Time spent in physical activity (and sedentary behaviour) for both weekdays and weekend days is shown in Table 5.3. Children, irrespective of sex or setting, spent similar time in

LMVPA on week and weekend days (p=0.86). Children spent significantly more time in high-light-intensity physical activity on weekend days (p=0.03) compared to weekdays and significantly more time in VPA on weekdays compared with weekend days (p=0.0001). Children spent significantly less time in sedentary behaviour on weekends (150.0± 59.4 vs. 160.1± 56.1, p=0.02) compared with week days.

Table 5.3 Time spent in physical activity and sedentary behaviour on weekdays and weekend days

	Weekdays (Monday - Friday)	Weekend days (Saturday - Sunday)
Sedentary (<100cpm)	160.1± 56.1 (158, 119-194)	150.0± 59.4 (147, 108-188) *
Low light (101 to 890cpm)	262.3± 47.0 (263, 234-293)	259.1± 48.3 (260, 230-294)
High light (891 to 1679cpm)	120.6± 34.2 (123, 100-146)	126.5±37.4 (129, 103-151) *
Moderate (1680 to 3367cpm)	78.9± 40.0 (75, 51-104)	79.4± 42.0 (75, 48-108)
Vigorous (>3368cpm)	15.7± 16.6 (11, 4-21)	11.7± 13.3 (7, 3-15) *
MVPA (>1680cpm)	94.6± 52.5 (86, 57-125)	91.1± 52.0 (84, 53-125)
LMVPA (>100cpm)	477.5± 75.3 (489, 438-532)	476.6± 82.5 (487, 434-541)

Data are presented as mean±SD (median, IQR); and as minutes per day
cpm=counts per minute, MVPA= moderate- to vigorous-intensity physical activity, LMVPA= light- to vigorous-intensity physical activity
* Indicates a significant difference between weekdays and weekend days (p<0.05)

5.3 Compliance with physical activity guidelines

For average LMVPA, 100% of the children with valid data met the current recommendation of 180 minutes of total physical activity (also referred to as LMVPA). When each day of wear was considered individually, the compliance remained 100%, meaning that every child in the sample did greater than 180 minutes of LMVPA per day.

In terms of the MVPA guideline (60 minutes of the 180 minutes of LMVPA should be 'energetic play', operationalised as MVPA), and for average MVPA, 78.2% of the sample (n=93 out of n=119) met the MVPA guideline [77,78]. The number of children who did not meet the guideline on each valid day of wear was n=80 out of n=119, therefore 32.8% of children met the MVPA guideline on every day of valid wear. When considering both the LMVPA and MVPA guideline, the same percentage of children who met the MVPA guideline met both components of the guideline, since compliance for the LMVPA guideline was 100%.

5.4 Sex differences for physical activity and sedentary behaviour

Tables 5.4 and 5.5 show time spent in physical activity and sedentary behaviour for weekdays and weekend days, respectively. Data are stratified by sex and setting. On weekdays, girls spent significant more time low light-intensity physical activity compared to boys; however,

boys spent significantly more time in high LPA, MVPA and VPA (all p<0.05). Boys and girls spent similar time in high LPA on weekend days. Boys spent significantly more time in MPA and VPA than girls (p<0.05) on weekend days. In terms of sedentary behaviour, girls were significantly more sedentary than boys (p=0.04) on weekdays. On weekend days, boys and girls spent similar time in sedentary behaviour. With reference to the physical activity guidelines, of the n=26 children who did not meet the physical activity guidelines, n=18 were girls and n=8 were boys (p=0.133).

5.5 Setting differences for physical activity and sedentary behaviour

Preschool children spent significantly more time in low and high LPA and VPA compared to Grade R children (p<0.05). Grade R children participated in significantly more MPA (p<0.001). Grade R children spent significantly more time in MPA and VPA, as well as LMVPA compared with children who attended the Preschool setting (p<0.05). Grade R children were significantly more sedentary than preschool children during the week, although weekend sedentary behaviour was similar. In terms of meeting physical activity guidelines, significantly more Preschool children (n=23) did not meet the physical activity guideline in comparison to the Grade R children (n=3), p=0.000.

Table 5.4 Time spent in physical activity and sedentary behaviour on weekdays

	Boys (n=52)	Girls (n=67)	Preschool (n=68)	Grade R (n=51)
Sedentary (<100cpm)	149.6± 55.2 (143, 109-183)	168.2± 55.6 (167, 127-203) #	151.8± 58.1 (146, 108-185)	171.0± 51.6 (171, 130-205) *
Low light (101 to 890cpm)	251.2± 47.0 (255, 224-284)	270.9± 45.2 (271, 243-300) #	269.3± 49.9 (274, 240-302.5)	253.2± 41.1 (254.5, 228-277) *
High light (891 to 1679cpm)	126.5± 33.0 (130, 106-150)	116.0± 34.4 (116, 96-141) #	123.9± 37.5 (129, 101-151)	116.2± 28.7 (115, 99-136) *
Moderate (1680 to 3367cpm)	93.1± 43.9 (90, 60-126)	68.0± 32.8 (65, 45-91) #	73.0± 42.6 (64.5, 42-95.5)	86.7± 34.9 (82, 62-109) *
Vigorous (>3368cpm)	20.1± 20.9 (13, 5-27)	12.4± 11.5 (9, 4-18) #	13.7± 15.1 (9, 3-18)	18.4± 18.3 (13, 6-23) *
MVPA (>1680cpm)	113.2± 60.0 (103, 67-153)	80.4± 40.5 (77, 51-107) #	86.7± 54.4 (75, 48-115)	105.1± 48.1 (98, 73-130) *
LMVPA (>100cpm)	491.0± 72.6 (502, 458-543)	467.2± 75.8 (479, 427-524) #	479.9± 84.1 (496, 440.5-543)	474.5± 62.1 (479, 437-520) *

Data are presented as mean±SD (median, IQR); and as minutes per day (between 07:00 and 18:00)
cpm=counts per minute, MVPA= moderate- to vigorous-intensity physical activity, LMVPA=light- to vigorous- intensity physical activity.
#Indicates a significant difference between boys and girls (p<0.05)
*Indicates a significant difference between the preschool and grade R children (p<0.05)

Table 5.5 Time spent in physical activity and sedentary behaviour on weekends

	Boys (n=52)	Girls (n=67)	Preschool (n=68)	Grade R (n=51)
Sedentary (<100cpm)	147.1± 56.6 (142, 104-187)	152.3± 61.7 (147, 112-188)	155.5± 62.5 (153.5, 112-189)	142.7± 54.6 (133, 105-178)
Low light (101 to 890cpm)	246.1± 50.0 (246, 214-281)	269.2± 44.6 (269.5, 247-300) #	264.3± 49.6 (267, 231.5-301)	252.1± 45.9 (255, 229-285)
High light (891 to 1679cpm)	128.6± 35.0 (127, 106-154)	124.8± 39.2 (130, 100-151)	122.3± 38.8 (124, 91-150.5)	132.0± 34.8 (132, 109-153)
Moderate (1680 to 3367cpm)	89.7± 45.2 (89, 55-120)	71.5± 37.6 (68, 45-95) #	69.6± 43.2 (58.5, 36-96)	92.6± 36.6 (89, 67-123) *
Vigorous (>3368cpm)	15.1± 16.0 (10, 3-21)	9.0± 10.2 (6, 3-11) #	8.5± 11.1 (5, 1.5-10)	15.9± 14.9 (12, 6-21) *
MVPA (>1680cpm)	104.7± 58.0 (102, 60-141)	80.5± 44.1 (75, 50-110) #	78.0± 52.1 (66, 38-106)	108.5± 46.7 (103, 75-140) *
LMVPA$^{\beta}$ (>100cpm)	479.4± 81.4 (486, 442-541)	474.5± 83.5 (488.5, 426-537)	464.7± 85.0 (477, 425.5-528)	492.6± 76.5 (509, 451-548) *

Data are presented as mean±SD (median, IQR); and as minutes per day (between 07:00 and 18:00)
cpm=counts per minute, MVPA= moderate- to vigorous-intensity physical activity, LMVPA=light- to vigorous-intensity physical activity
#Indicates a significant difference between boys and girls ($p<0.05$)
*Indicates a significant difference between the preschool and grade R children ($p<0.05$)

5.6 Patterns of light- to vigorous-intensity physical activity

Figure 5.1 shows the weekday (A) and weekend day (B) patterns by sex; Figure 5.2 shows the weekday (A) and weekend day (B) patterns by setting. The tabulated values that correspond with Figures 5.1 and 5.2 are included in Appendix D3, Table D3.1.

Sex differences for light- to vigorous-intensity physical activity

During the week, LMVPA was significantly higher for boys compared to girls during the morning (07:00-11:00) ($p<0.05$), and during some parts of the afternoon (eg.12:00-13:00, 14:00-16:00; all $p<0.05$). Weekend LMVPA was similar between boys and girls, with boys only significantly more physically active than girls between 16:00 and 17:00 ($p<0.05$).

Setting differences for light- to vigorous-intensity physical activity

Much like the sedentary behaviour patterns, LMVPA differed significantly between Preschool and Grade R children throughout the weekday, with the exception of the hour between 14:00 and 15:00 during which the Preschool children spent a greater proportion of their school day in LMVPA. On weekend days, LMVPA patterns were similar throughout the day with the exception of 07:00 and 08:00 and 17:00 and 18:00 (both $p<0.05$).

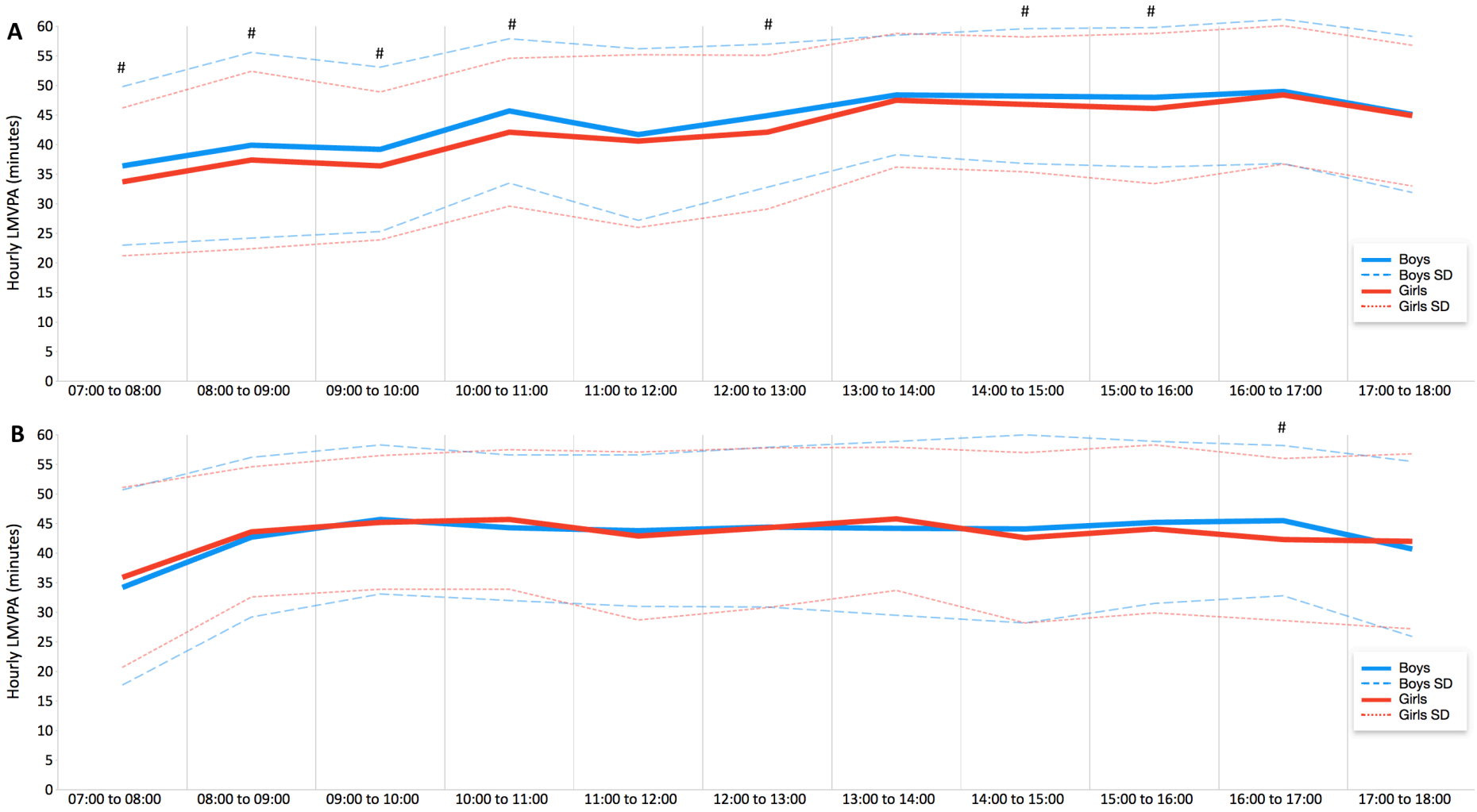


Figure 5.1 Patterns of LMVPA for boys and girls on weekdays (A) and weekends days (B)

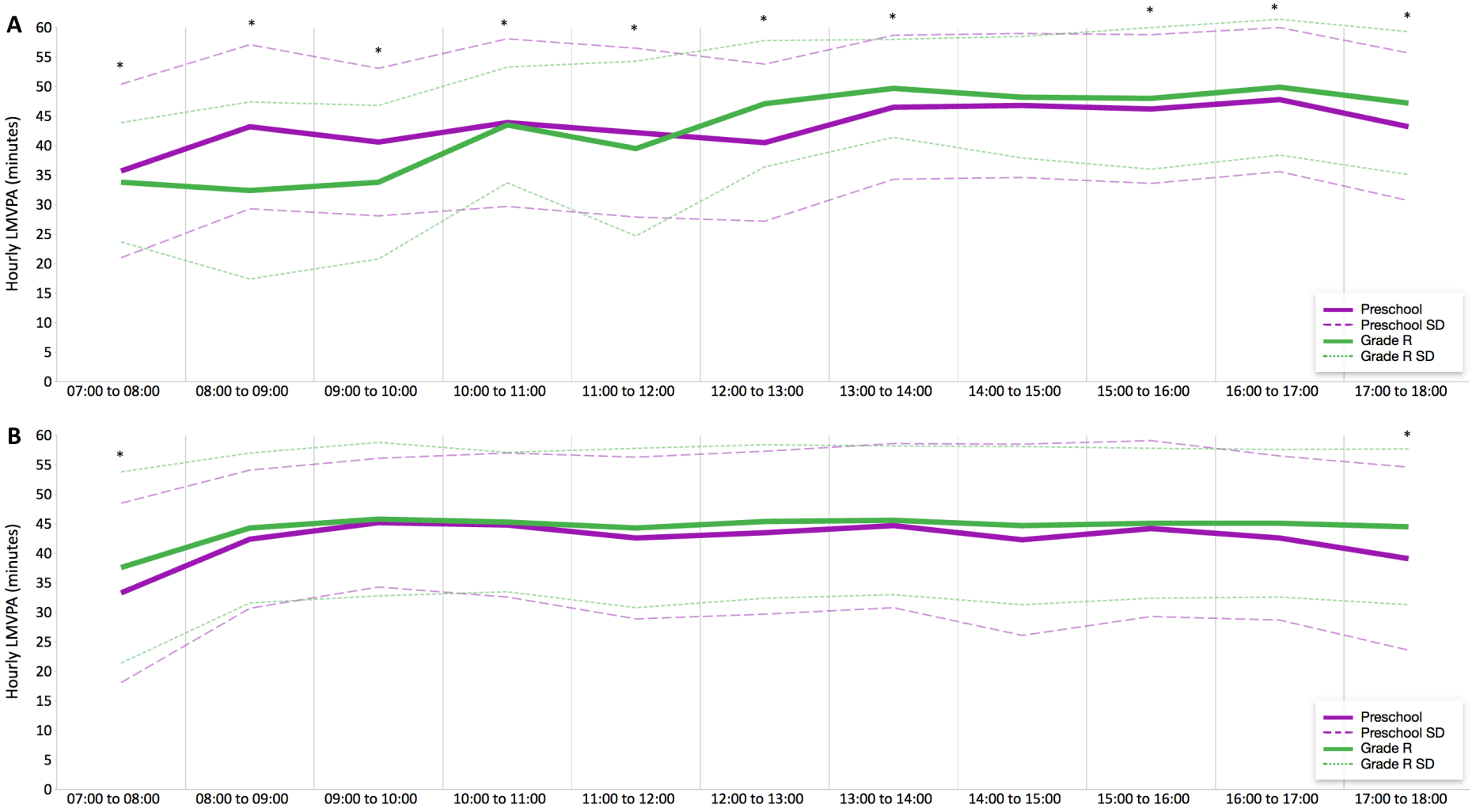


Figure 5.2 Patterns of LMVPA for Preschool and Grade R children on weekdays (A) and weekends days (B)

5.7 Patterns of moderate- to vigorous-intensity physical activity

Figure 5.3 shows the weekday (A) and weekend day (B) patterns by sex; Figure 5.4 shows the weekday (A) and weekend day (B) patterns by setting. The tabulated values that correspond with Figures 5.3 and 5.4 are included in Appendix D3, Table D3.2.

Sex differences for moderate- to vigorous-intensity physical activity

During the week, the time spent per hour in MVPA was significantly higher for boys compared to girls throughout the day. Although significant differences were identified, at most, the average difference in the time spent in MVPA per hour was four minutes. Weekend MVPA was similar between boys and girls for the first half of the day, with the exception of the hour between 08:00 and 09:00, where boys spent significantly more time in MVPA than girls. Boys spent significantly more time in MVPA on weekend day afternoons between 14:00 and 17:00.

Setting differences for moderate- to vigorous-intensity physical activity

Preschool children spent significantly more time during the weekday mornings in MVPA (specifically between 07:00 and 10:00) compared with Grade R children. However, in the afternoon the Grade R children spent significantly more time in MVPA compared to the preschool children. The difference between the preschool and Grade R children in weekday MVPA per hour ranged between three and seven minutes. On weekend days, Grade R children spent significantly more time in MVPA compared with the preschool children for the majority of the day, with the exception of 12:00-13:00 and 15:00-16:00 when no differences were evident ($p=0.06$ and $p=0.10$, respectively).

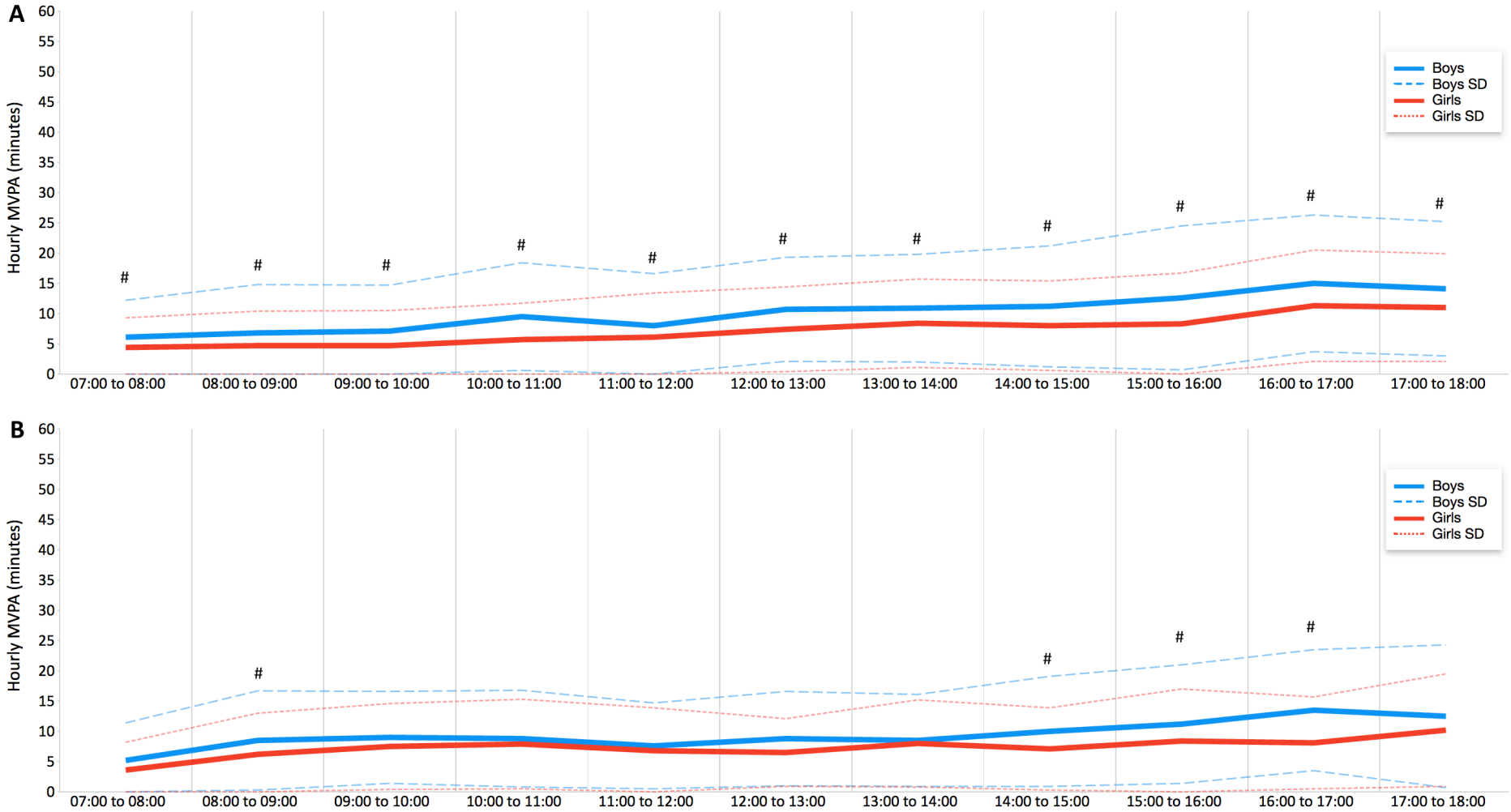


Figure 5.3 Time spent in MVPA per hour for boys and girls on weekdays (A) and weekends days (B)

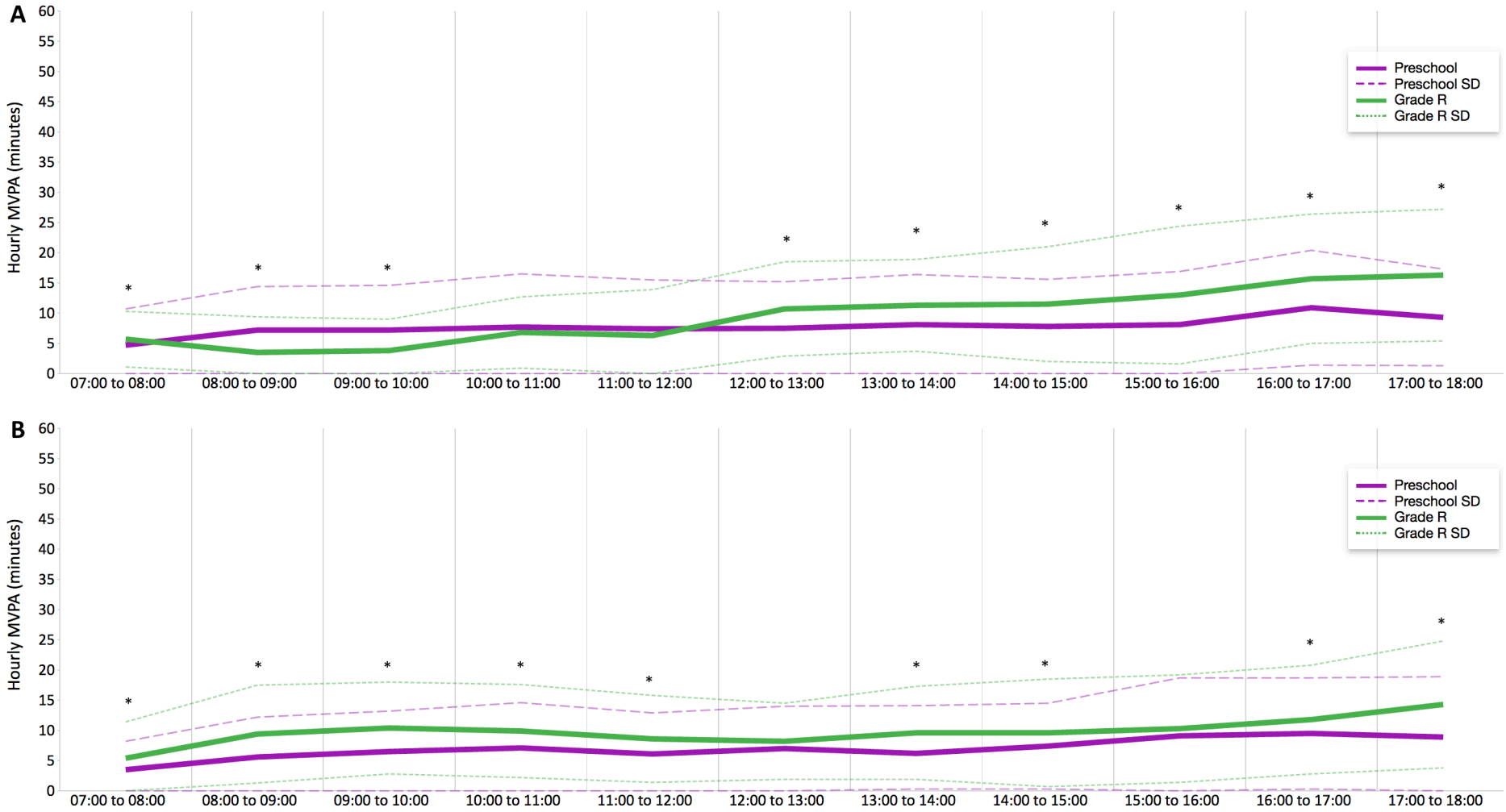


Figure 5.4 Patterns of MVPA for Preschool and Grade R children on weekdays (A) and weekends days (B)

5.8 Patterns of sedentary behaviour

Figure 5.5 shows the weekday (A) and weekend day (B) patterns by sex; Figure 5.6 shows the weekday (A) and weekend day (B) patterns by setting. The tabulated values that correspond with Figures 5.5 and 5.6 are included in Appendix D3, Table D3.3. Overall, the weekday patterns analysis showed that sedentary behaviour was highest during the morning periods (between 07:00 and 12:00), and decreased as the day progressed. Weekend day sedentary behaviour remained relatively consistent throughout the day, averaging between 15 and 20 minutes per hour.

Sex differences for patterns of sedentary behaviour

Girls were significantly more sedentary than boys on weekdays between 07:00 and 11:00 ($p<0.05$). Thereafter, except for one hour between 12:00 and 13:00, sedentary behaviour was similar between boys and girls. Weekend day sedentary behaviour hourly patterns were similar between boys and girls with both boys and girls spending 20 - 30% of each hour in sedentary behaviour.

Setting differences for patterns of sedentary behaviour

On weekdays, up until 13:00, Grade R children were significantly more sedentary than preschool children ($p<0.05$). However, in the afternoons on weekdays the pattern is reversed, with the preschool children engaging in more sedentary behaviour than the Grade R's. Specifically, significant differences were identified between the Grade R's and preschool children between 15:00 and 18:00. On weekend days, preschool children were significantly more sedentary than the Grade R children between 07:00 and 09:00, 11:00 and 12:00, and 17:00 and 18:00.

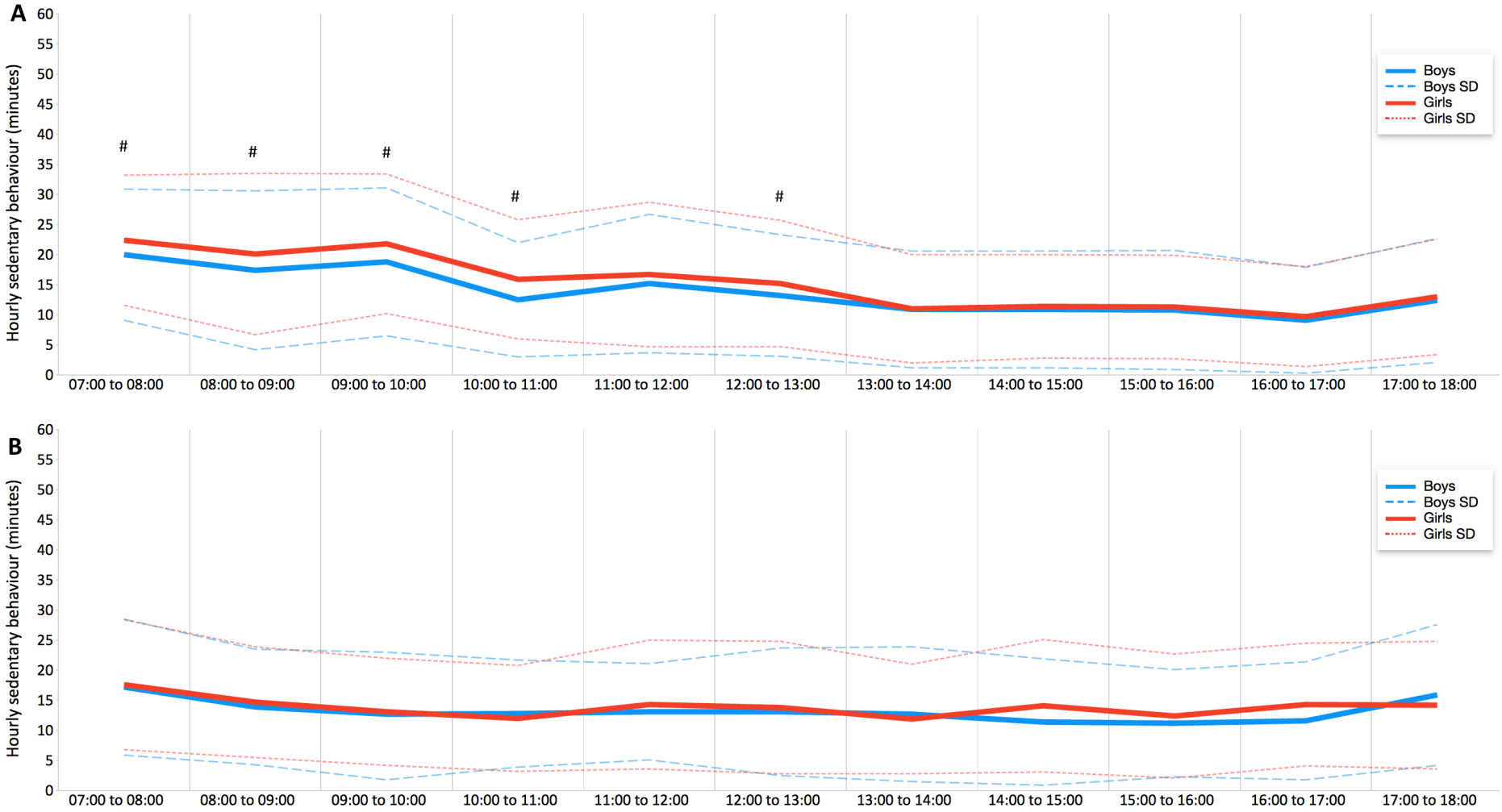


Figure 5.5 Patterns of sedentary behaviour for boys and girls on weekdays (A) and weekends days (B)

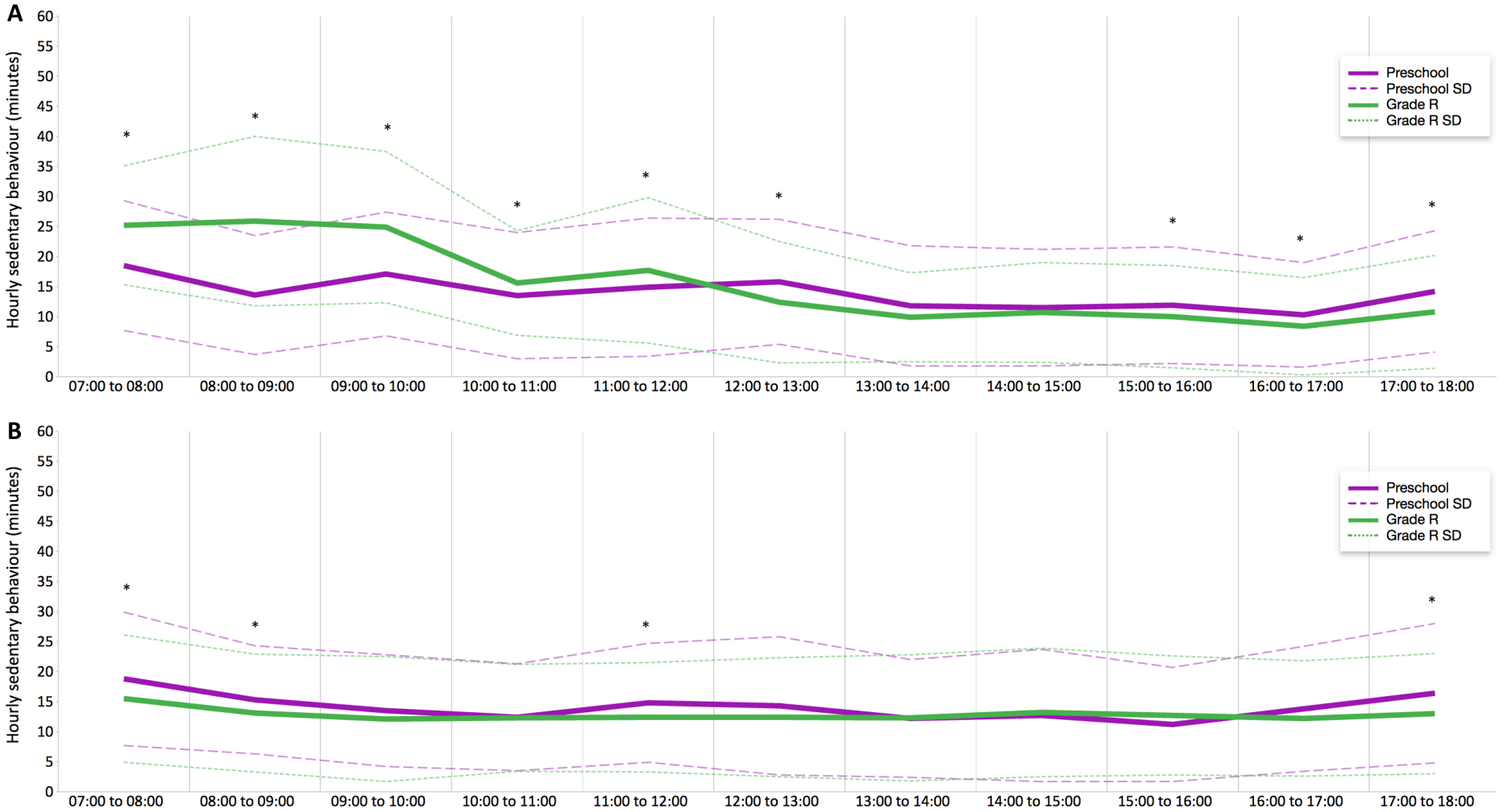


Figure 5.6 Patterns of sedentary behaviour for Preschool and Grade R children on weekdays (A) and weekends days (B)

5.9 Physical activity and weight status

The only physical activity variable that was found to be significantly correlated (using Spearman's rho) with BAZ was time spent in MVPA (rho=0.20, p=0.03). LMVPA and VPA were not significantly correlated with BAZ (rho=0.18 and 0.16, respectively, both p>0.05).

One-way ANOVA analyses were conducted to compare physical activity between the three different IOTF weight status categories, namely thinness, healthy weight and overweight/obesity. There were no between-group differences for weight status and time spent in LMVPA and VPA (p>0.05). However, there was a statistically significant difference between the IOTF weight status groups for time spent in MVPA ($F(2,116) = 3.3$, p=0.041). A Bonferroni multiple-comparison test revealed that MVPA was significantly different between the 'thin' and 'healthy weight' group, with the 'thin' children achieving significantly less MVPA than the 'healthy weight' children (p=0.036). No differences in physical activity were found between the 'thin' and 'healthy weight' children in comparison to the overweight/obese children. This may be a result of the limited number of children represented in the overweight/obese group.

5.10 Summary

In summary, compliance with physical activity guidelines was excellent when considering the LMVPA component of the guidelines (180 minutes per day). However, compliance was reduced when the MVPA component of the guidelines (60 minutes of the 180 minutes should be 'energetic play', operationalised as MVPA), was considered. Physical activity levels differed between weekdays and weekend days and boys spent significantly more time in MPA and VPA compared to girls. Conversely, girls were found to be more sedentary compared to boys.

Boys were consistently and significantly more physically active than girls, particularly for MVPA patterns during the week. There were few differences found between boys and girls in the physical activity patterns (LMVPA and MVPA) on weekend days. Girls were more sedentary than boys on weekday mornings, although sedentary behaviour patterns on weekend days were very similar between boys and girls.

The patterns of sedentary behaviour and physical activity between Preschool and Grade R children differed significantly, particularly during the week. The Grade R children were significantly more sedentary than the preschool children during what is known to be school time (between approximately 08:00 and 12:00). Conversely, and during the same period of time, the Preschool children were significantly more active (LMVPA and MVPA). However, the period of time after 12:00 revealed a 'cross-over', where the Grade R children engaged in less sedentary behaviour and more LMVPA and MVPA. The difference in MVPA patterns over the weekend between preschool and Grade R children were pronounced, with the Grade R children engaging in significantly more MVPA throughout most of the weekend day in comparison to the Preschool children. Furthermore, Preschool children classified as 'thin' engaged in lower volumes of MVPA in comparison to children of a normal weight.

Chapter Six:
Gross motor skill proficiency

This chapter aimed to describe the following in a sample of preschool-aged children from a rural, low-income setting in South Africa:

1. Gross motor skill proficiency;
2. Associations between gross motor skills, body composition and physical activity (objectively measured).

Specific objectives within this aim include:

i. Investigate differences between boys and girls,
ii. Investigate differences between children from Preschool and Grade R settings,
iii. Investigating the relationship between weight status and gross motor skill proficiency,
iv. Identifying factors that are associated with greater gross motor skill proficiency.

6.1 Descriptive characteristics

One hundred and twenty-two (96.8%) children completed the TGMD-2 testing. Four children refused to continue with the testing after performing the first one or two skills and their data were excluded from the analyses. The sample characteristics and differences by sex and setting for children who completed the testing are shown in Table 6.1. There were no differences between boys and girls for anthropometric measures. The percentages of children per weight status category according to the IOTF cut-offs [21] are also shown in Table 6.1. Almost 70% of the total sample classified as healthy weight, and 4.9% of the sample classified as overweight/obese. Thinness was prevalent in the total sample (25.4%), and there were significantly more 'thin' girls than boys (18.9% vs. 6.5%, p=<0.05).

Table 6.1 Descriptive results for children who completed the TGMD-2

	Total (n=122)	Boys (n=53)	Girls (n=69)	Preschool (n=67)	Grade R (n=55)
Age (y)	5.0 ±0.6	5.1 ±0.7	5.0 ±0.6	4.5 ±0.4	5.6 ±0.3*
BMI (kg.m^{-2})	15.2 ±1.5	15.7 ±1.5	14.9 ±1.4	15.2 ±1.6	2.1 ±1.4
BAZ	-0.1 ±1.0	0.2 ±1.0	-0.3 ±0.9	-0.7 ±1.1	-0.1 ±1.0
WAZ	-0.3 ±0.9	-0.1 ±0.1	-0.4 ±0.1	-0.4 ±0.1	-0.2 ±0.1
HAZ	-0.4 ±1.0	-0.5 ±0.1	-0.3 ±0.1	-0.6 ±0.1	-0.2 ±0.1*
IOTF weight status					
Thinness	25.4%	15.1%	33.3%#	26.9%	23.6%
Normal weight	69.7%	77.4%	63.8%	68.7%	70.9%
Overweight/Obese	4.9%	7.5%	2.9%	4.4%	5.5%

Data are presented as mean±SD
BAZ=BMI-for-age z-score, WAZ=weight-for-age z-score, HAZ=height-for-age z-score.
*Indicates a significant difference between Preschool and Grade R children (p<0.05)
#Indicates a significant difference between boys and girls (p<0.05)

6.2 Levels of gross motor skill proficiency

The locomotor and object control standard scores, as well as the GMQ scores are reported in Table 6.2. There were no significant differences between boys and girls for any standardised gross motor skill scores. The Grade R children had significantly higher locomotor (p=0.004) and object control (p=0.005) standard scores than the preschool children. GMQ scores were also significantly higher in the Grade R children (p=0.001) compared to the preschool children

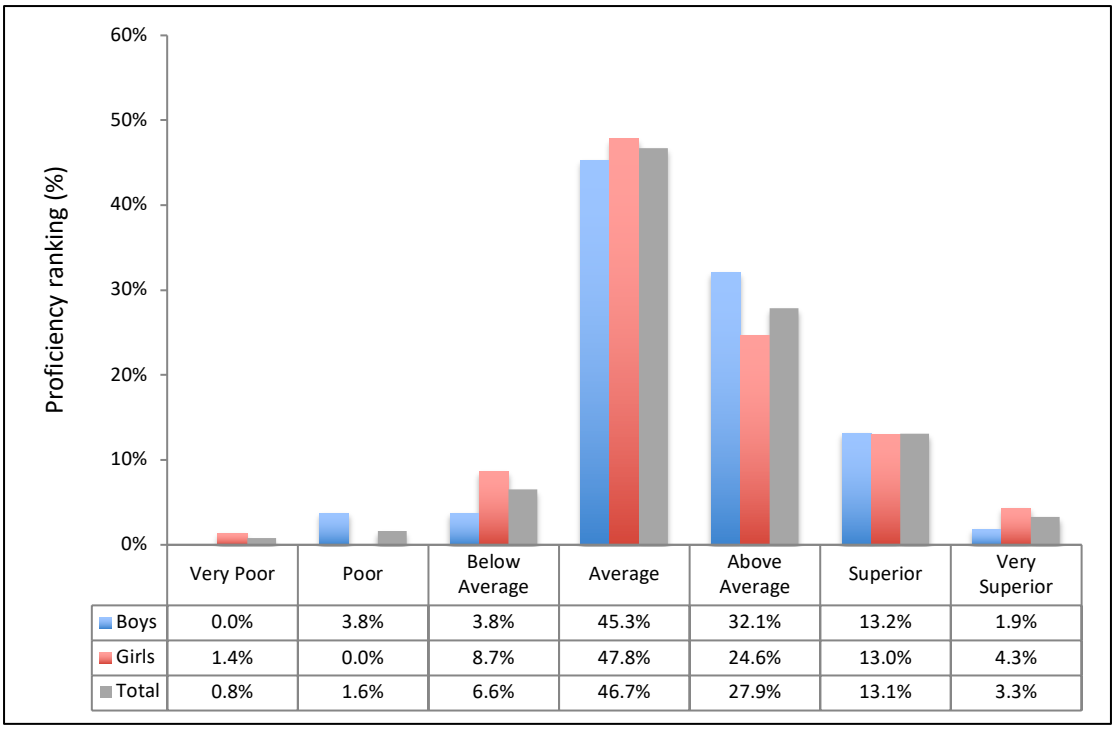
Table 6.2 Gross motor skill proficiency results for children who completed the TGMD-2

	Total (n=122)	Boys (n=53)	Girls (n=69)	Preschool (n=67)	Grade R (n=55)
Locomotor raw score [§]	35.2 ±6.7 36 (31-40)	35.3 ±6.5 37 (31-40)	35.1 ±6.9 36 (31-40)	33.6 ±7.2 34 (29, 39)	37.1 ±5.6 * 38 (34, 41)
Object control raw score [§]	29.7 ±5.9	31.7 ±5.5	28.2 ±5.8 [#]	28.1 ±5.7	31.6 ±5.7 *
Locomotor standard score [§§]	11.6 ±3.0	11.8 ±2.8	11.6 ±3.1	10.9 ±3.1	12.5 ±2.6 *
Object control standard score [§§]	11.0 ±2.6	10.9 ±2.1	11.0±2.9	10.4 ±2.4	11.7 ±2.6 *
GMQ [§§§]	107.7 ±14.2	108.0 ±12.5	107.6 ±15.2	103.8 ±14.6	112.5 ±12.1 *

Data are presented as mean±SD for normally distributed data, and median (IQR) for not-normally distributed data
*Indicates a significant difference between the preschool and grade R children (p<0.05)
#Indicates a significant difference between boys and girls (p<0.05)
GMQ=gross motor quotient
§TGMD-2 raw scores (locomotor and object control) calculated as 'out of 48'
§§TGMD-2 standard scores (locomotor and object control) between 8-12 are regarded as 'average', 13-14 as 'above average' and >15 as 'superior' or very superior
§§§TGMD-2 GMQ scores between 90-110 is regarded as 'average', 111-120 as 'above average' and >121 as 'superior' or very superior

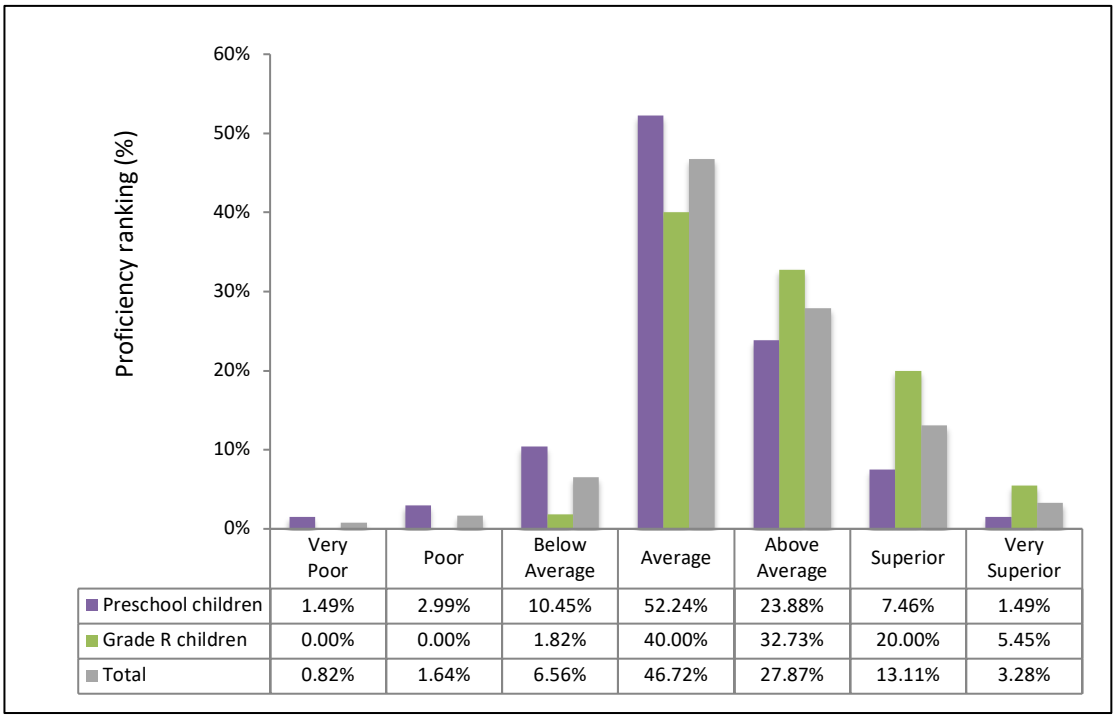
Gross motor skill proficiency using TGMD-2 rankings

Figures 6.1 and 6.2 illustrate the proportion of children per proficiency ranking (from very poor to very superior) by sex and setting, respectively. The majority of the children in the sample (91%) achieved an average or higher ranking. There were no differences between boys and girls. Grade R children were significantly better at performing the gross motor skills compared with preschool children (χ^2=12.7, p=0.047). Significantly more Grade R children had a ranking of above average, superior or very superior compared to preschool children (32.83% vs. 58.18%, p<0.05).



	Very Poor	Poor	Below Average	Average	Above Average	Superior	Very Superior
Boys	0.0%	3.8%	3.8%	45.3%	32.1%	13.2%	1.9%
Girls	1.4%	0.0%	8.7%	47.8%	24.6%	13.0%	4.3%
Total	0.8%	1.6%	6.6%	46.7%	27.9%	13.1%	3.3%

Figure 6.1 Proportion of boys and girls in each gross motor skills ranking category



	Very Poor	Poor	Below Average	Average	Above Average	Superior	Very Superior
Preschool children	1.49%	2.99%	10.45%	52.24%	23.88%	7.46%	1.49%
Grade R children	0.00%	0.00%	1.82%	40.00%	32.73%	20.00%	5.45%
Total	0.82%	1.64%	6.56%	46.72%	27.87%	13.11%	3.28%

Figure 6.2 Proportion of Preschool and Grade R children per gross motor skills ranking category

Gross motor skill proficiency for individual skills

Figures 6.3 and 6.4 illustrate the differences between boys and girls for locomotor skills and object control skills, respectively. In terms of locomotor skills, both boys and girls had greatest proficiency in the run (86.3% and 88.9%, respectively) and the hop (81.7% and 81.9%, respectively). Boys were least proficient in performing the gallop and girls were least proficient in performing the leap. In terms of object control skills, both boys and girls had

greatest proficiency in the kick. Overall, the average proficiency for object control skills was poorer than that of locomotor skills. The three poorest object control skills included the throw (52.0%), roll (51.9%) and stationary dribble (46.0%). Comparisons between boys and girls revealed that boys had significantly higher proficiency scores than girls for the leap ($p<0.001$) (Figure 6.3), as well as the strike ($p=0.003$), stationary dribble ($p<0.001$) and kick ($p<0.001$) (Figure 6.4).

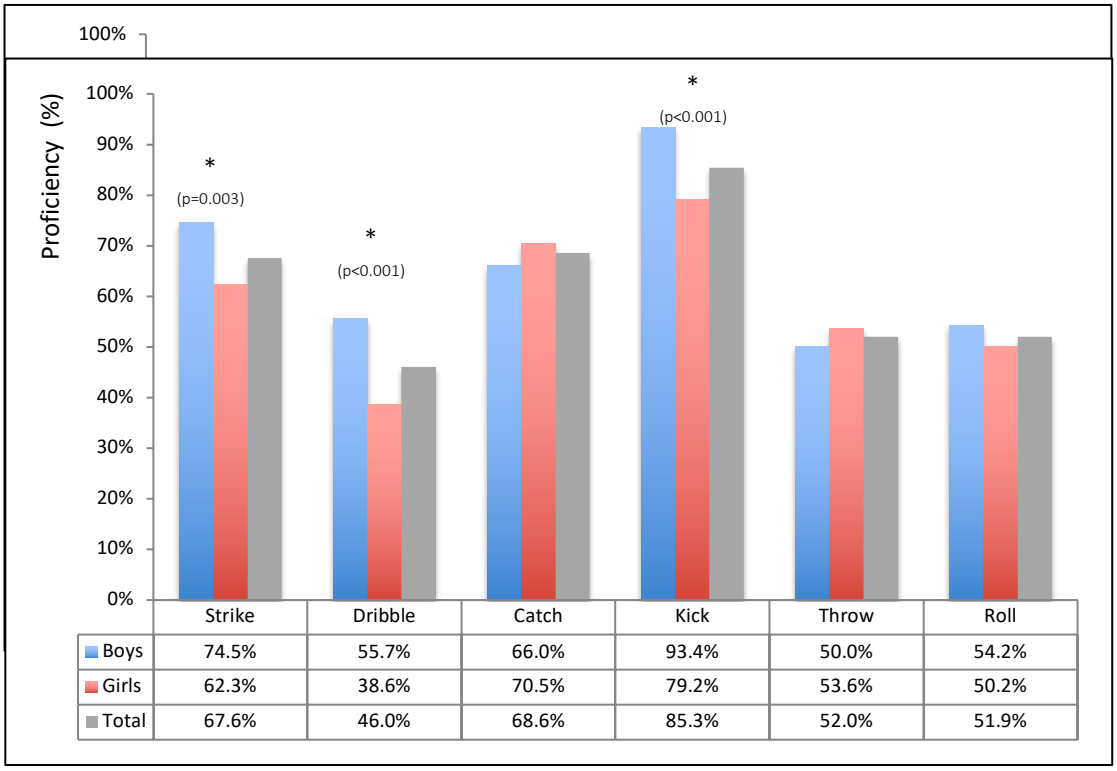


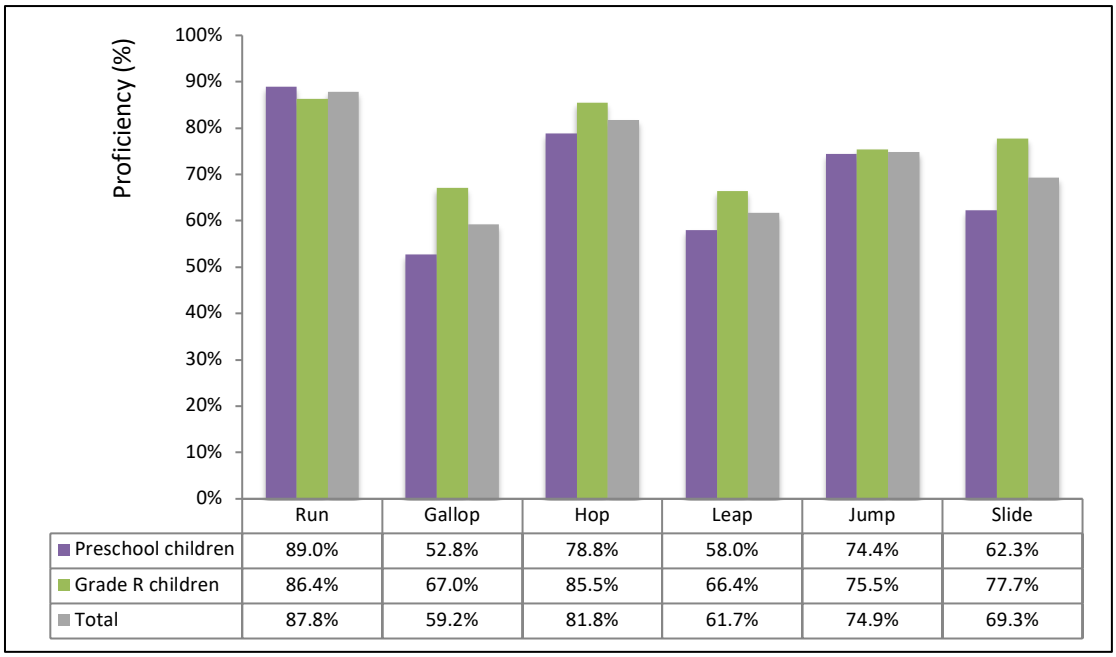
Figure 6.3 Proficiency of locomotor skills, by sex

Figure 6.4 Proficiency of object control skills, by sex

Figures 6.5 and 6.6, respectively, show the differences between settings (preschool and Grade R) for locomotor and object control skill raw scores. Grade R children were significantly more proficient in the gallop and slide compared to preschool children ($p=0.039$ and $p=0.005$, respectively). Grade R children also showed significantly greater proficiency in three of the object control skills, namely the strike ($p=0.036$), stationary dribble ($p<0.001$) and catch ($p<0.001$) compared with preschool children.

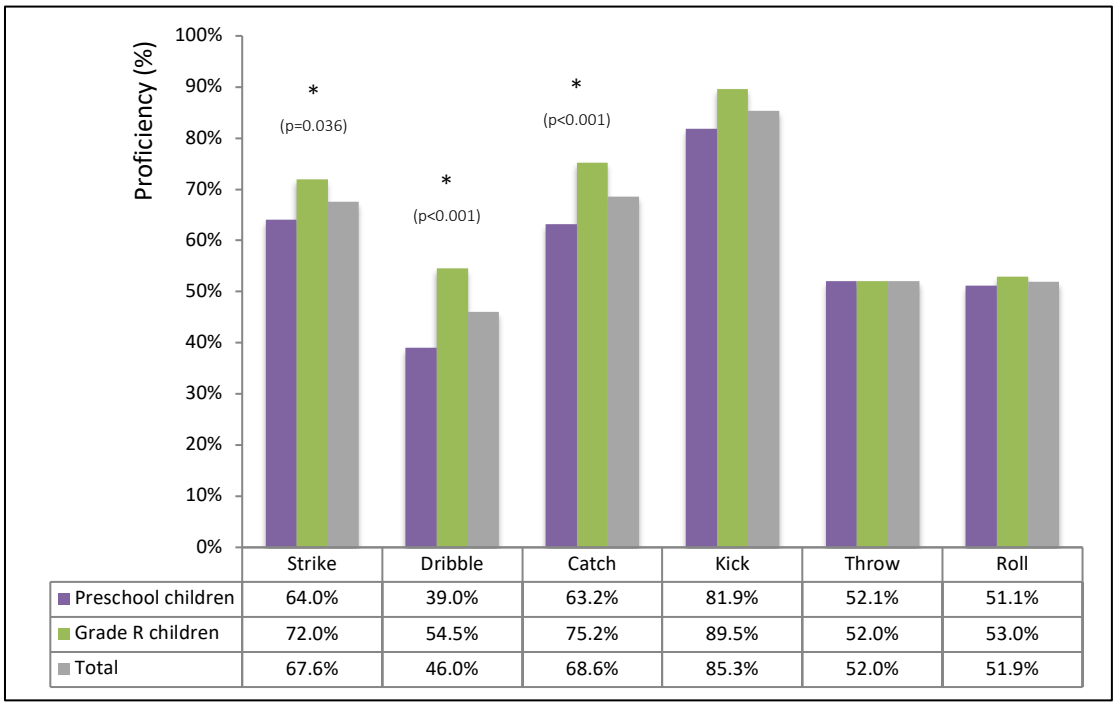
*
(p=0.005)

*
(p=0.039)



	Run	Gallop	Hop	Leap	Jump	Slide
Preschool children	89.0%	52.8%	78.8%	58.0%	74.4%	62.3%
Grade R children	86.4%	67.0%	85.5%	66.4%	75.5%	77.7%
Total	87.8%	59.2%	81.8%	61.7%	74.9%	69.3%

Figure 6.5 Proficiency of locomotor skills, by setting



	Strike	Dribble	Catch	Kick	Throw	Roll
Preschool children	64.0%	39.0%	63.2%	81.9%	52.1%	51.1%
Grade R children	72.0%	54.5%	75.2%	89.5%	52.0%	53.0%
Total	67.6%	46.0%	68.6%	85.3%	52.0%	51.9%

Figure 6.6 Proficiency of object control skills, by setting

6.3 Associations with gross motor skill proficiency

Gross motor skill proficiency and weight status

There were no associations between BAZ and any of the gross motor variables, including GMQ, locomotor or object control scores (standardised and raw scores). There were also no differences in any gross motor skill variables scores and IOTF weight status, indicating that in this sample of preschool children, gross motor skill proficiency is not associated with body composition.

One hundred and nine participants had valid TGMD-2 and accelerometry data. Regression analyses were performed to establish the factors associated with higher gross motor skill proficiency (represented by a higher GMQ). Characteristics of the sample included in these analyses are shown in Table 6.3.

Table 6.3 Sample characteristics of children with valid TGMD-2 and accelerometry data

Variable	Total (n=109)
Sex	n=48 boys; 44%
Age (y)	5.0± 0.6
BAZ	-0.1± 1.0
WAZ	-0.3± 1.0
HAZ	-0.4± 1.0
GMQ	107.5± 14.5
LPA (minutes per day)	382.5± 41.2 (382, 354-408)
MPA (minutes per day)	79.6± 30.9 (77, 57-99)
VPA (minutes per day)	14.8± 12.9 (11, 7-17)
MVPA (minutes per day)	94.4± 41.6 (88, 68-112)
LMVPA (minutes per day)	476.9± 51.4 (479, 449-513)
PA data shown as mean±SD (median, IQR) BAZ=BMI-for-age z-score, WAZ=weight-for-age z-score, HAZ=height-for-age z-score, GMQ=Gross motor quotient, LMVPA=light-to vigorous-intensity physical activity, MVPA=moderate- to vigorous-intensity physical activity, MPA=moderate-intensity physical activity, VPA=vigorous-intensity physical activity, LPA=light-intensity physical activity.	

Regression results for the variables associated with gross motor skill proficiency (using the GMQ) are shown in Table 6.4. Five different models are shown, each with a different physical activity variable. All five of the models were significant ($p<0.05$), and sex and body composition were shown to have no association with higher GMQ in any of the five models. Age was shown to be significantly associated with greater gross motor skill proficiency in all five models, irrespective of physical activity intensity (all $p<0.001$). The results of the first regression model ($p=0.001$, $R^2=0.16$, adjusted $R^2=0.13$) suggest that LMVPA is not associated with greater gross motor skill proficiency, as age was the only significant predictor of gross motor skill proficiency in this model. The second regression model ($p=0.0001$, $R^2=0.21$, adjusted $R^2=0.18$) showed that MVPA was positively associated with greater gross motor skill proficiency. As such, when separated, MPA and VPA were shown to be significantly and positively associated with greater gross motor skill proficiency (in the third model: $p=0.0001$, $R^2=0.21$, adjusted $R^2=0.18$, and fourth model: $p=0.0001$, $R^2=0.21$, adjusted $R^2=0.18$, respectively). Furthermore, for every minute of vigorous-intensity physical activity achieved on a single day, the model suggests that the child's GMQ increased by 0.31. The fifth regression model assessed whether age, sex, BAZ and LPA predicted greater gross motor skill proficiency. As with LMVPA, the results of the fifth regression model ($p=0.0012$, $R^2=0.16$,

adjusted R^2=0.13) suggest that LPA is not associated with greater gross motor skill proficiency, as age was the only significant predictor of gross motor skill proficiency in this model. Based on the regression analyses performed, age, MPA and VPA are predictors of GMQ in this rural sample of preschool children, while sex, body composition and physical activity of a light intensity are not.

Table 6.4 Factors associated with gross motor quotient (5 models shown)

Variables	Coefficient	t-value	p-value	95%CI
Model 1:				
Age	8.91	4.35	0.000	4.85,12.98
Sex (ref: boys)	0.88	0.32	0.748	-4.55, 6.31
BAZ	-0.14	-0.10	0.918	-2.75, 2.48
LMVPA	0.03	1.19	0.235	-0.02, 0.08
Constant	46.28	2.63	0.010	35.23, 79.99
Model 2:				
Age	7.12	3.41	0.001	2.98, 11.26
Sex (ref: boys)	3.15	1.12	0.266	-3.03, 7.7
BAZ	-0.28	-0.22	0.827	-2.80, 2.24
MVPA	0.10	2.75	0.007	0.03, 8.73
Constant	57.61	5.11	0.000	35.23, 79.99
Model 3:				
Age	7.41	3.54	0.001	3.26, 11.55
Sex (ref: boys)	2.99	1.05	0.297	-2.67, 8.64
BAZ	-0.14	-0.11	0.913	-2.67, 2.39
MPA	0.11	2.45	0.016	0.02, 0.21
Constant	56.33	4.90	0.000	33.54, 79.12
Model 4:				
Age	7.15	3.44	0.001	3.03, 11.26
Sex (ref: boys)	2.35	0.87	0.388	-3.03, 7.7
BAZ	-0.46	-0.36	0.720	-2.99, 2.07
VPA	0.31	2.84	0.005	0.09, 0.52
Constant	63.18	5.67	0.000	41.09, 85.26
Model 5:				
Age	8.15	3.76	0.000	3.85, 12.45
Sex (ref: boys)	0.97	0.35	0.726	-4.52, 6.47
BAZ	0.28	0.22	0.830	-2.31, 2.88
LPA	-0.03	-0.99	0.326	-0.10, 0.03
Constant	77.81	3.98	0.000	39.06, 116.56

BAZ=BMI-for-age z-score, LMVPA=light-to vigorous-intensity physical activity, MVPA=moderate-to vigorous-intensity physical activity, MPA=moderate-intensity physical activity, VPA=vigorous-intensity physical activity, LPA=light-intensity physical activity.

Regressions were also conducted to determine the factors that are associated with MPA, VPA and MVPA (shown in Table 6.5). Variables included were age, sex, body composition variables and GMQ. The model looking at factors associated with MPA was significant (p=0.000, R^2=0.27, adjusted R^2=0.24), with sex (boys) and GMQ showing associations with higher levels of MPA. The second model looking at variables associated with VPA was significant (p=0.000, R^2=0.24, adjusted R^2=0.21), with sex (boys) and GMQ being associated with higher levels of VPA. The p-values of BAZ and age approached significance. The third model looked at the factors associated with MVPA. The model was significant (p=0.000, R^2=0.29, adjusted R^2=0.26), GMQ was positively associated with higher levels of MVPA.

Table 6.5 Factors associated with moderate- and vigorous-intensity physical activity

Variables	Coefficient	t-value	p-value	95%CI
Model 1: Predictors of MPA				
Age	8.28	1.87	0.064	-0.48, 17.04
Sex (ref: boys)	-22.13	-4.10	0.000	-32.85, -11.42
BAZ	2.34	0.91	0.367	-2.78, 7.46
GMQ	0.47	2.45	0.016	0.09, 0.86
Constant	21.86	0.85	0.399	-29.32, 73.04
Model 2: Predictors of VPA§				
Age	3.42	1.82	0.071	-0.30, 7.15
Sex (ref: boys)	-6.22	-2.71	0.008	-10.77, -1.67
BAZ	1.90	1.73	0.087	-0.28, 4.07
GMQ	0.23	2.84	0.005	0.07, 0.40
Constant	-23.89	-2.31	0.023	-44.40, -3.37
Model 3: Predictors of MVPA				
Age	11.70	1.99	0.049	0.04, 23.36
Sex (ref: boys)	-28.35	-3.95	0.000	-42.6, -14.10
BAZ	4.24	1.23	0.220	-2.57, 11.04
GMQ	0.70	2.75	0.007	0.20, 1.22
Constant	-24.16	-0.75	0.457	-88.36, 40.05

BAZ=BMI-for-age z-score, MVPA=moderate-to vigorous-intensity physical activity, MPA=moderate-intensity physical activity, VPA=vigorous-intensity physical activity, GMQ=gross motor quotient

6.4 Summary

In summary, rural preschool-aged children have good gross motor skills, with more than 90% of children achieving an average or higher ranking for proficiency according to the TGMD-2. Boys had greater proficiency than girls in the leap, strike, dribble and kick. The Grade R children achieved significantly higher standardised and GMQ for gross motor skills than the preschool children. Grade R children were better at performing the gallop, slide, strike, stationary dribble and the catch compared to children attending the preschool setting. Neither body composition nor sex was associated with gross motor skill proficiency in this sample. However, gross motor skill proficiency and physical activity were positively associated, although these associations were stronger with physical activity at higher intensities.

Chapter Seven:
Direct observation of physical activity and sedentary behaviour

This chapter aimed to describe the following in a sample of preschool-aged children from a rural, low-income setting in South Africa:

1. Directly observed physical activity and sedentary behaviour within the preschool setting, as well as contextual and individual-level factors of physical activity,
2. Associations between gross motor skills, body composition and physical activity (directly observed).

Specific objectives within this aim include:

i. Investigate differences between boys and girls,
ii. Investigate differences between children from Preschool and Grade R settings,
iii. Identifying factors that are associated with higher levels of physical activity in the preschool environment.

A total of 1693 observations were completed (n=1066 of preschool children, n=627 of Grade R children) using the OSRAC-P. It is important to note that although this chapter reports on physical activity and sedentary behaviour in the context of the preschool environment, no direct comparisons are between the data presented in this chapter and Chapter 5. This chapter reports exclusively on the results from the observations using the OSRAC-P tool. In this chapter, 'the preschool day' refers to the school day (or time spent at school) for children from both settings (Preschool and Grade R).

7.1 Descriptive characteristics

Table 7.1 summarises the descriptive results for the children who were observed using the OSRAC-P tool. The boys and girls in the OSRAC-P sample were similar in BMI and other body composition variables. The only characteristic that was different between the preschool and Grade R children was their age (p=0.000) with Grade R children being older. Additionally, Table 7.1 also shows the percentages of observed children per weight status category according to the IOTF cut-offs [21]. There were two obese children in the OSRAC-P sample of children, but no overweight children. The distribution of children in the healthy weight and 'thin' categories were similar to that described in the TGMD sample in the previous chapter (69.1% and 27.3%, respectively).

Table 7.1 Descriptive characteristics of children that participated in the direct observation

	Total (n=55)	Boys (n=23)	Girls (n=32)	Preschool (n=33)	Grade R (n=22)
Age (y)	5.0 ±0.7	4.9 ±0.7	5.0 ±0.6	4.5 ±0.4	5.6 ±0.3*
BMI (kg.m^{-2})	15.1 ±1.5	15.3 ±1.2	14.9 ±1.7	15.2 ±1.5	14.9 ±1.6
BAZ	-0.2 ±1.0	-0.0 ±1.0	-0.3 ±1.1	-0.1 ±1.0	-0.3 ±1.0
WAZ	-0.3 ±0.9	-0.2 ±0.8	-0.4 ±1.0	-0.3 ±0.9	-0.2 ±1.0
HAZ	-0.3 ±1.0	-0.3 ±1.1	-0.3 ±1.0	-0.4 ±1.1	-0.1 ±0.7
IOTF weight status					
Thinness	27.3%	17.4%	34.4%	24.2%	31.8%
Normal weight	69.1%	82.6%	59.4%	72.7%	63.6%
Overweight/Obese	3.6%	0.0%	6.2%	3.0%	4.5%

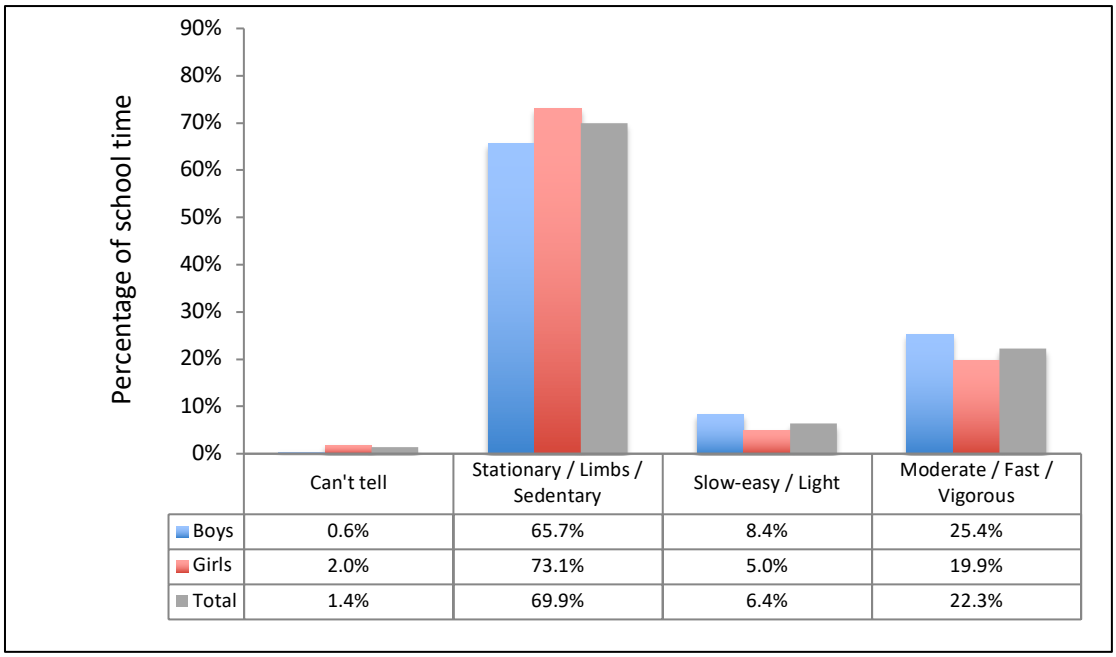
Data are presented as mean±SD
BAZ=BMI-for-age z-score, WAZ=weight-for-age z-score, HAZ=height-for-age z-score.
*Indicates a significant difference between the Preschool and Grade R children ($p<0.05$).
Thinness includes thinness categories 1,2 and 3; Obese category includes morbidly obese category.

7.2 Levels of physical activity and sedentary behaviour

For the following results, the OSRAC-P physical activity categories are combined as follows [95,301]:

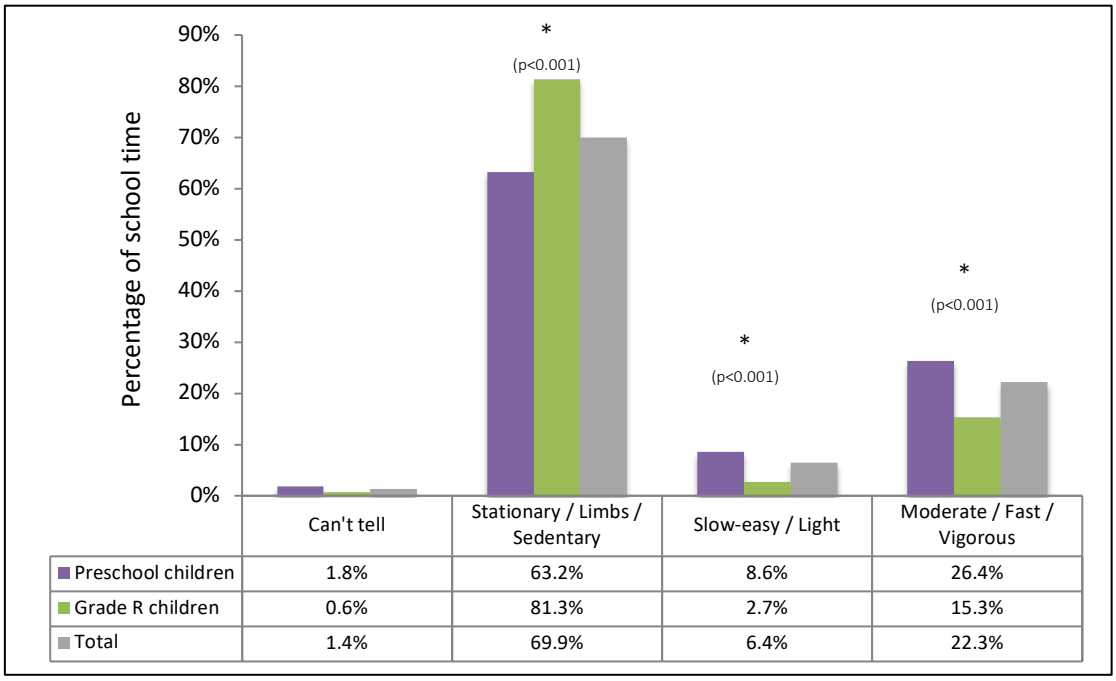
- 'stationary' and 'limb movement' are referred to collectively as sedentary behaviour,
- 'slow easy' is referred to as LPA,
- 'moderate' and 'fast' are referred to collectively as MVPA.

Irrespective of setting, children spent the greatest proportion of time in sedentary behaviour. As a whole, children spent 69.9% of the preschool day (08:00 until ±12:00) engaged in sedentary behaviour, 6.4% in LPA, and 22.3% in MVPA. Figures 7.1 and 7.2 illustrate the differences between sex and setting for proportion of time spent in each activity level, respectively. There were no observed differences between the percentage of time spent in each intensity level between the boys and girls. The chi-square analyses showed that during school time, the preschool children participated in significantly more LPA (9% vs. 3%, $p<0.001$) and MVPA (26% vs. 15%, $p<0.001$), and spent significantly less time in sedentary behaviour (81% vs. 63%, $p<0.001$) than the Grade R children.



	Can't tell	Stationary / Limbs / Sedentary	Slow-easy / Light	Moderate / Fast / Vigorous
Boys	0.6%	65.7%	8.4%	25.4%
Girls	2.0%	73.1%	5.0%	19.9%
Total	1.4%	69.9%	6.4%	22.3%

Figure 7.1 Proportion of time spent in different physical activity intensities, by sex



	Can't tell	Stationary / Limbs / Sedentary	Slow-easy / Light	Moderate / Fast / Vigorous
Preschool children	1.8%	63.2%	8.6%	26.4%
Grade R children	0.6%	81.3%	2.7%	15.3%
Total	1.4%	69.9%	6.4%	22.3%

Figure 7.2 Proportion of time spent in different physical activity intensities, by setting

7.3 Characteristics of physical activity type and group composition

Table 7.2 summarises the OSRAC-P categories pertaining to the type of activity, group composition (i.e. with or without an adult), initiator of activity (i.e. adult or child) and prompt for activity (with or without teacher prompts), by setting. All tabulated variables within each category are listed in descending order for the total sample, with the exception of 'cannot tell', which is always listed last, when applicable. The types of activities observed differed significantly between the preschool and Grade R children (p=0.000). Preschool children

engaged in a greater variety of types of activities, compared to the Grade R children. Six out of 19 OSRAC-P categories of activities were not observed and hence are not included in Table 7.2. These included 'dancing, expressive movement', 'cycling, skateboarding, roller skating, scooter', 'rocking on a teeter totter or on a horse', 'swimming or playing in a pool', 'rolling' and 'other'. Neither of the settings had any equipment with wheels, and therefore no riding activities were observed. One of the preschools had a teeter totter (called a see-saw in South Africa), but children were not observed using it.

Grade R children spent almost 50% of their school day seated compared to 39.2% for Preschool children. The percentage of activities initiated by the teachers differed significantly between the settings: 81.8% for the Grade R children vs. 46.7% for the Preschool children. Children spent about half their time in groups with an adult. However, there were minimal prompts to change the intensity or type of physical activity when the children were outdoors and/or during free playtime (96.5% and 98.6% of activity coded as 'no teacher prompts' for the Preschool children and for the Grade R children, respectively).

Table 7.2 Characteristics of physical activity type and group composition

Category *	Total (%)	Preschool (%)	Grade R (%)	p-value
Type of activity				
Sitting, squatting, kneeling	36.7	39.2	49.6	p<0.001
Standing	28.0	25.6	32.1	
Walking, marching	13.5	13.4	13.6	
Lying down	6.0	9.5	0.0	
Climbing, hanging	4.9	7.8	0.0	
Running	2.7	3.2	1.8	
Swinging	1.8	2.9	0.0	
Jumping, skipping, hopping, galloping	1.5	2.0	0.8	
Crawling	1.5	2.4	0.0	
Dancing, expressive movement	0.7	0.7	0.8	
Pulling or pushing an object or child	0.5	0.8	0.0	
Throwing, kicking, catching	0.4	0.1	0.8	
Rough and tumble play, wrestling, tumbling	0.1	0.2	0.0	
Cannot tell	1.7	2.4	0.6	
Group composition				
Group with adult	48.0	41.3	59.5	p=0.000
Group without adult	35.3	35.7	34.6	
One-to-one with peer	9.4	13.2	2.9	
Solitary	5.3	7.5	1.6	
One-to-one with adult	0.8	0.8	0.8	
Cannot tell	1.2	1.6	0.6	
Initiator				
Adult-initiated activity	59.7	46.7	81.8	p=0.000
Child- or peer-initiated activity	38.9	51.0	18.2	
Cannot tell who initiated	1.4	2.3	0.0	
Prompt for physical activity				
No teacher prompts	97.3	96.5	98.6	p=0.100
Teacher prompts child to maintain/increase PA	0.8	1.2	0.2	
Peer prompts child to maintain/increase PA	0.3	0.3	0.3	
Teacher prompts child to stop/decrease PA	0.3	0.3	0.3	
Peer prompts child to stop/decrease PA	0.1	0.2	0.0	
Cannot tell	1.2	1.5	0.6	
*Category code names are listed as in the OSRAC-P manual)				

Table 7.3 refers to the OSRAC-P categories pertaining to location (i.e. outside the centre, inside the centre, transition) or indoor and outdoor play context (for example, for indoors – group or circle time, transition, etc. and for outdoors – open space, fixed equipment, ball or object play etc.). All tabulated variables within each category are listed in descending order for the total sample. The times spent in different locations differed significantly between Preschool and Grade R children. Preschool children spent significantly more time outdoors than Grade R children (p=0.000) and had access to fixed play equipment (that was used 37.1% of the time spent outdoors). Six out of the 15 outdoor play context categories built into

the OSRAC-P were not observed. Those not observed were 'swimming pool', 'portable equipment', 'sociodramatic play props', 'time-out', 'riding or using push toys with wheels' and 'sandbox, designated digging area'. Activities that involved children playing in the sand (for example, using a stick to draw patterns in the sand), or activities that used the sand area (for example, in a game of tag), were coded as 'open space' activities.

Grade R children spent significantly more time indoors (p=0.000) compared to Preschool children, with a substantial percent of this time in 'group or circle time'. The Grade R children also spent 36.7% of their indoor time in 'transition between centres and activities or major classroom activities in the schedule'. Six out of the 18 indoor play contexts built into the OSRAC-P were not observed. Children were never observed in the play contexts of 'large block centres and activities', 'music centres or activities', 'socio-dramatic and pretend centres and activities', 'teacher-arranged and lead gross motor physical activity', 'computer, TV and videotapes', and 'other'. None of the schools in either setting had any blocks or any props for socio-dramatic or pretend play.

Table 7.3 OSRAC-P category location breakdown, by setting

Category	Total (%)	Preschool (%)	Grade R (%)	p-value
Location				
Outside the centre or building	54.6	62.6	41.2	p=0.000
Inside the centre or building	42.9	34.6	56.9	
Transition between inside and outside areas or between two settings in a preschool facility	2.5	2.8	1.9	
Outdoor context				
Open space or non-designated area	36.2	34.7	40.0	p=0.000
Fixed equipment	26.8	37.1	0.0	
Snacks, meals and food	16.9	12.9	27.5	
Teacher-arranged and lead gross motor physical activity	16.8	13.9	24.3	
Ball or object play	2.2	0.9	5.5	
Formal game	1.0	0.5	2.4	
Cannot tell	0.2	0.2	0.4	
Indoor context				
Group or circle time	42.7	39.4	46.2	p=0.000
Transition	23.2	10.2	36.7	
Nap and rest times	11.8	23.1	0.0	
Snacks, meals and food	8.5	9.7	7.3	
Self-care and self-help areas	5.6	9.7	1.4	
Books, pre-academic, writing, listening, science and math centres and activities	4.9	1.9	8.1	
Art centres and activities	1.4	2.7	0.0	
Gross motor activities	0.7	1.3	0.0	
Manipulative, fine motor and sensory centres and activities	0.1	0.3	0.0	
Cannot tell	1.1	1.9	0.3	

Figure 7.3 illustrates the patterns of physical activity for the school day in each setting. In instances where the children could not be seen, for example when a child was at the bathroom, their activity level was coded as 'cannot tell'. Overall, the Preschool settings had more variation of activity during their school day, with the exception of Preschool 1 having naptime towards the end of the preschool day. This contrasted with the Grade R setting's OSRAC-P activity patterns, which was characterised by prolonged bouts of sedentary behaviour early in the school day.

Table 7.4 provides additional anecdotal observations made during the observation period (but not covered by the OSRAC-P). In the Preschool settings, the teachers' primary role was as a supervisor rather than a teacher who facilitated learning. In general, in the Preschool setting teachers were not motivated to provide opportunities for the children for learning. The Grade R teachers took on a more of a teaching role, with the focus on preparation for the formal learning environment (Grade One), however the teachers (much like those in the Preschool setting) did not seem to have much enthusiasm for educating the children, and appeared to have little pedagogical insight or skill.

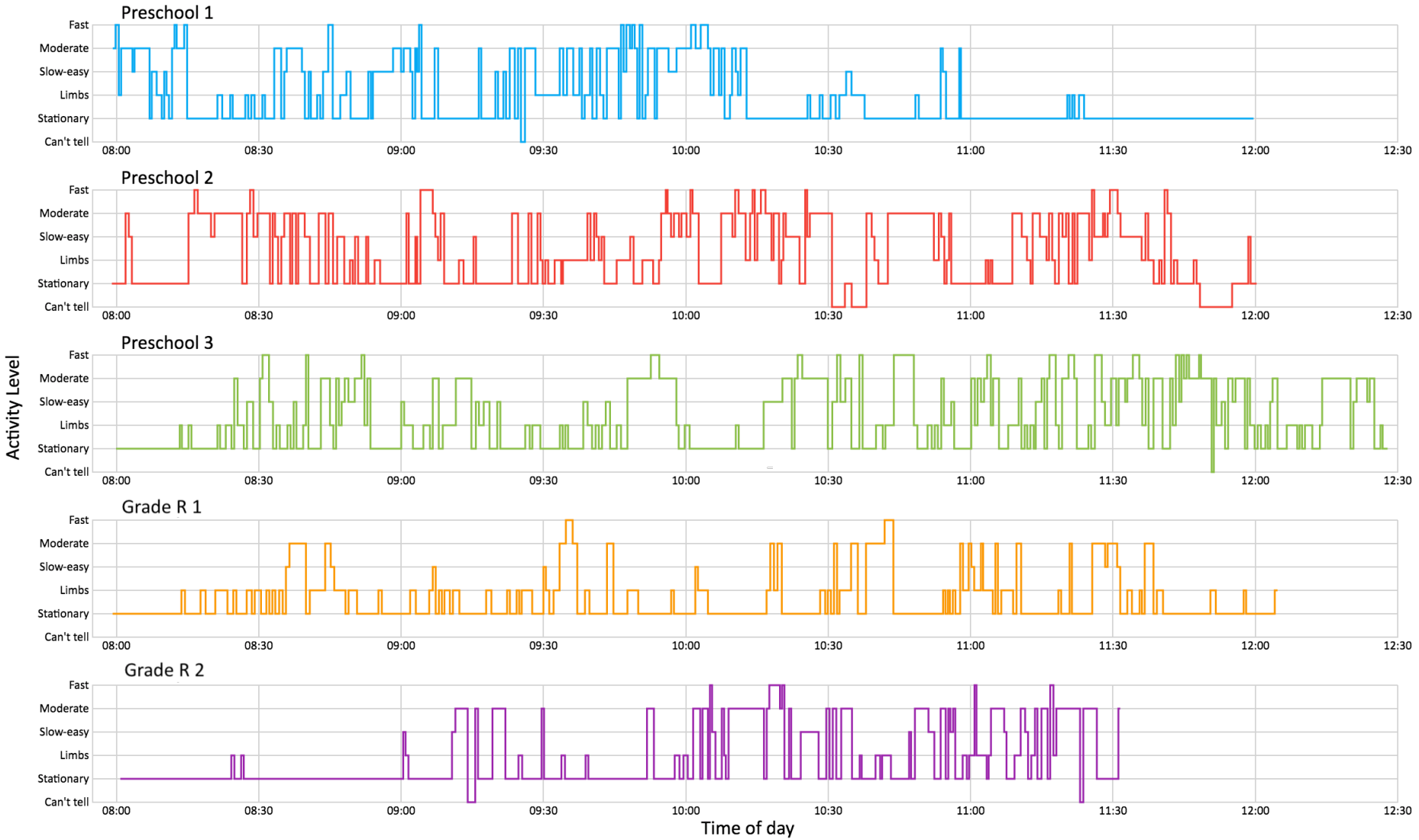


Figure 7.3 Pattern of activity observed throughout the school day, by school (setting and number)

Table 7.4 Anecdotal observations of teachers in Preschools and Grade R settings

Preschool 1	Preschool 2	Preschool 3	Grade R	Grade R 2
• The main role of the teachers appeared to be supervision of the children, as opposed to teaching or facilitating activities, within a relatively loosely structured day (in spite of the written schedules observed). In some respects, the preschools function as day-care or 'crèche' facilities, although the majority of the teachers seem have little passion for early childhood development, and their interactions with the children could often be described as apathetic and/or indifferent, and occasionally punitive. • Children under the age of 3 years (including infants) also attended the preschools, and teachers' attention seemed to be somewhat divided between the preschool and younger children. • The principals of the preschools were not often at the preschools. • Teacher-arranged gross motor activities included games using hula-hoops and fixed equipment, or games like 'duck-duck-goose' (facilitated by one teacher).			• The main role of the Grade R teachers appeared to be teaching and preparation for Grade One. To the best of our knowledge, teachers in the primary school settings have the minimum training required for Grade R teaching. However, the teachers did not seem to have much enthusiasm for educating children, and appeared to have little pedagogical insight or skill. • Teachers were slightly less punitive and more responsive to children, although they were not particularly attentive to the individual needs of children in their class, or to the social dynamics within the class. • Outdoor games often started with teachers being involved, but their interest was not for the full duration of the game.	
• One teacher appeared to be more knowledgeable and skilled regarding early childhood development, and was also the parent of one of the children. This teacher used more educational tools for learning, including pegboards and small blue chalkboards. There were enough so that children had their own; and children appeared to be familiar with the educational tools. • The other teacher was stricter, especially at naptime: Restless children were disciplined using a stick. During naptime, the teachers napped as well. • Teachers were grateful for the opportunity to be involved in the study.	• Teaching was often in the form of chanting or "parrot-style" learning: the teacher would say something, and the children repeated with no obvious understanding of the topic. No educational equipment was used at this school. • One teacher was a grandmother to one of the children. The principle of the school appeared to do more of the 'educational' activities, but this did not happen often. • While children were playing outside, teachers were observed using their mobile phones while sitting on the swings. • Teachers were less enthusiastic about their involvement in the study.	• Like preschool 1, one of the teachers appeared to be more knowledgeable about early childhood development. • During the group circle time, the children were given colouring-in books, but with no crayons or pencils. Another activity included the teacher asking each child (individually) to draw shapes on the chalkboard (on the wall of the classroom). • The principal was very accommodating of the researchers, but frequently asked for donations of resources for the preschool.	• During the observation period, it was common for teachers to stop the lesson to answer a mobile phone. • Despite their apparent lack of enthusiasm for teaching, teachers were gracious and welcoming to the researchers and seemed grateful for the opportunity to be involved in the study. The principal frequently asked for donations from the researchers. • At the time of the observation, the theme for the week was 'People who help us'. Children were taught about nurses, the police and doctors using pictures on the walls of the classroom. There was little inclusion of the children.	• One of the teachers was very accommodating of the researchers, but the other teacher routinely expected donations of resources for the school. The school principal was very welcoming of the researchers and accommodating of the research process. • At the time of the observation, the theme for the week was 'transport'. Children were shown pictures of taxi's and cars. There was a portion of the lesson that included the use of maths activity books (each child had their own book that appeared to have been worked in consistently).

7.4 Associations with physical activity in the preschool context

Table 7.5 provides a summary of the multinomial logistic regression results assessing factors within the preschool environment and gross motor skill proficiency (represented as by GMQ ranking from the TGMD-2) that are associated with physical activity intensity. The model was significant (p=0.000), and found that children were more likely to engage in LPA (vs. sedentary behaviour) if they were outdoors (p=0.021) or transitioning between outdoor and indoor environments (p=0.003), participating in an activity that was teacher-initiated (p=0.000), and if their GMQ ranking was 'below average' (p=0.044). Although sex was not associated (p=0.096) with LPA, the relative risk ration (RRR) indicates that girls are almost 40% less likely to engage in LPA than boys. Weight status and GMQ ranking were not associated with LPA.

In the same model, significant factors associated with higher levels of MVPA (vs. sedentary behaviour) included being outdoors or in transition (both p=0.000), engaging in a teacher-initiated activity (p=0.000), and higher GMQ ranking ('above average' p=0.018; 'superior' p=0.000). Children who achieved a GMQ ranking of 'above average' were 1.5 times more likely to participate in MVPA, and children who had a GMQ ranking of 'superior' were 2.5 times more likely to participate in MVPA. Preschool children who were overweight/obese were almost 80% less likely to engage in MVPA in the preschool setting (p=0.006). Sex was not associated with MVPA.

Table 7.5 Multinomial logistic regression results assessing factors associated with physical activity

	RRR	95% CI	p-value
Light PA (vs. sedentary behaviour)			
Sex			
Boy (ref)	1.00		
Girl	0.63	0.37 – 1.08	0.096
IOTF weight status			
Normal weight (ref)	1.00		
Thinness	0.75	0.37 – 1.51	0.420
Overweight/obese	0.33	0.07 – 1.55	0.160
Location			
Inside (ref)	1.00		
Transition	12.22	2.31 – 64.80	0.003
Outside	2.40	1.14 – 5.06	0.021
Initiator			
Adult (ref)	1.00		
Child	0.23	0.12 – 0.45	0.000
TGMD-2 rank			
Average (ref)	1.00		
Below average	2.66	1.02 – 6.88	0.044
Above average	1.30	0.75 – 2.26	0.342
Superior	1.00	0.50 – 1.98	0.990
MVPA (vs. sedentary behaviour)			
Sex			
Boy (ref)	1.00		
Girl	0.88	0.62 – 1.25	0.485
IOTF weight status			
Normal weight (ref)	1.00		
Thinness	0.79	0.52 – 1.19	0.263
Overweight/obese	0.21	0.07 – 0.64	0.006
Location			
Inside (ref)	1.00		
Transition	294.38	81.42 – 1064.27	0.000
Outside	27.83	13.20 – 58.66	0.000
Initiator			
Adult (ref)	1.00		
Child	0.55	0.39 – 0.77	0.000
TGMD-2 rank			
Average (ref)	1.00		
Below average	2.09	0.94 – 4.67	0.071
Above average	1.55	1.07 – 2.23	0.018
Superior	2.50	1.67 – 3.75	0.000
LR chi^2=478.93, p=0.000, Pseudo R^2=0.23			

RRR=relative risk ratio, CI=confidence interval, IOTF=International obesity task force, MVPA=moderate- to vigorous-intensity physical activity

7.5 Summary

These direct observations provide contextual information about the location, type, and context of the children's physical activity and sedentary behaviour. Findings highlight that characteristics of the school day differ substantially between the Preschool and Grade R settings such that children attending preschools are more physically active during their school day, whereas Grade R children have more time dedicated to learning and educational activities and are therefore more sedentary.

There are some similarities between the two settings, including an overall lack of variety of indoor and outdoor activities that are otherwise typical for preschool children (as described in the OSRAC-P manual). Although there were several observed activities that were initiated and/or led by the teachers, the teachers did very little to motivate children to maintain or increase physical activity (less than 3% of observations for all schools combined).

Factors associated with physical activity in the preschool context included gross motor skill proficiency, being outdoors, weight status and being engaged in an activity initiated by a teacher. Sex was not found to be associated with physical activity during the school hours.

Chapter Eight:
Parents' perceptions of home and community factors influencing pre-schooler's physical activity and sedentary behaviour

This chapter aimed to describe the following in a sample of preschool-aged children from a rural, low-income setting in South Africa:

1. Parent and/or caregiver perceptions of home and community factors that influence physical activity and sedentary behaviour;
2. Parent-reported child screen time.

Specific objectives within these two aims include:

i. To investigate differences between parent reports for boys and girls,
ii. To investigate differences between parent reports for children from Preschool and Grade R settings,

One hundred and forty-three parents completed the questionnaire. Two questionnaires were excluded from analysis: One because the parent indicated that the child was younger than three years of age, and the other because the parent did not disclose the sex of the child when completing the questionnaire. More parents of Grade R children completed the survey compared to parents of Preschool children (n=85, 60.3% vs. n=56, 39.7%, respectively). The mean age of parents was 39.1±13.9 years (range 16.5 – 76.9 years). The results that follow are reported according to the corresponding sections of the questionnaire, as described in the methods chapter (Table 3.5 in Chapter 3).

8.1 Demographic characteristics

Demographic information of parents is reported in Table 8.1. The majority of parents were women (96.5%), who spoke either Xitsonga or Sotho at home. More than half of the sample had not completed formal schooling: 54.6% had lower than a Grade 12 qualification. Most households (77.5%) reported having at least one other child under the age of 18 years living in the same home and 71.1% reported not owning a car. The relationship of the parent to the child differed between boys and girls. There were significantly more grandmothers reporting on preschool-aged girls (their granddaughters, 37.9%) and more mothers reporting on preschool-aged boys (their sons, 65.8%; p=0.039). However, the difference in the ages of the parents when stratified by child sex was not significant (41.6y versus 37.1y respectively, p=0.189). Additionally, when stratified by child sex, the level of education between the parents differed significantly (p=0.049), with parents of girls having achieved a higher level of education in comparison to parents of boys. The marital status of parents differed between children from the two settings. More of the parents of Preschool children reported having never married, whereas more Grade R parents reported that they were married (p=0.039).

Table 8.1 Demographic characteristics of the parents by child sex and by setting

	Total n=141	Boys n=76	Girls n=65	Preschool n=56	Grade R n=85
Home language (n=141) [§]					
Xitsonga	56.6	56.6	56.9	62.5	52.9
Sotho	42.7	42.1	43.1	37.5	45.9
Relationship to the preschool child (n=141) [§§]					
Mother	62.0	65.8	56.9 [#]	64.3	60.0
Father	2.1	1.3	3.1 [#]	0	3.5
Grandmother	30.3	25.0	37.0 [#]	28.6	31.8
Aunt	4.2	7.9	0 [#]	7.1	2.4
Uncle	1.4	0	3.1 [#]	0	2.4
Marital status (n=141)					
Married	33.8	34.2	31.8	23.2	40.2 *
Divorced	9.9	7.9	13.6	10.7	10.3
Living together	16.2	14.5	18.2	14.3	17.2
Widowed	10.6	9.2	12.1	12.5	9.2
Separated	4.9	5.3	4.6	1.8	6.9
Never married	24.7	29.0	19.7	37.5	16.1 *
Highest level of education (n=141)					
Grade 6 or lower	20.6	21.1	20.3 [#]	21.4	20.2
Grade 7-9	9.2	11.8	6.3 [#]	7.1	10.7
Grade 10-11	24.8	19.7	29.7 [#]	16.1	29.8
Grade 12 / matriculated	31.2	39.5	21.9 [#]	39.3	26.1
Tertiary diploma / certificate	12.8	6.6	20.3 [#]	16.1	10.7
University degree	1.4	1.3	1.6 [#]	0	2.4
Number of other children in the home (n=141)					
0	22.5	26.3	18.5	23.2	22.4
1	28.9	21.1	36.9	30.4	27.1
2	20.4	22.4	18.4	17.9	22.4
3	15.5	17.1	13.9	14.3	16.5
4 or more	12.5	13.2	12.3	14.3	11.8
Owner of a motor vehicle (n=141)					
Yes	28.9	29.0	29.2	30.4	28.2
No	71.1	71.1	70.1	69.6	71.8

Data presented as %

[§] One parent indicated "other", but did not disclose the language

[§§] There were no questionnaires completed by grandfathers

[#] indicates a significant difference between boys and girls ($p<0.05$)

* indicates a significant difference between the preschool and grade R children ($p<0.05$)

8.2 Self-reported physical activity levels of parents

One hundred and seventeen parents (81.8%) had valid GPAQ data that was included for analysis. Data from 18 participants were not included in the analyses due to invalid reporting of data, for example when daily physical activity and sedentary behaviour exceeded 24 hours per day or hours spent in occupational MVPA exceeded the amount of reported daily working hours.

Table 8.2 summarises the GPAQ results. For the occupational and leisure domains, the MPA and VPA are combined. Travel-based activity is reported as MPA, by design of the GPAQ [296]. Twenty-one parents (16.8%) reported that their occupation involved MPA and/or VPA. Twenty parents (18.3%,) reported using active travel, and the majority of parents (n=98, 82.4%) reported that they engaged in leisure-time MPA and/or VPA. There were no significant differences between parents of boys and girls, nor between parents of Preschool and Grade R children.

Table 8.2 GPAQ results for parents, stratified by child sex and setting

Physical activity variable	Total n=117	Boys n=62	Girls n=54	Preschool n=41	Grade R n=76
Occupational MVPA (min.wk^{-1})	146.7± 421.6	99.7± 341.7	203.4± 498.4	163.0± 442.7	137.9± 412.5
Transport MPA (min.wk^{-1})	128.0± 411.4	106.5± 338.2	155.1± 487	170.9± 561.8	104.9± 303.2
Leisure time MVPA (min.wk^{-1})	587.0± 603.2	551.3± 615.3	638.9± 591.6	561.5± 524.4	600.8± 644.7
Total MVPA (min.wk^{-1})	861.7± 883.4	757.4± 811.1	997.4± 951.5	895.4± 883.5	843.6± 888.7
Average daily MVPA (min.d^{-1})	123.1± 126.2	108.2± 115.9	142.5± 135.9	127.9± 126.2	120.5± 126.9
Sitting time (hr.d^{-1})	5.2± 2.6	4.9± 2.4	5.5± 2.9	5.3± 2.7	5.1± 2.6
Data are presented as mean±SD					

8.3 Preschool children's behaviours at home

Table 8.3 shows parent-reported mean time to bed at night, and wake up time in the morning. Almost half of the parents (49.7%) reported that their child sleeps during the day at home, and this varied on weekdays (n=70) and weekend (n=66) days. The average time spent in daytime sleeping (napping) was 1.5±0.8 hours per day in the week (Monday to Friday) and 1.4±0.7 hours per day on Saturdays and Sundays. Times to bed and wake up times were similar between boys and girls. However, wake up times on weekdays differed significantly between Preschool and Grade R children (p=0.0001), with Grade R children waking up earlier.

Table 8.3 Parent-reported child mean times to sleep and time to wake up

	Total n=141	Boys n=76	Girls n=65	Preschool n=56	Grade R n=85
Weekdays					
Time to bed	19:39± 00:37	19:36± 00:40	19:40± 00:32	19:41± 00:39	19:36± 00:35
Wake up time	06:01± 00:35	06:02± 00:37	06:00± 00:33	06:12± 00:36	05:53± 00:32 *
Weekend days					
Time to bed	19:57± 00:42	19:55± 00:39	19:58± 00:47	19:59± 00:38	19:55± 00:46
Wake up time	07:22± 00:59	07:16± 01:02	07:28± 00:55	07:20± 00:58	07:23± 00:59

Data are presented as time of the day (in hh:mm) ±SD (as hh:mm)
*Indicates a significant difference between the preschool and grade R children ($p<0.05$)

Parents' agreement with statements pertaining to what their preschool child does at home is shown in Table 8.4. Approximately half of parents reported that their preschool child was active by themselves (51.8%) or with other children in the home (55.3%). The majority of parents agreed that their child was physically active when their child was with friends (85.1%), and that their child was physically active for longer when with someone else (85.1%). Responses given by parents of boys and girls were similar, as was the responses given between parents of Preschool and Grade R children.

Table 8.4 Parent report of child's physically active behaviours at home, reported as agree (%)

	Total n=141	Boys n=76	Girls n=65	Preschool n=56	Grade R n=85
My preschool child is physically active by him/herself	51.8	52.6	50.8	50.0	52.9
My preschool child is physically active with other children living in our home (e.g. outdoor play, rough-and-tumble)	55.3	53.9	56.9	55.4	57.6
My preschool child is physically active with his/her friends (e.g. outdoor play, rough-and-tumble)	85.1	80.3	90.8	85.7	84.7
My preschool child is active for longer when he/she is with someone else than when on his/her own	85.1	81.6	89.2	83.9	85.9
My preschool child is competitive with other children when being physically active	78.7	77.6	80.0	78.6	78.8

'Agree' inclusive of 'agree' and 'strongly agree' responses.

Parents indicated that their children choose to be more physically active than to be indoor, and sedentary (Table 8.5). Almost 70% of children 'never' or 'rarely' choose to watch TV rather than being active, and parents indicated that 80.1% of the children are not more likely to play electronic games than be active than. Parents' for boys and girls, as well as for Preschool and Grade R children were similar for all variables.

Table 8.5 Parent report of the child's physical activities and sedentary behaviours at home

	Total n=141	Boys n=76	Girls n=65	Preschool n=56	Grade R n=85
My preschool child is more likely to watch TV than be active [§]					
Never / rarely (%)	68.1	71.1	64.6	66.1	69.4
Sometimes (%)	24.8	22.4	27.7	25.0	24.7
Most of the time / always (%)	6.4	5.3	7.7	8.9	4.7
My preschool child is more likely to play electronic games (e.g. video / computer games, cell phone games) than be active					
Never / rarely (%)	80.1	80.3	80.0	76.8	82.4
Sometimes (%)	15.6	15.8	15.4	17.9	14.1
Most of the time / always (%)	4.2	4.0	4.6	5.4	3.5
My preschool child is more likely to play inside/draw/do craft than be active					
Never / rarely (%)	52.5	59.2	44.6	53.6	51.8
Sometimes (%)	32.6	27.6	38.5	28.6	35.3
Most of the time / always (%)	14.9	13.2	16.9	17.9	12.9

[§]One parent indicated that they don't have a TV

Table 8.6 outlines the reasons why children may not be active. Parents reported that their children faced few barriers to being physically active. Less than 10% of parents indicated that lack of energy or time, enjoyment of physical activity, weight status or skill levels were barriers to physical activity participation for their child. For all variables, parent responses did not differ significantly between child sex and setting.

Table 8.6 Parents' reasons for their preschool child to not be active, reported as agree (%)

	Total n=141	Boys n=76	Girls n=65	Preschool n=56	Grade R n=85
My preschool child doesn't have enough energy to do more physical activity	6.4	9.2	3.1	7.1	5.9
My preschool child doesn't have enough time to do physical activity	9.2	9.2	9.2	8.9	9.4
My preschool child doesn't have anyone to be physically active with	7.8	6.6	9.2	5.4	9.4
My preschool child just doesn't enjoy being physically active	6.4	7.9	4.6	7.2	5.9
My preschool child is too overweight to participate in physical activity	8.5	7.9	9.2	5.4	10.6
My preschool child feels uncomfortable with groups of children	8.5	6.6	10.8	3.6	11.8
My preschool child doesn't have good enough skills (e.g. kicking, throwing, catching) to do more physical activity	9.9	7.9	12.3	3.6	14.1
My preschool child will have more freedom and opportunities to be active when he/she is older	29.1	30.3	27.7	23.2	32.9

'Agree' inclusive of 'agree' and 'strongly agree' responses.

Parent proxy report of their child's physical activity behaviours is in Table 8.7. The majority of parents (82.2%) reported that their child walked to school on a daily basis. Over two-thirds of the parents reported that their child played in their garden on most days of the week or daily; while just under half of the parents reported that their child play with bats and balls daily. The majority of parents reported that their child never used a bicycle or scooter to get to school (83.0%), to get to other places (90.1%) or for fun (81.6%).

Table 8.7 Parent report of the child's usual physical activity

	Total n=141	Boys n=76	Girls n=65	Preschool n=56	Grade R n=85
Walk to school					
Less than once a week	9.8	7.9	12.3	8.9	10.6
1-2 times a week	2.1	4.0	0	0	3.5
3-4 times a week	5.7	5.3	6.2	5.4	5.9
5-6 times a week/ daily	82.2	82.9	81.5	85.7	80.0
Walk to other places (e.g. shops, friends)					
Less than once a week	46.8	48.7	44.6	39.3	51.8
1-2 times a week	29.8	32.9	26.2	33.9	27.1
3-4 times a week	9.2	5.3	13.9	8.9	9.4
5-6 times a week/ daily	14.2	13.2	15.4	17.9	11.8
Walk for exercise or for fun					
Less than once a week	29.8	29.0	30.8	28.6	30.6
1-2 times a week	19.2	19.7	18.5	17.9	10.0
3-4 times a week	21.3	21.1	21.5	26.8	17.7
5-6 times a week/ daily	29.8	30.3	29.2	26.8	31.8
Ride a bicycle/ scooter to school					
Less than once a week	83.0	84.2	81.5	80.4	84.7
1-2 times a week	1.4	4.0	1.5	5.4	1.2
3-4 times a week	2.8	1.3	3.1	3.6	1.2
5-6 times a week/ daily	12.1	10.5	13.8	10.7	12.9
Ride a bicycle/ scooter to other places	90.1	89.5	90.8	85.7	92.9
Less than once a week	2.8	2.6	3.1	3.6	2.4
1-2 times a week	4.2	4.0	4.6	5.4	3.5
3-4 times a week	2.8	4.0	1.5	5.4	1.2
5-6 times a week/ daily					
Ride a bicycle/ scooter for fun					
Less than once a week	81.6	77.6	86.2	73.2	87.1
1-2 times a week	9.2	10.5	7.7	10.7	8.2
3-4 times a week	5.0	6.6	3.1	10.7	1.2
5-6 times a week/ daily	4.3	5.3	3.1	5.4	3.5
Walk the dog					
Less than once a week	56.7	55.3	58.5	46.4	63.5
1-2 times a week	5.7	4.0	1.5	10.7	2.4
3-4 times a week	0.7	1.3	7.7	1.8	0
5-6 times a week/ daily	5.7	6.6	4.6	7.1	4.7
Not applicable	31.2	39.9	29.2	33.9	29.4

Table 8.7 continued, Parent report of the child's usual physical activity

	Total n=141	Boys n=76	Girls n=65	Preschool n=56	Grade R n=85
Play with the dog					
Less than once a week	51.8	47.4	56.9	42.9	55.3
1-2 times a week	6.4	7.9	4.6	12.5	2.4
3-4 times a week	1.4	1.3	1.5	1.8	1.2
5-6 times a week/ daily	5.7	9.2	4.6	8.9	5.9
Not applicable	33.3	34.2	32.3	33.9	32.9
Play in the garden					
Less than once a week	14.2	11.8	16.9	7.1	18.8
1-2 times a week	3.6	5.3	1.5	5.4	2.4
3-4 times a week	13.5	5.3	23.1	12.5	14.1
5-6 times a week/ daily	68.9	77.6	58.5	75.0	64.7
Play with bats and balls					
Less than once a week	23.4	17.1	30.8	23.2	23.5
1-2 times a week	12.8	13.2	12.3	7.1	16.5
3-4 times a week	14.9	17.1	12.3	16.1	14.1
5-6 times a week/ daily	48.9	52.6	44.6	53.6	45.9
Swim in a pool					
Less than once a week	91.5	93.4	89.2	89.3	92.9
1-2 times a week	0.7	0	1.5	1.8	0
3-4 times a week	0.7	0	1.5	0	2.4
5-6 times a week/ daily	7.1	6.6	7.7	8.9	5.8

'Less than once a week' category inclusive of 'never' and 'rarely'
'Not applicable' category only included for questions about owning a dog

The answers provided by parents in the section of the questionnaire addressing the preschool child's engagement in screen time during the week and on the weekend; including TV time, playing on a Wii™/Eye toy or computer games was also decidedly unreliable for some of the leisure activities. Table 8.9 provides a report of the equipment available at home, including the different electronic items. Three parents reported having a Wii/Eye toy at home, and seven parents reported having an Xbox or PlayStation. However, the responses given between the sections tended to be contradictory of each other. For example, there were parents that reported not owning a television, but did report having a PlayStation or a Wii™. Therefore, the categories including PlayStation, Wii™, computer, smart phone and tablet are not reported. The time spent in the remaining screen time is summarised in Table 8.8. Parents' responses for boys and girls, as well as for Preschool and Grade R children were similar for all variables.

Compliance to screen time guidelines

In order to determine the average daily screen time for each child, weekday and weekend day screen time was combined and averaged. The average daily screen time for the sample was 0.5±0.3 hours per day. Based on the average daily screen time, the majority of the children met the screen time guidelines (of an hour or less per day) [77,78,251], with only 2.1% of children (n=3) reportedly exceeding one hour of screen time per day. All three children that did not meet screen time guidelines were boys.

Table 8.8 Parent report of type and time spent in screen time and indoor leisure activities on weekdays and weekend days, by sex and setting

	Total n=141	Boys n=76	Girls n=65	Preschool n=56	Grade R n=85
TV / video's / DVDs					
'Yes' (%)	84.4	86.8	81.5	91.1	80.0
Time on weekdays (hr/wk)	2.2± 1.6	2.1± 1.5	2.3± 1.6	2.1± 1.6	2.2± 1.5
	2.0 (1.0, 3.0)	1.7 (1.0, 3.0)	2.0 (1.0, 3.0)	1.0 (1.0, 3.0)	1.0 (2.0, 3.0)
Time on weekend (hr/wkd)	1.9± 1.0	2.0± 1.1	1.7± 0.9	1.7± 1.0	2.0± 1.0
	2.0 (1.0, 2.0)	2.0 (1.0, 2.0)	2.0 (1.0, 2.0)	1.0 (1.0, 2.0)	1.0 (2.0, 2.0)
Quiet play					
'Yes' (%)	46.8	43.4	50.8	46.4	47.1
Time on weekdays (hr/wk)	0.8± 1.2	0.7± 1.2	0.9± 1.2	1.0± 1.5	0.6± 0.9
	1.0 (1.0, 2.0)	1.0 (1.0, 2.0)	1.0 (1.0, 2.0)	1.0 (2.0, 3.0)	1.0 (1.0, 2.0)
Time on weekend (hr/wkd)	0.6± 1.6	0.6± 1.6	0.7±1.5	0.9± 2.1	0.5± 1.1
	1.0 (1.0, 2.0)	1.0 (1.0, 2.0)	1.0 (1.0, 2.0)	1.0 (1.0, 4.0)	1.0 (1.0, 2.0)
Imaginary games					
'Yes' (%)	36.9	32.9	41.5	37.5	36.5
Time on weekdays (hr/wk)	0.5± 1.1	0.5± 1.3	0.5± 0.9	0.3± 0.7	0.6± 1.3
	1.0 (0.5, 1.0)	1.0 (0.5, 2.0)	1.0 (0.1, 1.0)	0.5 (1.0, 1.0)	1.0 (0.4, 2.0)
Time on weekend (hr/wkd)	0.3± 1.2	0.4± 1.4	0.3± 0.8	0.3± 0.9	0.4± 1.3
	1.0 (0.5, 3.0)	1.0 (1.0, 3.0)	1.0 (0.5, 1.5)	0.8 (0.4, 1.0)	1.0 (1.0, 5.0)

'Yes' refers to parent report that the child engages in the respective indoor behaviour; data reported as mean±SD and median (IQR)

Parents' reporting of toys and equipment is shown in Table 8.9. The most commonly reported toys or equipment in the home were balls (87.9%), slides (29.1%) and soft balls (22.7%). Overall, there was very little variety of toys reported, and many of the parents reported that their preschool child had fewer than five toys or pieces of equipment with which to play. There were several differences between child sex and setting for the toy and equipment inventory: boys had more slides than girls (p=0.043), and Grade R children had fewer bats/racquets/golf clubs (p=0.005), trampolines (p=0.004) and access to a swimming pool at home (p=0.041). Many parents reported having a TV in the home (77.3%), as well as a video/DVD player (62.4%). There were no sex nor setting differences for electronic equipment at home.

Table 8.9 Parent report of toys and equipment at home, arranged according to type of toy, and listed in descending order per category

Toy/piece of equipment	Total n=141	Boys n=76	Girls n=65	Preschool n=56	Grade R n=85
Toys/equipment used for ball sports					
Balls (soccer, tennis, basket etc.)	87.9	86.8	89.2	83.9	90.6
Soft balls and toys suitable for indoor play	22.7	23.7	21.5	19.6	24.7
Volleyball, tennis or badminton net	13.5	13.2	13.9	19.6	9.4
Table tennis table and bats and balls	13.5	14.5	12.3	14.3	12.9
Bowls/Skittles/10-Pin Bowls	9.9	9.2	10.8	8.9	10.6
Basketball ring	3.6	2.6	4.6	3.6	3.5
Bats/racquets/golf clubs	3.6	5.3	1.5	8.9	0 *
Toys with wheels/toys used for locomotion					
Skipping rope	12.1	10.5	13.9	14.3	10.6
Skateboard	10.0	10.5	9.4	9.1	10.6
Scooter	8.5	7.9	9.2	8.9	8.2
Tricycle/Bicycle	5.7	5.3	6.2	8.9	3.5
Toys/Equipment for climbing/jumping/swinging					
Slide	29.1	22.4	36.9 #	30.4	28.2
Swings	12.8	10.5	15.4	14.3	11.8
Trampoline	5.7	6.6	4.6	12.5	1.2 *
Climbing equipment/trees suitable for climbing	5.0	5.3	4.6	1.8	7.1
Tree house	4.3	6.6	1.5	7.1	2.4
Other toys/pieces of equipment					
Child-appropriate gardening tools	9.2	10.5	7.7	12.5	7.1
Swimming pool/swimming-appropriate area	8.5	9.2	7.7	14.3	4.7 *
Pool or beach toys	6.4	5.3	7.7	7.1	5.9
Safety equipment (helmets, knee pads)	5.0	6.6	3.1	3.6	5.9
Sand pit	3.6	2.6	4.6	3.6	3.5
Frisbee	1.4	1.3	1.5	0	2.4
Electronic equipment					
TV	77.3	76.3	78.5	82.1	74.1
Video/DVD player	62.4	70.3	58.5	74.1	57.7

Data presented as % of parents confirming ownership of the toy/equipment
*Indicates a significant difference between the preschool and grade R children ($p<0.05$)

8.4 Parents' perceptions of parental barriers to child's physical activity

The majority of the parents reported that tiredness (83.2%), housework (79.7%), time spent working (76.2%) or caring for other children (86.0%) were 'never' or 'rarely' barriers to supporting their preschool child in physical activity (Table 8.9). Although 29.4% of parents reported owning a vehicle (in Table 8.1), it appears that car availability is perceived as a barrier to taking the child to places where they could engage in physical activity. Confidence in supporting the preschool child to be active was variable, with 62.9% of parents reporting feeling confident 'most of the time' or 'always', however 17.5% reported that they 'never' or 'rarely' feel confident. There were no differences in answers given between parents of boys and girls, however there were setting differences for two barriers: Parents of Preschool children reported time spent doing housework ($p=0.002$) and time spent at work ($p=0.012$)

less frequently as barriers to supporting their child's physical activity than the parents of the Grade R children.

Table 8.10 Parental barriers to their child's physical activity

	Total n=141	Boys n=76	Girls n=65	Preschool n=56	Grade R n=85
I am too tired to support my preschool child to be active (e.g. play outside with him/her, take him/her to the park)					
Never / rarely	83.0	82.9	83.1	89.3	78.9
Sometimes	12.8	11.8	13.9	10.7	14.1
Most of the time / always	4.3	5.3	3.1	0	7.1
The time I spend doing housework stops me from supporting my preschool child to be active					
Never / rarely	79.4	84.2	73.9	91.1	71.8 *
Sometimes	12.8	10.5	16.9	7.1	16.5 *
Most of the time / always	7.8	5.3	10.8	1.8	11.8 *
The time I spend working stops me from supporting my preschool child to be active					
Never / rarely	76.6	77.6	75.4	89.3	68.2 *
Sometimes	12.8	13.2	12.3	1.8	20.0 *
Most of the time / always	10.6	9.2	12.9	8.9	7.1 *
Looking after other children stops me from supporting my preschool child to be active					
Never / rarely	86.5	90.8	81.5	91.1	83.5
Sometimes	5.0	4.0	6.2	5.4	4.7
Most of the time / always	8.5	5.3	12.4	3.6	11.8
I always have a car available when I want to take my preschool child somewhere to be active					
Never / rarely	93.6	94.7	92.3	92.9	92.3
Sometimes	5.7	2.6	7.7	3.6	7.7
Most of the time / always	1.4	2.6	0	3.6	0
It is difficult to get to places for my preschool child to be active					
Never / rarely	58.2	57.9	58.5	57.1	58.8
Sometimes	7.8	7.9	7.7	7.1	8.2
Most of the time / always	34.0	34.2	33.8	35.7	32.9
I feel confident that I have the skills to support my preschool child to be active					
Never / rarely	17.8	19.7	15.4	12.5	21.2
Sometimes	19.2	15.8	23.1	21.4	17.7
Most of the time / always	63.1	64.5	61.5	66.1	61.2
No matter how I feel, I always make sure I give my preschool child opportunities to be active					
Never / rarely	13.5	15.8	10.8	14.3	12.9
Sometimes	22.0	21.1	23.1	19.6	23.5
Most of the time / always	64.5	63.2	66.2	66.1	63.5

*Indicates a significant difference between the preschool and grade R children ($p<0.05$)

Parental confidence to increase physical activity and reduce screen time is reported in Table 8.11. The greatest proportion of parents (38.3%) reported feeling 'not confident at all' in getting their preschool child to participate in three hours of physical activity each day, while 30.5% reported feeling extremely confident. More than half (53.2%) of the parents reported feeling 'not confident at all' in getting their child to be active instead of playing computer games, and 66.0% have no confidence in their ability to say 'no' to their child's requests to play on the computer or play electronic games. However, parents of Preschool children reported they were less confident in saying no their preschool child's requests to play electronic games than the Grade R parents (p=0.025).

Table 8.11 Parent self-efficacy to increase child's physical activity

	Total n=141	Boys n=76	Girls n=65	Preschool n=56	Grade R n=85
Get my preschool child to participate in at least three hours of physical activity every day over the next year					
Not at all confident	38.3	39.5	36.9	37.5	38.8
Moderately confident	31.2	30.3	32.3	30.4	31.8
Extremely confident	30.5	30.3	30.8	32.1	29.4
Get my preschool child to participate in a range of physical activities over the next year					
Not at all confident	10.6	14.5	6.2	10.7	10.6
Moderately confident	46.8	42.1	52.3	41.1	50.6
Extremely confident	42.6	43.4	41.5	48.2	38.8
Get my preschool child to be active when he/she wants to play on the computer or play electronic games over the next year					
Not at all confident	53.2	60.5	44.6	57.1	50.6
Moderately confident	29.8	25.0	35.4	30.4	29.4
Extremely confident	17.0	14.5	20.0	12.5	20.0
Say no to my preschool child's requests to play on the computer or electronic games over the next year					
Not at all confident	66.0	65.8	66.2	78.6	57.7 *
Moderately confident	20.6	18.4	23.1	10.7	27.1 *
Extremely confident	13.5	15.8	10.8	10.7	15.3 *

*Indicates a significant difference between the preschool and grade R children (p<0.05)

8.5 Parents' beliefs about physical activity and screen time

Parents' beliefs regarding the physical activity of preschool children was mixed, with 42% of the parents agreeing that their child should participate in three hours of physical activity per day, while 41.8% of the parents disagreed (Table 8.12). Parents mostly reported believing that they were satisfied with their child's physical activity (78.0%), and that they are active enough for their health (82.3%). The majority of parents (81.6%) believed that TV viewing time would not affect their preschool child's health. There were no significant differences between responses from parents of boys and girls. Significantly more parents of Grade R

children (50.6%) agreed that their child should do at least three hours of physical activity per day compared with parents of Preschool children (28.6%, p=0.006).

Table 8.12 Parents' beliefs and behaviours about their preschool child's physical activity and sedentary behaviour, reported as agree (%)

	Total n=141	Boys n=76	Girls n=65	Preschool n=56	Grade R n=85
I think that my preschool child should do at least three hours of physical activity every day	41.8	36.8	47.7	28.6	50.6 *
I am satisfied with the amount of physical activity my preschool child does	78.0	78.9	76.9	83.9	74.1
My preschool child does enough physical activity to keep him/her healthy	82.3	84.2	80.0	91.1	76.5
The amount of TV my preschool child watches would not affect his/her health	81.6	77.6	86.2	83.9	80.0
I limit how much time my preschool child is allowed to spend watching TV	64.5	78.9	63.1	53.0	81.4
I limit how much time my preschool child is allowed to spend using computer and electronic games	55.3	47.4	64.6	50.0	65.9
My preschool child is not allowed to throw balls or play ball-games inside the house	62.2	69.7	52.3	67.9	58.8
My preschool child is not allowed to play rough games or run inside the house	68.5	71.1	64.6	71.4	65.9
I have rules about physical activity to protect my preschool child from other people (e.g. not allowed outside the home garden on his/her own)	70.9	68.4	73.8	76.8	67.1
I have rules about physical activity to protect my preschool child from accidents with traffic (e.g. always holding adult hand near roads)	87.9	88.2	87.7	91.1	85.9
My preschool child is able to play freely in the backyard whenever he/she wants to	68.1	73.7	61.5	76.8	62.4
My preschool child is able to play freely in the street whenever he/she wants to	25.5	31.6	18.5	21.4	28.2
I take my preschool child outside to play if I think he/she has been inside for too long	46.8	50.0	43.1	51.8	43.5

'Agree' inclusive of 'agree' and 'strongly agree' responses.
*Indicates a significant difference between the preschool and grade R children (p<0.05)

8.6 Parent report of child's physical activity with friends and family

Parents' reporting of how often other people are active with their preschool child is summarised in Table 8.13. Fewer than half of the parents (41.1%) reported being physically active with their child on a daily basis, however 30.5% of the parents reported 'rarely' or 'never' being active with their child. Children in the community were reportedly the group that were most often active with preschool children (73.8% active 'daily' or '5-6 times per week').

Table 8.13 Parent report of people who are physically active with the preschool child

	Total n=141	Boys n=76	Girls n=65	Preschool n=56	Grade R n=85
You					
Less than once a week	30.5	29.0	32.3	23.2	35.5
1-2 times a week	17.7	17.1	18.5	14.3	20.0
3-4 times a week	10.6	10.5	10.8	8.9	11.8
5-6 times a week/daily	41.1	43.4	38.5	53.6	32.9
Your partner / spouse					
Less than once a week	33.3	36.8	29.2	26.8	37.6 *
1-2 times a week	12.1	6.6	18.5	3.6	17.7 *
3-4 times a week	6.4	6.6	6.2	3.6	8.2 *
5-6 times a week/daily	22.0	25.0	18.5	30.4	16.5 *
Not applicable	26.2	25.0	27.7	35.7	20.0 *
Siblings					
Less than once a week	23.4	22.4	24.6	14.3	29.4
1-2 times a week	7.1	4.0	10.8	8.9	5.9
3-4 times a week	8.5	5.3	10.8	7.1	8.2
5-6 times a week/daily	54.6	63.2	44.6	58.9	49.4
Not applicable	7.1	5.3	9.2	35.7	5.9
Whole family together					
Less than once a week	28.4	32.9	23.1	26.8	29.4
1-2 times a week	17.0	11.8	23.1	12.5	20.0
3-4 times a week	8.5	10.5	6.2	12.5	5.9
5-6 times a week/ daily	46.1	43.4	47.7	48.2	46.3
Cousins					
Less than once a week	51.1	55.3	46.2	50.0	51.8
1-2 times a week	20.6	19.7	21.5	21.4	20.0
3-4 times a week	9.2	10.5	7.7	8.9	9.4
5-6 times a week/daily	18.4	13.2	24.6	17.9	18.8
Not applicable	0.7	1.3	0	1.8	0
Uncles and/or aunts					
Less than once a week	46.8	48.7	44.6	44.6	48.2
1-2 times a week	12.1	10.5	13.9	14.3	10.6
3-4 times a week	12.7	10.5	15.4	8.9	15.3
5-6 times a week/daily	24.8	26.3	23.1	26.8	23.5
Not applicable	3.6	4.0	3.1	5.4	2.4
Grandparents					
Less than once a week	41.8	47.4	35.4	51.8	47.1
1-2 times a week	7.8	14.5	16.9	12.5	17.7
3-4 times a week	15.6	4.0	3.1	5.4	2.4
5-6 times a week/daily	34.4	31.6	36.9	41.1	29.4
Not applicable	5.0	2.6	7.7	7.1	3.5
Children in the community					
Less than once a week	14.2	15.8	12.3	8.9	17.7
1-2 times a week	5.7	4.0	7.7	10.7	8.2
3-4 times a week	6.4	6.6	6.2	17.9	5.9
5-6 times a week/daily	73.8	73.6	73.8	82.1	68.2

'Not applicable' category included for questions where the person completing the questionnaire did not (for example) have a spouse; or was the person in question, for example for 'I am the grandparent' for the 'Grandparents' question.

*Indicates a significant difference between the preschool and grade R children ($p<0.05$)

8.7 Parents' perceptions of the community

Parents' perceptions of the community are shown in Table 8.14. Parents appeared to perceive playgrounds in the community to be too few, lacking in variety, unsuitable for preschool children and unsafe for their child to play on. Perceptions of the playgrounds did not differ between parents of children of a different sex or attending a different preschool setting.

Table 8.14 Parents' perception of community playgrounds

	Total n=141	Boys n=76	Girls n=65	Preschool n=56	Grade R n=85
There are many playgrounds in our community that are suitable for my preschool child to play in	13.5	18.4	7.7	14.2	12.9
The playgrounds in our community have a variety of equipment so my preschool child doesn't get bored	15.6	21.5	9.2	19.6	12.9
The playgrounds in our community have equipment suitable for my preschool child's age and abilities	11.3	15.8	6.2	10.7	11.8
The playgrounds in our community have play equipment that is safe for my preschool child to play on	11.3	13.2	9.2	12.5	11.8
The playgrounds in our community are well used by other children	17.0	19.7	13.8	12.5	20.0
'Agree' inclusive of 'agree' and 'strongly agree' responses.					

Parents' perceptions of barriers to their child being physically active within their community are shown in Table 8.15. For a large proportion of parents, the community physical environment was not perceived to be a barrier to their child's physical activity. However, neighbourhood safety was perceived to be an issue, with 18.4% of parents agreeing that their neighbourhood is safe for children. Parents of boys and girls reported differently on walking and cycling trails, with the girls' parents reporting higher agreement than boys' parents that there are suitable walking and cycling trails in the neighbourhood for use (p=0.044). There were no significant differences between parents of Preschool and Grade R children.

Table 8.15 Parent-reported community barriers to the preschool child's physical activity

	Total n=141	Boys n=76	Girls n=65	Preschool n=56	Grade R n=85
There are major barriers to walking / cycling that make it hard for my preschool child and I to get from place to place (e.g. major roads, steep hills)	15.6	19.7	10.8	17.9	14.1
My preschool child and I would have to cross a busy road to get to areas where he/she can play	17.0	15.8	18.5	14.3	18.8
There are no lights or pedestrian crossings for my preschool child and I to use	27.0	30.2	23.1	30.4	24.7
There are no footpaths / pavements in our neighbourhood for my preschool child and I to use	24.1	18.4	30.8	28.6	21.2
My neighbourhood has walking/cycling trails suitable for my preschool child and I to use	14.9	14.5	15.4 #	16.1	14.1
My neighbourhood is safe for children	18.4	22.4	16.9	19.6	20.0

'Agree' inclusive of 'agree' and 'strongly agree' responses.
# indicates a significant difference between boys and girls ($p<0.05$)

Lastly, parents reported on the frequency of visits to places where their preschool child may be physically active (Table 8.16). Parents' responses show that travelling to other destinations to be physically activity was not a very common occurrence. The place visited most often was the shopping centre (12.1% on most days of the week, 12.8% between once and four times per week). For all variables, there were no statistically significant differences between parents of boys and girls, nor of Preschool and Grade R children. Although the parents reported more variation in frequency for visiting sports venues (for example, 16.1% of Preschool vs. 2.4% of Grade R children visiting on five or more days of the week), the difference in reported frequency of visits to sports venues between parents of Preschool versus Grade R children was not significant ($p=0.059$).

Table 8.16 Parent report of frequency of visits to places within the community where the child is physically active

	Total n=141	Boys n=76	Girls n=65	Preschool n=56	Grade R n=85
Local playground					
Never / once a month or less	85.1	78.9	92.3	78.6	89.4
Twice a month	2.8	2.6	3.1	5.4	1.2
1-2 times per week	6.4	10.5	1.5	8.9	4.7
3-4 times per week	2.8	3.9	1.5	3.6	2.4
5 or more times per week	2.8	3.9	1.5	3.6	2.4
Playground in another area					
Never / once a month or less	87.9	86.8	89.2	89.3	87.1
Twice a month	4.3	2.6	6.2	3.6	4.7
1-2 times per week	2.8	3.9	1.5	1.8	3.5
3-4 times per week	2.1	3.9	0	5.4	0
5 or more times per week	2.8	2.6	3.1	0	4.7
Sports venue (e.g. swimming pool, soccer field)					
Never / once a month or less	82.3	81.6	83.1	78.6	84.7
Twice a month	2.1	1.3	3.1	0	3.5
1-2 times per week	4.3	3.9	4.6	1.8	5.9
3-4 times per week	3.6	2.6	4.6	3.6	3.5
5 or more times per week	7.8	10.5	4.6	16.1	2.4
Indoor play centre					
Never / once a month or less	76.6	69.7	84.6	78.6	75.3
Twice a month	1.4	1.3	1.5	0	2.4
1-2 times per week	7.8	9.2	6.2	7.1	8.2
3-4 times per week	5.0	3.9	6.2	3.6	5.9
5 or more times per week	9.2	15.8	1.5	10.7	8.2
Family restaurant with play area					
Never / once a month or less	84.6	82.9	86.2	83.9	84.7
Twice a month	4.3	3.9	4.6	5.4	3.5
1-2 times per week	4.9	5.3	4.6	1.8	7.1
3-4 times per week	1.4	1.3	1.5	1.8	1.2
5 or more times per week	5.0	6.6	3.1	7.1	3.5
Shopping centre					
Never / once a month or less	69.5	69.7	69.2	67.9	71.6
Twice a month	5.7	3.9	7.7	8.9	3.5
1-2 times per week	8.5	7.9	9.2	7.1	9.4
3-4 times per week	4.3	3.9	4.6	5.4	3.5
5 or more times per week	12.1	14.5	9.2	10.7	12.9

8.8 Summary

Lacking energy, time, and enjoyment to do physical activity were not perceived barriers to physical activity for the preschool children. Physical activity was largely reported as being good for health, and necessary for preschool children, although more than half of all the parents disagreed that preschool-aged children should engage in at least three hours of

physical activity per day. Parent-reported family levels of activity were low, although preschool friends were perceived to improve/increase engagement in physical activity. According to the parents, the preschool-aged children in Agincourt have few toys and pieces of play equipment at home. Parents also perceived neighbourhood safety as a barrier for children to being active in the community. Compliance with screen time guidelines was excellent, as most children met current screen time guidelines.

Overall, there were few differences between parents of boys and girls, as well as between parents of Preschool and Grade R children. The most notable of the few significant differences observed between parents of Preschool and Grade R children was the belief that preschool-aged children should do at least three hours or physical activity per day, and that parents of Preschool children expressed significantly less confidence than the Grade R parents to refuse their preschool child's requests to play on the computer or electronic games.

Chapter Nine:
Discussion

9.1 Overview

The aim of this PhD thesis was to describe the following in a sample of preschool-aged children from a rural, low-income setting in South Africa:

1. Characteristics of the preschool/school environment;
2. Objectively measured physical activity;
3. Objectively measured sedentary behaviour;
4. Directly observed physical activity and sedentary behaviour within the preschool setting, as well as contextual and individual-level factors of physical activity;
5. Gross motor skill proficiency;
6. Associations between gross motor skills, body composition and physical activity objectively measured and directly observed);
7. Parent and/or caregiver perceptions of home and community factors that influence physical activity and sedentary behaviour;
8. Parent-reported child screen time (levels and compliance).

The Discussion of this thesis is structured according to the four behaviours, namely physical activity, sedentary behaviour, screen time and gross motor skills; and addresses the following:

i. Levels of each of the behaviours and, where appropriate, compliance with guidelines;
ii. Differences in behaviours between boys and girls;
iii. Differences in behaviours between Preschool children and Grade R children;
iv. Associations of behaviours with body composition; and
v. Home and community contextual factors which may be associated with the behaviours being investigated.

9.2 Physical activity

Levels of physical activity

This thesis is the first to report on objectively measured levels of physical activity (using accelerometry) in South African preschool-aged children from rural settings. The preschool children in this thesis engaged in high levels of physical activity, and on average, accumulated over 400 minutes of LMVPA per day. To date, few studies from LMICs have objectively assessed physical activity in preschool children. A study from Cameroon assessed physical activity in children aged two- to six-years old of varying weight status. In that study, LMVPA (also referred to as total physical activity in the literature) ranged from 195±70 to 264±69 minutes per day (depending on weight status) [26]. This is substantially less than the preschool-aged children in this thesis. Studies from HICs, such as Portugal [180], Belgium [178] and Canada [303] have also reported lower levels of LMVPA in comparison to this thesis (295 minutes, 108 minutes and 283 minutes of daily LMVPA, respectively). Substantial

differences in objectively measured LPA have also been reported in a review of pre-schooler's objectively measured physical activity, with 20 different studies (of 40 studies included in the review) reporting percentages of time spent per day in LPA between 3.9% and 32.6% [16].

In terms of MVPA, this thesis reported high levels of daily MVPA, with the preschool children engaging in an average of 94±52 minutes per day. This is considerably higher than the levels of MVPA reported in the preschool children in Cameroon, where levels of MVPA ranged between 5 and 10 minutes per day, depending on weight status [26]. Such vast differences between levels of MVPA have been described in a review of 37 studies (of 40 studies, briefly mentioned earlier) [16]. All but one of the studies reviewed came from HICs, and daily MVPA ranged between 1.7% (~13minutes per day) and 41.2% (~5.4hours per day). The one study from Mexico [304], also a LMIC [305], found that MVPA levels were high, with boys and girls engaging in 163±58 and 125±45 minutes per day, respectively. More recently, a study from Switzerland [181] has also reported high levels of MVPA (93±56 minutes per day), similar to those found in children in Agincourt.

The differences in LMVPA and MVPA observed between the pre-schoolers studied in this thesis and samples from other LMICs and HICs might be due to differences between the samples and the settings or aspects of physical activity measurement. For example, the review by Hnatuik and colleagues [16] reported that the 37 studies included used five different accelerometry devices for measurement, an issue that has been discussed previously in detail in methodological papers [164,167]. Key issues with comparing data collected using different devices include different technologies used in different brands of accelerometers (such as planes of motion measurable), placement of the device, and the fact that few devices have been validated for use [164,167]. The most notable of all challenges with accelerometry is that of how to analyse accelerometry data. Thus, it is also possible that the differences in levels of LMVPA and MVPA reported in studies are due to the use of different accelerometry cut points [16,306]). For example, the Pate cut points [280] for MVPA are lower than those of Sirard [283] (≥420 counts vs. ≥615 counts per 15 seconds in three-year-olds, see Table 3.2 for the other ages specified by Sirard) and therefore the Pate cut points will yield greater volumes of MVPA. The cut points chosen for this thesis were Pate's for MVPA: ≥420 counts/15 seconds [280], and Evenson's for sedentary behaviour: ≤25 counts/15 seconds [282]. Therefore, LMVPA was inclusive of activity >25 counts/15s. This combination of cut points has been validated in preschool-aged children [284]. Consequently, the choice of cut points in this thesis and others would result in more physical activity being classified as LMVPA and MVPA, which could explain the difference between levels of LMVPA and MVPA reported in this thesis and the studies discussed above [26,178,303]. When comparing levels of LMVPA and MVPA between the Agincourt preschool-aged children to pre-schoolers from other countries using similar accelerometry rules for analysis, it would appear that overall, preschool children from different countries are similar in terms of their LMVPA and MVPA. The findings in this thesis therefore confirm that physical activity in preschool children is not necessarily very different between countries that differ substantially (for example, Canada, Portugal and South Africa are quite different). Although it is possible that how the preschool children accumulate their physical activity differs between countries, further investigation is required to establish the nature of these differences.

Compliance with physical activity guidelines

This thesis is the first to report on compliance with physical activity guidelines using objective measures in South African preschool-aged children. To date, there are no studies from LMICs that have reported on pre-schoolers' compliance with the most current physical activity guidelines (that a healthy 24-hour day for a preschool-aged child includes 180 minutes of physical activity, of which at least 60 minutes is 'energetic play', operationalised as MVPA) [77,78]. In the absence of studies from LMICs that have reported on compliance with physical activity guidelines, comparisons to studies from HICs will be discussed. In this thesis, compliance with the LMVPA component of the guideline was excellent, with all children meeting (and many children far exceeding) the 180-minute guideline for every day of wear. This high level of compliance with guidelines (and high volumes of physical activity) reported in preschool children is fairly consistent with more recent literature (published in the last four years) reporting on compliance using objective measures in pre-schoolers from HICs (to the previous guideline that recommended 180 minutes of LMVPA [171-173]). For example, Vale and colleagues reported compliance rates of 97.3% and 99.4% for Portuguese preschool-aged girls and boys, respectively [180]. A study from the United Kingdom reported 100% compliance amongst four-year-olds [307], as did a study from Canada [308].

No studies from LMICs have reported on pre-schoolers' compliance with the MVPA component of the new physical activity guidelines [77,78], . Although, concurrent with the release of the new Australian and Canadian guidelines articles reporting compliance with these new guidelines were published [309,310]. In this thesis, 78.2% of the children met the MVPA guideline of 60 minutes of MVPA per day (as part of the total 180 minutes recommended). This is substantially lower than the high proportion of Australian pre-schoolers (93.1%) found to meet the physical activity guidelines (LMVPA and MVPA components) [309], and greater than the compliance reported in Canadian pre-schoolers (61.8%) [310]. The Australian authors used the same accelerometry rules as in this thesis (i.e. same cut points [284] and non-wear time [246]), although total wear time was longer and the number of days of wear time was less stringent, which could explain some of the variation. From an analysis perspective, it is interesting to note that the Canadian pre-schoolers had poorer compliance, given that a more favourable cut point was used. Although both methods of analysis and measurement are validated, having more valid days of accelerometry data is beneficial, as it provides a better representation of habitual activity in preschool children.

As previously discussed, the differences and similarities in compliance between studies could possibly result from the use of different accelerometry cut points. This has been detailed in a study which investigated compliance using different cut points [311], compliance (with NASPE guidelines [312] for MVPA) ranged from 9.0% to 99.9%, and daily LMVPA ranged from 127 minutes (using Sirard cut points [283]), to 371 minutes (using Pate cut points [280]) to 402 minutes (using Freedson cut points [306]). Although the NASPE guidelines differ slightly to the national guidelines set out by Australia, Canada and the United Kingdom, the principle holds that lower cut points yield greater volumes of activity. This could explain the variation in compliance rates reported over time (with studies increasingly making use of the LMVPA cut point set at >25 counts/15s [284]), while older studies more frequently used Sirard cut points [283].

Physical activity in boys and girls

The relationship between sex and physical activity differed depending on the tool used (accelerometry or direct observation). Overall, boys engaged in more objectively measured LMVPA and MVPA compared to girls, particularly on weekdays where the mean differences exceeded 20 and 30 minutes per day of LMVPA and MVPA, respectively. The difference found between boys and girls is consistent with the majority of the literature describing objectively measured physical activity in preschool children showing that overall, boys engage in more MVPA than girls [180,181,187,189,190,313]. This is consistent with the patterns analyses, which provided another perspective for understanding the distribution of physical activity of boys and girls throughout the day. The patterns analyses showed that boys spent more time in MVPA on both weekday and weekend afternoons. This is consistent with results from studies from Denmark [199] and Australia [200].

Physical activity during preschool hours did not differ between boys and girls, when measured using direct observation. This is contrary to other studies that have used the OSRAC-P. For example, a study from South Africa showed that girls were more likely to spend more time in MVPA than boys [95]. However, other studies from HICs (also using direct observation) show that boys are more physically active than girls [301,314,315].

The similarity in observed physical activity (i.e. when the OSRAC-P was used) between the boys and girls in this thesis is difficult to explain, given that differences were evident when physical activity was measured via accelerometry. This absence of differences when direct observation was used could be attributable to the shortened time frame used to capture physical activity (11 hours per day of accelerometry vs. 4 hours in total observed). Furthermore, the lack of differences between boys and girls using direct observation could be a result of how the physical activity data are captured. For example, using fixed play equipment such as swings, see-saws or jungle gyms is coded as MVPA (described as moderate/fast movements) in the OSRAC-P, but may not be assessed as MVPA when accelerometry is used. Also, the OSRAC-P requires an observational period (5 seconds) followed by a period of recording data, whereas the accelerometer captures data continuously, meaning that data captured by the accelerometer is likely to be more accurate in terms of the total intensity of physical activity measured. Although a comparison of instruments was beyond the scope of this thesis, it is probable that some playground (or preschool-based) activities are categorised differently by the two instruments.

Physical activity in the Preschool and Grade R settings

Much like the relationship between sex and physical activity, the differences found between Preschool and Grade R settings also differed depending on the tool used (accelerometry or direct observation). In this thesis, the Preschool children spent significantly more time in objectively measured LMVPA than Grade R children during the week (479.9min vs. 474.5min), although Grade R children spent significantly more time in objectively measured MVPA compared to Preschool children (105.1min vs 86.7min; both $p<0.05$) during the week. On weekend days, the Grade R's were significantly more active in terms of LMVPA (492.6min vs. 464.7min) and MVPA (108.5min vs. 78.0min; both $p<0.05$).

The differences between the Grade R and Preschool children's weekday objectively measured physical activity could be due to differences found between the Preschool and Grade R settings. This thesis reported several differences in the respective environments which could be contributing to the higher MVPA levels in the Grade R's: The assessment of the Preschool and Grade R settings showed that the Grade R children have larger areas of shared, open space available to them. Larger play areas have been favourably associated with higher levels of physical activity [188,316]. Although the Preschool settings had space (albeit less than the Grade R settings) and fixed equipment (in good condition), the principle discussed in the above section pertaining to the differences in MVPA captured by accelerometry applies here (i.e. perhaps some of the Preschool children's weekday MVPA was not captured by the accelerometer as it was taking place on fixed play equipment in the Preschool settings). The evidence describing associations between fixed equipment and physical activity has yielded mixed findings [317-319], and it is worth noting that the evidence reporting associations between portable equipment (such as balls and hula hoops) and physical activity is stronger [319,320]. Although the evidence suggests that portable equipment is more favourable for increased physical activity, in a setting like Agincourt it would appear that children are active in spite of having few portable pieces of equipment to play with (evident in both Preschool and Grade R settings) and no fixed equipment (as is the case for the Grade R's).

Another reason for the differences observed between the Preschool and Grade R children's objectively measured weekend physical activity could be related to the age of the children, with Grade R children being significantly older than the Preschool children (5.6 years vs. 4.4 years). Results from two longitudinal studies showed that the time spent in higher intensity physical activity (MVPA) increased with age [145,321]. It is possible that the Grade R children, being older, are more independent than the Preschool children and have more autonomy to be active, possibly explaining why Grade R children did an average of 30 minutes more MVPA per weekend day than Preschool children.

Differences between Preschool and Grade R children were also revealed in the objectively measured physical activity patterns. Preschool children spent significantly more time in LMVPA before and during the school day (between 07h00 and 12h00) compared with Grade R children. This pattern was reversed in the afternoon (12h00 until 18h00), with the Grade R children spending significantly more time in physical activity than the preschool children. It is likely that the increase in afternoon physical activity seen in Grade R children resulted from a combination of unstructured activities such as walking home from school and playing with friends on the roads or in the school playground (as no after-school extra mural activities were available to these children). Fieldwork notes following the OSRAC-P observations support these suggestions. Many children of all ages play informal soccer games on the school fields at the end of the day. This was a different scenario to the Preschool children, who did not necessarily leave the Preschool grounds when the scheduled 'learning component' of the preschool day ended (daily schedules shown in Table 4.3). This meant that Preschool children were likely to spend more time at the Preschool setting, where they could have spent time napping (indicated as 'rest in the daily schedules shown in Table 4.3) or playing on fixed equipment.

Results from the observed physical activity chapter supported the findings in above for objectively measured physical activity, in that Preschool children were observed engaging in significantly more LMVPA (8.6% vs. 2.7%, p<0.001) and MVPA (26.4% vs. 15.3%, p<0.001) than Grade R children. As mentioned earlier, Preschool children had access to fixed play equipment while the Grade R children did not, and this potentially contributed to the higher levels of LMVPA and MVPA in Preschool children. However, the OSRAC-P findings also showed that the Preschool children spent more time outdoors than the Grade R's (62.6% vs. 41.2% of preschool time, p=0.000), and that this was significantly associated with time spent in MVPA. A few previous studies show high levels of physical activity when fixed equipment is present [317-319], and that being outdoors is associated with higher volumes of physical activity [188]. Therefore, the Preschool setting is arguably more conducive to higher levels of physical activity during the preschool day.

The OSRAC-P physical activity data from this thesis showed that the children were more likely to be engaged in LPA and MVPA if a teacher initiated physical activity. This is consistent with research conducted in low-, middle- and high-income settings in South Africa [95], where pre-schoolers were 1.7 and 1.6 times more likely to engage in LPA and MVPA when busy with a teacher-initiated activity. This is perhaps indicative of children's responsiveness to teachers in a preschool environment. This is not consistent with some studies from HICs that have shown that children are more likely to engage in MVPA when doing activities alone [315] and activities that are not initiated by an adult [322]. It is important to note an activity that is initiated by the teacher is not necessarily facilitated by the teacher (as this is coded as 'teacher-arranged and lead gross motor physical activity'). For example, in both settings (Preschool and Grade R), the children were permitted and sometimes instructed to play outdoors for extended periods of time. However, during this outside time, teachers generally did not facilitate or lead the physical activities, and seldom prompted the children to be more physically active. Therefore, children that are under the supervision of teachers who are lenient with outdoor play would engage in more physical activity.

Physical activity and body composition

The distribution of thin, normal weight and overweight/obese children in this thesis did not reflect that described in the most recent SANHANES-1 [3]. However, this may be due to the differing definitions of overweight/obesity used by SANHANES (which made use of the WHO growth standards [22]) compared to the IOTF cut-offs [21] used in this thesis. Thus, it is possible that using the WHO growth standards would have resulted in a slightly different distribution of more overweight/obese children.

In this thesis, children with higher BAZ had greater levels of MVPA. This finding is contrary to evidence from HICs which shows that children who are obese participate in less MVPA [323]. Our sample had a small number of children who were classified as overweight/obese, and significantly more children were classified as thin. As a result, the mean BAZ for the preschool-aged children was negative. Therefore, the findings actually suggest that children with a higher BMI-z score (and in this context, healthier because it is closer to zero) tended to do more objectively measured MVPA. This is consistent with evidence from Cameroon [26], which reported significantly higher levels of MVPA in children classified as normal weight (and

overweight 10.4 minutes and 10.5 minutes per day, respectively), compared to children who were stunted (7.5 minutes per day) and stunted and overweight (5.3 minutes per day; $p<0.05$ for all). Although this thesis did not address stunting in detail and therefore no direct comparisons can be made, it is worth noting that preschool children who were reportedly thin (section 5.5) were less physically active than normal weight (and overweight). The findings from this thesis and the study from Cameroon [26] indicate that under-nutrition (of which stunting and thinness are examples [22]) is relevant when exploring physical activity of preschool-aged children in African countries.

The OSRAC-P findings from this thesis showed that overweight/obese pre-school children were 79% less likely to engage in MVPA during preschool time in comparison to their normal weight peers. This differs from findings from urban South Africa, where underweight children were found to be 74% less likely to engage in preschool-based MVPA in comparison to normal weight children, but the findings for overweight children in the urban sample were not significant (overweight children were 64% less likely than normal weight children, $p=0.054$; obese children were 51% less likely, $p=0.098$) [95]. It is possible that the differences reported between the urban and rural pre-schoolers in this thesis are due to the difference in distribution of underweight, normal weight and overweight/obese children; and that in this thesis, the overweight and obese children were categorised together. For example, the proportion of overweight/obese children observed in this thesis was 3.6%, which is substantially lower than the overweight/obese sample in the urban South African sample (11.3%) [95,324].

Home and community contextual factors where physical activity occurs

In this thesis, the majority of parents reported being satisfied with their child's physical activity, and agreed that their child was active enough for health. In addition, the majority of parents agreed that physical activity was good and necessary for preschool children's health. These findings are consistent with qualitative data reported in a study conducted in the same rural setting at the same time as this thesis [101,325]. In the qualitative study, parents expressed that the believed that physical activity is important for a preschool child's development, and that a lack of physical activity would probably be indicative of illness. Furthermore, parents reported no concern about their preschool child not engaging in enough physical activity, as the children were often active [325]. However, in this thesis, less than half of the parents agreed that their preschool child should participate in three hours of physical activity per day, which suggests that half of the parents believe that less than three hours of physical activity is enough to be healthy. However, it is also possible that this particular question in the questionnaire was misunderstood by the parents in that the question does not explicitly state that the three hours should be distributed throughout the day and thus may have been interpreted as three consecutive hours. The findings reported in this thesis suggest that parents have a basic understanding of the relationship between physical activity and health, and perhaps could benefit from additional education on specific benefits of physical activity, such as cardio-metabolic health, bone health, and cognitive development (detailed in section 2.6.1).

Parents perceived there to be few barriers to their preschool child's physical activity. However, less than 20% of the parents agreed that their neighbourhood was safe for children. Qualitative data support these findings [101,325], with neighbourhood safety being identified as a key barrier to young children's physical activity in this rural community. Theoretically, neighbourhood safety (particularly perceptions of neighbourhood safety) is associated with physical activity principally through minimising children's opportunities to participate in outdoor physical activity in the community. Since time spent outdoors in the preschool years is a strong correlate of physical activity in young children [19], and given that preschool children have less autonomy to decide where they play (because they are young), their parents are likely to consider safety when deciding where their preschool child may play outdoors [326]. Nonetheless, despite the perception of compromised neighbourhood safety, the preschool-aged children in this thesis still had high levels of LMVPA. Neighbourhood safety and how it impacts physical activity and obesity in preschool-aged children is well-cited in global literature [202,327-332], with studies from the United States [329] and Japan [333] reporting that poor neighbourhood safety negatively influences physical activity levels in young children. However, the findings pertaining to this topic are mixed. Other studies have found that the presence of crime (measured from police reports and other sources), as well as the perceived threat of crime in the neighbourhood, do not attenuate physical activity levels in preschool children [330,331] and are not associated with obesity (as a consequence of too little physical activity) [326-328].

In Agincourt, it is possible physical activity levels amongst preschool-aged children are high because children may not have a choice regarding some of their physical activity (for example, having to walk to and from school due to lack of a family vehicle or funds for a taxi). Concern for safety may therefore be secondary to the children getting to and from school. In this thesis, over 80% of parents indicated that their preschool child walks to school 5-6 times per week, indicating that children could be accumulating a substantial proportion of their physical activity in transit to and from school. This may partially explain the high volumes of objectively measured physical activity reported in this thesis, and is supported by the patterns of physical activity identified on weekdays. Specifically, during the hour before school started (07:00 to 08:00am), children spent an average of more than 30 minutes in LMVPA, irrespective of sex or setting. This is not unexpected, as high volumes of walking to school have been reported in older children and adolescents living in Agincourt [334] and other rural areas in Kwa-Zulu Natal [335]. In Agincourt, school children aged 11 to 15 years old reporting walking approximately 200 minutes per week [334].

9.3 Sedentary behaviour

Levels of sedentary behaviour

This thesis is the first to report on levels of objectively measured sedentary behaviour in South African preschool children. Children spent 160 minutes and 150 minutes in sedentary behaviour (defined as activity <25counts.25s^{-1} [284]) on weekdays and weekend days, respectively. This is substantially less than levels reported in several other international studies involving pre-schoolers [242,303,336,337], including the study from Cameroon (between 513±50 and 564±50 minutes per day) [26]. Differences could be attributed to the

different cut point used (≤800 counts per minute versus ≤25 counts per 15s used in this thesis). Other studies from HICs (using similar sedentary behaviour cut points), including Canada [303,336], the United Kingdom [242] and the United States [337] showed that preschool children in those countries accumulate more than double the volume of sedentary behaviour (between 328 minutes [336] and 436 minutes [303]) than the preschool-aged children in this thesis. These differences could be due to the levels of physical activity (specifically LMVPA) shown in the rural South African preschool children, which arguably displace sedentary behaviour. It is therefore not surprising that the time spent in sedentary behaviour is low, when such a large proportion of the day is spent being physically active.

Another possible explanation for the differences between behaviours in this sample and other studies is the difference in wear-time rules applied to the data. Although 24-hour accelerometry data were collected, only 11 hours of waking wear time were included for analysis (based on time to bed and wake-up times, described in section 3.3). This is less wear time than that reported in three of the four studies referenced earlier [242,303,337], where wear time ranged from 12.0 hours to 12.6 hours per day. However, this – at best – would only amount to an extra 1.5 hours of sedentary behaviour. Furthermore, in this thesis, 20 minutes of consecutive zero counts were classified as non-wear time and were excluded from analyses [246]. In previous studies, the criterion for removal of data is frequently 60 consecutive minutes of zero counts [242,303,337], which would result in more time being classified a sedentary behaviour. Thus, it is expected that the levels of sedentary behaviour would be less (as observed in this thesis) when compared to studies using greater non-wear time rules (60 versus 20 minutes) [246].

Sedentary behaviour in boys and girls

Consistent with the physical activity results discussed earlier, sedentary behaviour findings differed between boys and girls based on the tool used (accelerometry or direct observation). For objectively measured sedentary behaviour, girls were significantly more sedentary than boys on weekdays (168.2 minutes versus 149.6 minutes, $p<0.05$), while sedentary behaviour was similar between boys and girls on weekend days (147.1 minutes versus 152.3 minutes, $p>0.05$). The available literature describing objectively measured sedentary behaviour in this age group has found that boys and girls accumulate similar volumes of sedentary behaviour [338-341]. Thus, the sex differences found (on weekdays only) in this thesis could possibly be explained by the boys spending more time in LMVPA and MVPA than girls on weekdays.

The patterns analysis showed that during weekday mornings until 11am, girls were consistently more sedentary than boys, although as the weekdays progressed sedentary behaviour was similar, indicating that after the preschool day, boys' and girls' levels of sedentary behaviour are similar. On weekend days, sedentary behaviour appeared to remain relatively low and similar between boys and girls throughout the day. These findings suggest that differences found in sedentary behaviour between boys and girls (during weekday mornings) are likely to be influenced by factors other than sex in this sample, as after-school and weekend periods (when the children are free to play) are similar. This is contrary to other studies assessing patterns of sedentary behaviour, where girls are frequently shown to be more sedentary than boys, on weekdays and weekend days [200,307]. It is possible that the

objectively measured (patterns) differences shown on weekdays and during the preschool day are due to the girls being less physically active, and spending more time being engaged in activities with their friends that are more sedentary (such as sitting on the swings or sitting while drawing pictures in the sand), as opposed to the boys who spend more time engaged in activities of a higher intensity (such as running around). This is substantiated by qualitative evidence from teachers [342] and Australian mothers [343], where boys are generally described as being more willing to engage in rough-and-tumble play or to run around, as opposed to girls who may prefer more sedentary activities such as playing with dolls or doing craft activities.

Direct observation of sedentary behaviour within the preschool day found that levels were similar for boys and girls (65.7% and 73.1%, respectively, $p>0.05$). Much like the case with physical activity, this contradicts findings from the accelerometry component of this thesis (likely due to differences in the measurement tools described earlier), it is consistent with other studies that have utilised the OSRAC-P [301,314]. The similarities reported during the preschool day are likely due to the children being in the same environment and having similar activity demands at any time during the preschool day. For example, the boys and girls are not separated during any activities, so classroom-based activities (such as group/circle time) as well as outdoor activities (such as recess or free play) are always done as a group, leaving little room for variation between boys and girls in activity. Although the percentage of time spent in observed sedentary behaviour was similar, it is worth mentioning that sex was not significantly associated with LPA ($p=0.096$), but girls were 37% less likely to engage in LPA than boys. Although not significant (and possibly so due to the sample size), this is meaningful as it indicates that girls may be less inclined to be more active, and so preschool teachers should be aware of encouraging girls to be more active (or as active as the boys) during the preschool day.

Sedentary behaviour in the Preschool and Grade R settings

On weekdays, for boys and girls, sedentary behaviour decreased as the day progressed, with the most sedentary periods of the day being between 07h00 and 10h00, and the least sedentary time being 13h00 and 17h00. This is consistent with the literature describing sedentary behaviour patterns in pre-schoolers [198,200], where sedentary behaviour is reportedly higher during preschool time, and diminishes throughout the afternoon.

In terms of the school environment and observed sedentary behaviour using the OSRAC-P, the Grade R's in this thesis were observed engaging in significantly more sedentary behaviour than the Preschool children (63% versus 81%, $p<0.001$). This was less than the sedentary behaviour observed in urban low-income preschool settings (93%), where children reportedly have little, and in some preschools, no space to be physically active outdoors [95], which may account for the differences in observed sedentary behaviour. The OSRAC-P study from urban South Africa reported differences in sedentary behaviour between preschool children from urban low- and middle- to high-income schools [95].

Although the amount of time spent in pre-academic activities and books was limited in both settings, the Grade R teachers appeared to spend more time in formal instruction, which

could explain the higher levels of sedentary behaviour amongst Grade R's. The OSRAC-P results showed that a large percentage of the time spent indoors was for learning activities, with the Grade R children spending over a third (36.7%) of their indoor sedentary time (56.9% of total time observed) in 'transition'. When calculated as time, this amounted to approximately 50 minutes per day that the Grade R's spent waiting for teachers to proceed to the next classroom activity. In a 4-hour preschool day, this is a substantial amount of time to spend sitting and waiting quietly. This time could be used for the children to engage in a more beneficial activity, such as being physically active, building a puzzle, or drawing. This high percentage of transition time in rural Grade R settings highlights a potential area for intervention, perhaps involving teacher training. The Preschool children spent 10.2% of their time in transition, which is similar to what has been reported in urban South African children, where transition time was 7% in low- and 10% in mid- to high-income preschools [95].

9.4 Screen time

Levels and compliance with screen time guidelines

This thesis is also the first to describe screen time in South African preschool-aged children and report on compliance with screen time guidelines (<1 hour per day as recommended by Australia, Canada and the American Academy of Pediatrics) [77,78,251]. Overall, parent-reported screen time was very low, with children spending 2.3 hours per week (Monday to Friday), and less than two hours per weekend (Saturday and Sunday) in total screen time. The majority (97.9%) of the preschool children in this thesis were compliant with guidelines during the week and on weekends. This percentage is higher than screen time compliance reported in HICs, with compliance ranging between 22% and 78% [177,252,253]. The most likely explanation for this difference is that access to screens was reportedly low in this sample: even though most of the parents reported ownership of a television, smart phone and/or tablet, very few parents reported having a computer, laptop or electronic games in the home. Thus, children's opportunities to engage in screen time are limited by comparison with HICs where ownership of such devices is high. For example, 88% of Australians own smart phones [344], and in 2014-2015, 86% of Australians had access to internet at home (94% of which used desktop or laptop computers) [345]. In the USA, statistics from 2016 reported that 77% of Americans owned a smart phone, and 78% owned a desktop or laptop computer [346].

Screen time in boys and girls

No differences between boys and girls were shown for weekday or weekend day television/video/DVD time. This is consistent with research that has reported screen time in boys and girls in this age group [347,348]. With reference to the children in Agincourt, is likely due to the finding that ownership of screens was low overall, and did not differ between boys and girls.

Screen time in the Preschool and Grade R settings

No screen time was observed (using the OSRAC-P) in either setting. None of the Preschool or Grade R settings had access to any screens, and therefore, preschool-aged children in Agincourt do not accumulate any screen time in the preschool setting. This is contrasted with

evidence reviewed by Vanderloo [256], who reported that the preschool environment is one that is particularly conducive to high levels of screen time. The difference between this thesis and the studies reviewed by Vanderloo are likely due to limited funding, limited access to electricity, and therefore reduced access to screens in these rural settings. Although screen time was not observed during the period of observation, it may be worth promoting the continued benefits of free play and physical activity over screen time to preschool teachers and child minders. This is relevant considering the growing urbanisation in South Africa [3], as well as in settings such as Agincourt [266,349], which could influence ownership and accessibility of screen-based devices in these settings.

Home contextual factors where screen time occurs

Although the parents reported relatively low levels of their preschool child's screen time, it is concerning that the majority of the parents agreed that too much screen time would not affect their child's health. This is contrary to findings from HICs including Australia and Canada, where parents have expressed concern about the health consequences of screen time for preschool-aged children [253,350], as well as concern that screen time is a barrier to children being active [351]. Given that screen time was not perceived to be bad for health, it was not surprising to find that many of the parents did not report placing limits on their children's screen time. This could be due to the perception that time spent watching television is educational, hence beneficial, as suggested in the qualitative study done in Agincourt [101,325]. However, it may also be because participation in screen time is low, and parents do not feel the need to further restrict it. Given the limited accessibility to screens and low levels of screen time of the children in this thesis, it is also possible that parents' understanding of 'too much' screen time is limited.

9.5 Gross motor proficiency

Levels of gross motor proficiency

The findings of thesis contribute to a growing body of literature describing gross motor skill proficiency in South Africa. The preschool-aged children in this thesis displayed adequate proficiency overall, with the majority of the sample (91%) achieving an 'average' or higher GMQ ranking for proficiency. This is consistent with the findings from studies from several different geographical locations across South Africa [102,210,276,287], where levels of mastery and proficiency are reportedly high, even in low-income settings. The findings in this thesis are also in line with a recent study conducted in five-year-olds from Myanmar, also a LMIC, where 90.7% of the children had GMQ rankings of 'average' or higher [224]. This is contrary to international findings [225-228], where it has been shown that children from low-income settings are more than twice as likely to have low competency in object control gross motor skills in comparison to their high-income counterparts [352]. Based on these findings alone, there is a probable need for the development of norms for gross motor development in the preschool years specific to LMICs or South Africa. It is possible that these observed levels of proficiency are attributable to the high levels of physical activity observed in these children, and that objectively measured and observed MVPA was associated with greater gross motor proficiency. This is in alignment with studies that have suggested that physical

activity provides an opportunity for preschool children to develop and practice gross motor skills [18,85,97].

Gross motor skill proficiency in boys and girls

In terms of between-sex differences for gross motor variables using the TGMD-2, it is important to note that the TGMD-2 norms for the object control component of the test differ between boys and girls. Girls require lower raw scores than boys for the object control component of the TGMD-2 to achieve the same standard score and/or age equivalent [104]. This may explain results showing no differences between boys and girls for any of the standardised scores, including GMQ.

In terms of locomotor skills, boys showed greater proficiency than girls in the leap, but were similar for the five other locomotor skills measured. This is somewhat contrary to findings from a recent study from South Africa, which reported that girls had greater gross motor proficiency in selected locomotor skills, including skipping and hopping [210]. However, Pienaar and colleagues used the Kinderkinetics Screening Assessment [285]. Although this assessment examines skills that overlap with those included in the TGMD-2, the performance criteria for 'mastery' differ to those in the TGMD-2, making it difficult to compare the Agincourt pre-schoolers to those tested using the Kinderkinetics assessment. Other South African data, collected from preschool children in an urban low-income setting found that preschool girls and boys achieved similar locomotor scores using the TGMD-2, although scores for the individual skills were not specified [276]. The study from Myanmar referred to earlier used the TGMD-2, and found that boys outperformed girls in the run, but that girls performed the gallop significantly better than the boys [224]. In Australia, girls have been found to perform better on the locomotor component of the TGMD-2 compared to boys [97], specifically in the gallop and hop. Overall, the international literature (largely from HICs) suggests that girls and boys are similar in locomotor skills [221,222,232].

In terms of object control skills, differences between boys and girls were also only observed in the analysis of individual skill raw scores, for the stationery dribble, strike and kick. The finding that the boys displayed greater proficiency in three object control skills is consistent with the majority of the literature describing sex differences for object control gross motor skills, using raw scores [18]. The South African study using the Kinderkinetics Screening Assessment also reported greater proficiency for all three object control skills that were assessed (catching, kicking and throwing) [210]. Boys' superior object control skills are frequently reported in studies from HICs using the TGMD-2, including studies from the United States [229], Canada [232], Australia [97,209] and the United Kingdom [221]; as well as in LMICs including Brazil [222] and Myanmar [224]. These findings have inspired researchers to develop interventions that have improved proficiency in preschool-aged girls' object control skills [223]. Although it has not yet been established whether girls can 'catch up' to boys, the findings reported in this thesis suggest that girls in Agincourt may benefit from a similar intervention so that they can improve their object control skills.

In this thesis, although the boys displayed greater proficiency in the kick than the girls, it is notable that the kick was performed the best by boys and girls. Proficiency in kicking is not unexpected in South African children, particularly boys (of any age). There is a strong soccer 'culture' among South Africans, particularly in low-income areas where the game is played widely [353], both formally (in a league format) and informally. It is therefore possible that this soccer 'culture' and being surrounded by other children, some of whom are older, in the community is a potential source of kicking 'coaching'. This is supported by the findings in the questionnaire, in that 73.8% of parents reported that their child was active with children in the community 5-7 days weekly. Furthermore, the parent's questionnaire revealed that although the preschool children have a limited variety of toys at home, almost 90% of parents said that their children had balls at home (and nearly half of the parents reported that their children play with bats and balls 5-7 days weekly). It is possible that the preschool-aged children in Agincourt are practicing the skills for which they have the appropriate equipment. While this is evidently having a positive effect on their ability to kick, it does not explain the lower levels of proficiency in the object control skills for which the scores were not as high (for example, in the dribble, throw and roll). Further research is required to establish how and why these differences between skills would occur.

Gross motor skills differences between Preschool and Grade R children

The differences shown between the Preschool and Grade R children were expected considering the significant age difference between the different settings (4.4 years vs. 5.6 years, respectively). Even within the narrow age range for preschool-aged children included in this thesis (three to five years of age), the progression of gross motor skill proficiency is expected as age is the most consistent correlate of gross motor skill proficiency [18,206]. The proficiency in locomotor raw skills was significantly greater in the Grade R children compared to the Preschool children for the slide and the gallop. In terms of object control skills, the Grade R children outperformed the Preschool children in the strike, stationary dribble and catch. The Preschool children were not more proficient than the Grade R's for any of the skills tested.

The level of gross motor skill proficiency that these children display is good despite the scarcity of play equipment in the Preschool and Grade R settings (shown in Table 4.1), and with very limited, if any, organised sport, extra-mural activities and teacher instruction. This finding challenges the literature that states that it is necessary for children to learn and master gross motor skills through 'proper' instruction (including the teaching of technique and structured opportunities to gross motor skills) [96,354]. However, as discussed earlier, these preschool children are exceptionally active, irrespective of sex or setting. It is possible that high levels of unstructured LMVPA and MVPA may, in areas like Agincourt, be sufficient for these children to learn and practice gross motor skills.

Gross motor skills and body composition

The findings from this thesis suggest that body composition is not associated with gross motor skill proficiency. This is contrary to findings from South Africa [114] as well as studies conducted in HICs, where obesity has been associated with lower gross motor skill proficiency

in preschool-aged children [108,111,355]. Specific skills that have been found to be negatively associated with body composition include jumping [108], hopping [108], balancing [114] and catching [114], although combined locomotor and object control skills have also been shown to be compromised in obese Italian pre-schoolers [355]. Given the uneven distribution of preschool children in Agincourt being classified as thin, normal weight and overweight/obese, it is likely that the absence of an association between gross motor skill proficiency and overweight/obesity is due to a lack of variance (less than 5% classified as overweight/obese, nearly 70% were classified as normal weight). In addition to this, there was little variance in the distribution of TGMD-2 scores.

Summary

The aim of this thesis was to describe the physical activity, sedentary behaviour, screen time and gross motor skills of preschool children in rural South Africa, and to explore the context in which these factors that contribute to overweight/obesity occur. The intention was that the findings of this thesis would then provide the foundation for an intervention that would optimise body composition by reducing overweight/obesity in rural children in South Africa. The results of this thesis suggest that overweight/obesity was not a concern in the target population, and that none of the behaviours measured (physical activity, sedentary behaviour and screen time) nor gross motor skills require urgent modification or intervention.

9.6 Implications of findings and recommendations

This section addresses the implications of the findings discussed above, and includes appropriate recommendations for the 1) preschool child, 2) parents and caregivers, 3) preschool teachers and preschool settings, 4) community, and 5) government and policy makers.

Preschool child

Preschool-aged children in Agincourt engage in high volumes of physical activity (LMVPA), and it would appear that intervention to increase LMVPA would not be necessary in this setting. However, compliance with respect to the 'energetic play' or MVPA component of the physical activity guidelines was less promising. Therefore, the preschool children in Agincourt should be encouraged to be more active at higher intensities to achieve maximum health benefits.

While high levels of physically activity are certainly a positive attribute from the perspective of physical activity research (as it is well known that physical activity is greatly beneficial to children's health and development, detailed in Chapter 2, section 2.6.1), it is possible that in this particular sample of preschool-aged children, the high levels of physical activity, combined with low levels of teacher engagement are potentially at the expense of early learning. This is particularly relevant in the Preschool settings, where observed physical activity was significantly higher, on account of spending most of their school day outdoors. While the benefits of free play in preschool children have been well established [80], it would be important for future research to establish whether the high levels of free play in these children is compromising their cognitive development and school readiness. It would also be

valuable to conduct studies that determine whether or not these high levels of physical activity (and desired levels of screen time) are maintained throughout the Primary School years, as it is understood that physical activity and sedentary behaviour do track from the preschool years (early childhood) into childhood [139].

The findings from this thesis suggest that an intervention to reduce overweight/obesity is not warranted in pre-schoolers in Agincourt, as thinness was more prevalent. Further insights into thinness and underweight, and how these concepts relate to physical activity in rural preschool children may be worth investigating. It has previously been suggested that in settings where under-nutrition is prevalent in preschool-aged children, like South Africa [3], promoting increased levels in physical activity may compromise other areas of development (such as cognitive development) in children who are under-nourished and present with energy deficiencies. Increasing energy expenditure (by increasing physical activity) could potentially take away much-needed energy from other areas of the body (like the brain). This issue is pertinent in the preschool years, being a time of rapid brain development [356].

The children in Agincourt have good gross motor skills, despite a lack of instruction, toys and play equipment. This finding warrants further research that investigates the mechanisms through which these children develop their gross motor skills. This research would be relevant in other low-income settings in South Africa, where gross motor proficiency is also reportedly high [102,210,276,287].

It is evident that these preschool children have a solid foundation upon which to progress these skills, and with proper instruction [96], these children could master these skills, particularly those that were performed less well (such as the stationary dribble). Therefore, it would be worthwhile to establish whether the high levels of gross motor proficiency are progressed throughout the Primary School years (up until approximately age 10 years, as this is said to be when mastery is achieved [206]).

Parents and caregivers

Based on the findings of this thesis, parents and caregivers are positive about the role that physical activity plays in their preschool child's life, and acknowledge that physical activity is important for health and development. Future studies assessing parental perceptions and beliefs regarding pre-schooler's physical activity (and sedentary behaviour) should assess parent-child dyads to properly understand how parents and caregivers may influence a preschool-aged child's physical activity. It is therefore probable that information about the benefits of physical activity would be well received by parents, and that parents would be receptive to increasing their knowledge in this regard. Parents of preschool children have been described as the 'gatekeepers' of their children's physical activity [357], and therefore parents in Agincourt should be encouraged to provide support and opportunities to their preschool child, so that they may continue being physically active.

Although the majority of the pre-schoolers in Agincourt did not engage in excessive screen time, it is concerning that parents do not believe that there are health risks associated with excessive screen time. Although access to screens in Agincourt appears to be lower than that

seen in other countries or income ranges (and this could be a contributing reason for the low screen time), it is also important to consider that the urbanisation or economic transition of the Agincourt community [266] may result in increased access to screens over the next few years, and so the low levels of screen time reported in this thesis may change over time. Therefore, screen time should be monitored, and education (for parents, teachers as well as children) undertaken so that the low levels reported in this thesis can be continued when the transition occurs.

Preschool teachers and preschool settings

The observation of the Preschool and Grade R environments revealed several limitations within the school system and teaching capacity: The preschool children, particularly the Grade R children, spent a substantial portion of their sedentary time 'in transition' (waiting for classroom or academic activities to begin or continue) in the classroom, which is potentially because teachers have limited lesson plans and limited capacity for actual teaching (detailed in Chapter 7). Teachers therefore require training that would enable them to use their teaching time more effectively, and therefore better prepare preschool-aged children for primary school. In terms of physical activity, a lack of training with respect to physical activity in preschool-aged children may be the reason for virtually no teacher-prompts and limited teacher-initiated (and facilitated) activities. Given the amount of time that the children spent sedentary 'in transition', teachers may benefit from training that could enable them to replace or break up this sedentary time with MVPA. By increasing MVPA during the preschool day, it is possible that more children would be able to achieve the 'energetic play' or MVPA component of the new physical activity guidelines [77,78]. An example of an intervention that has made use of the principle of replacing sedentary transition time with activities that are at a higher level of intensity (MVPA) is "Jump Start" [13,358]. Future research could evaluate the feasibility of adapting such interventions (as well as others detailed in a review of sedentary behaviour interventions [359]) for South African settings.

It was also made clear by some of the teachers that many of them had never received gross motor skills training for young children and were unsure as to how to conduct physical activity and gross motor skill sessions/learning experiences with little or no equipment. Although this did not appear to have a detrimental effect on children's gross motor skill proficiency, it may be beneficial for the teachers to be trained and capacitated to provide structured physical activity learning experiences. In light of the fact that the Preschool and Grade R settings were different in several respects, training for teachers and child minders in each setting should be tailored to the needs of the teachers and child minders in each setting.

An additional recommendation for future research could include a longitudinal study that compares children who attend Preschools versus children who do not attend Preschools on health outcomes, movement behaviours (including physical activity and sedentary behaviour) and developmental outcomes (such as cognitive development). It would be of interest to determine whether children differ according to these outcomes when beginning Grade R.

Community

Based on the findings in this thesis, neighbourhood safety is one of the few perceived barriers to physical activity reported by the parents. Although the children were engaged in high levels of physical activity, it is still important that parents (and children) feel safe in their communities when playing or being physically active outdoors. Agincourt, as described in section 3.1, is a rural tribal village that is governed by a tribal authority and falls under the jurisdiction of a municipal authority. If it were possible to get buy-in from tribal and municipal authorities, as well as buy-in from community members, there are a few options for promoting safer play for preschool children. These include 1) nominating youth in the same community to be 'play leaders' for the preschool-aged children, and 2) allocating space for safe play and age-appropriate parks. These interventions/developments have been implemented in other parts of South Africa [360-363], although most programmes are reliant on external funding.

Government and policy makers

While the challenges for intervening at a policy or governmental level are substantial and duly noted, there is a need for a working national preschool curriculum that is inclusive of physical education (or structured physical activity learning experiences) and gross motor development. This has been previously emphasised in the South African setting [364], where recommendations were made to include physical education (from Grade R all the way to high school) as part of the school curriculum. However, follow-up studies have reported that despite the recommendation of a new curriculum, simply enforcing a new 'physical activity policy' is insufficient [365]. In South Africa, the implementation of physical education at all levels of schooling (preschool [366], primary school [365,367] and high school [365,368] levels) are reportedly hampered by the absence of willing and well-trained teachers, poor provision of equipment for teaching any form of physical education, poorly maintained facilities appropriate for physical activity and physical education, all of which government support is required. Thus, the implementation and maintenance of new policies and programmes need to be properly funded and supported, and then implemented and monitored. However, intervention at government level is likely to not be feasible in the near future, in light of the additional challenges faced in South Africa (and specifically Agincourt), such as HIV/AIDS, communicable- and non-communicable diseases, teenage pregnancy [260]; as well as poverty and unemployment [101,325].

In section 2.10, an overview of the early childhood development (ECD) sector in South Africa was provided, and the three key ECD strategies were highlighted: "1) To deliver comprehensive services to young children, using all opportunities of contact with families; to extend early child care and education through home- and community-based programmes, beginning with the poorest communities not reached by current services; 2) To ensure food security and adequate daily nutrition for the youngest children to avert the life-long damaging effects of stunting; 3) To launch well-designed high-profile parent support programmes through media campaigns, community activities and services that acknowledge and reinforce the importance of positive parenting for young children" [259].

Overall, these key ECD strategies highlight that early child care services, nutrition and parent education are especially important in the South African ECD context; and it appears that physical activity is not prioritised. However, there does not need to be trade-off between these different components and health behaviours that all contribute to a healthier young child. The findings presented in this thesis suggest that physical activity levels are high and are perceived to be beneficial by parents. It is also well-established that parents of preschool-aged children play a pivotal role in their child's physical activity [19,195]. Thus, instead of physical activity competing with issues such as positive parenting and nutrition (both of which are currently prioritised), physical activity could rather be used as a vehicle or a medium through which other goals are achieved. Therefore, policy makers and experts should consider the inclusion of physical activity (and possibly aspects of gross motor skills) when developing programmes that reinforce positive parenting.

Projects such as the 2016 HAKSA Report Card [4], as well as the development of South African-specific 24-hour movement guidelines (as done in Australia and Canada [77,78]) could play a role in informing policy makers about the importance of preschool children's movement behaviours, with the hope of leading these authorities to prioritise them.

9.7 Strengths and limitations of this thesis

The main strength of this thesis is that it is the first to objectively measure physical activity and sedentary behaviour in South African rural preschool-aged children, as well to report on screen time in this age group. The results of this thesis therefore contribute significantly to an otherwise incomplete body of literature describing preschool children's physical activity in South Africa, and in LMICs more generally. With regards to the methodology surrounding the objective physical activity measurement, the preschool children demonstrated excellent compliance with wearing the accelerometer. Furthermore, the use of more than one analytical method to analyse the accelerometry component (using a patterns analysis in addition to the more 'traditional' methods) also contributes to the strength and significance of this thesis.

With respect to the gross motor skill testing, it is possible that the lack of differences reported between boys and girls was due to not being adequately powered to show statistically significant differences. Additionally, had the sample size been greater it may have been possible to detect differences between boys and girls within the Preschool and Grade R settings. Although the sample size was possibly smaller than ideal, it was still possible to explore the correlates of gross motor skills which is a novel contribution to the South African literature.

There were some limitations in the methodology of this thesis. The use of the IOTF BMI cut-offs to define overweight/obesity has been shown to have some bias and a low sensitivity for measuring over-fatness (i.e. a high proportion of children with 'normal' or 'healthy' BMI-for-age are actually excessively fat) [369]. Thus, this study may have benefitted from using an additional measure of body composition to get a clearer indication of overweight/obesity prevalence in the sample.

The OSRAC-P tool (having been developed in the USA) included several items that were not tailored to South African rural settings, such as playing in a sandpit (as opposed to only having sand to play in) or being outdoors during time of performing sanitary tasks (including hand washing and going to the toilet). However, these activities were not likely to sway the results of the thesis pertaining specifically to physical activity and sedentary behaviour, as the time spent in these activities was proportionally lower than other activities. Another potential limitation with the OSRAC-P was that of sample size (in terms of number of children observed and therefore number of observations made in each setting). General time constraints of the study influenced the sample size, and so observations were performed once at each school, and the observational period was between 08h00 and ±12h00, for the sake of consistency between Preschool and Grade R settings. However, the preschool day did continue beyond 12h00 in the Preschool settings. Despite this limitation, the OSRAC-P data collected provided a great deal of insight in the contextual physical activity and sedentary behaviours.

Due to logistical constraints (i.e. timing of funding received and timing constraints), the parents who completed the parents' questionnaire were not matched to the preschool children for whom physical activity data were available. Thus, it was not possible to assess associations between contextual factors and children's behaviours, although this would have been ideal. Still, the parent questionnaire provided valuable contextual information for this thesis and identified key areas which may be worthy of future investigation.

Administration of the parent questionnaire also presented several challenges, including literacy of the parents completing the questionnaire (in some case the parents could not read or write), as well as translation of the English version to Xitsonga. Several constructs and concepts explored in the questionnaire did not translate from English into Xitsonga easily (or at all, in some instances), with nuances of the English questions and responses lost in translation. In South Africa, back-translation of questionnaires (in general) tends to be prohibitively expensive, and so the questionnaire was translated by a Xitsonga speaker from Agincourt and checked by another Xitsonga speaker (also based in Agincourt). The challenges presented by the translation of some concepts could potentially increase the likelihood of certain concepts being comprehended incorrectly. To minimise these challenges, a fieldworker administered the questionnaire to parents and caregivers who were unable to complete the questionnaire themselves. The PhD candidate was available to explain terms to the parents and caregivers that could speak English. However, it is possible that this only somewhat alleviated the language problem.

The questionnaire used in this thesis was adapted from the HAPPY [294] and Pre-PAQ [295] questionnaires. During the process of adapting the questionnaires, the intention was to make the questionnaire applicable for South Africans living in low- and high-income settings in South Africa, as well as in urban and rural settings. Therefore, there were questions in the questionnaire that may have been less applicable in the rural setting (Agincourt), due to income status or geographical location. In Agincourt, it became apparent that several questions pertaining to organised sports were not applicable in the rural setting, and therefore answers provided were found to be somewhat unreliable and were omitted. It was also apparent that the parents' report of certain activities and ownership of items did not

always match anecdotal evidence or was contradicted in another component of the questionnaire. For example, 5.6% of parents reported that their children participated in Monkeynastix, an organised movement education programme. This is not possible, as the programme is not offered in Agincourt, and the nearest Monkeynastix branch is over 100km away from Agincourt, according to the Monkeynastix website [83]. Some parents also reported that their children use bicycles to travel to school but did not report having a bicycle at home.

A convenience sample of children from one rural village in South Africa was recruited for this thesis. Therefore, the results of this thesis cannot be generalised to all preschool-aged children (rural or otherwise) across South Africa. It is also worth acknowledging that Agincourt is a thoroughly researched area [260] as it is the location of the MRC/Wits Research Unit. Research fatigue, defined as the process by which people become tired of engaging in research or resist participation in any further research [370], is therefore an issue that may explain the difficulty in recruiting parents, specifically for the questionnaire component of this study. This issue of research fatigue in the context of Agincourt has been addressed elsewhere [2]. However, this was the first study in Agincourt that involved the Preschool and Grade R settings, and the first to objectively measure physical activity and sedentary behaviour, and the first to assess gross motor skills in Agincourt. Therefore, the Preschools and Primary Schools were willing to accommodate the research due to its novelty. Overall, the benefits of using this site for research far outweighed the limitation of potential research fatigue.

9.8 Conclusion

Although overweight/obesity was not found to be a prominent problem in Agincourt, overweight/obesity in South African preschool-aged children is high [3] and is projected to increase (across African countries) [1]. Interventions developed in HICs have found success in reducing overweight/obesity in preschool-aged children by increasing physical activity, or reducing sedentary behaviour and/or screen time, or improving gross motor skills. However, the results of this thesis have shown that preschool-aged children in Agincourt are already engaging in high levels of physical activity (particularly of a light- to vigorous-intensity), low levels of sedentary behaviour and screen time and display good gross motor skill proficiency. Therefore, developing an intervention to reduce overweight and obesity in Agincourt, especially by way of using interventions that aim to increase total physical activity, reduce sedentary behaviour and screen time, and/or improve gross motor skills, is not justified. Thus, the findings of this thesis have highlighted the importance of conducting exploratory research within a community before developing and implementing intervention, as the findings of this thesis differed from what was initially predicted.

It is well-established that children benefit immensely from being physically active and proficient in gross motor skills, as well as from engaging in little-to-no screen time in the preschool years. Therefore, it is important that the results of this thesis be used to reinforce healthy activity-related behaviours in this population of preschool children, and that teachers and parents are empowered to support and encourage their preschool child/children to

continue being physically active. It is necessary that preschool-aged children in Agincourt are encouraged to remain physically active, and to engage in more 'energetic play'. It is also imperative to encourage the maintenance of the low levels of screen time reported in this thesis.

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Appendices

Appendix A

Map of South Africa

Appendix B1

Physical activity and gross motor skills in preschool children
Parent Information Sheet

Dear parent / caregiver

I am Dr Catherine Draper, a researcher with the University of Cape Town and Wits University. Our research team is doing a study to look at physical activity and gross motor (movement) skills of preschool children. The aim of this study is to measure and observe the physical activity of children in preschools in Bushbuckridge. Your child's preschool has agreed to be part of this study, and we would like to invite your child to take part.

Firstly, as part of this study, your child's height and weight will be measured. Secondly, they will take part in some fun and easy activities that are designed to assess gross motor skills in young children. The test includes activities such as running, galloping, hopping, leaping, jumping, sliding, hitting, bouncing, catching, kicking and throwing a ball. The assessment activities will take 20-30 minutes. Your child will be video recorded while they do the assessment activities, and these video recordings will then be analysed by the student conducting this study. These videos will only be seen by the research team, and won't be shown to anyone else. The assessment activities will be done during the day at your child's preschool.

The student conducting the assessment is trained to do the activities with children, so your child will be safe. The activities are similar to games your child would play at preschool, so they do not put your child at risk. However, if for some reason your child is hurt during the assessment, the student is trained in First Aid and will be able to handle the situation appropriately. If we pick up any developmental delays in the assessment, we will be able to assist with referring your child to someone who will be able to assist them. The student will be assisted by someone who will be able to communicate with your child in Shangaan, so they will be able to understand all the instructions during the assessment.

Thirdly, we will measure your child's activity levels. This is done using a small electronic device called an accelerometer. The accelerometer is about the same size as a small matchbox, and your child would wear it on a belt around their waist for seven days for the entire day (at school and at home), and while they are sleeping. The only time they should take it off is when they bath, shower or swim. Someone from the research team will come to your child's preschool to put on the accelerometer, and will come and collect it after seven days. Lastly, your child will be observed at their preschool, during the school day. The student will watch your child for a short period of time (15-30 minutes) and make notes about his/her activities.

We will not use your child's name or the name of your child's preschool when we report on the results, so your child will remain anonymous. Your child will not be forced to take part in the study, and they will be free to stop doing the activities at any time if they feel uncomfortable. They will receive a small gift to thank them for their participation. If your child does not want to take part, this will not affect their participation in any activities at their preschool. We will be developing a programme to promote physical activity and health of preschool children. The results of this study will help us to make we develop a programme that will be appropriate and successful.

If you have any queries about the study, please contact Dr Catherine Draper at (021) 650 4570, University of Cape Town.

Appendix B2

Physical activity and gross motor skills in preschool children
Parent Consent Form

If you are willing for your child to participate, please could you sign below and return this form with your child to their preschool. Your signature also indicates that you understand the aims of the study, and have had the opportunity to ask any questions which have been answered in your home language.

Name of child: _____

Name of parent: _____

Signature / mark / thumbprint of parent: _____

Date: _____

Name of investigator: Dr Catherine Draper

Signature of investigator: _____

Date: _____

If you have any queries about the study, please contact Dr Catherine Draper at (021) 650 4570, University of Cape Town. Should you have any queries regarding the ethics of this study, please contact:
Prof Marc Blockman, Chairperson, Health Science Faculty Research Ethics Committee, University of Cape Town at (021) 406 6492, or E52-24 Groote Schuur Hospital Old Main Building, Observatory, 7925.

This study adheres to the guidelines described in the Declaration of Helsinki Ethical Principles for Medical Research Involving Human Subjects.

Physical activity and gross motor skills in preschool children
Parent questionnaire information sheet

Dear parent / caregiver

I am Dr Catherine Draper, a researcher with the University of Cape Town. Our research team is doing a study to look at physical activity and gross motor (movement) skills of preschool children. As part of this study, we will be developing a programme to promote physical activity and health of preschool children, and in order to make sure that we develop a programme that will be appropriate and successful, we would like your input.

We would like to invite you to complete a questionnaire that will ask you about the following:

- Some general information about yourself
- Your physical activity habits
- Your home and your neighbourhood (community)
- Your child's activity during the week and on the weekend.

It will take approximately 30-60 minutes to complete the questionnaire, and you will be able to complete the questionnaire in your home language. You can either complete the questionnaire with the assistance of someone from our research team, or you can complete the questionnaire on your own at home, and return it with your child to his or her school.

Your answers to these questions will be used to help us develop a programme that will assist parents to promote physical activity and health of their children. There are no right or wrong answers to the questions you will be asked in the questionnaire, and it is important for you to answer these questions as honestly as possible so that we can get the most correct information. Although the person giving out the questionnaire may know your name, neither your name nor the name of your child's preschool will be used when reporting on this study and your name will not be connected to your answers in the questionnaire. Your personal details and responses to the questions will therefore be kept confidential.

There are no right or wrong answers to the questions you will be asked in the questionnaire, and it is important for you to answer these questions as honestly as possible so that we can get the most correct information. Although the person giving out the questionnaire may know your name, neither your name nor the name of your child's preschool will be used when reporting on this study and your name will not be connected to your answers in the questionnaire.

We understand that completing this questionnaire is voluntary. You are able to withdraw from the study at any time. If you choose not to be involved in this study, there will be no negative consequences for you or your child. Your participation in this study will be extremely helpful for us when we develop our programme, and we hope to ultimately improve the health and well-being of children from your communities.

If you have any queries about the study, please contact Dr Catherine Draper at (021) 650 4570, University of Cape Town.

Appendix B4

Physical activity and gross motor skills in preschool children
Parent questionnaire consent form

If you are willing to complete this questionnaire, please could you sign below. Your signature will confirm that you know you are able to withdraw from the study at any time. Your signature also indicates that you understand the aims of the study, and have had the opportunity to ask any questions which have been answered in your home language.

Name: _____

Signature / mark / thumbprint: _____

Date: _____

Name of investigator: Dr Catherine Draper

Signature of investigator: _____

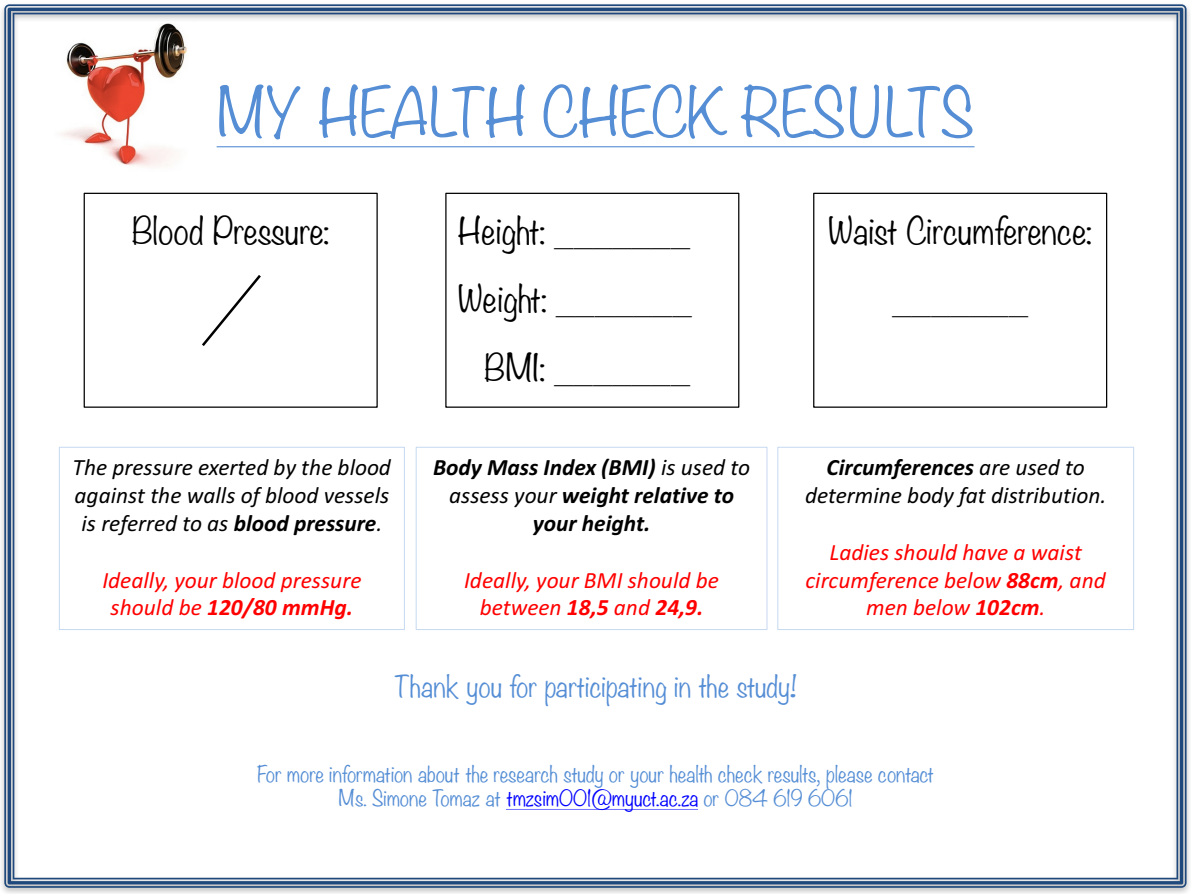
Date: _____

If you have any queries about the study, please contact Dr Catherine Draper at (021) 650 4570, University of Cape Town. Should you have any queries regarding the ethics of this study, please contact:
Prof Marc Blockman, Chairperson, Health Science Faculty Research Ethics Committee, University of Cape Town at (021) 406 6492, or E52-24 Groote Schuur Hospital Old Main Building, Observatory, 7925.

This study adheres to the guidelines described in the Declaration of Helsinki Ethical Principles for Medical Research Involving Human Subjects (2013).

Appendix B5

Health check card



Appendix C1

Physical activity environment observation		
School / centre name		
Date of observation		
Start time		
End time		
Outdoor area		
Outdoor playground		
Size		
Used by anyone else		
If no playground, what is used instead?		
Playground surface	**Present**	**Primary surface**
Rubber mats		
Gravel / stones		
Concrete		
Tar		
Brick / paving		
Grass		
Dirt		
Sand		
Wood chips		
Other		
Drinking water available and operational		
Vegetation		
Garden		
Trees		
Shrubs		
Type of shade		
Man-made roof / cover		
Natural trees		
Nearby buildings		
Temporary awning / tent		
Umbrella		
Other		
How much of playground is covered in shade?		
<⅓		
⅓ - ⅔		
>⅔		
Flatness		
Completely flat		
Some incline / decline		
Significant incline / decline		
Overall cleanliness of outdoor area		
Most or all equipment is in good aesthetic condition		
Some lack of cleaning maintenance, equal mix of well and poorly maintained elements		
Very unclean or poorly maintained		

Equipment		
Fixed play equipment	**Indoor**	**Outdoor**
Balancing surfaces, e.g. balance beams, boards, etc.		
Aiming structures, e.g. basketball / netball hoops		
Climbing structures, e.g. jungle gyms, ladders, etc.		
Hanging equipment, e.g. monkey bars		
Merry-go round		
Pool		
Sandbox		
See-saw		
Slide		
Swinging equipment, e.g. swings, rope, tyre swings, etc.		
Tricycle track		
Tunnels		
Dramatic play structure, e.g. play house		
Shed / storage for equipment		
Other		
Material of most fixed equipment		
Metal		
Plastic		
Wood		
Other		
Overall condition of fixed equipment		
Excellent condition and completely functional equipment		
Fair condition or partial functioning of elements of equipment		
Poor condition or lack of function		
Portable play equipment	**Indoors**	**Outdoors**
Ball play equipment		
Climbing structures		
Floor play equipment		
Jumping play equipment, e.g. skipping ropes, hula hoops		
Parachute		
Push/pull toys, e.g. wagon, scooters etc.		
Riding toys, e.g. tricycles, cars etc.		
Rocking and twisting toys, e.g. rocking horse etc.		
Sand/water play toys, e.g. buckets, scoops, shovels etc.		
Slides		
Twirling play equipment, e.g. ribbons, scarves, batons etc.		
Stacking structures, e.g. building blocks		
Other		

Indoor play space		
Is indoor play space suitable for:		
Quiet play / not a lot of room for movement		
Limited movement / some active play (able to move by walking, skipping, hopping, jumping, etc.		
All activities		
	Number	**How often used**
TV / DVD / video player		
Other video games		
Computer		

Policies	
Time scheduled for physical activity / play	
Structured	
Free play	
Outdoor	
Curriculum / lesson plans for physical activity / gross motor skills	

Written policy on physical activity	**Spoken**	**Written**
Safety checks of equipment		
Weather		
Active play and inactive time		
TV use and TV viewing		
Play environment		
Staff supporting PA		
PA education		
Withholding PA / play as punishment		
Other		
Compliance with policies		
Communication of policies to parents		

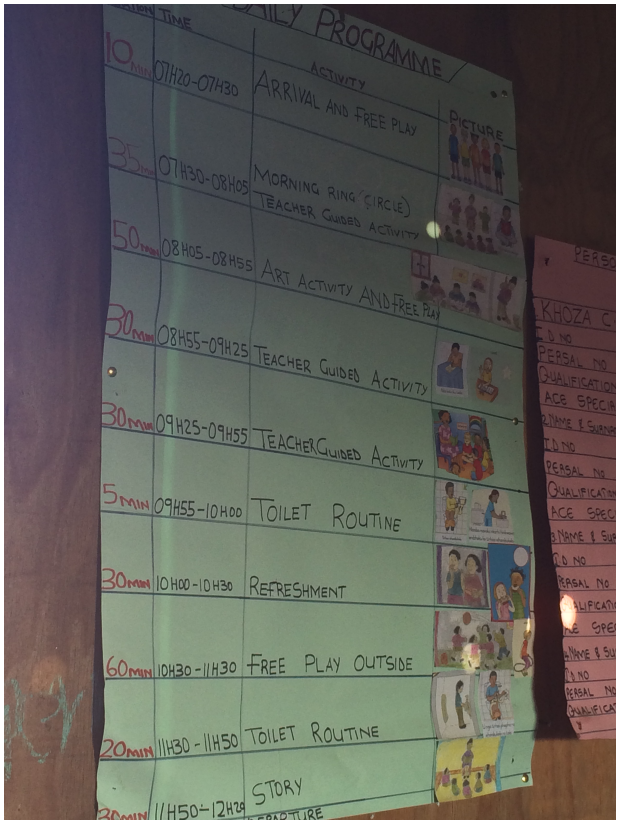
Training for staff on physical activity / gross motor skills
Promotional material about physical activity / gross motor skills
Extra-mural physical activity programmes

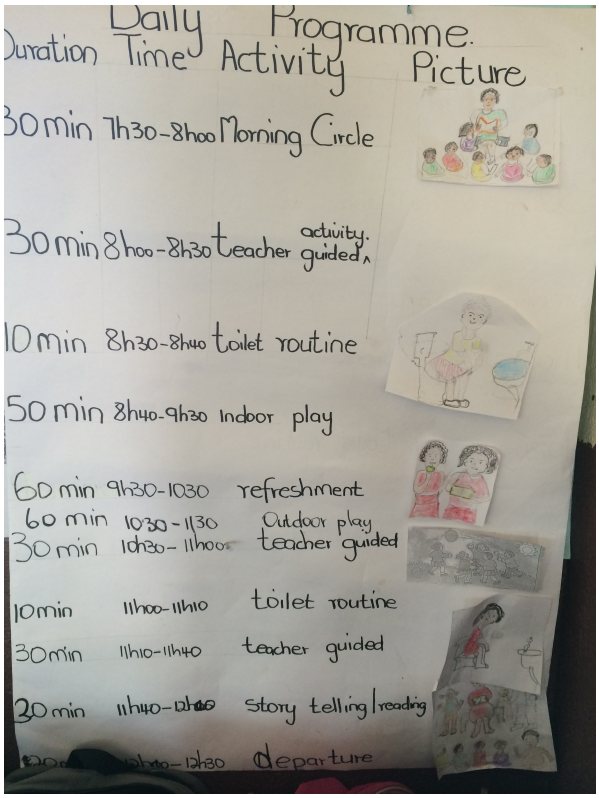
Barriers to promoting a health chid care environment	
Lack of support from administration	
Lack of support from teachers	
Lack of support from parents / caregivers / families	
Lack of staff training on physical education	
Limited opportunities for physical education	
Insufficient funds	
Lack of physical education resources	

What do they need to improve promotion of physical activity / gross motor skills in their centre?

Appendix C2

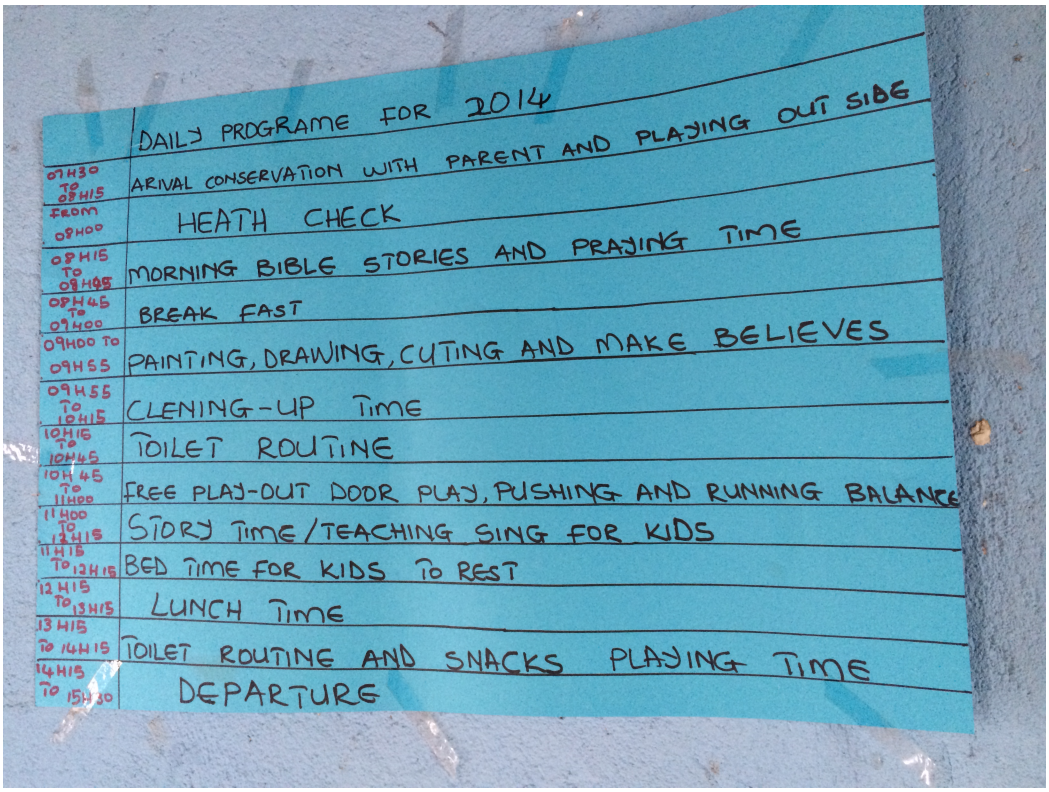
Photographs of the preschool daily schedules





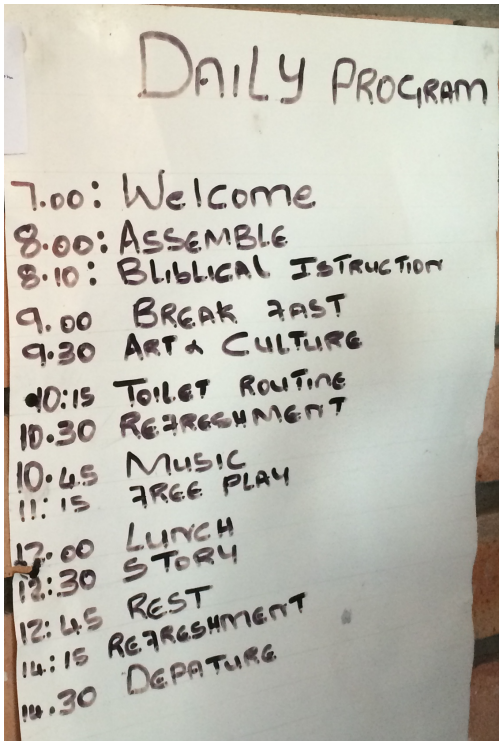
Daily Programme.

Duration	Time	Activity	Picture
30 min	7h30-8h00	Morning Circle	
30 min	8h00-8h30	teacher activity guided	
10 min	8h30-8h40	toilet routine	
50 min	8h40-9h30	Indoor play	
60 min	9h30-1030	refreshment	
60 min	1030-1130	Outdoor play teacher guided	
30 min	10h30-11h00		
10 min	11h00-11h10	toilet routine	
30 min	11h10-11h40	teacher guided	
30 min	11h40-12h00	Story telling/reading	
	12h00-12h30	Departure	



DAILY PROGRAME FOR 2014

07H30 TO 08H15	ARIVAL CONSERVATION WITH PARENT AND PLAYING OUT SIDE
FROM 08H00	HEATH CHECK
08H15 TO 08H25	MORNING BIBLE STORIES AND PRAYING TIME
08H45 TO 09H00	BREAK FAST
09H00 TO 09H55	PAINTING, DRAWING, CUTING AND MAKE BELIEVES
09H55 TO 10H15	CLENING-UP TIME
10H15 TO 10H45	TOILET ROUTINE
10H45 TO 11H00	FREE PLAY-OUT DOOR PLAY, PUSHING AND RUNNING BALANCE
11H00 TO 12H15	STORY TIME/TEACHING SING FOR KIDS
11H15 TO 12H15	BED TIME FOR KIDS TO REST
12H15 TO 13H15	LUNCH TIME
13H15 TO 14H15	TOILET ROUTINE AND SNACKS PLAYING TIME
14H15 TO 15H30	DEPARTURE


DAILY PROGRAM
7.00: Welcome
8.00: ASSEMBLE
8.10: BIBLICAL ISTRUCTION
9.00 BREAK FAST
9.30 ART & CULTURE
10:15 TOILET ROUTINE
10.30 REFRESHMENT
10.45 MUSIC
11:15 FREE PLAY
12.00 LUNCH
12:30 STORY
12:45 REST
14:15 REFRESHMENT
14.30 DEPATURE

Appendix D1

Accelerometry instruction sheet

Keep sticker/ number ***on top***

Keep the belt on ***all day***!

Keep the red box in the ***front*** of the waist on the ***right***

You can cover the belt with your child's clothes to hide it from view

Keep belt on ***all night*** when ***sleeping***

Take the belt off when taking a ***bath / shower*** or when ***swimming***

Appendix D2

Accelerometry methods

This appendix details the following:

1. How 'time to bed' and 'wake-up time' was determined using two different methods
2. The results of the comparison of the two different methods

Table 1. Summary of the different methods used to determine 'time to bed' and 'wake up time'

	1. Manual method	2. Non-wear (sleep) algorithm
Programme(s) used	ActiLife v.6 (sleep scoring tab), followed by MS Excel and ActiLife (scoring tab)	Software developed by McVeigh et al (1); followed by MS Excel and ActiLife.
Epoch length	15s (2)	60s for algorithm (1); 15s when in ActiLife
Identification of 'time to bed' and 'wake up time'	Manual inspection of the data in ActiLife using the 'sleep scoring' tab. The 'time to bed' and 'wake up time' times were manually entered in to MS Excel	Automated algorithm (1) used to determine non-wear periods: These are determined by firstly searching for prolonged periods (⩾180min) of low activity, and then by searching for sustained periods of higher intensity activity on either side of the non-wear times. The non-wear period (in-bed) is then taken as the first minute with a count ⩽89 that follows 10min of which ⩾4min contains counts ⩽50. The wear period (out-of-bed time) is taken as the first minute with ⩾91 that is followed by 10min containing ⩾3min with counts >200.
Definition of valid week- and weekend-night	Week nights can be thought of as 'school nights'; Sunday night to Thursday night Weekend nights are then nights that do not precede a 'school day': Friday and Saturday nights. These are referred to when discussing average 'time to bed'. 'Wake up time' refers to weekdays (Monday to Friday) and weekend days (Saturday and Sunday)	
Minimum number of valid days	3 week days and 1 weekend day (2)	Same as method (1), (2)

Using the two methods described in Table 1, it was possible to determine the waking wear for child preschool child using the 'time to bed' and 'wake up time'. The results are shown in Table 2:

Table 2. Objectively measured 'time to bed' and 'wake up time'

	1. Manual method	2. Non-wear (sleep) algorithm
Time to bed		
Week night	19:50:09	20:23:15
Weekend night	19:53:15	20:36:22
Wake up time		
Weekday	06:07:13	05:48:46
Weekend day	06:32:52	06:21:49

After determining the waking wear time per child using the 'time to bed' and 'wake up time', different combinations of blocks of time were assessed for compliance. Previous studies have chosen time points on the basis that 75% of the sample has valid wear time (3) (described as compliance from now on, and in the dissertation) for the time period. The compliance for different time blocks is shown in Table 3.

Table 3. Compliance per time block

Time block	Compliant children (n=, %)
06:00 – 19:00	14, 11.8%
07:00 – 20:00	19, 16.0%
07:00 – 19:00	70, 58.8%
07:00 – 18:00	93, 78.2% *
*Compliance >75%, and used for further analysis	

The hours between 07h00 and 18h00 were included for analysis as 78.2% (at least 75%) of the sample had wear time for that time period. Using ActiLife, a time filter was applied to exclude the hours outside 07h00 and 18h00.

References:

1. McVeigh JA, Winkler EAH, Healy GN, Slater J, Eastwood PR, Straker LM. Validity of an automated algorithm to identify waking and in-bed wear time in hip-worn accelerometer data collected with a 24 h wear protocol in young adults. Physiol Meas. 2016 Sep 21;37(10):1636–52.

2. Cliff DP, Reilly JJ, Okely AD. Methodological considerations in using accelerometers to assess habitual physical activity in children aged 0-5 years. J Sci Med Sport. Elsevier; 2009 Sep;12(5):557–67.

3. van Cauwenberghe E, Jones RA, Hinkley T, Crawford D, Okely AD. Patterns of physical activity and sedentary behaviour in preschool children. Int J Behav Nutr Phys Act. 2012;9(1):138.

Appendix D3

Table D3.1 Time spent in LMVPA on weekdays and weekend days in minutes per hour, by sex and setting

	Weekdays (Fig 5.1 A)		Weekend days (Fig 5.1 B)		Weekdays (Fig 5.2 A)		Weekend days (Fig 5.2 B)	
Hours of day	Boys	Girls	Boys	Girls	Preschool	Grade R	Preschool	Grade R
07:00 – 08:00	36.4± 13.4 (37, 30-47)	33.7± 12.5 (34, 26-42) #	34.2± 16.5 (36, 21-49)	35.9± 15.2 (40, 28-47)	35.7± 14.7 (38, 26-47)	33.8± 10.1 (33, 26-40) *	33.3± 15.2 (36, 24-45)	37.6± 16.2 (42, 29-50) *
08:00 – 09:00	39.9± 15.7 (44, 30-52)	37.4± 15.0 (40, 27-50) #	42.7± 13.5 (46, 35-53)	43.6± 11.0 (46, 39-52)	43.2± 13.9 (47, 37-53)	32.4± 15.0 (32, 22-45) *	42.4± 11.7 (45, 37-50)	44.3± 12.7 (48, 38-54)
09:00 – 10:00	39.2± 13.9 (42, 32-50)	36.4± 12.5 (38, 28-47) #	45.7± 12.6 (50, 39-55)	45.2± 11.3 (48, 39-54)	40.6± 12.5 (43, 35-50)	33.8± 13.0 (34, 25-44) *	45.2± 10.9 (48, 38-54)	45.8± 13.0 (50, 40-55)
10:00 – 11:00	45.7± 12.2 (48, 42-55)	42.1± 12.5 (45, 37-51) #	44.3± 12.3 (47, 40-52)	45.7± 11.8 (49, 42-54)	43.9± 14.2 (48, 38-54)	43.5± 9.8 (45, 39-50) *	44.8± 12.2 (48, 40-53)	45.3± 11.8 (48, 41-53)
11:00 – 12:00	41.7± 14.5 (44, 34-53)	40.6± 14.6 (44, 33-52)	43.8± 12.8 (46, 40-52)	42.9± 14.2 (46, 39-54)	42.2± 14.3 (46, 35-53)	39.5± 14.8 (42, 29-52) *	42.6± 13.7 (46, 38-51)	44.3± 13.5 (47, 40-54)
12:00 – 13:00	44.9± 12.1 (48, 39-54)	42.1± 13.0 (45, 36-52) #	44.4± 13.5 (49, 37-54)	44.3± 13.5 (48, 39-53)	40.5± 13.3 (43, 33-51)	47.1± 10.7 (50, 42-55) *	43.5± 13.8 (48, 38-53)	45.4± 13.0 (50, 40-54)
13:00 – 14:00	48.4± 10.1 (51, 44-56)	47.5± 11.3 (50, 44-55)	44.2± 14.7 (50, 35-55)	45.8± 12.1 (50, 41-54)	46.5± 12.2 (50, 41-55)	49.7± 8.3 (51, 46-56) *	44.7± 13.9 (50, 40-54)	45.6± 12.6 (50, 38-55)
14:00 – 15:00	48.2± 11.4 (52, 44-56)	46.8± 11.4 (50, 43-55) #	44.1± 15.9 (52, 37-55)	42.6± 14.4 (45, 36-54)	46.8± 12.2 (50, 43-55)	48.2± 10.3 (51, 44-56)	42.3± 16.2 (48, 35-55)	44.7± 13.4 (49, 39-55)
15:00 – 16:00	48.0± 11.8 (51, 44-56)	46.1± 12.7 (49, 42-55) #	45.2± 13.7 (49, 40-55)	44.1± 14.2 (47, 38-55)	46.2± 12.6 (49, 41-55)	48.0± 12.0 (51, 44-56) *	44.2± 14.9 (48, 40-55)	45.1± 12.7 (48, 40-54)
16:00 – 17:00	49.0± 12.2 (53, 46-57)	48.4± 11.7 (52, 46-56)	45.5± 12.7 (48, 39-56)	42.3± 13.7 (45, 33-53) #	47.8± 12.2 (51, 44-56)	49.9± 11.5 (53, 48-57) *	42.6± 13.9 (46, 35-54)	45.1± 12.5 (49, 39-54)
17:00 – 18:00	45.1± 13.2 (49, 37-55)	44.9± 11.9 (47, 40-54)	40.7± 14.8 (46, 31-51)	42.0± 14.8 (46, 35-54)	43.2± 12.5 (45, 37-53)	47.2± 12.1 (51, 42-56) *	39.1± 15.5 (43, 29-51)	44.5± 13.2 (48, 39-54) *

Data presented as mean±SD (median, IQR)

#Indicates a significant difference between boys and girls ($p<0.05$), * Indicates a significant difference between the preschool and grade R children ($p<0.05$)

Note: There are cases where the means+SDs >60minutes, possibly due to the data not being normally distributed. Data were checked for inconsistencies; no data points >60 minutes.

Table D3.2 Time spent in MVPA on weekdays and weekend days in minutes per hour, by sex and setting

	Weekdays (Fig 5.3 A)		Weekend days (Fig 5.3 B)		Weekdays (Fig 5.4 A)		Weekend days (Fig 5.4 B)	
Hour per day	Boys	Girls	Boys	Girls	Preschool	Grade R	Preschool	Grade R
07:00 – 08:00	6.1± 6.1 (5, 1-9)	4.4± 4.9 (3, 1-7) #	5.2± 6.2 (3, 0-8)	3.6± 4.6 (2, 0-5)	4.7± 6.0 (2, 0-7)	5.7± 4.6 (5, 2-8) *	3.5± 4.7 (1.5, 0-5)	5.4± 6.0 (3.5, 0.5-8) *
08:00 – 09:00	6.8± 8.0 (4, 0-10)	4.7± 5.7 (3, 0-7) #	8.5± 8.2 (7, 1-13)	6.2± 6.8 (4, 1-9) #	7.2± 7.2 (5, 2-11)	3.5± 5.9 (1, 0-5) *	5.6± 6.6 (3, 0.5-8)	9.4± 8.1 (7, 3-14) *
09:00 – 10:00	7.1± 7.6 (5, 1-11)	4.7± 5.8 (3, 0-7) #	9.0± 7.6 (7, 3-14)	7.5± 7.1 (6, 2-11)	7.2± 7.4 (5, 1-11)	3.8± 5.2 (2, 0-5) *	6.5± 6.7 (5, 1-9)	10.4± 7.6 (9, 5-16) *
10:00 – 11:00	9.5± 8.9 (7, 3-14)	5.7± 6.0 (4, 1-8) #	8.8± 8.0 (7, 3-14)	7.9± 7.4 (6, 3-10)	7.7± 8.8 (5, 1-12)	6.8± 5.9 (5, 2-10)	7.1± 7.5 (5, 2-9)	9.9± 7.7 (8, 4-14.5) *
11:00 – 12:00	8.0± 8.6 (5, 1-12)	6.1± 7.3 (4, 0-9) #	7.6± 7.1 (6, 2-13)	6.8± 7.1 (5, 1-9)	7.4± 8.1 (5, 1-12)	6.3± 7.6 (4, 0-9)	6.1± 6.8 (4, 1-9)	8.6± 7.2 (7, 3-12.5) *
12:00 – 13:00	10.7± 8.6 (9, 4-16)	7.4± 7.0 (6, 2-11) #	8.8± 7.8 (7, 3-14)	6.5± 5.6 (5.5, 2-10)	7.5± 7.7 (5, 1-11)	10.7± 7.8 (10, 5-15) *	7.0± 7.0 (5, 1.5-11)	8.2± 6.3 (7, 3-12)
13:00 – 14:00	10.9± 8.9 (9, 4-17)	8.4± 7.3 (7, 3-12) #	8.5± 7.6 (6, 2-14)	8.0± 7.2 (6, 2-12)	8.1± 8.3 (6, 2-11)	11.3± 7.6 (11, 5-17) *	7.2± 6.9 (5.5, 2-11)	9.6± 7.7 (8, 4-15.5) *
14:00 – 15:00	11.2± 10.0 (9, 3-17)	8.0± 7.4 (6, 3-12) #	10.0± 9.1 (9, 2-14)	7.1± 6.8 (5, 2-11) #	7.8± 7.8 (6, 2-11)	11.5± 9.5 (9, 4-17) *	7.4± 7.1 (5, 1-12.5)	9.6± 8.9 (8.5, 3.5-13) *
15:00 – 16:00	12.6± 11.9 (9, 4-17)	8.3± 8.4 (6, 2-11.5) #	11.2± 9.8 (9, 3-16)	8.4± 8.6 (6, 2-12) #	8.1± 8.8 (5, 2-11)	13.0± 11.4 (10, 4-18) *	9.1± 9.6 (6, 2-13.5)	10.3± 8.9 (9, 3-16)
16:00 – 17:00	15.0± 11.3 (13, 6-21)	11.3± 9.2 (9, 4-17) #	13.5± 10.0 (11.5, 4-21)	8.1± 7.6 (6, 3-12) #	10.9± 9.5 (9, 3-17)	15.7± 10.7 (15, 8-22) *	9.5± 9.2 (7, 3-14)	11.8± 9.0 (10, 4.5-18) *
17:00 – 18:00	14.1± 11.1 (13, 5-21)	11.0± 8.9 (10, 4-16) #	12.5± 11.8 (9, 3-19)	10.2± 9.3 (8, 3-14)	9.3± 8.0 (7, 2-15)	16.3± 10.9 (15, 8-24) *	8.9± 10.0 (6, 1.5-12)	14.3± 10.5 (12, 6-21) *

Data presented as mean±SD (median, IQR)

#Indicates a significant difference between boys and girls ($p<0.05$), * Indicates a significant difference between the preschool and grade R children ($p<0.05$)

Table D3.3 Time spent in sedentary behaviour on weekdays and weekend days in minutes per hour, by sex and setting

	Weekdays (Fig 5.5 A)		Weekend days (Fig 5.5 B)		Weekdays (Fig 5.6 A)		Weekend days (Fig 5.6 B)	
Hours of day	Boys	Girls	Boys	Girls	Preschool	Grade R	Preschool	Grade R
07:00 – 08:00	20.0± 10.9 (20.5, 11-27)	22.4± 10.8 (24,15-30) #	17.2± 11.3 (15, 7-26)	17.6± 10.8 (17, 10-23)	18.5± 10.8 (18, 10-26)	25.2± 9.9 (26, 19-32) *	18.8± 11.1 (18, 10.5-26.5)	15.5± 10.6 (14, 7-22.5) *
08:00 – 09:00	17.4± 13.2 (14.5,7-26)	20.1± 13.4 (18, 9-29.5) #	13.9± 9.6 (12.5, 6-20)	14.7± 9.2 (14, 8-21)	13.6± 9.9 (11, 6-20)	25.9± 14.1 (27, 14-36) *	15.3± 9.0 (14.5, 9-20.5)	13.1± 9.8 (10, 5-21) *
09:00 – 10:00	18.8± 12.3 (18, 8-26)	21.8± 11.6 (21,13-29.5) #	12.7± 10.9 (9, 5-19)	13.1± 8.9 (11.5, 6-19)	17.1± 10.3 (16, 9-23)	24.9± 12.6 (25, 15-33) *	13.5± 9.3 (11, 6-20)	12.1± 10.4 (9, 4-19)
10:00 – 11:00	12.5± 9.5 (11, 5-17)	15.9± 9.9 (15, 9-22) #	12.8± 8.9 (11.5, 7-18)	12.0± 8.8 (10, 5-17)	13.5± 10.5 (12, 5-19)	15.6± 8.7 (15, 10-21) *	12.4± 8.9 (11, 6-17)	12.3± 8.9 (11, 6-17)
11:00 – 12:00	15.2± 11.5 (13, 6-21)	16.7± 12.0 (14,7-23.5)	13.1± 8.0 (12.5± 8-19)	14.3± 10.7 (13, 6-18)	14.9± 11.5 (13, 6-20)	17.7± 12.1 (16, 8-26) *	14.8± 9.9 (14, 8-21)	12.4± 9.1 (11, 5-18) *
12:00 – 13:00	13.2± 10.1 (10, 6-18)	15.2± 10.5 (14, 7-20) #	13.1± 10.6 (9, 5-20)	13.8± 11.0 (11.5, 6-19)	15.8± 10.4 (14,8-21)	12.4± 10.1 (10, 5-18) *	14.3± 11.5 (11, 6-21)	12.4± 9.9 (10, 5.5-17.5)
13:00 – 14:00	10.9± 9.1 (9, 4-15)	11.0± 9.0 (9, 4.5-14)	12.7± 11.2 (9, 4-19)	11.9± 9.1 (9, 5-17)	11.8± 10.0 (10, 4-16)	9.9± 7.4 (9, 4-14)	12.2± 9.8 (9, 5-17.5)	12.3± 10.5 (9, 4-18.5)
14:00 – 15:00	10.9± 9.7 (8, 4-15)	11.4± 8.6 (9, 5-15.5)	11.4± 10.5 (8, 4-17)	14.1± 11.0 (11.5, 5-22)	11.5± 9.7 (9, 5-16)	10.7± 8.3 (9, 4-15)	12.7± 11.0 (9, 4-19.5)	13.2± 10.7 (10, 5-19.5)
15:00 – 16:00	10.8± 9.9 (8, 3-16)	11.3± 8.6 (9, 5-17)	11.2± 8.9 (10, 4-17)	12.4± 10.3 (10, 3-19)	11.9± 9.7 (9,5-17)	10.0± 8.5 (7, 3-15) *	11.2± 9.5 (8.5, 3-17.5)	12.7± 9.9 (10.5, 4-18.5)
16:00 – 17:00	9.1± 8.8 (7, 3-12)	9.7± 8.3 (8, 3-14)	11.6± 9.8 (10, 4-16)	14.3± 10.2 (12, 6-20)	10.3± 8.7 (8, 4-14)	8.4± 8.1 (6, 3-11) *	13.8± 10.4 (12, 5.5-19)	12.2± 9.6 (9, 5-17)
17:00 – 18:00	12.4± 10.3 (9, 4-18)	13.0± 9.6 (12, 5-19)	15.9± 11.7 (12.5, 7-23)	14.2± 10.6 (13, 5-22)	14.2± 10.1 (12, 6-21)	10.8± 9.4 (9, 4-15) *	16.4± 11.6 (14, 6.5-24)	13.0± 10.0 (11.5± 5-19.5) *

Data presented as mean±SD (median, IQR)

#Indicates a significant difference between boys and girls ($p<0.05$)

*Indicates a significant difference between the preschool and grade R children ($p<0.05$)

Appendix E

TGMD-2 performance criteria

Locomotor:

Skill	Technique
Run	1. Arms move in opposition to kegs, elbows bent 2. Brief period where both feet are off the ground 3. Narrow foot placement landing on heel or toe (i.e., not flat-footed) 4. Non-support leg bent approximately 90 degrees (i.e., close to buttocks)
Slide	1. Body turned sideways so shoulders are aligned with the line on the floor 2. A step sideways with lead foot followed by a slide of the trailing foot to a point next to the lead foot 3. A minimum of four continuous step-cycles to the right 4. A minimum of four continuous step-cycles to the left
Hop	1. Non-support leg swings forward in a pendular fashion to produce force 2. Foot of non-support leg remains behind body 3. Arms flexed and swing forward to produce force 4. Takes off and lands three consecutive times on preferred foot 5. Takes off and lands three consecutive times on non-preferred foot
Jump	1. Preparatory movement includes flexion of both knees with arms extended behind body 2. Arms extend forcefully forward and upward reaching full extension above the head 3. Take off and land on both feet simultaneously 4. Arms are thrust downward during landing
Leap	1. Take off on one foot and land on the opposite foot 2. A period where both feet are off the ground longer than running 3. Forward reach with the arm opposite the lead foot
Gallop	1. Arms bent and lifted to waist level at take-off 2. A step forward with the lead foot followed by a step with the trailing foot to a position adjacent to or behind the lead foot 3. Brief period where both feet are off the ground 4. Maintains a rhythmic pattern for four consecutive gallops

Object control:

Skill	Technique
Strike	1. Dominant hand grips bat above the non-dominant hand 2. Non-preferred side of the body faces the tosser with feet parallel 3. Hip and shoulder rotation during swing 4. Transfers body weight to front foot 5. Bat contacts ball
Catch	1. Preparation phase where hands are in front of the body and elbows are flexed 2. Arms extend while reaching for the ball as it arrives 3. Ball is caught by hands only

Overhand throw	1. Wind-up is initiated with downward movement of hand/arm 2. Rotates hip and shoulders to a point where the non-throwing side faces the wall 3. Weight is transferred by stepping with the foot opposite the throwing hand 4. Follow-through beyond ball release diagonally across the body toward the non-preferred side
Roll	1. Preferred hand swings down and back, reaching behind the trunk while chest faces cones 2. Strides forward with foot opposite the preferred hand towards the cones (front) 3. Bends knees to lower body 4. Releases ball close to the floor so ball does not bounce more than 4 inches (±10cm) high
Kick	1. Rapid continuous approach to the ball 2. An elongated stride or leap immediately prior to ball contact 3. Non-kicking foot placed even with or slightly in back of the ball 4. Kicks ball with instep of preferred foot (shoelaces) or toe
Bounce (stationary dribble)	1. Contacts ball with one hand at about belt level 2. Pushes ball with fingertips (not a slap) 3. Ball contacts surface in front of or to the outside of foot on the referred side 4. Maintains control of ball for four consecutive bounces without having to move feet to retrieve it

Parent / caregiver questionnaire

Today's date:_____

Parent / Caregiver name:	
Parent / Caregiver date of birth:	
Preschool child's name:	
Preschool child gender:	Preschool child date of birth:

Instructions

Thank you for taking the time to complete this questionnaire. We would like the main carer of the child named above to complete it. It will take you approximately 20 minutes to complete, although this may vary depending on your answers.

We will refer to your child who is participating in this study as 'your preschool child'. Throughout this questionnaire, we will refer to some terms that you will need to understand. These terms are:

- 'physical activity' by this we mean when your preschool child is participating in active play (e.g. running around, playing on jungle gyms), walking or cycling to places, or sport. This includes time at playgrounds or other play spaces, time outdoors in the garden, and any other time inside when your preschool child is being active.
- 'your community' by this we mean your suburb or your local neighbourhood in which you live.
- 'preschool' by this we mean either the preschool that your preschool child attends. Preschool generally has a structured program where children attend on specific days of the week for a set period. Preschool usually caters for children aged three to six years.

Please answer ALL the questions in the questionnaire. Here are some examples of how to tick your answer:

Does someone in your home own a car?

✓	Yes	o	No

Please tell us how much you agree or disagree with the following statements. (tick ONE response on each line)

	Strongly disagree	Disagree	Neither agree/disagree	Agree	Strongly agree
I think that my preschool child should do at least three hours of physical activity every day	o	✓	o	o	o

About you and your family

1. What relationship are you to the preschool child in this study? (tick ONE box)

o	Mother	o	Father
o	Grandmother	o	Grandfather
o	Aunt	o	Uncle
o	Other (please state)		

2. What is your current marital status? (tick ONE box)

o	Married	o	Divorced
o	Living together	o	Widowed
o	Separated	o	Never married

3. What is your highest level of education? (tick ONE box)

o	Grade 6 / Standard 4 and below	o	Grade 7-9 / Standard 5-7
o	Grade 10-11 / Standard 8-9	o	Grade 12 / Standard 10 / Matric
o	Tertiary diploma / Certificate	o	University degree

4. What is your home language? (tick ONE box)

o	English	o	isiXhosa
o	Afrikaans	o	Shangaan / Xitsonga
o	Other (please state):		

5. How many other children under the age of 18 years (siblings, step siblings, foster children etc.) currently live in your house?

6. Please use the table below to tell us about the other children in your home:

Other children	Child's date of birth	Boy or girl?
1		o Boy o Girl
2		o Boy o Girl
3		o Boy o Girl
4		o Boy o Girl
5		o Boy o Girl
6		o Boy o Girl
7		o Boy o Girl

7. Does someone in your home own a car?

o	Yes	o	No

Your physical activity levels

Work-related physical activity:

This includes paid and unpaid work. Unpaid work includes activities that you might do at home, e.g. housework.

1. What kind of activity does your work involve? (tick ONE)

Mostly sitting	o	Go to question 8 if you ticked any of these boxes
Mostly standing	o	
Mostly walking for short periods (±5 minutes at a time)	o	
Mostly doing MODERATE-intensity activity (that makes you sweat a bit and breathe hard, and your heart to beat faster) or VIGOROUS-intensity activity (that makes you sweat a lot and breathe very hard, and your heart to beat very fast)	o	Continue to question 2 if you ticked this box

2. Does your work involve MODERATE activities (like brisk walking or carrying light loads) for at least 10 minutes at a time?

o	Yes – please answer questions 3 & 4 below	o	No – please go to question 8

3. How many days do you do MODERATE activities as part of your work?	Days:	
4. How long do these MODERATE activities last for?	Hours:	Minutes:

5. Does your work involve VIGOROUS activities (like heavy lifting, fetching or carrying water) for at least 10 minutes at a time?

o	Yes – please answer questions 6 & 7 below	o	No – please go to question 8

6. How many days a week do you do VIGOROUS-intensity activities as part of your work?	Days:	
7. How long do these VIGOROUS-intensity activities last for?	Hours:	Minutes:

8. How long is your usual workday?

Hours:	Minutes:

Travel-related physical activity:

9. Do you walk or use a bike for at least 10 minutes at a time to get to and from places (e.g. work, shops, church, your friend's house)? This does not include activities at work that you have already mentioned.

o	Yes – please answer questions 10 & 11 below	o	No – please go to question 12

10. How many days each week do you usually walk or cycle for at least 10 minutes to get to and from places?	Days:	
11. How much time each week do you usually spend walking or cycling to and from places?	Hours:	Minutes:

Leisure time physical activity:

This includes physical activity you do in your leisure or spare time, for recreation, enjoyment or fitness, e.g. walking for exercise, playing a sport, gardening. This activity is done when you are NOT working.

12. In your leisure or spare time, do you do any VIGOROUS-intensity physical activity (like running, strenuous sports or weightlifting) lasting more than 10 minutes at a time?

o	Yes – please answer questions 13 & 14	o	No – please go to question 15

13. In a usual week, how many days do you do vigorous activities as part of your leisure or spare time?	Days:	
14. On a usual day, how much time do you spend doing this?	Hours:	Minutes:

15. In your leisure or spare time, do you do any MODERATE-intensity activities (like brisk walking, carrying children for long periods, cycling or swimming) lasting more than 10 minutes at a time?

o	Yes – please answer questions 16 & 17	o	No – please go to question 18

16. In a usual week, how many days do you do moderate activities as part of your leisure or spare time?	Days:	
17. On a usual day, how much time do you spend doing this?	Hours:	Minutes:

Sitting/resting activity:

This includes time sitting at a desk, visiting friends, reading or sitting down to watch television. Please include the time you spend sitting during working hours and your leisure or spare time.

18. On a usual day, how much time do you spend sitting/resting at WORK?

Hours:	Minutes:

19. On a usual day, how much time do you spend sitting/resting in your LEISURE or SPARE TIME?

Hours:	Minutes:

Your preschool child and what they do at home

1. During the week and on the weekend, what time does your preschool child child USUALLY go to sleep at night and wake up in the morning?

	Week (Mon-Fri)	Weekend (Sat & Sun)
Time to sleep at night		
Time to wake up in the morning		

2. Does your preschool child sleep during the day at home?

o	Yes	o	No – please go to question 4

3. If yes, how many hours does your preschool child usually sleep during the day at home?

	Week (Mon-Fri)	Weekend (Sat & Sun)
Time spent sleeping during the day at home (hours)		

4. Please tell us how much you agree or disagree with these statements. (tick ONE response on each line)

	Strongly disagree	Disagree	Neither agree/disagree	Agree	Strongly agree	
My preschool child is physically active by him/herself	o	o	o	o	o	
My preschool child is physically active with other children living in our home (e.g. outdoor play, rough-and-tumble)	o	o	o	o	o	There are no other children living in our home
My preschool child is physically active with his/her friends (e.g. outdoor play, rough-and-tumble)	o	o	o	o	o	
My preschool child is active for longer when he/she is with someone else than when on his/her own	o	o	o	o	o	
My preschool child is competitive with other children when being physically active	o	o	o	o	o	

5. Please tell us how often your preschool child might do the following things. (tick ONE response on each line)

	Never	Rarely	Sometimes	A lot of / most of the time	Always	
My preschool child is more likely to watch TV than be active	o	o	o	o	o	We don't have a TV
My preschool child is more likely to play electronic games (e.g. video / computer games, cell phone games) than be active	o	o	o	o	o	We don't have E-games
My preschool child is more likely to play inside/draw/do craft than be active	o	o	o	o	o	

6. Below are some reasons that might stop your preschool child from doing more physical activity than he/she already does. How much do you agree or disagree with each of the following statements? (tick ONE response on each line)

	Strongly disagree	Disagree	Neither agree/disagree	Agree	Strongly agree
My preschool child doesn't have enough energy to do more physical activity	o	o	o	o	o
My preschool child doesn't have enough time to do physical activity	o	o	o	o	o
My preschool child doesn't have anyone to be physically active with	o	o	o	o	o
My preschool child just doesn't enjoy being physically active	o	o	o	o	o
My preschool child is too overweight to participate in physical activity	o	o	o	o	o
My preschool child feels uncomfortable with groups of children	o	o	o	o	o
My preschool child doesn't have good enough skills (e.g. kicking, throwing, catching) to do more physical activity	o	o	o	o	o
My preschool child will have more freedom and opportunities to be active when he/she is older	o	o	o	o	o

7. This question is about some of the physical activities that your preschool child might do. How often does your preschool child USUALLY do the following physical activities during a typical WEEK? (tick ONE response on each line)

	Never / Rarely	Less than once a week	1-2 times a week	3-4 times a week	5-6 times a week	Daily	
Walk to school	o	o	o	o	o	o	
Walk to other places (e.g. shops, friends)	o	o	o	o	o	o	
Walk for exercise or for fun	o	o	o	o	o	o	
Ride a bicycle/scooter to school	o	o	o	o	o	o	
Ride a bicycle/scooter to other places	o	o	o	o	o	o	
Ride a bicycle/scooter for fun	o	o	o	o	o	o	
Walk the dog	o	o	o	o	o	o	We don't have a dog
Play with the dog	o	o	o	o	o	o	We don't have a dog
Play in the garden	o	o	o	o	o	o	
Play with bats and balls	o	o	o	o	o	o	
Swim in a pool	o	o	o	o	o	o	

8. The following questions are about ORGANISED sports, games or activities that your preschool child does during a typical week and on weekends. By organised sports or activities, we mean attending a session at a particular time with a coach, teacher, or trainer. During a TYPICAL WEEK, does your preschool child participate in any of the following activities? Please tick 'Yes' or 'No' for each activity. Please also complete how many times a week your child participates in this activity.

Sport, games or activities	**Yes**	**No**	**Times per week**
Swimming	o	o	
Modern / hip-hop dancing	o	o	
Ballet	o	o	
Traditional dancing	o	o	
Monkeynastics	o	o	
Play Ball	o	o	
Other (please state):	o	o	
Other (please state):	o	o	

9. Which of the following indoor LEISURE activities does your preschool child USUALLY do during a typical WEEK when they are NOT at preschool? Tick either 'Yes' or 'No' for each item.

If you tick 'Yes', please write the TOTAL time your preschool child participates in the activity between Monday and Friday, and the TOTAL time your preschool child participates in the activity on Saturday and Sunday). If you tick 'Yes' for an activity and your child only participates in that activity during either the school week or the weekend, please write '0' in the TOTAL time column for the period they do not do that activity. Here is an example:

During a typical WEEK what leisure activities does your preschool child usually do?	**Yes**	**No**	**TOTAL time on weekdays (Mon-Fri)**	**TOTAL time on weekend days (Sat & Sun)**
TV / video's / DVDs	✓	o	6 hours	4 hours
Quiet play (Lego™, books, dolls, board games)	✓	o	0 hours	2 hours 30 minutes

During a typical WEEK what leisure activities does your preschool child usually do?	**Yes**	**No**	**TOTAL time on weekdays (Mon-Fri)**	**TOTAL time on weekend days (Sat & Sun)**
TV / video's / DVDs	o	o		
Playstation©/ Nintendo©/ X-Box©/ Gameboy©/ other computer games	o	o		
Wii™/ Eye Toy	o	o		
Computer/ internet (excluding games)	o	o		
Smart phone / digital tablet (e.g. iPad)	o	o		
Quiet play (e.g. Lego™, books, dolls, board games)	o	o		
Imaginary games (e.g. dress up, make believe)	o	o		

10. How long does your child spend in a car or any other motorised transport (e.g. taxi or bus) in the week and on the weekends? Please answer in hours and minutes, per day (average).

Weekdays (Monday – Friday), per day	Hours:	Minutes:
Weekend days (Saturday and Sunday), per day	Hours:	Minutes:

Being a parent/caregiver to your preschool child

1. Please state how often the following statements apply to you and your family. (tick ONE response on each line)

	Never	Rarely	Sometimes	A lot / most of the time	Always
I am too tired to support my preschool child to be active (e.g. play outside with him/her, take him/her to the park)	o	o	o	o	o
The time I spend doing housework stops me from supporting my preschool child to be active	o	o	o	o	o
The time I spend working stops me from supporting my preschool child to be active	o	o	o	o	o
Looking after other children stops me from supporting my preschool child to be active	o	o	o	o	o
I always have a car available when I want to take my preschool child somewhere to be active	o	o	o	o	o
It is difficult to get to places for my preschool child to be active	o	o	o	o	o
I feel confident that I have the skills to support my preschool child to be active	o	o	o	o	o
No matter how I feel, I always make sure I give my preschool child opportunities to be active	o	o	o	o	o

2. How confident are you that you could do the following over the next year? (tick ONE response on each line):

	Not at all confident	Moderately confident	Extremely confident
Get my preschool child to participate in at least three hours of physical activity every day over the next year	o	o	o
Get my preschool child to participate in a range of physical activities over the next year	o	o	o
Get my preschool child to be active when he/she wants to play on the computer or play electronic games over the next year	o	o	o
Say no to my preschool child's requests to play on the computer or electronic games over the next year	o	o	o

Your beliefs and behaviours as a parent/caregiver

1. Please tell us how much you agree or disagree with the following statements about your beliefs and behaviours as a parent/caregiver. (tick ONE response on each line)

	Strongly disagree	Disagree	Neither agree/disagree	Agree	Strongly agree
I think that my preschool child should do at least three hours of physical activity every day	o	o	o	o	o
I am satisfied with the amount of physical activity my preschool child does	o	o	o	o	o
My preschool child does enough physical activity to keep him/her healthy	o	o	o	o	o
The amount of TV my preschool child watches would not affect his/her health	o	o	o	o	o
I limit how much time my preschool child is allowed to spend watching TV	o	o	o	o	o
I limit how much time my preschool child is allowed to spend using computer and electronic games	o	o	o	o	o
My preschool child is not allowed to throw balls or play ball-games inside the house	o	o	o	o	o
My preschool child is not allowed to play rough games or run inside the house	o	o	o	o	o
I have rules about physical activity to protect my preschool child from other people (e.g. not allowed outside the home garden on his/her own)	o	o	o	o	o
I have rules about physical activity to protect my preschool child from accidents with traffic (e.g. always holding adult hand near roads)	o	o	o	o	o
My preschool child is able to play freely in the backyard whenever he/she wants to	o	o	o	o	o
My preschool child is able to play freely in the street whenever he/she wants to	o	o	o	o	o
I take my preschool child outside to play if I think he/she has been inside for too long	o	o	o	o	o

Your friends, family and home

1. How often are the following people physically active with your preschool child? (tick ONE response on each line)

	Never / Rarely	Less than once a week	1-2 times a week	3-4 times a week	5-6 times a week	Daily	
You	o	o	o	o	o	o	
Your partner / spouse	o	o	o	o	o	o	I do not have a partner
Siblings	o	o	o	o	o	o	My child does not have siblings
Whole family together	o	o	o	o	o	o	
Cousins	o	o	o	o	o	o	
Uncles and/or aunts	o	o	o	o	o	o	I am the child's aunt/uncle
Grandparents	o	o	o	o	o	o	I am the grandparent
Children in the community	o	o	o	o	o	o	

2. Please think about the types of toys and equipment that your preschool child has available at home to be physically active with. Tick in the boxes next to the toys or equipment you have in your home.

Balls (soccer, tennis, basket etc.)		Skateboard	
Basket ball ring		Skipping rope	
Bats/racquets/golf clubs		Slide	
Tree house		Swings	
Frisbee		Table tennis table and bats and balls	
Child-appropriate gardening tools		Trampoline	
Pool or beach toys		Tricycle/Bicycle	
Roller blades or skates		Volleyball, tennis or badminton net	
Sand pit		Scooter	
Bowls/Skittles/10-Pin Bowls		Soft balls and toys suitable for indoor play	
Climbing equipment/trees suitable for climbing		Swimming pool/swimming-appropriate area	
Safety equipment (helmets, knee pads)		Other:	
Other:		Other:	

3. Please think about the electronic equipment / facilities you have in your home. Tick in the boxes next to the equipment / facilities you have in your home.

Video/DVD player		Internet access	
Digital tablet (e.g. iPad)		Smart phone	
TV		Wii/eye-toy	
Desktop computer		Laptop computer	
Playstation©/X-Box©/ Gameboy©/Nintendo©		Other:	

Your community

1. Think about the playgrounds in your community. How much do you agree or disagree with the following statements? (tick ONE response on each line)

	Strongly disagree	Disagree	Neither agree/disagree	Agree	Strongly agree
There are many playgrounds in our community that are suitable for my preschool child to play in	o	o	o	o	o
The playgrounds in our community have a variety of equipment so my preschool child doesn't get bored	o	o	o	o	o
The playgrounds in our community have equipment suitable for my preschool child's age and abilities	o	o	o	o	o
The playgrounds in our community have play equipment that is safe for my preschool child to play on	o	o	o	o	o
The playgrounds in our community are well used by other children	o	o	o	o	o

2. This question is about moving around your community. How much do you agree or disagree with the following statements? (tick ONE response on each line)

	Strongly disagree	Disagree	Neither agree/disagree	Agree	Strongly agree
There are major barriers to walking / cycling that make it hard for my preschool child and I to get from place to place (e.g. major roads, steep hills)	o	o	o	o	o
My preschool child and I would have to cross a busy road to get to areas where he/she can play	o	o	o	o	o
There are no lights or pedestrian crossings for my preschool child and I to use	o	o	o	o	o
There are no footpaths / pavements in our neighbourhood for my preschool child and I to use	o	o	o	o	o
My neighbourhood has walking/cycling trails suitable for my preschool child and I to use	o	o	o	o	o
My neighbourhood is safe for children	o	o	o	o	o

3. This question is about places your preschool child might go to be physically active. For each place listed, please tell us how often your preschool child usually goes there. (tick ONE response on each line)

	Never	Once a month or less	Twice a month	Once a week	Twice a week	3-4 times a week	5 or more times a week
Local playground	o	o	o	o	o	o	o
Playground in another area	o	o	o	o	o	o	o
Sports venue (e.g. swimming pool, soccer field)	o	o	o	o	o	o	o
Indoor play centre	o	o	o	o	o	o	o
Family restaurant with play area	o	o	o	o	o	o	o
Shopping centre	o	o	o	o	o	o	o

Thank you for completing this questionnaire!