Intervening to reduce sedentary behaviour in early childhood

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by

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Submitted in fulfilment of the requirements for the degree of
Doctor of Philosophy

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No.	Chapter	Publication
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2	Five	**Downing KL**, Hinkley T, Salmon J, Hnatiuk JA, Hesketh KD. Do the correlates of screen time and sedentary time differ in preschool children? BMC Public Health. 2017;17:285. Impact factor: 2.265
3	Six	**Downing KL**, Salmon J, Hinkley T, Hnatiuk J, Hesketh KD. A mobile technology intervention to reduce sedentary behaviour in 2- to 4-year-old children (Mini Movers): study protocol for a randomised controlled trial. Trials. 2017;18(1):97. Impact factor: 1.969

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No.	Chapter	Publication
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Conference presentations

Oral presentations

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2. **Downing K***, Salmon J, Hinkley T, Hnatiuk J, Hesketh K. Mini Movers: a randomised controlled trial to reduce sedentary behaviour in 2- to 4-year-old children. Australian & New Zealand Obesity Society, October 2017, Adelaide, Australia.

3. **Downing K***, Salmon J, Hinkley T, Hnatiuk J, Hesketh K. Mini Movers: a randomised controlled trial to reduce sedentary behaviour in 2- to 4-year-old children. International Society of Behavioural Nutrition and Physical Activity, June 2017, Victoria, Canada.

4. **Downing K***, Hnatiuk J, Hinkley T, Salmon J, Hesketh K. Interventions to reduce sedentary behaviour in 0-5 year olds: A systematic review and meta-analysis. International Society for Physical Activity and Health Congress, November 2016, Bangkok, Thailand.

5. **Downing K***, Hinkley T, Salmon J, Hnatiuk J, Hesketh K. Correlates of preschool children's objectively assessed sedentary behaviour. International Society for Physical Activity and Health Congress, November 2016, Bangkok, Thailand.

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7. **Downing K***, Hinkley T, Salmon J, Hesketh K. Parental influences on preschool children's objectively assessed sedentary time. Population Health Congress, September 2015, Hobart, Australia.

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* denotes presenter

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1. **Downing K**, Hinkley T, Salmon J, Hnatiuk J, Hesketh K. Ecological correlates of preschool children's screen time. International Congress of Behavioural Medicine, December 7-10 2016, Melbourne, Australia.

2. **Downing K**, Hnatiuk J, Hinkley T, Salmon J, Hesketh K. Interventions to reduce sedentary behaviour in 0-5 year olds: A systematic review. Population Health Congress, September 6-9 2015, Hobart, Australia.

Abstract

Evidence suggests that sedentary behaviour (i.e., any waking behaviour performed in a sitting, reclining or lying posture, and requiring little energy expenditure) is associated with multiple adverse health and developmental outcomes across the lifespan. Additionally, sedentary behaviour has been shown to track, such that children who engage in high levels of sedentary behaviour in early life will continue to do so into later childhood, adolescence and adulthood. In early childhood (birth through 5 years), screen time is the most commonly studied sedentary behaviour and has been consistently associated with increased risk of overweight/obesity, poor psychosocial health and decreased cognitive development. Accordingly, national and international public health guidelines recommend that children under 2 years should not be exposed to any screen time and that children aged 2 to 5 years should have no more than one hour of screen time per day. Guidelines also recommend that all children from birth through 5 years should not be sedentary, restrained or kept inactive for more than one hour at a time, with the exception of sleeping. Despite this, many young children spend large amounts of time in objectively assessed sedentary time and many exceed current screen time recommendations.

It is evident that there is the need for feasible and efficacious interventions targeting reductions in sedentary behaviour. To inform the development of appropriate intervention strategies it is important to identify the factors that are associated with sedentary behaviour in young children. However, existing research examining correlates of young children's sedentary behaviour has been limited by the inclusion of only a small number of correlates. There is also a lack of understanding of whether the correlates of young children's objectively assessed sedentary time and screen time are the same. No known research has comprehensively investigated correlates of young children's sedentary time and screen time in the same sample across multiple levels of the ecological model.

Previous interventions to reduce young children's sedentary behaviour have shown modest results. This may be due to a number of methodological limitations. Few interventions have been conducted outside the preschool/childcare setting and many have limited potential for scalability. This thesis makes a novel contribution to the extant literature relating to young children's sedentary behaviour. It provides improved understanding of correlates of sedentary behaviour across multiple domains of the ecological model and strategies to reduce sedentary behaviour in young children.

Firstly, to determine the effectiveness of existing interventions to reduce sedentary behaviour in early childhood, a systematic review and meta-analysis of randomised controlled trials were undertaken. In total, 31 studies were included in the systematic review and 24 in the meta-analysis. Objectively assessed sedentary time and proxy-reported screen time were examined as separate outcomes. Although a significant intervention effect was observed for both outcomes, changes were modest (19 and 17 minutes per day for sedentary time and screen time, respectively). Subgroup analyses suggest that for screen time, interventions of six months or longer duration and those conducted in a community-based setting were most effective. For sedentary time, interventions targeting physical activity (and reporting changes in sedentary time) were more effective than those directly targeting sedentary time. Parental involvement in interventions also appeared to be important for behaviour change.

Secondly, a cross-sectional study examining ecological correlates of objectively assessed sedentary time and screen time in a sample of preschool children (3 to 5 years) in Melbourne, Australia was conducted. Parents reported their child’s usual screen time and a range of potential correlates across the individual, social and physical environment level of the ecological model. Children in the study wore accelerometers for eight days to objectively assess sedentary time. Minutes per day spent in screen time and sedentary time were the primary outcome variables. The final sample included 937 children (54% boys) with valid screen time data and 724 children (55% boys) with valid accelerometry data. Children spent 108.5 (standard deviation [SD] 69.6) minutes per day in screen time and were sedentary for 301.1 (SD 34.1) minutes per day. There were no differences in screen or sedentary time between boys and girls.

In multivariable linear regression models, few common correlates were identified for screen time and sedentary time. However, each additional hour of sleep was associated with around seven minutes less sedentary time per day for girls and six minutes less screen time per day for boys. The only other consistent correlates for boys and girls were parental self-efficacy to limit screen time and use of screen time rules; parents who reported that they had higher self-efficacy, and implemented screen time rules, to limit screen time had children who spent significantly less time in that behaviour. For boys, parents who reported that they get bored watching their child play had sons who spent almost 15 minutes less per day in screen time. Maternal television viewing was positively associated with boys' screen time, such that mothers who had high levels of television viewing had sons with high screen time, while paternal age was positively associated with boys' sedentary time. Girls whose mothers were born in Australia engaged in more than 15 minutes less per day of screen time than girls whose mothers were born overseas. On the contrary, girls whose fathers had a mid-level of education (completed secondary school, trade or diploma) had significantly higher screen time than girls whose fathers had a low-level of education (not completed high school). Finally, parents who reported that that they had concerns about their child's physical activity and sedentary behaviour, and that their child preferred sedentary behaviours to being active, had daughters with higher levels of screen time. Although few common correlates of sedentary time and screen time were identified, these findings provide novel and valuable information that can be used for intervention development. In particular, the modifiable correlates of total sedentary and screen time identified in this study could be targeted in interventions to reduce these behaviours.

Finally, informed by the findings from the systematic review and the cross-sectional study, an innovative intervention to reduce young children's (2 to 4 years) sedentary behaviour was developed and piloted. Mini Movers was a parent-focused, text message delivered intervention aiming to support parents to reduce the amount of time their children spent in prolonged sedentary behaviour. Fifty-seven parents and children were recruited through playgroups, Facebook and snowball sampling, and randomised to either the intervention or wait-list control group. The six-week pilot intervention was predominantly delivered via text messages. It was underpinned by the CALO-RE taxonomy of behaviour change techniques and Social Cognitive Theory, with strategies focused on increasing parental knowledge, building self-efficacy, setting goals and providing reinforcement. Retention was high (93%) and process evaluation results showed the intervention was highly acceptable to parents. The majority of intervention components were reported to be useful and relevant. Qualitative interviews with parents in the intervention group showed that parents were positive about the program and particularly liked the goal-setting component and the practical ideas provided. Compared with children in the control group, children in the intervention group had significantly less screen time post-intervention, with an adjusted difference (95% confidence interval [CI]) of -35.0 (-64.1, -5.9) minutes per day (Cohen's *d*=0.82). All other measures of sedentary behaviour were in the expected direction, with small to moderate effect sizes.

This thesis expands on the existing knowledge regarding correlates of and opportunities to reduce young children's sedentary behaviour. Findings from previous interventions to reduce sedentary behaviour in early childhood were synthesised and correlates of sedentary behaviour across multiple levels of the ecological model were investigated; results from these two studies were used to inform the development of a novel intervention to reduce young children's time in a range of sedentary behaviours. Text message delivery of the intervention appeared to be feasible for parents and has the potential to assist them in reducing their children’s sedentary behaviour. Although there is a continued need for future research to investigate opportunities to promote healthy sedentary behaviour habits in young children, this thesis provides valuable information to inform future, larger scale randomised controlled trials.

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List of Abbreviations

95% CI	95% Confidence Interval
AAP	American Academy of Pediatrics
BMI	Body mass index
CARS	Children's activity rating scale
HAPPY	Healthy Active Preschool and Primary Years
LMVPA	Light-, moderate- to vigorous-intensity physical activity
LPA	Light-intensity physical activity
MET	Metabolic equivalent unit
MVPA	Moderate- to vigorous-intensity physical activity
OSRAC-P	Observational System for Recording Physical Activity in Children-Preschool
RCT	Randomised controlled trial
ROC-AUC	Area under the receiver operating characteristic curve
SEP	Socioeconomic position
SMS	Short message service
UK	United Kingdom
USA	United States of America

Glossary of Terms

Early childhood: children aged birth through 5 years (unless otherwise specified)

Light-intensity physical activity (LPA): physical activity that results in a slight increase in breathing, heartbeat and body temperature (1.5-3 METs)

Metabolic equivalent (MET): a measure of energy expenditure, where one MET is the energy used by the body while resting quietly

Moderate- to vigorous-intensity physical activity (MVPA): physical activity that results in a moderate to large increase in breathing, heartbeat and body temperature (≥3 METs)

Preschool children: children aged 2 through 5 years, regardless if they attend preschool (unless otherwise specified)

Restraint or restrained: any situation where a child is kept sedentary or inactive (e.g., in a stroller, car seat or high chair)

Screen time: any screen-based sedentary behaviours (e.g., television viewing, electronic games, computer use, smartphone use)

Sedentary behaviour: any waking behaviour characterised by an energy expenditure ≤1.5 METs while in a sitting or reclining posture

Sedentary time: objectively measured sedentary time

CHAPTER ONE

Introduction

Sedentary behaviours are emerging as important to understand and intervene on from a young age. They are a unique group of behaviours that are distinct from physical inactivity. Sedentary behaviour refers to any waking behaviour typified by very low energy expenditure and undertaken in a sitting, reclining or lying posture (e.g., reading, watching television) (Tremblay et al. 2017). Research suggests that the health impacts of excessive sedentary behaviour across the lifespan may be profound, including type 2 diabetes, all-cause and cardiovascular mortality, increased body mass index (BMI), poor psychosocial health and decreased cognitive development (Carson et al. 2016; LeBlanc et al. 2012; Proper et al. 2011). These health and developmental outcomes are independent of levels of physical activity, making assessment of sedentary behaviour a separate and key area of public health research.

Children aged 2 to 5 years are the focus of this thesis. This is a critical stage during which sedentary behaviour habits are established (Jones et al. 2013), and the adverse health and developmental outcomes associated with sedentary behaviour are evident even in these very young children (LeBlanc et al. 2012). Published interventions to reduce sedentary behaviour in early childhood demonstrate modest results and many have limited potential for scalability (Downing et al. 2016b).

The aim of this thesis is to understand parental and other correlates of young children’s sedentary behaviour, and to develop and pilot a parent-focused intervention to reduce sedentary behaviour in young children. Four papers, including a systematic review and meta-analysis, a cross-sectional study, a methodological (protocol) paper, and a pilot randomised controlled trial (RCT; comprising quantitative and qualitative methods) are presented in this thesis. This thesis is presented in the form of a thesis by publication. It comprises three published, peer-reviewed papers and one paper under review; the papers are all included in their entirety.

Chapter Two discusses published research highlighting the importance of reducing sedentary behaviour in young children. The adverse health outcomes associated with different types of sedentary behaviour in early childhood are discussed, including the tracking of sedentary behaviour through childhood and into adolescence, in addition to correlates of sedentary behaviour that have been previously investigated.

Chapter Three (Paper One) presents a systematic review and meta-analysis of RCTs to decrease sedentary behaviour in early childhood (birth through 5 years). The aim of this review and meta-analysis was to evaluate the effectiveness of behavioural interventions that report sedentary behaviour outcomes during early childhood, with a view to inform the development of an intervention for this thesis. In Chapter Four, the thesis aims, approach and methods are explained.

Chapter Five (Paper Two) describes secondary analyses of cross-sectional data from 1002 3- to 5-year-old children. Analyses were undertaken to determine the correlates of objectively assessed sedentary time and parent-reported screen time in preschool children, in order to identify potential mediators of change.

Chapter Six (Paper Three) describes the methodological details of the Mini Movers RCT, a text-message delivered intervention for parents, informed by results from Chapters Three and Five. The intervention rationale and study protocol are described in this chapter. The feasibility and efficacy results of Mini Movers are presented in Chapter Seven (Paper Four), which comprises both quantitative and qualitative research methods.

Finally, Chapter Eight provides an overview of the findings from this thesis. The strengths and limitations of the research are discussed, as well as future research directions and practical implications.

CHAPTER TWO

Literature review

2.1 Introduction

The aim of this chapter is to provide an overview of the existing literature on sedentary behaviour in early childhood. Although the focus of this thesis is on the preschool years (aged 2 to 5 years), literature from early childhood broadly (i.e., birth through 5 years) and school-aged children (i.e., 5 years and older) will be drawn on and discussed where specific literature on preschool children is not sufficient.

This chapter begins with a definition of sedentary behaviour and its distinction from physical inactivity. The health consequences of high levels of sedentary behaviour, including physical health, fundamental movement skills development, psychosocial health and cognitive development, in addition to the tracking of sedentary behaviour over time, are then discussed.

This is followed by an outline of sedentary behaviour recommendations for young children internationally. Measurement of sedentary behaviour in early childhood is discussed, with a focus on the challenges of measuring different types of sedentary behaviour in this age group. Next, the current prevalence of sedentary behaviour in young children is summarised. Appropriate theory to guide research in sedentary behaviour in early childhood is then introduced, followed by a detailed overview of correlates of preschool children's sedentary behaviour.

2.2 Defining sedentary behaviour and physical inactivity

Energy expenditure is often measured in metabolic equivalents (METs), where one MET is the energy used by the body while resting quietly (Pate, O'Neill & Lobelo 2008). Sedentary behaviour is defined as "any waking behaviour characterised by an energy expenditure ≤1.5 METs while in a sitting, reclining or lying posture" (Tremblay et al. 2017). Examples include activities such as reading, writing, watching television, and other forms of screen time (e.g., electronic game and computer use) while sitting, reclining or lying.

Physical inactivity refers to "an insufficient physical activity level to meet present physical activity recommendations" (Tremblay et al. 2017). It is important to note that sedentary behaviour and physical inactivity are distinct constructs that can co-exist. As such, it is possible for individuals to engage in prolonged periods of sedentary behaviour whilst still meeting physical activity guidelines and hence not be classified as physically inactive (Owen et al. 2010). As mentioned in Chapter One, the focus of this thesis is on young children's sedentary behaviour.

For young children, aged 5 years and younger, examples of sedentary behaviour include engaging in screen time (e.g., television, computer, tablet, phone) while sitting, reclining or lying; reading, drawing, painting or other quiet play while sitting; and time spent restrained (e.g., in car seats, high chairs or strollers) (Tremblay et al. 2017). Some of these behaviours, such as reading and quiet play, are beneficial for cognitive development (Carson et al. 2015; De Temple & Snow 2003; Tunks 2009) and should be encouraged during the early years. In contrast, other sedentary behaviours such as television viewing and use of other screens, and extended time spent restrained, have few known health or developmental benefits (LeBlanc et al. 2012; Okely et al. 2008). It is these detrimental sedentary behaviours that will be the focus of this thesis. For the purposes of this thesis: "sedentary time" refers to objectively measured time spent sedentary; "sitting time" refers to objectively measured time spent sitting; "screen time" refers to any screen-based sedentary behaviours (e.g., television viewing, electronic games and computer use); "restraint" or "time spent restrained" refers to any situation where a child is kept sedentary or inactive (e.g., in a stroller, car seat or high chair); and "sedentary behaviour" is the overarching term used to describe any or all of these behaviours. Health and developmental outcomes associated with young children's sedentary behaviour are discussed in the following section.

2.3 Impact of sedentary behaviour on young children's health and development

Blair et al. (1989) developed a framework hypothesising that childhood physical activity has direct benefits for childhood health, and both direct and indirect benefits for adult health. Okely et al. (2008) posit that, modifying this framework for sedentary behaviour, there may also be short-term health consequences

(Pathway A) and both direct (Pathway B) and indirect (Pathway E) long-term health consequences of sedentary behaviour in childhood. A modified version of this framework for sedentary behaviour is shown in Figure 2.1 below.

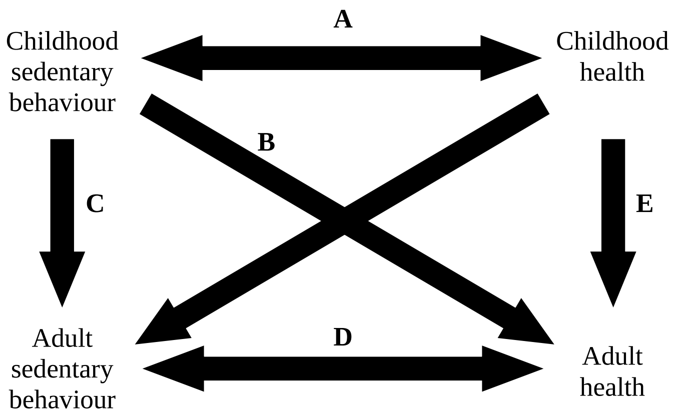

Figure 2.1 A conceptual framework for promoting reduced sedentary behaviour in children; modified from Blair et al. (1989)

Sedentary behaviour across the lifespan has been cross-sectionally and longitudinally associated with a number of negative health outcomes, including type 2 diabetes, all-cause and cardiovascular mortality, increased risk of overweight and obesity, and decreased cognitive development (LeBlanc et al. 2012; Proper et al. 2011; Tremblay et al. 2011). Although the evidence in young children is less conclusive, emerging evidence suggests that negative health outcomes are evident even in these early years. Research to date has largely focused on television viewing rather than total or other types of sedentary behaviour in early childhood (LeBlanc et al. 2012); however, television viewing is just one type of sedentary behaviour. Although there is a lack of evidence investigating health outcomes of other types of sedentary behaviour (including objectively assessed sedentary time) in this population, there is still sufficient evidence regarding the negative associations of screen time on young children's health and development, and guidelines have been established in acknowledgement of this (discussed in Section 2.4).

The focus of this thesis is on the preschool years (broadly 2 to 5 years of age). However, given the dearth of existing literature for this age group and the propensity for sedentary behaviour to track (Pathway C in Figure 2.1; discussed further in Section 2.3.5), health and developmental outcomes of sedentary behaviour throughout childhood will be discussed, highlighting the evidence in preschool children. The current evidence is summarised in the following sub-sections, which cover physical health (e.g., overweight and obesity), fundamental movement skill development, psychosocial health, and cognitive development associated with sedentary behaviour. Where possible, associations for different types of sedentary behaviour (e.g., screen time and sedentary time) are discussed separately. Evidence of the tracking of sedentary behaviour over time will also be presented.

2.3.1 Physical health and development

Overweight/Obesity

A review of sedentary behaviour and health indicators in children aged under 5 years found that increased television viewing, the most commonly studied sedentary behaviour in this age group, is associated with unfavourable adiposity (measured by body mass index [BMI], body fat or skinfolds) in experimental and longitudinal studies (LeBlanc et al. 2012). In a similar review of school-aged children (5 to 17 years), which included all study designs (i.e., cross sectional, retrospective, prospective, case control, randomised controlled trial [RCT], longitudinal), Tremblay et al. (2011) identified 170 studies examining the association between sedentary behaviour and body composition. An overall positive association was found between watching more than two hours of television per day and risk of overweight/obesity; results also showed that RCTs have shown that reductions in television viewing lead to decreases in BMI. The association between television viewing and overweight/obesity (and other health outcomes) may be moderated by other factors such as unhealthy dietary behaviours, which have been shown to be associated with television viewing in young children (Ford, Ward & White 2012) and in older children, adolescents and adults (Pearson & Biddle 2011). That is, the health outcomes associated with television viewing may be partly explained by the increased energy intake from unhealthy foods and beverages consumed during and after viewing.

No studies that objectively assessed sedentary time were identified in the review by LeBlanc et al. (2012). Since the publication of that review, two cross-sectional studies (Byun, Liu & Pate 2013; Collings et al. 2013) and one longitudinal study (Espana-Romero et al. 2013) (all n>300) have investigated the association between objectively assessed sedentary time and BMI in preschool children. All of those studies reported no association. One study has examined the cross-sectional and longitudinal (over a 12 month period) associations between sedentary time and body composition in 3- to 5-year-old children (n=111) (Butte et al. 2016). That study reported, counter-intuitively, a positive association between sedentary time and fat-free mass (kg) cross-sectionally, but no associations between sedentary time and BMI, fat mass (kg) or percent fat mass, and no significant associations longitudinally. In school-aged children, an update of the review by Tremblay et al. (2011) reported that, overall, objectively assessed sedentary time does not seem to be associated with overweight/obesity (Carson et al. 2016).

The lack of evidence of an association between overweight/obesity and sedentary time in both preschool and school-aged children may in part be due to issues related to the measurement of sedentary time (discussed more in Section 2.5), in particular the potential misclassification of sedentary time as light-intensity physical activity (LPA) or vice versa. Although outside the scope of this thesis, further research using posture-based objective measure of sedentary time is required to determine associations with overweight/obesity. Alternatively, there may be insufficient heterogeneity in overweight/obesity to detect associations, or the association may not exist for children of this age.

To date, only one study has been identified that has investigated health outcomes associated with time spent restrained in early childhood. Sijtsma et al. (2013) examined the associations of parent-reported time spent in unrestricted movement and time spent restrained in a baby car seat (at age 9 months) with researcher-measured anthropometrics at ages 9 and 24 months in a sample of 1722 infants in The Netherlands. Time spent moving unrestrictedly at age 9 months was inversely associated with Z-score waist circumference at 9 months, and change in Z-scores weight-for-height and weight-for-age between 9 and 24 months. Infants whose parents reported that they never used baby seats showed a decline in Z-score weight-for-height compared to those who reported using baby seats, but in contrast, Z-score waist circumference-for-age declined in infants who sat for one hour or more in baby seats (Sijtsma et al. 2013). Despite the inconsistency in findings, overall this study suggests that time spent restrained is adversely associated with measures of overweight/obesity. No other health outcomes of time spent restrained have been investigated, and hence restraint will not be discussed in any of the subsequent health outcome sections. Despite the paucity of studies investigating health outcomes of time spent restrained, many national recommendations for sedentary behaviour (discussed in Section 2.4) suggest that time spent restrained should be limited (Australian Government Department of Health 2014; Hong Kong Government Department of Health 2012; Tremblay et al. 2012b; UK Department of Health 2011). This recommendation likely exists given that any time spent restrained may minimise opportunities for children to be active. Moreover, given the evidence that overall sitting time is associated with deleterious health outcomes in adults (Thorp et al. 2011), it is logical to posit that any time spent restrained or sedentary during early childhood may have short- or long-term negative health implications.

Cardiovascular risk factors

Given that chronic diseases such as cardiovascular disease take many years to develop and are typically not seen in children, risk factors (such as hypertension, raised blood glucose levels, and raised cholesterol/lipid levels) are often examined in children to ascertain the risk of developing these diseases in the future. There is currently very little research into the association of sedentary behaviour and cardiovascular risk factors in children aged 5 years and younger; two cross-sectional studies have been identified that report the association between sedentary behaviour and blood pressure. Crispim, Peixoto and Jardim (2014) found that watching television for two or more hours (compared to less than two hours) per day was not associated with high blood pressure in 3- to 5-year-old children. Conversely, Martinez-Gomez et al. (2009) found that television viewing and total screen time (comprising television, video, computer, and video game use) were both positively associated with systolic and diastolic blood pressure, but found no association between sedentary time and blood pressure in 3- to 8-year-old children. Differences in the findings related to television viewing/screen time may be explained by differences in data management and analyses in the two studies. Crispim, Peixoto and Jardim (2014) dichotomised children's blood pressure to high blood pressure (systolic and diastolic blood pressure above the 95th percentile) or low blood pressure (systolic and diastolic blood pressure below the 95th percentile), while Martinez-Gomez et al. (2009) examined blood pressure as a continuous variable. Moreover, Martinez-Gomez et al. (2009) adjusted for child sex, age, height, and percentage of body fat, whereas Crispim, Peixoto and Jardim (2014) did not adjust for covariates.

Evidence in school-aged children suggests that television viewing is longitudinally associated with increased serum cholesterol and blood pressure, and screen time is cross-sectionally associated with increased blood pressure, glucose, fasting insulin and insulin resistance (Tremblay et al. 2011). There is also evidence for a dose-response risk for markers of metabolic syndrome and cardiovascular disease with increased television viewing and total screen time in school-aged children (Tremblay et al. 2011). More recent evidence suggests that high levels and frequency of television viewing are significantly associated with increased clustered cardiometabolic risk scores (Carson et al. 2016). Finally, a large birth-cohort study in New Zealand found that television viewing from ages 5 to 15 years was associated with raised serum cholesterol at age 26 years (Hancox, Milne & Poulton 2004).

No studies have been identified that examine the association between sedentary time and cardiovascular risk factors in young children. Although there is limited evidence in school-aged children, research suggests that there may be an association between sedentary time and high-density lipoprotein cholesterol, but there are mainly null findings for other risk factors (including blood pressure and clustered cardiometabolic risk scores) (Carson et al. 2016).

Musculoskeletal health

The deleterious association between sedentary behaviour and bone health has been well-documented in adults (Tremblay et al. 2010). However, that association has been investigated very infrequently in children; only two cross-sectional studies have been identified in the early childhood period. In a sample of 368 preschool children (4 to 6 years), Janz et al. (2001) found that television viewing was significantly inversely associated with bone mineral density and bone mineral content in girls, but not boys. Herrmann et al. (2015) reported no association between bone stiffness index (measured using quantitative ultrasound) and screen time or, after controlling for moderate- to vigorous-intensity physical activity (MVPA), sedentary time in a much larger sample (n=1512) of 2- to 5-year-old children.

A recent systematic review on sedentary behaviour and bone health in children, adolescents and young adults found that objectively measured sedentary time is negatively associated with bone outcomes of the lower extremities in school-aged children, independent of MVPA (Koedijk et al. 2017). However, no associations were observed for total body bone health and there was insufficient evidence to support an association between lumbar spine bone health and sedentary time. It may be that musculoskeletal and bone health outcomes associated with sedentary behaviour emerge later in life. In a small (n=10) laboratory study of 3- to 5-year-old children, Howie et al. (2017) examined head, trunk and arm postures, and upper trapezius muscle activity whilst children were using a tablet, watching television and playing with non-screen toys. When using a tablet, children had greater mean head, trunk and upper arm angles compared to both watching television and non-screen toy play; the authors suggest that this may result in adverse musculoskeletal symptoms later in life. However, given the small sample size and the controlled conditions of the study, inferences cannot be drawn.

Fundamental movement skill development

Fundamental movement skill development is the attainment of basic locomotor (e.g., jumping) and object control (e.g., ball catching/throwing) skills. These skills ultimately assist with the development of specific sports skills and, subsequently, sufficient participation in organised and non-organised physical activities (Clark & Metcalfe 2002; Gallahue & Ozmun 2006). There is a strong, positive association between physical activity and fundamental movement skills in childhood and adolescence (Lubans et al. 2010), and evidence suggests that sedentary behaviour may also be associated with fundamental movement skills. Cross-sectional studies of preschool children have reported mixed results. In Australian preschool children, neither total sedentary time (n=46) (Cliff et al. 2009) nor parent-reported sedentary electronic game use (n=53) (Barnett et al. 2012) have been shown to have an association with locomotor or object control skills. Conversely, a study of preschool children in the United States of America (USA) found that children with higher sedentary time had lower locomotor scores (Williams et al. 2008). That study had a relatively large sample size (n=198) compared to the two Australian studies, which may not have been adequately powered to detect associations (Barnett et al. 2012; Cliff et al. 2009). Additionally, differences in findings may be explained by different outcome measures: Williams et al. (2008) used a motor skill protocol developed as part of the study, while Cliff et al. (2009) and Barnett et al. (2012) used the Test of Gross Motor Development (TGMD-2). However, in a longitudinal study with almost 2000 2-year-olds (followed up at age 5 years), Pagani, Fitzpatrick and Barnett (2013) found that television viewing at age 2 years was unfavourably associated with locomotion skills but not associated with object control skills (assessed using the TGMD-2) at age 5 years.

Overall, evidence suggests that there may be an association between sedentary behaviour and locomotor skills, but not object control skills. It may be that time spent in sedentary behaviours in early childhood displaces time for physical activity, where locomotor skills are practiced and developed. Whereas object control skills may take longer to develop regardless of time spent being physically active. This is supported by evidence in older children and adolescents, which suggests that there is an association between physical activity and fundamental movement skills, but not between sedentary behaviours and fundamental movement skills (Lubans et al. 2010).

2.3.2 Psychosocial health

A recent systematic review of sedentary behaviour and health indicators in the early years found six studies examining the association between television viewing and psychosocial health in toddlers (1 to 3 years) and preschoolers (3 to 5 years) (LeBlanc et al. 2012). That review included only intervention/experimental and prospective studies, and concluded that there is evidence for a dose-response association between high levels of television viewing and poor indicators of psychosocial health (outcomes were victimization, bullying, antisocial behaviour, pro-social scores, emotional reactivity, aggressive and externalizing problems) in both toddlers and preschoolers (LeBlanc et al. 2012). However, it is important to note that some of these associations were found in only one or two studies, so results should be interpreted with caution. Another review of sedentary behaviour and psychosocial well-being in children aged 2 to 6 years identified 15 studies (including observational and interventions) and, while overall findings for associations were inconclusive, there was evidence of a dose-response association between higher levels of television viewing and increased aggression, attention problems, externalizing behaviours, and poorer classroom engagement (Hinkley et al. 2014a).

Only one study investigating the association between objectively assessed sedentary time and psychosocial well-being was identified in that review (Hinkley et al. 2014a); Ebenegger et al. (2012) reported that less sedentary time was associated with higher scores of hyperactivity/inattention. One additional study has been identified that investigated associations between sedentary time and psychosocial health in young children. Irwin et al. (2015) utilised the Child Temperament Questionnaire (CTQ) to measure soothability, sociability, and emotionality in a cross-sectional study of 216 preschool children. Results showed no association between sedentary time and any of the three outcomes. In school-aged children, total sedentary time has been shown to have no association with self-esteem or self-worth (Faulkner, Carson & Stone 2014); however, it has been associated with depressive (Johnson et al. 2008) and emotional symptoms (Brodersen et al. 2005) in adolescent girls. As with other health and developmental outcomes, it may be that the adverse psychosocial outcomes associated with sedentary time are not evident until later in life. Alternatively, the lack of associations may potentially be due to the difficulties associated with measuring psychosocial health in very young children.

2.3.3 Cognitive development

Evidence from a systematic review of interventions and prospective studies suggests that there is a consistent dose-response association between increased television viewing and poorer cognitive development in toddlers (1 to 3 years) (LeBlanc et al. 2012). Specifically, that review found that television viewing predicts attention, vocalisation count, language delays, reading recognition, comprehension and memory scores in infants, and vocalisation, classroom engagement, and mathematics scores in toddlers. No evidence was found in that review for cognitive outcomes associated with sedentary behaviour in preschool children.

A more recent review focusing only on sedentary behaviour and cognitive development found that although many of the studies were of weak to moderate quality, evidence suggests that screen time (and in particular television viewing) was either not associated with or detrimentally associated with cognitive development (Carson et al. 2015). Studies published since have reported mixed findings. Cross-sectional studies have reported no associations between video games and hyperactivity or attention span (Linebarger 2015) or between computer use and speech disorders (Rajchanovska & Ivanovska 2015). However, a significant association has been found between increased mobile phone use and speech disorders (Rajchanovska & Ivanovska 2015).

Longitudinal studies report similarly mixed findings. Blankson et al. (2015) found that after adjusting for covariates, television viewing at either 3 or 4 years of age was not associated with vocabulary, cognitive inhibitory control, working memory capacity, or overall executive function. However, McKean et al. (2015) report significant associations between higher television viewing at age 4 years and lower language development at age 7 years. The lack of consistent measures of cognitive development in this population makes it difficult to compare results. Additionally, there are potentially different associations with cognitive outcomes depending on the specific type of screen (e.g., “passive” television viewing compared to tablet use). Evidence from a review in school-aged children suggests that higher duration of television viewing is significantly associated with lower academic achievement; however, in general, no association is observed between computer or video game use and academic achievement (Carson et al. 2016).

No studies have been identified examining the association between objectively assessed sedentary time and cognitive development in early childhood. In school-aged children, few studies have been conducted and results are mixed. One study has reported no association between sedentary time and academic achievement (measured by grade point average) (Syvaoja et al. 2013), but one study has reported strong associations between sedentary time and academic achievement in five domains (language, reading, writing, spelling, and numeracy) (Maher et al. 2016).

2.3.4 Summary of health and developmental outcomes

In summary, there is emerging evidence that some sedentary behaviours during early childhood, particularly television viewing, are associated with a number of unfavourable physical, psychosocial and cognitive health and developmental outcomes (Figure 2.1; Pathway A). However, there is evidently a significant gap in the literature (which is outside the scope of the current thesis) with respect to the health and developmental outcomes of total sedentary time in this population, with the majority of studies focussing solely on television viewing. Given that evidence suggests that sedentary behaviour throughout childhood is associated with unfavourable outcomes, it is also important to consider Pathway C, i.e., whether sedentary behaviour tracks over time, to determine the necessity for early intervention. This is also important given that many health outcomes may not be evident until later in life.

2.3.5 Tracking of sedentary behaviour

The term "tracking" refers to the stability of a particular behaviour over time (Bloom 1964), or the maintenance of an individuals' relative rank over time within a cohort (Malina 1996). For the purposes of this thesis, tracking of sedentary behaviour refers to whether sedentary behaviour habits established early in life are maintained (i.e., are stable) over time; that is, whether a child who is highly sedentary at a young age is still sedentary at an older age (Pathway C in Figure 2.1). Longitudinal observations of the same cohort, with correlations between time points, are used to estimate the tracking of particular behaviours (Malina 1996).

Jones et al. (2013) conducted a systematic review to examine the tracking of physical activity and sedentary behaviour in early childhood (0 to 5 years) and from early childhood to middle childhood (6 to 11 years). Tracking coefficients were classified as small (<0.30), moderate (0.30 to 0.49) or large (≥0.50). There was evidence of moderate tracking both during early childhood and from early childhood to middle childhood, with 83% of studies reporting moderate or large tracking of sedentary behaviour (time periods ranging from one to two years). The majority of included studies reported time spent watching television or engaging in other screen time behaviours. Only one included study reported total sedentary time (Kelly et al. 2007) and one reported total sedentary behaviour from parent proxy report (Taylor et al. 2009); both studies found moderate tracking coefficients. Larger tracking coefficients were generally found for television viewing (Jones et al. 2013), suggesting that television viewing may be more stable over time than overall sedentary behaviour. Similarly, another systematic review of the tracking of sedentary behaviours of young people (3 to 18 years) identified two studies (utilising the same sample with different follow-up periods) suggesting that television viewing tracks moderately from age 5 years into adolescence and adulthood (Biddle et al. 2010). Given that sedentary behaviour has been shown to track, it is important to establish low levels of these behaviours during the developmental period so that these low levels continue throughout childhood and into later life. Given the negative health consequences associated with some sedentary behaviours, and given that sedentary behaviour tends to track through childhood and potentially to adulthood, recommendations to limit these behaviours in young children have been incorporated into national and international public health guidelines.

2.4 Sedentary behaviour recommendations

In 2001, the American Academy of Pediatrics (AAP) was the first association to introduce recommendations for limiting screen time for young children, stating that parents should:

- "Limit children's total media time (with entertainment media) to no more than one to two hours of quality programming per day; and
- Discourage television viewing for children younger than 2 years" (Committee on Public Education 2001, p. 424).

In 2006, the AAP also recommended that for children aged 4 to 6 years "parents should reduce sedentary transportation by car and stroller" (Council on Sports Medicine and Fitness and Council on School Health 2006, p. 1838), and in 2013 issued a statement reinforcing the screen time recommendations described above (Council On Communications and Media 2013). However, these recommendations were based on expert consensus rather than on scientific evidence. The AAP updated their recommendations in 2016 to suggest that digital media use (except video-chatting) should be avoided in children younger than 18 to 24 months, and that for children aged 18 to 24 months only high-quality media should be introduced and solo media use should be avoided (Council On Communications and Media 2016).

In 2010, Australia was the first country to introduce evidence-based recommendations for sedentary behaviour for children aged 0 to 5 years. A discussion paper (Okely et al. 2008) reviewing current evidence for the health outcomes, measurement, prevalence and correlates of physical activity and sedentary behaviour was compiled, from which physical activity and sedentary behaviour recommendations were developed. As sedentary behaviour is the focus of this thesis, only those recommendations will be discussed. The sedentary behaviour recommendations are:

- "For children 2 to 5 years of age, sitting and watching television and the use of other electronic media (DVDs, computer and other electronic games) should be limited to less than one hour per day;
- Children younger than 2 years of age should not spend any time watching television or using other electronic media (DVDs, computer and other electronic games); and
- Infants, toddlers and pre-schoolers (birth to 5 years) should not be sedentary, restrained, or kept inactive, for more than one hour at a time, with the exception of sleeping" (Australian Government Department of Health 2014).

Similar sedentary behaviour recommendations have since been developed in Canada and the United Kingdom (UK); both recommend that time spent sedentary (restrained) should be minimised for children under 5 years (Tremblay et al. 2012b; UK Department of Health 2011). However, the UK recommendations are vague in that they do not provide a specific time to minimise restraint to, nor do they provide specific suggestions for screen time (UK Department of Health 2011). The Canadian recommendations are consistent with the Australian recommendations in suggesting minimising restraint to no more than one hour at a time, that children under 2 years should not be exposed to any screen time, and that screen time for children aged 2 to 4 years should be limited to less than one hour per day (Tremblay et al. 2012a). Hong Kong has also released sedentary behaviour guidelines for young children; however, they differ slightly from the Australian, Canadian and UK recommendations. The Hong Kong guidelines suggest that children under 2 years should avoid screen time and children aged 2 to 6 years should limit screen time to no more than two hours per day (Hong Kong Government Department of Health 2012).

Finally, in 2017, New Zealand released physical activity, sedentary behaviour and sleep recommendations for children aged under 5 years (New Zealand Ministry of Health 2017). These guidelines were the first to include recommendations for breaking up sitting time in early childhood. The guidelines recommend that regular activity breaks should be provided to young children to limit the amount of time a child spends sitting. Consistent with Australian and Canadian recommendations, they also suggest that screen time should be discouraged for children under 2 years of age, and limited to less than one hour every day for children aged 2 years or older. Time spent using equipment that restricts free movement (e.g., high chairs or strollers) should be also be limited. Similar to the UK guidelines, no specific times to minimise restraint to are provided. In order to measure sedentary behaviour (to determine prevalence of meeting recommendations, investigate health outcomes, etc.), valid and reliable instruments are required. These instruments are described in the following section.

2.5 Assessment of sedentary behaviour

Appropriate tools are required to assess sedentary behaviour to determine compliance with sedentary behaviour recommendations, to determine correlates of sedentary behaviour and to evaluate intervention effectiveness (Colley et al. 2013). Young children's sedentary behaviour can be measured using subjective (e.g., proxy report) or objective (e.g., accelerometers, direct observation) methods. There are advantages and limitations to all methods of measurement; however, it has been suggested that in children and adolescents, subjective and objective measurements should be used concurrently to determine both overall sedentary behaviour and the type and context of behaviour (Lubans et al. 2011). Further, different methods of assessment may be necessary for different types of sedentary behaviour. For example, total sedentary behaviour is likely to be challenging to recall accurately and may be best assessed using an objective measure, whereas habitual screen time cannot currently be measured objectively and is best assessed using subjective instruments. Measurement tools commonly used to determine levels of sedentary behaviour are described in the following sub-sections.

2.5.1 Proxy report

Self-report measures are often used to reliably assess physical activity and sedentary behaviour in older children and adolescents. However, these measures are not considered appropriate for children under the age of 10 years as they are unlikely to have the cognitive ability to accurately recall activities (Dollman et al. 2009; Trost 2007). Instead, proxy report by parent, caregiver or teacher is the key means of subjective assessment for children under 10 years. To date, children's sedentary behaviour has most commonly been measured by parental proxy report of screen time (Loprinzi & Cardinal 2011). Proxy report measures include diaries, log books, checklists, and questionnaires (Dollman et al. 2009; Lubans et al. 2011). The key advantage of proxy report measures is the provision of contextual information on specific types of sedentary behaviours, for example, the assessment of different types of screen behaviours (Colley et al. 2012). Proxy reports are also relatively inexpensive and easy to administer, and hence are often used in large epidemiological studies where other measurement tools may not be practical or cost-effective (Trost 2007). However, these measures can be subject to social desirability and recall bias, whereby parents may under- or over-report the amount of time their child spends in particular behaviours (Lubans et al. 2011; Reilly et al. 2008). Reliance on proxy report of screen time may also not provide an accurate estimate of overall sedentary behaviour. It would be very difficult to measure all types of individual sedentary behaviours with proxy report (e.g., listing time spent reading, doing puzzles, playing with blocks, sitting not playing), and challenging for parents to accurately estimate the sum of all these pursuits in a single global assessment. Additionally, parents are not able to report their child's sedentary behaviour while in preschool/childcare.

Proxy report validity and reliability

Few studies have reported the reliability and validity of proxy report measures of sedentary behaviour in children 5 years and younger. A systematic review evaluating the validity and reliability of sedentary behaviour measures in children and adolescents identified just two studies that included children in this age group (Lubans et al. 2011). One study compared 10-day parent diaries of 5-year-old children's television viewing with time-lapse video observations (Anderson et al. 1985). The authors reported test-retest reliability (over a one month period) to be of borderline acceptability (*r*=0.72) for the television diaries, and reported good criterion validity assessed by correlation (*r*=0.84) between the television diary and video observations (Anderson et al. 1985). The other study found acceptable test-retest reliability (*r*=0.80) for television viewing items included in a parent questionnaire, but did not report on the validity of the items (Taras et al. 1989). Another systematic review, investigating the measurement of television viewing in children and adolescents, found that proxy report was used consistently for 0- to 5-year-old children but that the validity and reliability of the measures was not often reported (Bryant et al. 2007). Studies published subsequent to those systematic reviews have generally found moderate to good test-retest reliability for screen time questionnaires (Campbell et al. 2013; Hinkley et al. 2012a; Hinkley et al. 2014b) and for television diaries (Mendoza et al. 2013).

Proxy report may also be used to measure the amount of time young children spend restrained; however, to date only one study has been identified that reports the reliability of a proxy report tool to measure time spent restrained (Hesketh et al. 2014a). That study assessed time in a range of different situations that restrain movement, including in a bouncer or swing, stroller or pram, car seat or capsule, high chair or other chair, playpen, and baby carrier or sling, at child ages 4, 9 and 20 months. The majority of individual items had acceptable test-retest reliability (intra-class correlation >0.50), with the exception of time spent restrained in a bouncer/swing and in a highchair at child age 4 months which did not show acceptable reliability (Hesketh et al. 2014a).

2.5.2 Direct observation

There are no observation tools developed specifically for measuring young children's sedentary behaviour. However, tools designed to measure physical activity have been used to capture sedentary behaviour. Direct observation involves trained researchers observing and recording the types of activities undertaken over a predetermined period of time (Pate, O'Neill & Mitchell 2010). Sedentary behaviour is usually recorded as an "intensity" of activity, i.e., activities are recorded as either sedentary, light, moderate, or vigorous in intensity. Hence, direct observation may not necessarily measure true sedentary behaviour as defined by the Sedentary Behaviour Research Network (Tremblay et al. 2017). For example, the Observational System for Recording Physical Activity in Children- Preschool (OSRAC-P) consists of six "physical activity level categories" ranging from "stationary" (which includes standing still, i.e., not sitting) to "fast". It is therefore possible that a child's activity may be classified as stationary, and hence sedentary, but they may not necessarily be sitting.

Two of the most commonly used direct observation tools are the Children's Activity Rating Scale (CARS) and the OSRAC-P (a modified version of CARS) (Oliver, Schofield & Kolt 2007). The CARS has been validated to measure physical activity in preschool children using VO_2 (a measure of energy expenditure) and assessed for inter-observer agreement, with high percent agreement reported (84.1±10.1%) (Puhl et al. 1990). However, when the CARS was assessed for between-day and between-year stability in preschool children (DuRant et al. 1993), higher levels of reliability were found for the higher intensity activity levels, rather than time spent sedentary. The OSRAC-P also shows acceptable inter-observer agreement; however, there was significant variability in observer classification of physical activity level and type (Brown et al. 2006), again highlighting the limitations of direct observation for classifying sedentary behaviour.

Direct observation allows the collection of a range of data, including the type of sedentary behaviour (e.g., sitting, reading, watching television), the social and environmental context, and the location (Pate, O'Neill & Mitchell 2010), with less risk of bias than proxy report measures (Lubans et al. 2011). Participant reactivity to observation (in which children may alter their behaviour in the presence of an observer) can be of concern; however, this has been shown to occur rarely with young children (Puhl et al. 1990). The key limitation of direct observation is researcher burden, primarily the cost and time involved in using trained researchers (Dollman et al. 2009; Pate, O'Neill & Mitchell 2010). Direct observation is therefore not suitable for measuring “habitual” behaviour; it is more suitable for small, short-term studies, and is typically undertaken in preschool or childcare settings rather than in family homes, due to the intrusive nature.

2.5.3 Accelerometers

Accelerometers are commonly used as an objective measure of sedentary time in preschool children (Hnatiuk et al. 2014; Pate, O'Neill & Mitchell 2010). They are small, lightweight monitors that are usually worn on a belt around the hips (Pate, O'Neill & Mitchell 2010) or, more recently, on the wrist (Chandler et al. 2016; Johansson et al. 2014). Accelerometers detect accelerations of the body in either the vertical plane (uniaxial) or in multiple planes (omnidirectional), traditionally using piezoelectric sensors (Chen & Bassett 2005) but more recently using capacitive sensors (John, Tyo & Bassett 2010). The raw acceleration data are referred to as “counts” of activity. The counts are summed and stored in the internal memory of the monitor at the end of each pre-determined period of time, referred to as an “epoch”. At the end of the period of wear, the raw output from the accelerometer can be downloaded to a computer for analysis. The number of counts per epoch is compared with predetermined thresholds or cut points to identify time being sedentary.

Accelerometers have the advantage of providing an objective measurement of sedentary time that is not subject to reporting biases (Lubans et al. 2011). They also measure sedentary time in free-living conditions and in real-time, allowing estimates of usual sedentary behaviour at particular times of the day, with little participant burden (Lubans et al. 2011; Pate, O'Neill & Mitchell 2010). However, disadvantages of the use of accelerometers include the relatively high cost and the high-level technical knowledge and software required to analyse the data. Furthermore, accelerometers do not provide contextual information nor do they distinguish between types of sedentary behaviours, only providing data on overall sedentary time (Lubans et al. 2011), which additionally may be misclassified stationary standing time.

Accelerometer validity and reliability

The ActiGraph is one of the most commonly used accelerometers that is commercially available for use in research studies. It has been validated (in a hip-worn position) for measuring sedentary time in preschool children against direct observation using criteria based on the CARS, showing high correlation (r = 0.70) (Sirard et al. 2005) and a moderate area under the receiver operating characteristic curve (ROC-AUC; 0.61) (De Decker et al. 2013). The ActiGraph has also been validated for measuring sedentary time (comparing existing cut points for classifying sedentary time; discussed further in the following sub-section) against whole room calorimetry and direct observation in 4- to 6-year-old children (Janssen et al. 2013b). Other studies have validated the ActiGraph for measuring overall physical activity of preschool children against direct observation and energy expenditure (oxygen consumption [VO_2] measured on a breath-by-breath basis), but have not reported the validity of the monitor for measuring sedentary time specifically (Fairweather et al. 1999; Pate et al. 2006). Those studies found high correlations ranging from r=0.82 to r=0.87 for overall counts per minute for physical activity. The validity of the ActiGraph for assessing sedentary time in toddlers (aged 1 to 3 years) has been reported in two studies. Those studies found moderate to high sensitivity (ranging from 67.0% to 100%), low to moderate specificity (ranging from 23.9% to 75.4%) and moderate to high ROC-AUC values (ranging from 0.56 to 0.98) (Johansson et al. 2014; Van Cauwenberghe et al. 2011a). One of those studies also examined the feasibility of using accelerometers with toddlers, and found 83% of parents perceived wearing the accelerometer as “not unpleasant and not pleasant”, with no parents perceiving it as “unpleasant” (Van Cauwenberghe et al. 2011a). Finally, the ActiGraph has also been calibrated and cross-validated against CARS for wrist-worn placement in preschoolers (Johansson et al. 2014).

Other accelerometers available commercially include the Actiwatch, Actical, Actiheart and RT3. The Actiwatch has been highly correlated (r = 0.74) with overall physical activity (using the CARS) in 5- to 6-year-old children; however, the correlation for sedentary time specifically was not reported (Finn & Specker 2000). The Actical, Actiheart and RT3 accelerometers have been validated against oxygen consumption (as a measure of energy expenditure) simultaneously in one study of preschool children, with positive predictive rates of 77%, 75% and 76%, respectively (Adolph et al. 2012). While accelerometers have been shown to be valid, reliable and feasible to use in this population, there are a number of contentious issues regarding the recording and analysis of the data, including the use of different cut points to classify sedentary time.

Accelerometer cut points

While raw accelerometer data can be used to describe total or average counts of movement per minute, cut points are required to classify the behaviour as either sedentary time, light-, moderate- or vigorous-intensity physical activity (Ridgers & Fairclough 2011). For sedentary time, cut-points indicate the maximum number of counts per epoch that denote the epoch as sedentary time. There is considerable variation in existing cut points for young children's sedentary behaviour and the use of different cut points has been shown to influence the classification of sedentary time (Trost et al. 2012). It is important for studies to use appropriate and consistent cut points not only to accurately assess sedentary behaviour, but also to allow for comparison between samples. Existing cut points for children aged 5 years and under are summarised in Table 2.1.

Table 2.1 Accelerometer cut points for classifying sedentary time in young children

Study	Accelerometer	Sample age	Sedentary cut point (per 15s epoch)
Evenson et al. (2008)	ActiGraph	5-8 years	≤25
Pate et al. (2006)	ActiGraph	3-5 years	≤37
Reilly et al. (2003)	ActiGraph	3-4 years	≤275
Sirard et al. (2005)	ActiGraph	3 years	≤301
		4 years	≤363
		5 years	≤398
Trost et al. (2012)	ActiGraph	16-36 months	≤25
Van Cauwenberghe et al. (2011a)	ActiGraph	1-3 years	≤37
Van Cauwenberghe et al. (2011b)	ActiGraph	3-6 years	≤372

Janssen et al. (2013a) evaluated the classification accuracy of existing ActiGraph cut points used in preschool children (against direct observation using CARS) in a sample of 4- to 6-year-olds. The authors found that the Evenson cut points were the most accurate for classifying sedentary behaviour. They concluded that, based on their findings, a cut point of ≤25 counts per 15 second epoch (Evenson et al. 2008) should be used to classify sedentary behaviour in preschool children (Janssen et al. 2013a). Trost et al. (2011) reached the same conclusion in a sample of children aged 5 to 15 years.

Posture-based accelerometers

In recent years, posture-based accelerometers and inclinometers such as the *activ*PAL™ (PAL Technologies Ltd, Glasgow, Scotland) have been used to measure sedentary behaviour (specifically sitting time) by measuring posture (i.e., sitting/lying versus standing) (Ridgers et al. 2012). The *activ*PAL™ is a small, lightweight monitor that is worn on the mid-anterior aspect of the thigh (Martin et al. 2011). The monitor uses algorithms to identify periods of sitting, standing and walking (Grant et al. 2006), allowing the objective assessment of sitting time. Data can be used to identify posture transitions (e.g., from sitting to standing) as breaks in sitting time, which have been shown to potentially mitigate the negative health outcomes associated with extended periods of sedentary behaviour in adults (Healy et al. 2008).

The *activ*PAL™ has similar advantages to hip-worn accelerometers, in that it provides an objective measurement of sitting time that is not subject to reporting biases. Further, it assesses sitting time in free-living conditions and in real time. This allows for estimates of sitting time at particular times of the day. However, the *activ*PAL™ may not accurately capture postures such as kneeling (Janssen et al. 2014). In addition, they are expensive and require high-level knowledge and software to analyse the data.

activPAL™ validity and reliability

The *activ*PAL™ has been tested for validity in preschool children, with conflicting results. When compared against the Actical and ActiGraph accelerometers, the *activ*PAL™ shows moderate agreement at the group level, but poorer agreement at the individual level (Martin et al. 2011; Van Cauwenberghe et al. 2012). Similarly, the *activ*PAL™ has been shown to have poor classification accuracy (ROC-AUC = 0.6) when compared to direct observation in 4- to 6-year-olds (De Decker et al. 2013). However, other studies have found acceptable validity for the *activ*PAL™ for classifying sitting time in preschool children when compared against direct observation alone (Davies et al. 2012) and against room calorimetry in conjunction with direct observation (Janssen et al. 2013b). Further, the *activ*PAL™ has been shown to have acceptable reliability (≥0.80 correlation coefficient) in preschool children when the monitor is worn for at least 5 days (Davies et al. 2012). It has also been shown to have acceptable practical utility, in that parent responses to the practicality of using the *activ*PAL™ are generally positive (Davies et al. 2012). Davies, Reilly and Paton (2012) also found a high correlation ($r = 0.79$) between the number of posture transitions, e.g., from sitting to standing, and direct observation in preschool children.

The differing results of validation studies are largely due to the different criterion measures utilised. While both the Actical and ActiGraph accelerometers have been validated for measuring sedentary time in preschool children, they primarily determine sedentary behaviour as a lack of movement, which does not align with the most recent definition of sedentary behaviour (Tremblay et al. 2017). In contrast, the *activ*PAL™ measures posture, such as sitting and lying, to determine sedentary behaviour. Hence, there will be some disagreement between these instruments when measuring sedentary behaviour (Van Cauwenberghe et al. 2012).

2.5.4 Summary of assessment of sedentary behaviour

In summary, the most appropriate tool for assessing sedentary behaviour depends on the outcome of interest. Given the advantages and limitations of each of the tools described above, a combination of both subjective and objective measures is recommended to comprehensively assess time spent in different types of sedentary behaviour. Having accurate measures of young children's sedentary behaviour is important for determining the population prevalence of these behaviours, in particular how many children are meeting government guidelines. The current prevalence of sedentary behaviour in young children is discussed in the following section.

2.6 Prevalence of sedentary behaviour in young children

The differing types of sedentary behaviour, for example screen time and restraint, and the varying tools used to measure these different types of sedentary behaviours in young children make it difficult to provide accurate estimates of overall sedentary behaviour across the population. Estimates of preschool children's screen time range from a mean of 57 to 246 minutes per day (Aggio et al. 2015; Asplund et al. 2015; Berglind & Tynelius 2017; Bleakley, Jordan & Hennessy 2013; Brockmann et al. 2016; Carson & Janssen 2012; Carson, Rosu & Janssen 2014; Carson et al. 2010; Carson et al. 2013; Datar, Nicosia & Shier 2013; Dawson-Hahn, Fesinmeyer & Mendoza 2015; Garriguet et al. 2016; Hinkley et al. 2012b; Kabali et al. 2015; Lee et al. 2016; Loprinzi et al. 2014; Loprinzi, Schary & Cardinal 2013; Magee, Lee & Vella 2014; Miguel-Berges et al. 2017; Okely et al. 2009; Peck et al. 2015; Sanders et al. 2015; Sijtsma et al. 2015; Tandon et al. 2011; Vaughn, Hales & Ward 2013; Veldhuis et al. 2014; Xu et al. 2016b). The percentage of children meeting the AAP guidelines of no more than two hours per day of screen time (Council On Communications and Media 2013) ranges from 21% to 91% (Asplund et al. 2015; Briefel, Deming & Reidy 2015; Carson & Janssen 2012; Carson et al. 2010; Hinkley et al. 2012b; Loprinzi, Schary & Cardinal 2013; Okely et al. 2009; Peck et al. 2015; Schrempft et al. 2015; Tandon et al. 2011; Veldhuis et al. 2014; Wijtzes et al. 2013a; Wijtzes et al. 2013b). Adherence to the more stringent Australian and Canadian recommendations of no more than one hour per day of screen time (Australian Government Department of Health 2014; Tremblay et al. 2012b) ranges from 18% to 71% (Carson & Janssen 2012; Carson et al. 2010; Carson et al. 2013; Colley et al. 2013; Garriguet et al. 2016; Hinkley et al. 2012b; Miguel-Berges et al. 2017; Vanderloo & Tucker 2015; Wijtzes et al. 2013a; Wijtzes et al. 2013b).

There are evidently vastly different estimates of both screen time and compliance with screen time recommendations. This may largely be due to age variations between and within the samples. Firstly, comparing estimates of screen time between samples is difficult. For example, results from a study where the mean age is 3 years may be very different to results from a study where the mean age is 5 years. Secondly, despite the relatively narrow age band (generally 3 to 5 years, but some studies examined children from birth through 5 years), within-sample screen time tended to be higher for older children. However, few studies stratified results by age; for those studies including a wider age range (e.g., one study included children from 6 months to 4 years (Kabali et al. 2015)), the screen time habits for younger children may be very different to those of older children within the sample. Early childhood is a period of rapid development; children aged 6 months who are not yet mobile or verbal are at a very different stage developmentally (both physically and in terms of attention span) to children aged 4 years, and therefore engage in screen time in different ways. Hence, reporting a mean value may not provide an accurate estimate.

Differences in estimates may also be explained by the range of different tools used to assess screen time in those studies; some tools utilised continuous measures of screen time (e.g., (Veldhuis et al. 2014)) while others utilised categorical measures (e.g., a 7-point scale from ‘none’ to ‘≥3 hours/day’(Carson, Rosu & Janssen 2014)). Various screen-based behaviours were also assessed to determine overall screen time (e.g., some studies assessed only television viewing and video game use (Berglind & Tynelius 2017), while others assessed additional behaviours such as non-game computer use (Colley et al. 2013)). Finally, other factors, such as the variability in sampling techniques and sample sizes (ranging from 96 participants (Dawson-Hahn, Fesinmeyer & Mendoza 2015) to 12389 participants (Peck et al. 2015)) may explain some of the variability in estimates of screen time. Regardless, the high levels of screen time in young children are concerning, particularly given that evidence shows that only around 50% (or fewer) of young children are meeting current Australian recommendations of no more than one hour of screen time per day (Australian Government Department of Health 2014).

A systematic review of the prevalence of objectively assessed physical activity and sedentary time in children under 6 years of age also found substantial variation in estimates of time spent sedentary, with a median of 77% of waking time spent in sedentary time across all included studies (Hnatiuk et al. 2014). The proportion of time per day spent being sedentary, measured by accelerometry, ranged from 23% to 94%, or from three to 12 hours per day, while observational studies reported between 55% and 89% of time spent sedentary (Hnatiuk et al. 2014). The review concluded that these vast differences in estimates of sedentary time measured by accelerometry may be attributable to the use of different cut points, with some studies utilising cut points that have not been validated in preschool children. In addition, differing inclusion criteria (i.e., the minimum number of hours/days of accelerometer wear time) may have resulted in variability in results. Several studies reporting young children's sedentary time have been published since that review. Estimates of time spent sedentary in those studies range from 241 to 468 minutes per day (approximately four to eight hours per day) (Aguilar-Farías et al. 2015; Barbosa et al. 2016; Barkin et al. 2017;

Berglind & Tynelius 2017; Borkhoff et al. 2015; Butte et al. 2016; Cerin et al. 2016; Dawson-Hahn, Fesinmeyer & Mendoza 2015; Garriguet et al. 2016; Hesketh et al. 2014b; Hnatiuk, Hesketh & van Sluijs 2016; Hughes et al. 2016; Johansson et al. 2015; Konstabel et al. 2014; Møller et al. 2017; Schmutz et al. 2017; Senso et al. 2015; Tandon, Saelens & Christakis 2015; Vanderloo & Tucker 2015; Vaughn, Hales & Ward 2013; Wijtzes et al. 2013b); slightly less variation than observed in the review by Hnatiuk et al. (2014). However, there were still considerable differences in the cut points utilised in those studies. Thirteen studies used “low” cut points (i.e., ≤20 to ≤152 counts per minute) (Barkin et al. 2017; Borkhoff et al. 2015; Cerin et al. 2016; Dawson-Hahn, Fesinmeyer & Mendoza 2015; Garriguet et al. 2016; Hesketh et al. 2014b; Hnatiuk, Hesketh & van Sluijs 2016; Konstabel et al. 2014; Møller et al. 2017; Schmutz et al. 2017; Senso et al. 2015; Tandon, Saelens & Christakis 2015; Vaughn, Hales & Ward 2013), while six studies used “high” cut point (i.e., ≤456 to ≤1580 counts per minute) (Barbosa et al. 2016; Berglind & Tynelius 2017; Butte et al. 2016; Johansson et al. 2015; Vanderloo & Tucker 2015; Wijtzes et al. 2013b). There were no substantial differences between estimates of sedentary time in studies that utilised low versus high cut points. The study reporting the highest sedentary time (468 minutes per day) used *activ*PAL™ accelerometers to objectively assess sitting time (Aguilar-Farías et al. 2015).

The only studies that have reported levels of restraint have been in children younger than 2 years; that is, no studies in preschool children have reported levels of restraint. One of those studies found that 9-month-old infants spent an average of 1.1 hours per day in baby seats; no other measures of restraint were reported

(Sijtsma et al. 2013). The other study reported that infants spent a median of 103 minutes per day in situations that restricted movement (e.g., in a bouncer, swing, stroller, car seat or baby carrier) at 4 months old, 137 minutes per day at 9 months old, and 120 minutes per day at 20 months old (Hesketh et al. 2014a). The lack of studies reporting prevalence of time spent restrained in preschool children may be because children of this age do not have as many occasions to be restrained as younger children; for example, by the age of 3 years most children would not be using bouncers/rockers or highchairs. However, preschool children still use car seats and many parents still use strollers for children of this age, despite not needing to. Given that sedentary behaviour recommendations suggest that all children aged 5 years and younger should minimise time spent restrained, it is important to assess time in this behaviour in preschool aged children as well as infants and toddlers.

In order to better understand young children’s sedentary behaviour habits, and particularly why many children are exceeding current screen time recommendations, it is important to investigate correlates of these behaviours. Behavioural theories can provide a framework through which these associations can be explored; these theories are discussed in the following section.

2.7 Behavioural theories for understanding young children's sedentary behaviour

The application of behavioural theories can assist in identifying potential correlates of sedentary behaviour. This can help to explain why some children are not meeting recommendations and is useful for identifying particular areas that may be targeted in interventions (Sallis & Owen 1998). Furthermore, theoretical models can also be used to inform the development of interventions. King et al. (2002) argue that interventions based on theoretical models are more successful and effective than atheoretical interventions. Although interventions to increase school-aged children's physical activity are increasingly being based on theory (Salmon, Brown & Hume 2009), interventions in children aged 5 years and younger still generally neglect to use theory to inform their strategies (Hesketh & Campbell 2010).

Although there are a number of theoretical models used in existing epidemiological studies, many are models which have been developed to explain adult health behaviours and hence they are not appropriate for use in studies in this population. These include the transtheoretical model (Grimley et al. 1994; Prochaska et al. 1994), the theories of reasoned action and planned behaviour (Trost et al. 2002) and the Health Belief Model (Janz & Becker 1984). On the other hand, social cognitive theory (Bandura 1986), the family influence model (Kimiecik, Horn & Shurin 1996), and ecological models (Bronfenbrenner 1979; Campbell, Hesketh & Davison 2010) may be more appropriate for this age group as they take into account broader social and environmental influences which may be more relevant to young children. Ecological models provide an over-arching framework that depicts the various levels of influence on behaviour (Bronfenbrenner 1979). Social cognitive theory and the family influence model propose constructs within these broader individual, social and environmental contexts, such as parental and home environmental influences, that may be more relevant in this age group than the psychological constructs on which adult theories are primarily based. The following sub-sections will review each of these theories and models to determine the most appropriate for use in this thesis.

2.7.1 Family influence model

The family influence model was developed to examine the influences on children's physical activity and is based on components of social cognitive theory (described in Section 2.7.3) and the expectancy-value model (Wigfield & Eccles 2000). It proposes that a child's home environment is essential for understanding the influence of family on children's behaviour (Kimiecik, Horn & Shurin 1996). According to the model, the child's belief system, which is related to the parent's belief system, interacts with the environment to influence the child's behaviour (Figure 2.2).

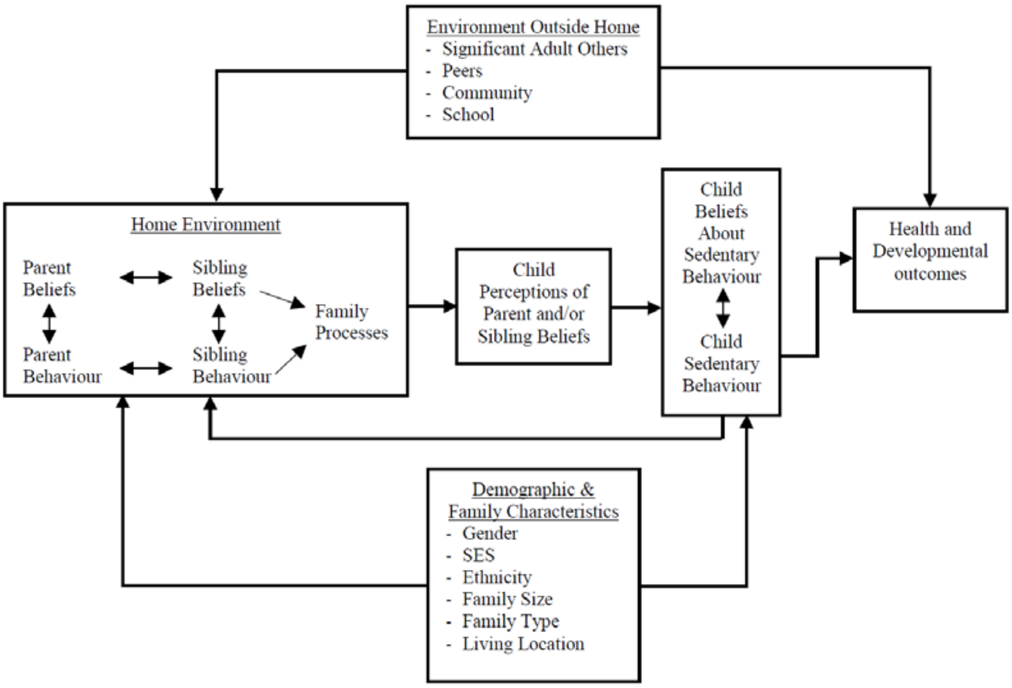

Figure 2.2 Family influence model for children's sedentary behaviour; adapted from Kimiecik, Horn and Shurin (1996)

To date, studies utilising the family influence model have tended to focus more on the psychological components of the model (i.e., children’s and parent’s beliefs) than the influence of the home and outside home environments (Dempsey, Kimiecik & Horn 1993; Kimiecik & Horn 1998; Kimiecik, Horn & Shurin 1996). In addition, the model has not previously been used to understand correlates of young children’s sedentary behaviour. Although some aspects of this model are clearly important, it may not be useful for very young children given the emphasis on cognitive aspects; it is important to also consider other broader influences.

2.7.2 Ecological models

Traditionally, ecological models suggest that influences on behaviours exist within the ecological environment, which includes the micro-, meso-, exo-, and macrosystems, each nested within the next respectively (Figure 2.3) (Bronfenbrenner 1979). The microsystem refers to the proximal influences on the individual (such as family and friends), the mesosystem involves the interrelations between two or more settings in which the individual is involved (such as preschool/childcare and home), the exosystem incorporates the indirect more distal settings that influence the individual (such as the community or neighbours), and the macrosystem refers to the broader cultural influences on the individual (such as societal beliefs and economic conditions) (Bronfenbrenner 1979).

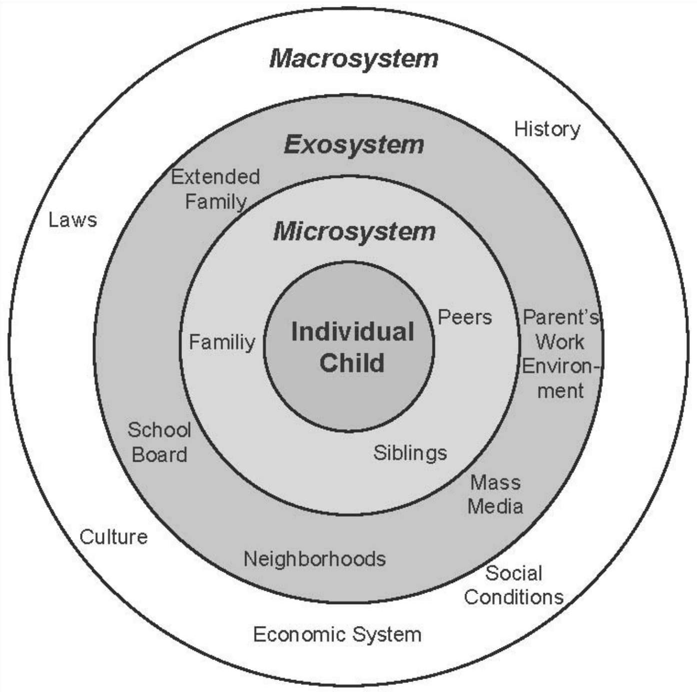

Figure 2.3 Bronfenbrenner's (1979) ecological model describing influences on a child (image taken from Niederer et al. (2009))

In health promotion and epidemiological research, ecological models have tended to focus on just three levels of influence: microsystem, exosystem and macrosystem (also known as individual, social and physical environment) (Davison & Birch 2001; Salmon & King 2005; Stokols 1992). The ecological model has been used consistently in recent years to group correlates according to their potential level of influence on physical activity and sedentary behaviour in adults (Rhodes, Mark & Temmel 2012; Trost et al. 2002), school-aged children (Sallis, Prochaska & Taylor 2000; Van Der Horst et al. 2007), preschool children (Hinkley et al. 2008; Hinkley et al. 2010) and toddlers (Duch et al. 2013). Ecological models have been criticised for being broad, failing to identify directional associations and interactions between variables, and failing to identify specific constructs of influence (Brug, Oenema & Ferreira 2005). However, they are useful for understanding a wide range of potential influences on behaviours and hence for examining multilevel correlates.

There are versions of this model that have been modified for use with children to have more of a focus on parenting, e.g., the ecological model of predictors of childhood overweight (Davison & Birch 2001) and the family ecological model (Campbell, Hesketh & Davison 2010). However, for the purposes of this thesis, a broader ecological model was used to explore potential correlates of sedentary behaviour (in Section 2.8 and in Chapter Five; Paper Two) to allow for comparison with previous studies.

2.7.3 Social cognitive theory

Social cognitive theory suggests that behaviours, cognitive and other personal factors, and environmental events interact with each other reciprocally to influence behaviour (Bandura 1986). That is, behaviours are not just influenced by personal factors and the environment, nor is the environment an outcome of behaviours and personal factors. Rather, those three factors display reciprocal determinism (Glanz, Rimer & Lewis 2002). Key components of social cognitive theory include self-efficacy (i.e., an individual’s confidence in performing a particular behaviour even when faced with challenges), outcome expectations, behaviour capability, observational learning and reinforcement (Sallis & Owen 1998). Bandura (1986) asserts that social cognitive theory can be used to explore the ways in which cognitive and environmental factors can influence human behaviour.

Social cognitive theory is the most commonly used theory in physical activity and sedentary behaviour interventions with young children (Nixon et al. 2012). Given this, social cognitive theory was used in the development of the pilot intervention described in Chapters Six and Seven. For the purposes of the intervention, social cognitive theory was used to target the behaviour of the parents, which would in turn change the behaviour of the children (i.e., the outcomes).

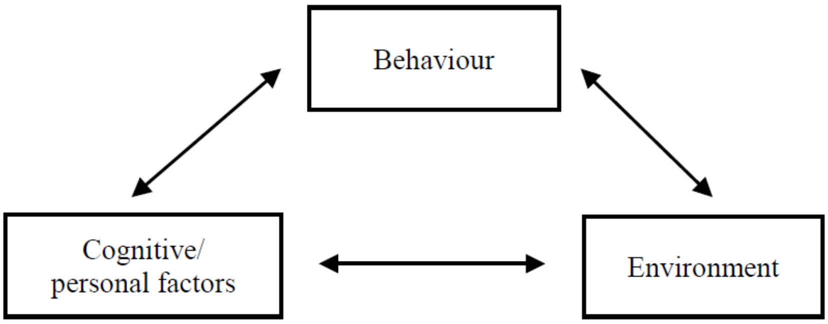

Figure 2.4 Social cognitive theory (Bandura 1986)

2.8 Correlates of sedentary behaviour in young children

The ecological model (described in Section 2.7.2) was used as a framework to group the potential levels of influence of the correlates with young children's sedentary behaviour within this section. The following sub-sections discuss potential correlates that have been associated with sedentary behaviour in preschool children. Following the ecological model structure used in the reviews mentioned in Section 2.7.2, correlates will be discussed across three levels:

- Individual level (demographic and biological variables; behavioural variables; psychological variables);
- Social level (family variables and broader social variables); and
- Physical environment level (home physical environment, neighbourhood environment and preschool/childcare environment).

Summaries of correlates are presented in tables in Appendix A. Although the data were not collected as part of a systematic review, they were collected systematically and results were coded following the approach established by

Sallis, Prochaska and Taylor (2000), and replicated in other reviews (Hinkley et al. 2008; Hinkley et al. 2010) whereby the consistency of an association is determined by the proportion of reported findings that support an association in a given direction. Associations are coded 0 (no association), + (positive association), or **–** (negative association). Overall associations were given when four or more studies supported an association in a particular direction; see Table 2.2. When fewer than four studies had investigated the hypothesised association, no overall association was coded.

Table 2.2 Rules for classifying variables regarding strength of evidence of assocation with sedentary behaviour (Sallis, Prochaska & Taylor 2000)

% of studies supporting association (in ≥4 studies)	Summary code	Meaning of code
0-33	00	No overall association
34-59	?	Indeterminate/inconsistent association
60-100 (positive direction)	++	Positive overall association
60-100 (negative direction)	--	Negative overall association

2.8.1 Individual level correlates

Demographic and biological variables

There are a number of child and family demographic and biological variables that have been investigated as potential correlates of sedentary behaviour in early childhood. Summaries of these correlates are presented in Appendix A (Table A1). The two most commonly studied of these variables are child sex and age.

Child sex consistently shows no association with television viewing (Berglind & Tynelius 2017; Burdette et al. 2003; Carson & Janssen 2012; Christakis et al. 2004; Dennison, Erb & Jenkins 2002; Jago et al. 2005; Kourlaba et al. 2009; Manios et al. 2009; Miller et al. 2008; Taylor et al. 2009; Tey et al. 2007; Truglio et al. 1996; Vandewater et al. 2007; Veldhuis et al. 2014) or with total screen time (Carson & Janssen 2012; Carson, Rosu & Janssen 2014; Christakis et al. 2004; Garriguet et al. 2016b; Hinkley et al. 2012b; Loprinzi, Schary & Cardinal 2013b; Tandon et al. 2011) in preschool children. This lack of association seems to be consistent over time and between countries. However, despite these largely consistent findings across studies, a small number of studies have reported sex differences. Four out of 21 studies have found that boys have higher screen time than girls (Adams & Prince 2010; Barr-Anderson et al. 2011; Berglind & Tynelius 2017; Lee et al. 2016). Such differences in findings may be due to the slightly higher ages of children in those studies (i.e., mean age of 4 years or more), compared to studies that report no association with sex including children younger than 1 year of age (e.g., (Carson, Rosu & Janssen 2014)). Evidence shows that school-aged (LeBlanc et al. 2015) and adolescent (Salmon et al. 2011) boys engage in higher levels of screen time compared with girls, suggesting that this sex difference may emerge at a later stage.

Conversely, although the studies frequently report that child sex is not associated with sedentary time in preschool children (Borkhoff et al. 2015; Cardon & De Bourdeaudhuij 2008; Hannon & Brown 2008; Hesketh et al. 2014b; Johansson et al. 2015; Møller et al. 2017; Pate et al. 2008; Pate et al. 2004; Schmutz et al. 2017; Temple et al. 2009; Vanderloo & Tucker 2015), some studies have reported that girls engage in higher levels of objectively measured sedentary time than boys (Berglind & Tynelius 2017; Fisher et al. 2005; Jago et al. 2005; Montgomery et al. 2004; Taylor et al. 2009; Wijtzes et al. 2013b). Given that research has consistently found that preschool boys are more active than girls, it is logical to posit that girls would be more sedentary (with the operationalisation of young children's physical activity as light-, moderate- and vigorous-intensity physical activity [LMVPA], i.e., anything other than sedentary time). The differences in findings may be due to differences in the tools used to assess sedentary time, including different accelerometers, heart rate monitoring and direct observation.

Child age has consistently been shown to be positively associated with television viewing in preschool children (Anand & Krosnick 2005; Campbell et al. 2010; Carson & Janssen 2012; Christakis et al. 2004; Dennison, Erb & Jenkins 2002; Jago et al. 2005; Manios et al. 2009; Natsiopoulou & Melissa-Halikiopoulou 2009). However, that association is indeterminate for total screen time, with some studies reporting a positive association (Asplund et al. 2015; Carson & Janssen

2012c; Carson, Rosu & Janssen 2014; Christakis et al. 2004) and others reporting no association (Carson & Janssen 2012a; Hinkley et al. 2013b; Veldhuis et al. 2014). On the contrary, studies consistently show that child age is not associated with sedentary time in this age group (Byun, Dowda & Pate 2011; Cliff et al. 2009; Dolinsky et al. 2011; Hannon & Brown 2008; Ostbye et al. 2013; Schmutz et al. 2017).

In addition to age and sex, other child demographic and biological variables such as ethnicity (race) and BMI have been investigated as potential correlates of young children's sedentary behaviour. Child ethnicity is consistently associated with television viewing in preschoolers (Kuepper-Nybelen et al. 2005; Njoroge et al. 2013; Sallis et al. 1993; Veldhuis et al. 2014; Wijtzes et al. 2013a), such that non-Caucasian (or non-native) children engage in significantly higher levels of television viewing. In contrast, ethnicity has been shown to have no association with total sedentary time in preschool children (Jago et al. 2005; Ostbye et al. 2013; Pate et al. 2008; Pate et al. 2004). BMI has also been shown to have no association with sedentary time (Byun, Liu & Pate 2013; Cliff et al. 2009; Dolinsky et al. 2011; Hesketh et al. 2014b; Johansson et al. 2015; Ostbye et al. 2013; Senso et al. 2015 ; Wijtzes et al. 2013b) or total screen time (Adams & Prince 2010; Asplund et al. 2015; Garriguet et al. 2016; Hinkley et al. 2013; Sijtsma et al. 2015). The association between BMI and television viewing, while more extensively investigated, is indeterminate. Some studies report no association (Burdette & Whitaker 2005; Cox et al. 2012; Kourlaba et al. 2009; Okely et al. 2009; Raynor et al. 2009; Taverno Ross et al. 2013) while others report that increased television viewing is associated with an increased BMI

(Brown et al. 2010; Fuller-Tyszkiewicz et al. 2012; Manios et al. 2009; Miller et al. 2008; Tey et al. 2007). Of note, cross-sectional examination of Australian children participating in a large cohort study showed no association between BMI and television viewing at age 2 years and a positive association at ages 4 and 6 years (Fuller-Tyszkiewicz et al. 2012). Likewise, when stratifying by age, Manios et al. (2009) found a significant positive association between BMI and television viewing for children aged 3 to 5 years, but not those aged under 3 years. Results from these two studies suggest that the association between BMI and television viewing may become stronger over time. However, given that these studies are cross-sectional in design, causality cannot be determined. Overall, evidence for an association between BMI and sedentary behaviour is largely inconclusive.

Similarly, parent BMI has been shown to have a positive association with preschool children's television viewing in four studies (Brown et al. 2010; Miller et al. 2008; Proctor et al. 2003; Wijtzes et al. 2012) and no association in one study (Manios et al. 2009) (overall positive association), but consistently no association with children's sedentary time (Byun, Dowda & Pate 2011; Dolinsky et al. 2011; Schmutz et al. 2017; Wijtzes et al. 2013b). In addition to parent BMI, a number of other family biological and demographic variables, primarily parental characteristics, have also been investigated as possible correlates of young children's sedentary behaviour. However, they have been investigated too infrequently to determine overall associations for sedentary time and screen time, and no conclusive associations have been determined for their association with television viewing. Firstly, some studies report no association between parental age and television viewing (Veldhuis et al. 2014; Yalcin et al. 2002 (maternal age)) and others report a negative association (Miller et al. 2008; Yalcin et al. 2002 (paternal age)). Findings for the association between television viewing and maternal employment are similarly inconclusive. Some studies report that children with mothers who are in paid employment watch less television (Brown et al. 2010; Burgi et al. 2010; van Rossem et al. 2012), some report no association (Manios et al. 2009; Vandewater et al. 2007; Wijtzes et al. 2012), and one study has reported that children watch more television if their mother is employed (Hawkins et al. 2009). Finally, findings for the association between children's television viewing and parent's marital status are mixed. Three studies each have reported no association (van Rossem et al. 2012; Vandewater et al. 2007; Wijtzes et al. 2012) and a positive association (Miller et al. 2008; Vandewater et al. 2007; Veldhuis et al. 2014), such that children whose parents are not married have higher levels of television viewing.

One final family demographic variable that is of interest is socioeconomic position (SEP). There are a number of ways to measure SEP, including individual-level indicators such as maternal education and income, or area-level indicators such as area of residence. Maternal or parent education is one of the most commonly used proxies for SEP in young children (Timperio et al. 2004; Tremblay & Willms 2003). In preschool children, parental education is consistently inversely associated with both television viewing (Burgi et al. 2010; Manios et al. 2009; Miller et al. 2008; Proctor et al. 2003; Truglio et al. 1996; van Rossem et al. 2012; Veldhuis et al. 2014; Yalcin et al. 2002) and screen time (Carson & Janssen 2012; Carson, Rosu & Janssen 2014; Downing, Hinkley & Hesketh 2014; Garriguet et al. 2016; Tandon et al. 2011). However, studies consistently report no association between parental education and sedentary time (Burgi et al. 2010; Dolinsky et al. 2011; Downing, Hinkley & Hesketh 2014; Hesketh et al. 2014b; Pate et al. 2004; Vanderloo & Tucker 2015; Wijtzes et al. 2013b).

Overall, with the exception of child sex which consistently showed no association with sedentary time, television viewing and screen time, evidence suggests that demographic and biological correlates may vary between these different sedentary behaviours in preschool children. The lack of correlates identified for sedentary time may potentially be due to measurement issues and differing cut points used for accelerometers. Another explanation is that many correlates are context and behavioural specific. Objectively assessed sedentary time is a measure of all sedentary behaviours together; however, sedentary behaviours are not all equal. For example, the correlates of screen time would likely be different to the correlates of sitting in a car. Finally, children's screen time is most often measured by parent report, as are potential correlates. There may therefore be consistent reporting biases (e.g., parents may perceive that girls are more sedentary than boys). Other demographic and biological variables, such as waist circumference, child first-born status, breastfeeding duration, language spoken at home, family size, parent ethnicity, and parent migrant status have been investigated too infrequently as correlates of sedentary behaviour to draw overall conclusions. In addition to these variables, there may be behavioural factors associated with sedentary behaviour.

Behavioural variables

The behaviours of young children, both self- and parent-directed, and their associations with sedentary behaviour have been studied relatively infrequently (see Appendix A; Table A2). The most commonly investigated behavioural correlate is physical activity. However, evidence for its association with television viewing is inconclusive, with three studies finding a negative association (Brown et al. 2010; Jago et al. 2005; Kourlaba et al. 2009), one finding a positive association (Yamamoto et al. 2011), and two finding no association (Cox et al. 2012; Proctor et al. 2003). It is not clear why these differences in findings were observed. Potentially the differences may be due to large variations in sample size (ranging from n=106 (Proctor et al. 2003) to n=2560 (Brown et al. 2010)) and varying sample characteristics (e.g., locations included Greece (Kourlaba et al. 2009), Germany (Yamamoto et al. 2011) and Australia (Cox et al. 2012)). Evidence for the association between physical activity and sedentary time is equally indeterminate in preschoolers. Cox et al. (2012) found that parent-report of child total sedentary behaviour is positively associated with LPA and MVPA in Australian preschool children, such that children who participate in higher levels of physical activity also have higher levels of sedentary time. Conversely, a study in the USA found no association between accelerometer assessed sedentary time and LPA or total physical activity (LMVPA), and a negative association between sedentary time and MVPA (Taverno Ross et al. 2013). This suggests that preschool children who engage in more vigorous activity may have lower levels of sedentary behaviour, perhaps as a result of physical activity displacing time that would otherwise be spent sedentary. Alternatively, it may be that children who engage in more vigorous-intensity activities generally have more energy and find it difficult to sit still. Outdoor play time has been shown to have no association with television viewing in three studies (Burdette & Whitaker 2005; Kuepper-Nybelen et al. 2005; Vandewater et al. 2007) and a negative association with television viewing in one study (Tey et al. 2007). Only two studies have investigated the association between outdoor play time and sedentary time; both found a negative association (Brown et al. 2009; Schmutz et al. 2017).

A number of studies have investigated the association of healthy and unhealthy eating habits with sedentary behaviour in preschool children. Evidence suggests that energy intake is positively associated with television viewing, such that children with higher daily energy intake also watch more television (Cox et al. 2012; Manios et al. 2009; Miller et al. 2008; Proctor et al. 2003). Furthermore, studies have also found that children who exhibit unhealthy eating patterns (e.g., the consumption of energy dense/junk foods) watch more television (Brown et al. 2010; Cox et al. 2012; Miguel-Berges et al. 2017d; Miller et al. 2008), while those who exhibit healthy eating patterns (e.g., consumption of skim milk/high levels of fruit and vegetable intake) watch less television (Cox et al. 2012; Manios et al. 2009; Miguel-Berges et al. 2017d; Miller et al. 2008). Ford, Ward and White (2012) conducted a systematic review examining the association between television viewing and diet in children aged 2 to 6 years. Results showed that as little as one hour of television viewing per day was associated with adverse dietary outcomes in the majority of included studies. However, given that most of the studies to date are cross-sectional, there may be reverse causality such that watching more television may promote poorer dietary behaviour.

Sleep duration has been investigated as a potential correlate of young children's sedentary behaviour. Findings are equivocal: two studies have reported a significant inverse association between sleep duration and television viewing (Marinelli et al. 2014; Miller et al. 2008), but two studies have reported no association (Brockmann et al. 2016; Yalcin et al. 2002). The studies reporting no association had relatively small sizes (n<200) compared to those that reported a significant association (n>1200), suggesting that they may have been underpowered. Studies have reported no association of sleep duration with total screen time (Sijtsma et al. 2015) or likelihood of meeting screen time recommendations (Hinkley et al. 2013). However, one study in a large cohort of Australian children (n=3427) reported that screen time at 4 years of age was significantly inversely associated with sleep duration at 6 years of age, and screen time use at 6 years of age was significantly inversely associated with sleep duration at 8 years of age (Magee, Lee & Vella 2014). Finally, one study reported no association at ages 3.5 and 5 years, and an inverse association between screen time and sleep duration at age 2 years (Xu et al. 2016b). It is not clear why such differences in findings are observed. However, given that longitudinal analyses suggest that screen time is associated with less sleep, this association warrants further investigation.

Other potential behavioural correlates (e.g., participation in organised activities, play frequency, playgroup attendance) have been investigated in only one or two studies, and hence overall associations cannot be determined. With the exception of physical activity, dietary habits and sleep, very little research exists on behavioural correlates of sedentary behaviour in preschool children.

Psychological variables

For children, psychological correlates include constructs such as preferences for particular behaviours (e.g., preference for watching television over physical activity), requests (e.g., child requests to be active) and constraints (e.g., child does not have enough energy to be active). Despite the lack of a clear association between sedentary behaviour and physical activity above, constructs relating to physical activity are included in this section given they are a continuum, e.g., having a preference for screen time over physical activity. Only 13 psychological variables have been investigated as potential correlates of preschool children's sedentary behaviour, with each only being investigated in one study (see Appendix A; Table A3). As such, overall conclusions cannot be drawn. Briefly, one study investigated the association of infant temperament, self-regulation, psychological difficulties, emotionality temperament, activity temperament, shyness temperament, and cognitive performance with sedentary time (Schmutz et al. 2017). No associations were found, with the exception of activity temperament (preferred levels of activity and speed of action) which was inversely associated with sedentary time (Schmutz et al. 2017). Hinkley et al. (2013) found no associations for the child being active by him/herself, child requests for physical activity, child constraints to physical activity (e.g., not enough energy, not enough time), and child preferences for physical activity with meeting screen time recommendations. However, Vaughn, Hales and Ward (2013) reported an inverse association between child preferences for physical activity and both sedentary time and television viewing. Finally, Truglio et al. (1996) found a positive association between the child's interest in television viewing and the amount of television they watched, but no association between the child's enjoyment of print (e.g., books, magazines) and television viewing. Given that these variables have been investigated so infrequently, further research is required to determine psychological correlates of sedentary behaviour in this population. The following section investigates social level correlates of sedentary behaviour.

2.8.2 Social level correlates

In the ecological model, the social level includes both family and broader social variables. For young children, these generally consist of parental behaviours and beliefs, as children of this age are mostly dependent on their parents or other adults to provide opportunities for, and to limit, sedentary behaviour. A summary of social level correlates for preschoolers is presented in Appendix A (Table A4). Although a large number of potential correlates have been investigated (63 in total), only three have been investigated frequently enough to draw overall conclusions. One of the most commonly investigated correlate of young children's sedentary behaviour is parental modelling. Eight studies have investigated the association between parent self-reported and child proxy-reported television viewing in preschoolers (Barr-Anderson et al. 2011; Bleakley, Jordan & Hennessy 2013; Jago et al. 2013; Jago et al. 2012; Kourlaba et al. 2009; Manios et al. 2009; Wijtzes et al. 2012; Yalcin et al. 2002); all reported a positive association. This suggests that parental television viewing is an important (and potentially modifiable) correlate of children's television viewing. Likewise, there is a positive association between parental sedentary behaviour and children's screen time (Asplund et al. 2015; Carson & Janssen 2012; Carson, Stearns & Janssen 2015; Hinkley et al. 2013). Maternal television viewing has been negatively associated with children meeting screen time recommendations in one study, such that children are less likely to meet the recommendations if their mothers engage in high levels of television viewing (Hinkley et al. 2013). However, that association was not found for father's television viewing (Hinkley et al. 2013). Three studies have investigated the association between objectively measured parent and child sedentary time, and found that preschool children whose parents engaged in extensive amounts of sedentary time also had high amounts of sedentary time (Barkin et al. 2017; Hesketh et al. 2014b; Ruiz et al. 2011). One study has reported no association between parent and child sedentary time measured by *activ*PAL™ accelerometers (Hughes et al. 2016); however, that study included a very small sample of preschool children and their parents (n=16) and hence may not have been powered to detect associations.

Parental influences can also help to reduce time their children spend in sedentary behaviour, for example, by limiting time in specific behaviours such as television viewing. Parental rules regarding screen time have been investigated on a number of occasions as a potential correlate of sedentary behaviour in this age group. In preschool children, screen time rules are consistently, significantly inversely associated with television viewing (Downing, Hinkley & Hesketh 2014; Kuepper-Nybelen et al. 2005; Spurrier et al. 2008; Truglio et al. 1996; Vaughn, Hales & Ward 2013). Findings for the association between parental rules and total screen time are mixed; two studies have reported a negative association (Barr-Anderson et al. 2011; Downing, Hinkley & Hesketh 2014), one has reported a positive association (Gubbels et al. 2011), and two have reported no association (Asplund et al. 2015; Hinkley et al. 2013).

Finally, the presence of siblings or number of children in the house has been investigated as a potential correlate of television viewing in four studies, with none finding an association (Byun, Dowda & Pate 2011; Kourlaba et al. 2009; Manios et al. 2009; Yalcin et al. 2002). Similarly, two studies have reported no association between the presence of siblings and sedentary time (Byun, Dowda & Pate 2011; Schmutz et al. 2017); however, one study found that children with two or more siblings engaged in less sedentary time than those without siblings (there was no association for children with one sibling) (Wijtzes et al. 2013b). One study found no association between having any younger siblings and sedentary time, but that children with any older siblings spent less time sedentary (Hnatiuk, Hesketh & van Sluijs 2016). This suggests that potentially the influence of older sibling's behaviours are more pertinent for young children.

Studies have investigated a range of other parental influences on young children's sedentary behaviour, including barriers to, perceptions of, and concerns about screen time, modelling of physical activity, maternal self-efficacy, and maternal smoking. These variables have been investigated very infrequently (generally only one study each) and as such conclusions about their associations with sedentary behaviour cannot be determined. Other social level correlates include preschool teacher education and physical activity training; however, these have also been investigated too infrequently to determine overall associations. There may be additional preschool/childcare variables and other physical environment variables that are associated with sedentary behaviour in this age group; evidence regarding these physical environment level correlates is reviewed in the following section.

2.8.3 Environmental level correlates

For young children, potential environmental correlates consist of factors in the home, preschool/childcare, and the wider neighbourhood. Environmental level correlates of sedentary behaviour are summarised in Appendix A (Table A5). In the home environment, variables such as the presence of a television in the bedroom, the number of electronic media devices in the home, yard space, and yard characteristics, have been investigated as potential correlates of sedentary behaviour. However, these variables have each been investigated in only a small number of studies. Results are disparate for the number of televisions in the home; one study found that the presence of three or more televisions in the home had no association with screen time (Barr-Anderson et al. 2011); however, another study found that having four or more televisions in the home was associated with increased weekend screen time for boys, but not girls (Jago et al. 2012). Additionally, Asplund et al. (2015) found that having two or more televisions in the home was associated with significantly more screen time in a sample of low-income Latino children. In multivariable analyses, Hinkley et al. (2013) found that the number of functioning televisions in the home was inversely associated with girls, but not boys, meeting Australian screen time recommendations. Such differences in results may be attributable to the social or cultural differences in the countries in which the studies were conducted; one study included American Indian children in the USA (Barr-Anderson et al. 2011), one included Latino children in the USA (Asplund et al. 2015), one was undertaken in Portugal (Jago et al. 2012), and one was undertaken in Australia (Hinkley et al. 2013). The presence of a television in the bedroom has been shown to have no association with screen time in preschool children in three studies

(Asplund et al. 2015; Barr-Anderson et al. 2011; Jago et al. 2012), and a positive association with screen time in two studies (Carson & Janssen 2012; Wijtzes et al. 2012) (overall indeterminate association). Somewhat counterintuitively, there has also been no association found between having a television in the bedroom and preschool children's television viewing in three studies (Burdette & Whitaker 2005; Dennison et al. 2004; Vandewater et al. 2007); however, one study reported that children with a television in their bedroom spent more time watching television than children without a television in their bedroom (Dennison, Erb & Jenkins 2002). In school-aged children, having a television in the bedroom is consistently associated with increased television viewing (Temmel & Rhodes 2013). Potentially parents of preschool children monitor the use of televisions in the bedroom closely, whereas there may be a lack of parental monitoring in older children that results in higher television viewing.

Broader neighbourhood environmental correlates, such as region of residence and neighbourhood safety, may also influence young children's sedentary behaviour (e.g., if the neighbourhood is unsafe children may spend more time indoors and hence have more opportunities to be sedentary). As with home environmental variables, these have been investigated in very few studies. Two cross-sectional studies have investigated the association between perceived neighbourhood safety and television viewing in preschool children and found an inverse association (Burdette & Whitaker 2005; Datar, Nicosia & Shier 2013). Although causality cannot be determined, this suggests that children may be more likely to stay inside and engage in sedentary behaviours such as television viewing if their parents perceive the neighbourhood to be unsafe. Similarly, one study of Swiss preschoolers has reported a positive association between neighbourhood safety concerns and sedentary time, such that children whose parents have more concerns about the safety of their neighbourhood spend more time sedentary (Schmutz et al. 2017). In addition to physical environmental influences, other environmental factors such as day of the week (i.e., weekdays compared to weekend days) have been investigated as potential correlates of children’s sedentary behaviours; however, findings are equivocal. Two studies have reported a positive association between day of the week and sedentary time (such that children are more sedentary on weekdays compared to weekend days) (Cardon & De Bourdeaudhuij 2008; Vanderloo & Tucker 2015), one study has reported an inverse association (Berglind & Tynelius 2017), and two studies have reported no association (Hesketh et al. 2014b; Taylor et al. 2009). Likewise, three studies have shown that there is no association between day of the week and television viewing (Burdette & Whitaker 2005; Manios et al. 2009; Raynor et al. 2009), but one has reported a negative association (Natsiopoulou & Melissa-Halikiopoulou 2009).

Finally, studies have investigated the association between preschool or childcare centre-based variables, such as preschool quality, availability of playground equipment, time outdoors while in care, and screen time at preschool/childcare, and young children’s sedentary behaviour. In preschool children, these variables have been investigated in too few studies to determine overall associations with any sedentary behaviour. However, in infants/toddlers non-parental child care has been investigated as a correlate of television viewing in five studies. Four of those studies reported no association (Lumeng et al. 2006; Tomopoulos et al. 2007;

Zimmerman & Christakis 2005; Zimmerman, Christakis & Meltzoff 2007) and one reported that children in centre-based child care were significantly less likely to exceed screen time recommendations (based on television viewing alone) than children in home-based care or not in any care (Certain & Kahn 2002).

2.8.4 Summary of correlates of sedentary behaviour

Despite the large number of studies identified that investigate potential correlates of sedentary behaviour in young children, the majority have been investigated in only a small number of cross-sectional studies. Therefore, it is difficult to determine overall associations of multiple correlates with sedentary behaviour. Furthermore, the majority of variables have been investigated only as correlates of television viewing time, with few studies reporting on other types of or overall sedentary behaviour. Correlates that were identified as being positively associated with television viewing were child age, child race (non-Caucasian), parent BMI, energy intake, unhealthy eating patterns, and parent screen time (also positively associated with total screen time). Correlates that were negatively associated with television viewing were parental education, healthy eating patterns, and screen time rules. The magnitude of associations varied greatly for all correlates; therefore, it is difficult to draw conclusions about the size of effects. No consistent correlates of sedentary time were identified: of those that were investigated frequently enough to draw overall conclusions, none were associated with sedentary time. Only six Australian studies were identified that reported correlates of sedentary behaviour in preschool children; hence further investigation into the correlates of young Australian children’s sedentary behaviour is warranted. Finally, most studies have neglected to consider variables across all levels of the ecological model. It is important to consider multilevel correlates simultaneously to determine the relative contribution of correlates across all domains, particularly when developing intervention strategies to reduce time in sedentary behaviour.

The following chapter contains a published systematic review that synthesises evidence of the effectiveness of approaches to reduce sedentary behaviour in young children. This is then followed by the overarching aims of this thesis and the candidate’s contribution to data collected for specific studies.

CHAPTER THREE

Paper One: Interventions to reduce sedentary behaviour in 0-5-year-olds: a systematic review and meta-analysis of randomised controlled trials

3.1 Introduction

Chapter Two described the evidence of both the short- and long-term associations between sedentary behaviour and health, psychological and cognitive development in early childhood and the high prevalence of sedentary behaviour exhibited in this age group. There is a clear need to synthesise current evidence of the effectiveness of interventions to decrease sedentary behaviour in young children. Numerous interventions have been developed and implemented within this age group; however, their efficacy in changing behaviours varies considerably. Therefore, a systematic review and meta-analysis of interventions that aim to decrease sedentary behaviour in children aged birth to 5 years was undertaken by the candidate. This chapter has been published in the British Journal of Sports Medicine (Impact factor: 6.557) as:

Downing KL, Hnatiuk JA, Hinkley T, Salmon J, Hesketh KD. Interventions to reduce sedentary behaviour in 0–5-year-olds: a systematic review and meta-analysis of randomised controlled trials. Br J Sports Med. Published Online First: 06 October 2016. doi: 10.1136/bjsports-2016-096634.

The Authorship Statement for this manuscript is contained in Appendix B.

BJSM Online First, published on October 6, 2016 as 10.1136/bjsports-2016-096634

OPEN ACCESS

Interventions to reduce sedentary behaviour in 0–5-year-olds: a systematic review and meta-analysis of randomised controlled trials

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ABSTRACT

Aim or objective To evaluate the effectiveness of behavioural interventions that report sedentary behaviour outcomes during early childhood.
Design Systematic review and meta-analysis.
Data sources Academic Search Complete, CINAHL Complete, Global Health, MEDLINE Complete, PsycINFO, SPORTDiscus with Full Text and EMBASE electronic databases were searched in March 2016.
Eligibility criteria for selecting studies Inclusion criteria were: (1) published in a peer-reviewed English language journal; (2) sedentary behaviour outcomes reported; (3) randomised controlled trial (RCT) study design; and (4) participants were children with a mean age of ≤5.9 years and not yet attending primary/elementary school at postintervention.
Results 31 studies were included in the systematic review and 17 studies in the meta-analysis. The overall mean difference in screen time outcomes between groups was −17.12 (95% CI −28.82 to −5.42) min/day with a significant overall intervention effect (Z=2.87, p=0.004). The overall mean difference in sedentary time between groups was −18.91 (95% CI −33.31 to −4.51) min/day with a significant overall intervention effect (Z=2.57, p=0.01). Subgroup analyses suggest that for screen time, interventions of ≥6 months duration and those conducted in a community-based setting are most effective. For sedentary time, interventions targeting physical activity (and reporting changes in sedentary time) are more effective than those directly targeting sedentary time.
Summary/conclusions Despite heterogeneity in study methods and results, overall interventions to reduce sedentary behaviour in early childhood show significant reductions, suggesting that this may be an opportune time to intervene.
Trial registration number CRD42015017090.

INTRODUCTION

Sedentary behaviour is defined as any waking activity requiring ≤1.5 metabolic equivalent of tasks and performed in a sitting or reclining posture[1] (eg, television viewing, sitting in a stroller). During early childhood (ie, birth through 5 years[2]), television viewing has been longitudinally and experimentally associated with excess adiposity, poor psychosocial health and poor cognitive development.[3] Additionally, total screen time (comprising television viewing, electronic games and computer use) has been associated with poor psychosocial health[4] and delayed cognitive development[5] in early childhood. While health outcomes of objectively measured sedentary time in early childhood are yet to be established, evidence suggests that sedentary time is associated with an increased risk of overweight/obesity in school-aged children and youth.[6] This is relevant because sedentary behaviours track from early childhood into the school-aged years.[7]

Recommendations for limiting sedentary behaviour in early childhood have been introduced in numerous countries (eg, Australia, Canada and USA). These suggest that children under 2 years of age engage in no screen time and children aged 2–5 years engage in no more than 1 hour of screen time per day.[8–10] Recommendations from Australia and Canada also suggest that children aged 5 years and younger not be restrained (eg, kept inactive in a high chair) for more than 1 hour at a time, except when sleeping.[8 9] Evidence suggests that young children in Australia[11] and Canada[12] engage in around 2 hours of screen time daily, while children in the USA[13] engage in it around 4 hours daily. Moreover, up to 83% of children aged 2 years and younger in the USA[14] and up to 82% and 78% of children aged 3–5 years in Canada[15] and Australia,[11] respectively, exceed recommendations for their respective age group. With only one study until now reporting on the percentage of young children kept restrained,[16] prevalence of these behaviours remains unclear. Estimates of overall sedentary behaviour for children under 6 years of age using objective measures (eg, accelerometers, observation) range from 23% to 94% of their daily waking time.[17] Evidence suggests that many young children engage in less than optimal amounts of sedentary behaviours, highlighting a need for interventions to reduce the prevalence of these behaviours.

While systematic reviews of interventions to increase physical activity or prevent obesity during early childhood have also assessed sedentary behaviour,[18–23] none have focused solely on sedentary behaviour outcomes. Sedentary behaviours are a distinct group of behaviours; high levels of sedentary behaviour can be accumulated even when children meet physical activity recommendations (ie, 3 hours or more per day[8 24 25]). Given this, it may be that behaviour-specific interventions are needed; that is, effective strategies to reduce screen time or time spent restrained may be different from those that are effective at promoting active play. Reviews of interventions specifically targeting sedentary behaviour in young children are required to determine this.

Systematic reviews of interventions to reduce sedentary behaviour across children and adolescents more broadly have been published.[26–32] Three of these included a meta-analysis,[27–29] which is

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important for determining the overall effectiveness of interventions. Biddle *et al*[27] and Maniccia *et al*[28] both concluded that interventions to reduce sedentary behaviour have a small but significant effect. Conversely, Wahi *et al*[29] concluded no evidence of effectiveness, but that interventions in the preschool age hold promise. However, no systematic reviews have focused exclusively on the early childhood period. Birth through 5 years of age is a critical developmental period. Children reach a number of important developmental milestones during this time[33] and there are stronger parental and family influences given that young children are much less independent than school-aged children and youth. Therefore, strategies shown to be effective in older children may not translate to this younger population. The aim of this systematic review and meta-analysis is to evaluate the effectiveness of behavioural interventions that reported sedentary behaviour outcomes during early childhood.

METHODS

This review is registered with the PROSPERO International Prospective Register of Systematic Reviews (number CRD42015017090). The PRISMA Statement[34] guidelines were followed in reporting.

Search strategy

A systematic search was conducted in March 2016. EBSCOhost (Academic Search Complete, CINAHL Complete, Global Health, MEDLINE Complete, PsycINFO, SPORTDiscus with Full Text) and EMBASE databases were searched. Full details of the EBSCOhost search strategy are shown in table 1 (search terms were modified as appropriate for EMBASE). Reference lists of included articles were also reviewed to identify any additional studies.

One author (KLD) reviewed titles identified in the initial search. Two authors (KLD and JAH) then independently reviewed the included abstracts; abstracts were excluded when both authors deemed that the study did not meet inclusion criteria for the review. The same two authors then reviewed the full text of the remaining articles to determine final inclusion. Inconsistencies were resolved with discussion between those two authors or, if consensus could not be reached, with all other authors.

Inclusion criteria

The following inclusion criteria were applied: (1) published in a peer-reviewed English language journal; (2) study reported sedentary behaviour outcomes; (3) randomised controlled trial (RCT) study design was employed; and (4) participants were children with a mean age of 5.9 years or younger and not yet attending primary/elementary school at postintervention. No restrictions were placed on the publication period or intervention setting. Where more than one study reported results from the same sample, the study that reported sedentary behaviour as a main outcome was included.

Table 1 Search strategy: EBSCOhost

Search	Search terms
1	"sedentary behavio*" OR sedentar* OR sitting OR "physical inactivity" OR "screen time" OR screen-time OR "small screen" OR "screen based" OR screen-based OR "electronic media" OR television OR TV OR "electronic game*" OR e-game* OR "e game*" OR computer OR video OR DVD OR "video games" OR restraint OR restrained OR stroller OR "high chair" OR "play pen" OR playpen OR "baby carrier" OR "car seat"
2	infan* OR baby OR babies OR toddler* OR "young child*" OR child* OR "early childhood" OR "early years" OR preschool* OR pre-school*
3	intervention* OR trial OR "randomi*ed controlled trial" OR RCT OR "primary prevention"
4	1 AND 2 AND 3

Data extraction

Data were extracted using a standardised form by one author (KLD) and included: study characteristics (eg, country, year); participant characteristics (eg, sample size, age, sex); intervention components (eg, setting, duration, content); sedentary behaviour measure (eg, objective measure, parent report); and changes in the outcome (eg, change in sedentary behaviour).

Methodological quality and risk of bias assessment

Study quality and risk of bias were assessed independently by two authors (KLD and JAH) using a modified published rating scale.[35] Six methodological components were assessed: (1) selection bias (eg, sample representativeness); (2) study design (eg, RCT); (3) confounders (eg, controlling for baseline differences between groups); (4) blinding (eg, whether the outcome assessor was aware of group allocation); (5) validity and reliability of data collection methods (eg, whether the tool(s) to measure sedentary behaviour were reported to be valid and reliable, with appropriate supporting information such as criteria or references); and (6) withdrawals and dropouts (eg, whether withdrawals were reported in terms of numbers and/or reasons). Each component was given a quality score of weak, moderate or strong, in line with the accompanying instructions for the tool. Components that were not reported were given a weak rating. As recommended in the Cochrane Handbook for Systematic Reviews of Interventions,[36] no overall quality/risk of bias score was produced. Initial inter-rater reliability between the two authors (determined using Cohen's κ coefficient) was 80% (κ=0.71). Discrepancies in assessment between authors were discussed until consensus was reached.

Statistical analysis

Meta-analyses were conducted using Review Manager V.5.3 (Revman; The Cochrane Collaboration, Oxford, UK). The mean (SD) between-groups difference in screen time and/or sedentary time from baseline to postintervention was extracted from studies and entered into Revman. Where reported, the adjusted mean difference was used. If not reported, the mean difference was calculated in Stata V.13.0 (StataCorp, Texas, USA). A random-effects model was used for the meta-analysis.[37] Heterogeneity was assessed through observation of the χ^2 (Q) and I^2 statistics. A Q value with a significance of $p \leq 0.05$ was considered significant heterogeneity, while for the I^2 value 25% was considered low, 50% was considered moderate and 75% was considered high heterogeneity.[38] A priori, it was decided that if high heterogeneity was present, subgroup analyses would be conducted for child age, intervention duration, intervention setting and targeted behaviour/s (whether the intervention aimed to increase physical activity and simply reported sedentary time results, or directly targeted decreasing sedentary time). Post hoc, it was decided to include the type of sedentary cut point used (ie, a 'low' vs a 'high' cut point) as a potential moderator in the sedentary time meta-analysis.

RESULTS

Study characteristics

The number of studies identified and excluded at each stage is shown in figure 1 (PRISMA Statement[34] flow diagram).

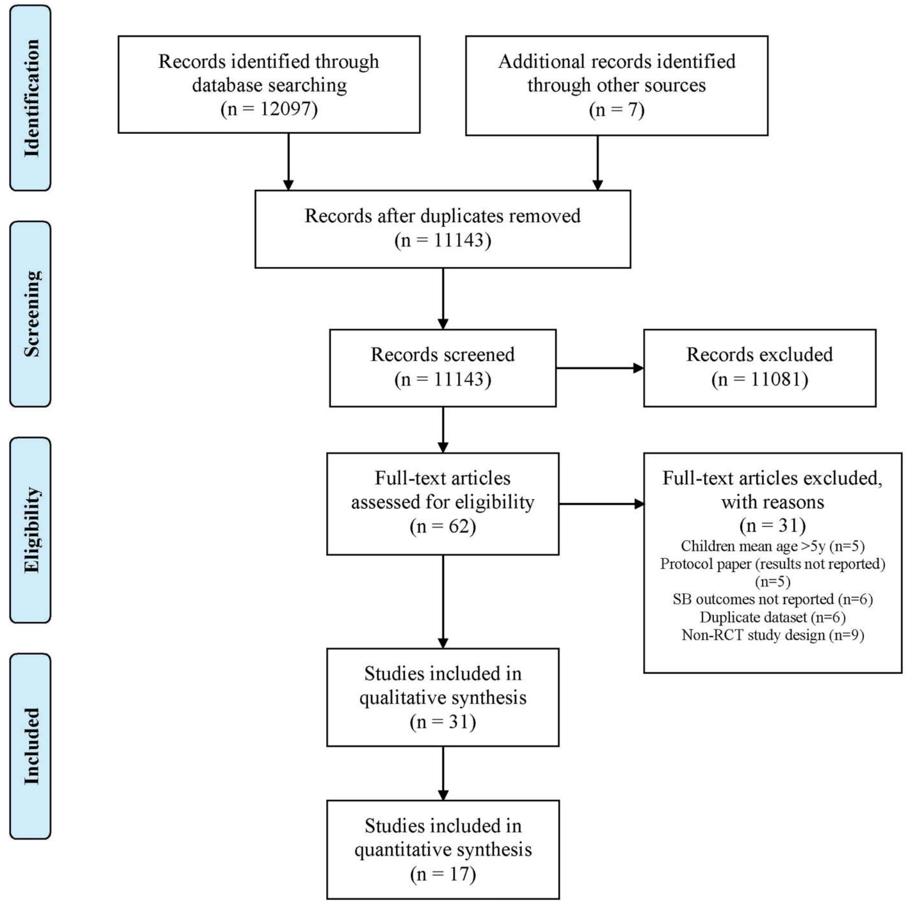

Figure 1 PRISMA statement flow chart. RCT, randomised controlled trial; SB, sedentary behaviour.

Thirty-one studies met the inclusion criteria; a summary of included studies is presented in online supplementary table S1. The majority of included studies (n=29) used a cluster-based sampling design. Of the included studies, 18 reported changes in screen time, 8 reported changes in sedentary time (measured by accelerometry or direct observation), 4 reported changes in screen time and sedentary time, and 1 reported changes in screen time and parent-reported sedentary behaviour. No studies were identified that aimed to specifically reduce (or reported changes in) time spent restrained. Approximately half of the studies (n=15) were conducted in the USA,[39–53] five in Australia,[54–58] three in Belgium,[59–61] two in the UK[62 63] and one each in Canada,[64] Germany,[65] Switzerland,[66] the Netherlands,[67] Israel[68] and Turkey.[69] Five studies included participants with a mean age under 3 years,[54 55 60 63 70] whereas the remainder targeted preschool-aged children (3–5 years). Intervention duration ranged from a once-off session to 24 months. The majority of interventions (n=23; 74.2%) were 10 weeks or longer in duration. Sample sizes ranged from 22[55] to 885[52] participants. Studies were conducted in a range of settings, including preschools/kindergartens/day care centres,[40 41 43–46 48 51 52 58–63 65 66 68] the home,[39 42 49 50 53 69 70] primary care settings (eg, paediatric offices)[47 64 67] and community-based settings.[54 55 57] Results are discussed below, by setting.

Screen time

Preschool/day care setting

Nine studies targeting screen time were conducted in the preschool/kindergarten setting and 1 in a day/childcare setting. Of the 9 preschool interventions, 8 implemented child educational sessions (either alone or in conjunction with physical activity/movement breaks and/or parent education) with topics relating to a range of health behaviours (ie, nutrition, physical activity, screen time and/or sleep). Three of these reported significant between-group differences in screen time ranging from 13 to 40 min/day, in favour of the intervention group.[41 46 66] One study found no intervention effect for the entire sample, but small effects for some behaviours in some subgroups.[61] The remaining 4 studies using child education strategies did not report significant intervention effects on screen time.[43–45 68] The 1 study in this setting that did not use child education sessions implemented a number of preschool policy changes, including healthy menu changes and changes to screen time practices, in addition to parent education sessions and newsletters.[40] While that study found no screen time differences between groups postintervention, they found that children in control centres had significantly greater increases across the intervention in computer use ($p<0.01$) and watching television ($p<0.0001$) than children in intervention centres. The one study conducted in a day care centre (targeting children under 2 years) provided parents with an informative poster and tailored feedback on their child's physical activity, sedentary behaviour and diet-related behaviours and found no significant differences between groups postintervention.[60]

Home setting

Of the 7 studies conducted in the home setting, 4 were successful in reducing screen time.[39 50 69 70] Two of those studies[35 46] used face-to-face contact (eg, motivational counselling, in-person conferences), in addition to mailed or emailed educational materials/resources and phone contact. Both found significant differences in daily television viewing, of 37 and 64 min/day, respectively, in favour of the intervention group. One of the other studies that successfully decreased screen time was delivered remotely (ie, via mailed materials and one phone call), and found a significant difference of around 47 min/day of screen time postintervention ($p<0.001$).[69] The remaining successful study was delivered in the home by trained nurses providing education to mothers around active play and family physical activity.[70] That study found a significantly lower percentage of children in the intervention compared to the control group watching television for more than 60 min a day (14% v 22%, $p=0.02$) postintervention. The 3 non-successful studies employed an in-home counselling session for parents and educational materials,[42] monthly mailed interactive kits (including child activities and incentives) followed by motivational interviewing telephone calls,[49] and online parent education sessions.[53]

Primary-care setting

Three studies were conducted in a primary care setting, of which 2 were effective at decreasing screen time. One study consisted of a once-off session (length not specified) around diet, outside play and television viewing and found that intervention group children were significantly less likely to watch more than 2 hours of television per day compared with controls.[67] The other study involved four face-to-face sessions and three phone calls. It showed a significant decrease in television viewing of around 22 min/day for the intervention compared to usual care group.[47] The non-successful study used one 10 min behavioural counselling session on health impacts and strategies to decrease screen time.[64]

Community-based setting

Finally, 3 studies were conducted in a community-based setting; of those, only one reported significant findings. Campbell *et al*[54] conducted a 15-month dietitian-delivered intervention with parents in their existing first-time parent groups, using anticipatory guidance around diet, physical activity and screen time. They found a significant difference in television viewing between intervention and control groups postintervention of 16 min/day (at child age 19 months). One of the non-successful studies used anticipatory guidance to facilitate group discussions around screen time recommendations, outcomes of screen time and strategies to participate in healthy levels of screen time.[55] The other implemented weekly workshops for parents and children, including guided active play, healthy snack time, interactive education and skill development for parents and supervised creative play for children.[57]

Sedentary time

Preschool/day care setting

Nine of the 13 studies that reported changes in sedentary time were conducted in preschools and 1 was conducted in childcare centres. Of those, 4 were effective at decreasing sedentary time, 3 of which had a primary aim to increase physical activity,[48 51 65] and one which targeted sedentary time directly. Two physical activity interventions had no parental involvement and reported significant differences of 41–51 min less sedentary time per day between intervention and control groups.[48 51] The other study augmented an existing physical activity programme at preschools with parental involvement and found that, compared with controls, children in intervention preschools spent 11 min less in sedentary time per day ($p=0.019$).[65] The study that specifically targeted sedentary behaviour involved environmental changes in the classroom (eg, computers on a raised desk), movement breaks, stories and activities for children and newsletters for parents.[61] That study did not find an intervention effect on sedentary time overall; however, there was a significant decrease in sedentary time on weekdays ($p=0.03$) and during school hours ($p=0.04$) for children from high socioeconomic area kindergartens. The 6 non-successful interventions in this setting used physical activity lessons/programmes,[52 62] parent education sessions,[43 63] play equipment and markings in the playground[59] and implementation of physical activity policies and practices.[58]

Home setting

One study was conducted in the home.[49] It used mailed interactive kits including child activities and incentives followed by telephone coaching sessions, but found no significant effect.

Community-based setting

Two studies were conducted in community-based settings; neither was successful at reducing sedentary time. One used parent education and anticipatory guidance in group discussions.[55] The other implemented weekly guided play and education workshops for parents and children.[57]

Meta-analysis

Seventeen studies reporting a continuous measure of screen time and seven reporting a continuous measure of sedentary time were included in the meta-analysis. A forest plot of the mean difference, in minutes per day spent in screen time and sedentary time, is presented in figure 2. The overall mean difference for both screen time and sedentary time between intervention and control groups was −17.76 (95% CI −26.90 to −8.62), with a significant overall effect of $Z=3.81$ ($p=0.0001$). The overall mean difference in screen time was −17.12 (95% CI −28.82 to −5.42) minutes per day with a significant overall intervention effect ($Z=2.87$, $p=0.004$). The overall mean difference in sedentary time between groups was slightly higher than screen time, at −18.91 (95% CI −33.31 to −4.51); however, the intervention effect was slightly lower ($Z=2.57$, $p=0.01$).

Examination of heterogeneity statistics revealed very high heterogeneity for both screen time and sedentary time results ($\chi^2=139.24$ ($p=<0.00001$), $I^2=89\%$ and $\chi^2=264.64$ ($p<0.00001$), $I^2=98\%$, respectively). Hence, as decided a priori, subgroup analyses were conducted for child age, intervention duration, intervention setting and targeted behaviour/s (whether the intervention aimed to increase physical activity and simply reported sedentary time results, or directly targeted decreasing sedentary time). However, for sedentary time, all of the studies included in the meta-analysis involved preschool-aged children and 6 of the 7 studies were conducted in preschools. Owing to the lack of variability in these characteristics for sedentary time outcomes, subgroup analyses were only conducted for intervention duration and targeted behaviour/s. Tables 2 and 3 present results of these subgroup analyses for screen time and sedentary time, respectively.

Results suggest that the most effective interventions for screen time were long duration (≥6 months; $Z=4.39$, $p<0.0001$) and conducted in a community-based (eg, community venue; $Z=3.97$, $p<0.0001$), home ($Z=2.47$, $p=0.01$) or preschool/childcare setting ($Z=2.49$, $p=0.01$). In subgroup analyses of the targeted behaviours, results suggest a significant effect regardless of whether the study targeted sedentary behaviour alone ($Z=3.48$, $p=0.0005$) or included diet and

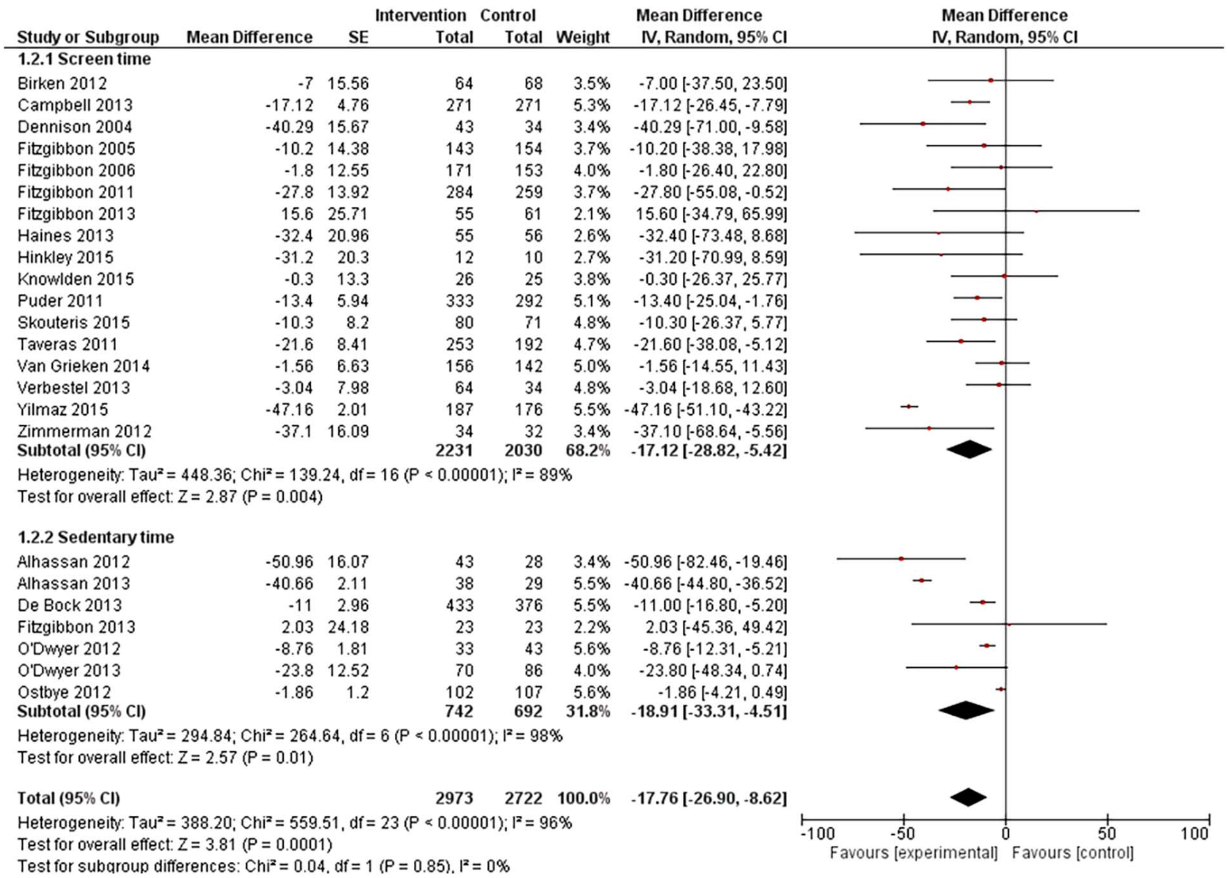

Figure 2 Forest plot of the mean overall difference (95% CI) for each study included in the meta-analysis.

Table 2 Subgroup analyses for studies reporting screen time outcomes

Subgroup	Number of studies	Mean difference (min/day)	95% CIs		Z	p Value	Heterogeneity within subgroups		
			Lower	Upper			χ^2	I^2 (%)	p Value
Duration of intervention									
Short (<6 months)	11	−15.45	−32.63	1.73	1.76	0.08	93.36	89	<0.00001
Long (≥6 months)	6	−16.14	−23.33	−8.94	4.39	<0.0001	6.34	21	<0.0001
Behaviours targeted									
Targeted SB alone	4	−34.24	−53.53	−14.95	3.48	0.0005	7.44	60	0.06
Targeted SB, PA and diet	13	−12.19	−17.72	−6.65	4.31	<0.0001	14.38	17	0.28
Child age									
<3 years	4	−13.17	−20.70	−5.64	3.43	0.0006	3.21	6	0.36
≥3 years	13	−18.20	−32.54	−3.87	2.49	0.01	100.65	88	<0.00001
Setting									
Preschool/childcare	7	−11.97	−21.41	−2.54	2.49	0.01	7.69	22	0.26
Home	4	−30.55	−54.80	−6.31	2.47	0.01	12.86	77	0.005
Community-based (eg, community venues)	3	−16.03	−23.93	−8.12	3.97	<0.0001	1.10	0	0.58
Healthcare centre/paediatric office	3	−9.91	−23.88	4.05	1.39	0.16	3.52	43	0.17

PA, physical activity; SB, sedentary behaviour.

physical activity (Z=4.31, p<0.0001). Similarly subgroup analyses for age indicate a significant intervention effect both for studies with children aged younger than 3 years and for studies with children aged 3–5 years (Z=3.43, p=0.0006 and Z=2.49, p=0.01, respectively). However, there was high heterogeneity in the 3–5-year subgroup (χ^2=100.65 (p<0.00001), I^2=88%), which was not evident in the younger than 3-year subgroup (χ^2=3.21 (p=0.36), I^2=6%), suggesting that there may be other moderating factors influencing outcomes for the older age group.

For sedentary time, results of subgroup analyses show no differences for intervention length, with both short-duration and long-duration interventions found to be not significant. However, long-duration interventions approached significance (Z=1.85, p=0.06). Interventions that targeted physical activity alone, but reported sedentary time results, were shown to be

Table 3 Subgroup analyses for studies reporting sedentary time outcomes

Subgroup*	Number of studies	Mean difference (min/day)	95% CIs Lower	Upper	Z	p Value	Heterogeneity within subgroups χ^2	I^2 (%)	p Value
Duration of intervention									
Short (<6 months)	4	−20.71	−44.73	3.32	1.69	0.09	132.70	98	<0.00001
Long (≥6 months)	3	−10.97	−22.60	0.67	1.85	0.06	17.00	88	0.0002
Behaviours targeted									
Targeted PA alone	3	−31.90	−56.88	−6.92	2.50	0.01	68.15	97	<0.00001
Targeted PA and SB	4	−6.22	−12.78	0.35	1.86	0.06	12.65	76	0.005
Sedentary cut point									
Low cut point†	3	−5.74	−13.95	2.46	1.37	0.17	8.23	76	0.02
High cut point‡	4	−29.54	−52.89	−6.19	2.48	0.01	134.85	98	<0.00001

*Subgroup analyses for behaviours age and setting not performed for sedentary time outcomes due to lack of variability in studies.
†Low cut points included Evenson sedentary cut point: ≤15 counts/15 s, Pfeiffer sedentary cut point: <38 counts/15 s, and De Bock sedentary cut points: boys <46 counts/15 s.
‡High cut point included Sirard sedentary cut points: 3 years ≤301 counts/15 s, 4 years ≤363 counts/15 s, 5 years ≤398 counts/15 s.
PA, physical activity; SB, sedentary behaviour.

more effective (Z=2.50, p=0.01) than interventions that actually aimed to decrease sedentary time in addition to promoting physical activity (Z=1.86, p=0.06). With respect to the moderator analysis for type of sedentary cut point used, 3 studies[43 49 65] were classified as using a 'low' cut point (<15 counts, <38 counts or <46 counts/15 s epoch) and 4 studies[48 51 62 63] were classified as using a 'high' cut point (3-year-old ≤301 counts, 4-year-old ≤363 counts, 5-year-old ≤398 counts/15 s epoch). Results of the analysis suggest that studies using a high cut point had a significant overall effect (Z=2.48, p=0.01), while those using a low cut point did not (Z=1.37, p=0.17).

Methodological quality and risk of bias

Scores for each study are presented in table 4. Briefly, most studies scored moderate quality for selection bias; all scored strong for study design; the majority scored strong for confounders; the majority scored moderate for blinding; almost half scored weak for data collection methods; and the majority scored strong for withdrawals and dropouts.

DISCUSSION

This study systematically reviewed interventions that reported changes in young children's sedentary behaviours. Thirty-one RCTs were included in the review, of which 17 were included in a screen time meta-analysis and 7 in a total sedentary time meta-analysis. Results of the meta-analyses suggest that interventions to reduce screen time and sedentary time have a statistically significant postintervention effect of around 17 and 19 min/day (favouring the intervention group), respectively. Given that evidence suggests preschool-aged children spend ∼2 hours/day on screen time,[11 12] a reduction of 17 min is promising. Similarly, results for sedentary time are encouraging, particularly considering their benefits for physical activity. For young children, physical activity recommendations encompass light-intensity, moderate-intensity and vigorous-intensity physical activity (ie, anything but sedentary time). Hence, a 19 min reduction in sedentary time may potentially equate to an increase in physical activity of up to 19 min, 10% of the recommended 3 hours daily. It is also important to consider the variability in findings between studies; some studies showed decreases in sedentary time of up to almost 1 hour, suggesting that larger decreases are possible within these behavioural interventions. However, given that children may be spending up to 12 hours/day sedentary,[17] compared to around 2 hours/day on screen time, there is greater scope for reduction in sedentary time.

Subgroup meta-analyses showed some trends in studies that reported screen time outcomes; however, given the small number of studies included in some subgroups, results should be interpreted with caution. Nonetheless, results do suggest that screen time interventions with a duration of 6 months or longer are more effective than shorter interventions. In a meta-analysis of children's (0–18 years) sedentary behaviour, Biddle *et al*[27] found that interventions of more than 12 months duration were more effective than 5–12-month interventions. Only four studies included in this meta-analysis had a duration of 12 months or longer; therefore, dichotomising at 6 months was more appropriate. Given that screen time is a habitual behaviour that may be hard to change, perhaps interventions of longer duration are required to change the habits of both parents/carers and children in order to decrease young children's time in this behaviour.

Results also suggest that interventions conducted in a home, community-based or preschool/childcare setting are more effective at reducing children's screen time than those conducted in a healthcare centre/paediatric office setting. In particular, community-based interventions had the highest overall effect and very low heterogeneity. Interventions with greater parent focus may be more effective given the strong parental influence on children of this young age. While the three interventions conducted in a healthcare setting/paediatric office also had parental involvement, they were all implemented at a scheduled health visit. Hence, despite the face-to-face nature of the interventions, parents may have been more focused on their child's general health and not receptive to behavioural messages. Moreover, 2 of those 3 studies involved only a short, once-off session and hence may not have been long enough to result in significant behaviour changes. While interventions conducted in the preschool/childcare setting were the most common and showed a significant overall effect in the meta-analysis, only three of the seven included studies had a significant intervention effect. This suggests that while the preschool setting is regularly targeted as a convenient setting for behavioural interventions, it may not be the most effective. This has been similarly noted in other reviews of interventions in this age group, with lack of

Table 4 Methodological quality for included studies

Author, year	Selection bias	Study design	Confounders	Blinding	Data collection methods	Withdrawals and dropouts
Alhassan *et al*, 2012[48]	Weak	Strong	Strong	Moderate	Moderate	Strong
Alhassan *et al*, 2013[51]	Weak	Strong	Strong	Moderate	Moderate	Strong
Annesi *et al*, 2013[52]	Moderate	Strong	Weak	Moderate	Strong	Weak
Birken *et al*, 2012[64]	Moderate	Strong	Strong	Strong	Weak	Strong
Campbell *et al*, 2013[54]	Moderate	Strong	Strong	Strong	Moderate	Strong
Cardon *et al*, 2009[59]	Moderate	Strong	Weak	Moderate	Moderate	Strong
De Bock *et al*, 2013[65]	Strong	Strong	Strong	Moderate	Weak	Moderate
De Craemer *et al*, 2016[61]	Weak	Strong	Weak	Moderate	Moderate	Strong
Dennison *et al*, 2004[41]	Moderate	Strong	Strong	Moderate	Weak	Moderate
Evans *et al*, 2011[42]	Moderate	Strong	Weak	Moderate	Weak	Weak
Fitzgibbon *et al*, 2005[44]	Moderate	Strong	Strong	Weak	Weak	Weak
Fitzgibbon *et al*, 2006[45]	Moderate	Strong	Strong	Weak	Weak	Strong
Fitzgibbon *et al*, 2011[46]	Moderate	Strong	Strong	Moderate	Weak	Moderate
Fitzgibbon *et al*, 2013[43]	Moderate	Strong	Weak	Moderate	Weak	Strong
Haines *et al*, 2013[39]	Weak	Strong	Strong	Moderate	Weak	Strong
Hinkley *et al*, 2015[55]	Weak	Strong	Weak	Strong	Strong	Weak
Jones *et al*, 2015[58]	Moderate	Strong	Weak	Moderate	Strong	Strong
Knowlden *et al*, 2015[53]	Moderate	Strong	Strong	Moderate	Strong	Strong
Lerner-Geva *et al*, 2015[68]	Moderate	Strong	Strong	Moderate	Weak	Weak
Natale *et al*, 2014[40]	Moderate	Strong	Weak	Moderate	Strong	Weak
O'Dwyer *et al*, 2012[63]	Weak	Strong	Strong	Moderate	Moderate	Strong
O'Dwyer *et al*, 2013[62]	Weak	Strong	Strong	Weak	Moderate	Strong
Østbye *et al*, 2012[49]	Weak	Strong	Strong	Moderate	Weak	Moderate
Puder *et al*, 2011[66]	Strong	Strong	Strong	Moderate	Strong	Strong
Skouteris *et al*, 2015[57]	Moderate	Strong	Weak	Moderate	Weak	Strong
Taveras *et al*, 2011[47]	Weak	Strong	Strong	Moderate	Moderate	Strong
van Grieken 2014[67]	Weak	Strong	Strong	Moderate	Weak	Weak
Verbestel *et al*, 2013[60]	Weak	Strong	Strong	Moderate	Weak	Moderate
Wen *et al*, 2012[56]	Moderate	Strong	Strong	Strong	Moderate	Moderate
Yilmaz *et al*, 2015[69]	Moderate	Strong	Strong	Strong	Weak	Strong
Zimmerman *et al*, 2012[50]	Weak	Strong	Strong	Moderate	Moderate	Moderate

parental involvement suggested as a potential reason for the lower efficacy in this setting.[19]

Results of the subgroup analysis for age showed a larger overall effect on screen time for studies that targeted younger (<3 years) compared to older (3–5 years) children. However, the vast majority of studies targeted the older age group. Wahi *et al*[29] found that interventions aimed at reducing screen time in children aged ≤18 years were not effective, but that the preschool age group did hold promise. The current review supports this, and suggests that interventions may be more beneficial when aimed at even younger children. It is unclear whether this observation is related directly to the age of the children or is a reflection of the format and setting of interventions for the younger age group. As already noted, interventions conducted in the preschool setting showed limited effectiveness. Clearly, further research into children younger than 3 years is warranted.

While fewer studies were included in the meta-analysis for sedentary time, and the overall intervention effect was smaller than for the screen time meta-analysis, results nonetheless showed a significant overall effect with a similar reduction in daily minutes to screen time. However, there was extremely high heterogeneity among these studies. Subgroup analyses suggest that interventions targeting increases in physical activity, but not those directly targeting sedentary time, had a significant overall intervention effect. Physical activity guidelines for young children include light-intensity, moderate-intensity and vigorous-intensity physical activity. It may be that increasing physical activity is an effective strategy for reducing sedentary time in young children, by shifting time spent sedentary along the spectrum of activity.

A limitation of this review is that some studies could not be included in the meta-analysis due to non-continuous measures of screen or sedentary time being reported. Therefore, fewer studies were included in the meta-analysis than in the systematic review; it is possible that the inclusion of these studies could modify the results observed. Limitations of the individual studies included in the review must also be considered. A number of pilot studies with relatively small sample sizes were included. These studies may not have been powered to detect small changes in sedentary behaviours, potentially influencing the meta-analysis results. Moreover, the studies included in the review varied widely in their intervention objectives, settings, methodologies and modes, making it difficult to compare findings. This is highlighted by the high heterogeneity observed in most of the meta-analyses undertaken. Finally, individual study quality varied greatly. Few studies scored 'strong' ratings for selection bias, blinding or data collection methods. While this may be due to lack of reporting (as opposed to actual poor methodologies), it is important to note. A recent review of correlates of physical activity reported similar findings in terms of study quality.[71] Future RCTs would benefit from following the CONSORT statement[72] when reporting results.

Results of this systematic review and meta-analysis suggest that interventions targeting screen time would benefit from being longer in duration (ie, ≥6 months) and conducted in a setting with high parental involvement. This review also highlighted the relatively few studies undertaken in children aged under 3 years and outside the preschool setting. Further research is required to investigate different strategies for reducing objectively assessed sedentary time in early childhood; the considerable heterogeneity of studies and lack of clear trends in subgroup analyses make it difficult to draw conclusions about the types of interventions or strategies that are effective in this population. It will also be important for future interventions to target and include measures of screen time beyond just television viewing. With technology such as smartphones and tablets becoming ubiquitous, and often used as a 'babysitting' tool, parents may be underestimating their child's screen time. In addition, future interventions should consider targeting child restraint, given that a number of countries have recommendations for limiting the amount of time children spend restrained. Until now, no interventions have been identified that target time spent restrained in early childhood.

CONCLUSIONS

Given the negative health outcomes associated with some sedentary behaviours in early childhood,[3 4] it is vital to investigate effective strategies to reduce time in these behaviours. Results from this systematic review and meta-analysis suggest that interventions to decrease screen time and sedentary time in children aged birth through 5 years have a relatively large, statistically significant overall effect. This supports the implementation of interventions in early childhood to reduce sedentary behaviours, and suggests that this appears to be an ideal age to intervene.

What are the findings?

- Interventions to reduce screen time and overall sedentary behaviour in early childhood have a significant overall effect of 17 and 19 min/day, respectively.
- Few interventions to reduce sedentary behaviour have been conducted in children younger than 3 years and outside the preschool setting, suggesting that further research is needed.

How might it impact on clinical practice in the future?

- Early childhood may be an opportune time to intervene to reduce sedentary behaviour.
- Future interventions would benefit from being longer in duration (>6 months) and having high parent involvement.

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Contributors KLD conceptualised the study, carried out the database searches, screened the titles, abstracts and full-text papers, extracted the data, conducted the quality assessment, conducted the meta-analysis and drafted the initial manuscript. JAH screened the abstracts and full-text papers, conducted the quality assessment, reviewed and revised the manuscript, and approved the final manuscript as submitted. TH, JS and KDH were consulted where necessary for full-text inclusion, reviewed and revised the manuscript, and approved the final manuscript as submitted.

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Supplement Table 1 Summary of included studies (by intervention setting)

Author	Sample	Design, setting & duration	Sessions	Behaviours targeted	Intervention	Control	SB measure	Results
Preschool/childcare setting								
Alhassan 2012[48] *USA*	n=114 (low SES Hispanic and African-American) 49% boys Mean age 4.5±0.6y	RCT Preschool 6 months	30 min/ day PA sessions, 5 days/week	PA, FMS, SB	Locomotor skill (LMS)-oriented lesson plans delivered by trained teachers	Unstructured free time	ActiGraph accel (15s epoch; Sirard cut point[a], valid data: ≥9h/day, ≥4 weekdays)	Significant difference for % sedentary time during preschool hours between IV and control groups, adjusted mean diff (95% CI): -9.6 (-17.5, -1.8), p=0.02
Alhassan 2013[51] *USA*	n=67 56.5% boys Mean age 4.1±0.7y	Group-randomised design Preschool 4 weeks	12 30-min PA sessions (3 days/ week for 4 weeks)	PA & SB	Structured outdoor playtime sessions; age-appropriate, moderate- to vigorous-intensity physical activities for making outdoor playtime more effective at increasing PA	Usual play	ActiGraph accel (15s epoch; Sirard cut point[a], valid data: ≥9h/day, ≥4 weekdays)	Significant group by time interactions observed for total daily (F(1, 37) = 10.83, p=0.01) and during school (F(1, 37) = 10.25, p=0.01) & of time spent sedentary No significant differences in after-school/ evening time spent sedentary (p=0.07)
Annesi 2013[52] *USA*	n=885 49% boys Mean age 4.4±0.5y	RCT Preschool 9 months	Daily structured 30-min PA session (PA measured at 1, 5 and 9 months)	PA & SB	Preschool PA lessons; both treatment and control teachers received initial training but treatment teachers received an additional 4h training and retained a binder of daily lesson plans (including gross motor skills and behavioural skill training, e.g., goal setting, self-monitoring)	Usual PA program	ActiGraph accel (15s epoch; Pate cut point[b], criteria for valid data not reported)	% of school day in sedentary time (based on a mean of accel data from months 1, 5, and 9): IV: 59.8±9.7 control: 59.1±7.3 (p>0.05)

Author	Sample	Design, setting & duration	Sessions	Behaviours targeted	Intervention	Control	SB measure	Results
Cardon 2009[59] *Belgium*	n=583 52% boys Mean age 5.3±0.4y	RCT Preschool F/u conducted 4-6 weeks post-implementation	n/a	PA & SB	Preschools randomly assigned to one of the following conditions: 1) play equipment provided, 2) markings painted on the playground, 3) play equipment provided and markings painted, 4) control condition.	No changes to playground	ActiGraph accel (15s epoch, Sirard cut point[a], no criteria for valid data required; monitors worn only during recess pre- and post-test)	No significant IV effects for any of the groups; estimated effect of IV on % time spent sedentary: Play equipment group: β = 2.1 (95% CI -3.1, 7.3) Markings group: β = -1.1 (95% CI -6.3, 4.1) Play equipment and markings group: β = -1.7 (95% CI -9.1, 5.6)
De Bock 2013[65] *Germany*	n=826 52% boys Mean age 5.0±0.2y	RCT Preschools 6-9 months	n/a	PA & SB	Augmented state-sponsored PA program; parents motivated to develop and implement their own project ideas for promoting children's PA	Non-participatory, state-sponsored PA program	Actiheart accel (15s epoch, De Bock cut point[c], valid data: ≥1 weekday and ≥1 weekend day)	At 12 months, compared with control children, IV children spent 11 minutes less being sedentary per waking day (95% CI 5.39, 17.01, p=0.019)
De Craemer 2016[61] *Belgium*	n=859 54.4% boys Mean age: 4.4±0.6y	RCT Kindergarten 24 weeks	Three 1-hour sessions for kindergarten teachers	Diet, PA & SB	Kindergarten teachers received training and were given a guide which included suggestions of environmental changes in the classroom (e.g. computers on a raised desk), movement breaks, stories, and fun activities to decrease screen time. Parents received two newsletters and two tip cards containing different tips and strategies for reducing screen time.	Usual kindergarten program	Screen time: parent survey (hours spent watching TV and using a computer/ video games during free time/ leisure time) ActiGraph accel (15s epoch, Evenson cut point[d], valid data: ≥6h/day on ≥2 weekdays and ≥1 weekend day)	No overall intervention effect for either sedentary time or screen time on total sample (all p>0.05), but some effects on specific subgroups: Significant intervention effects on sedentary time on weekdays (β = -4.20; p = 0.03) and during school hours (β = -2.48; p = 0.04) found for children from high SES kindergartens Significant intervention effect on TV viewing for

Author	Sample	Design, setting & duration	Sessions	Behaviours targeted	Intervention	Control	SB measure	Results
								girls on weekend days (β = -9.98; p = 0.04) Significant intervention effect on computer use on weekend days for children from low SES kindergartens (β = -6.43; p = 0.03)
Dennison 2004[41] *USA*	n=77 50% boys Age range 2.6-5.5y	RCT Preschool and day care centres 39 weeks	Seven 1-h sessions dedicated to TV	Diet & SB	Program staff (an early childhood teacher and a music teacher) visited each day care or preschool centre in the intervention group once a week to provide a 1-hour session; half of each session was spent in musical activities; 10 mins eating a snack; and 20 mins participating in an interactive educational session.	Health and safety education	Screen time; parent survey (TV and computer/ video game playing hours on Saturday and Sunday and average weekday in the past week)	Difference in mean changes (95% CI) between groups: TV viewing: Weekdays: −0.62 (−1.11 to −0.12), p=0.02 Saturday: −0.63 (−1.44 to 0.17), p=0.11 Sunday: −0.99 (−1.73 to −0.25), p=0.01 Children viewing ≥2h/day: −21.5 (−42.5 to −0.5) p=0.045 Computer/video game use: Weekdays: −0.11 (−0.34 to 0.13), p=0.33 Saturday: −0.07 (−0.49 to 0.34), p=0.70 Sunday: −0.03 (−0.27 to 0.21), p=0.79
Fitzgibbon 2005[44] *USA*	n=331 (>80% Latino) 50% boys Age range 3-5y	RCT Head Start sites 14 weeks	Children: three 40-min sessions/ week Parents: weekly	Diet, PA & SB	Child education on nutrition, physical activity, and decreasing sedentary behaviour; PA session. Parents received weekly newsletters and homework assignments.	General health concepts	TV viewing; parent survey (average h/day watching TV)	No significant differences in TV h/day between groups post-intervention (mean diff = diff: -0.17 [95% CI -0.17, 0.30]), at 1 year f/u (mean diff = -0.17 [95% CI -0.75, 0.42]) or at 2 year f/u (mean

Author	Sample	Design, setting & duration	Sessions	Behaviours targeted	Intervention	Control	SB measure	Results
			newsletters					diff = -0.11 [95% CI -0.60, 0.38])
Fitzgibbon 2006[45] *USA*	n=300 (>90% black) 51% boys Age range 3-5y	RCT Head Start sites 14 weeks	Children: three 40-min sessions/ week Parents: weekly newsletters	Diet, PA & SB	Child education on nutrition, physical activity, and decreasing sedentary behaviour; PA sessions (3/week). Parents received weekly newsletters and homework assignments.	General health concepts	TV viewing; parent survey (average h/day watching TV)	No significant differences in TV h/day between groups post-intervention (mean diff = 0.03 [95% CI -0.38, 0.44]) or at 2 year f/u (mean diff = 0.00 [95% CI - 0.38, 0.38])
Fitzgibbon 2011[46] *USA*	n=669 (majority black) 47% boys Age range 3-5y	RCT Head Start programs at public schools 14 weeks	Two to three 40-min sessions per week	Diet, PA & SB	Trained teachers delivered 2-3 weekly sessions related to healthy eating, increasing PA and decreasing SB. Parents received a weekly newsletter, homework assignments and a CD with teacher's lessons.	Health and safety	Screen time; parent survey (time child spent watching TV/ videos/ DVDs, playing video games, or using a computer on an average weekday and average weekend day; mins/day TV and total screen time calculated using a weighted average of time spent on weekdays and weekend days)	Screen time mins/day was significantly lower for IV group than control group post-intervention (mean diff = -27.8 [95% CI -55.1, -0.5], p=0.05) No significant difference for TV min/day (mean diff: -10.2 [95% CI -24.9, 4.6] p=0.16)
Fitzgibbon 2013[43] *USA*	n=146 (Hispanic) 50% boys Mean age 54.2±5.0mo	RCT Preschool 14 weeks	Children: three 40 min sessions per week. Parents: six 90 min sessions	Diet, PA & SB	Family-based intervention including child sessions on nutrition instruction and aerobic activity, and parent sessions on healthful eating and family exercise plus 30 mins of moderate PA.	Children: once weekly general health intervention Parents: weekly general health	ActiGraph accel (15s epoch; Pfeiffer cut point[e]; valid data: ≥8h/day on ≥4 days); Screen time;	No significant differences between groups for % sedentary time (β = −0.27 [95% CI −6.59, 6.05], total screen time (β = 0.26 [05% CI −0.58, 1.10]) or TV viewing (β = 0.07 [95% CI

Author	Sample	Design, setting & duration	Sessions	Behaviours targeted	Intervention	Control	SB measure	Results
					Parents also received weekly newsletters to parallel the children's school-based component.	newsletters	parent survey (min/day watching TV, playing video games and using a computer on average weekday and average weekend day)	−0.41, 0.56]) post-IV
Jones 2015[58] *Australia*	n=90 Sex split not reported Age range 3-5y	RCT Childcare centres 12 months	Three 1-h workshops with centre staff	Diet, PA and SB	Development of written nutrition and physical activity policies; staff role modelling of physically active play; staff provision of prompts and positive comments to children to encourage PA; provision of adult-guided fundamental movement skill development activities every day for at least 75 % of children; restriction of sedentary screen time to less than weekly.	3 newsletters (for centres) containing information on healthy eating and PA (unrelated to intervention)	Direct observation using System for Observing Play and Leisure in Youth (SOPLAY); 1-day (between 9am and 3pm) observation, in 10min intervals	No significant difference between proportion of children engaged in sedentary behaviour in IV group (44.8%, 95% CI 41.5, 48.1) and control group (49.2%, 95% CI 45.8, 52.5) at follow-up (p=0.49)
Lerner-Geva 2015[68] *Israel*	n=204 53.6% boys IV; 54.4% boys group control Age range 4-6y	RCT[f] Kindergartens 10 weeks	10 nutrition lessons and 5 30-min PE lessons/ week	Diet, PA & SB	Child education lessons covering nutrition topics and daily exercise program delivered by a trained teacher of physical education.	Usual kindergarten program	Screen time; parent survey (hours of TV viewing and computer use in a typical week)	No significant differences between IV and control groups screen time h/day (intervention effect estimate = -0.08 [95% CI -0.45, 0.28], p=0.65)
Natale 2014[40] *USA*	n=307 51% boys Age range 2-5y	RCT Preschool 6 months	Parents: six sessions	Diet, PA & SB	Policy changes to improve nutrition, increase PA and decrease TV, and teacher training; monthly educational dinners, monthly newsletters and at-	Injury prevention education	Screen time; parent survey (h/day child watched TV, watched or played video games, and	Over time children in control centres spent significantly more time on the computer (p<0.01) and watching TV (p<0.0001) than children in IV centres

Author	Sample	Design, setting & duration	Sessions	Behaviours targeted	Intervention	Control	SB measure	Results
					home activities focused on increased PA and fresh produce intake, decreased intake of simple carbohydrate snacks, and decreased screen time for parents.		used a computer during the past 30 days)	
O'Dwyer 2012[63] *UK*	n=182 51.9% boys Mean age 2.8±0.6y	RCT Preschools (attached to SureStart centres) 10 weeks	Five sessions	PA & SB	Educational workshops for parents, log book to self-monitor home activity, instructional and educational materials throughout intervention (including guidelines, manuals, games).	Usual physical activity provision	ActiGraph accel (5s epoch; Sirard cut point[a]; valid data: ≥521 and ≥483 mins/day on weekdays and weekend days, respectively, at baseline and ≥466 and ≥448 mins/day for weekdays and weekend days, respectively, at post-test, and ≥2 valid weekdays and 1 valid weekend day)	Significant intervention effect on both weekday (β = −8.76 [95% CI −12.32, −5.2]) and weekend day (β = −23.11 [95% CI −29.17, −17.06]) sedentary time
O'Dwyer 2013[62] *UK*	n=240 51.7% male Mean age 4.5±0.6y	RCT Preschool (attached to SureStart centres) 6 weeks	Six sessions	PA & SB	Preschool teachers participated in a 6-week active play programme. Comprehensive resource pack provided to each school with activity cards.	Usual PA provision	ActiGraph accel (5s epoch, Sirard cut point[a]; valid data: ≥623min at baseline, ≥565min post-test [calculated by defining 80% of total length of time during which 70% of sample wore the accel)	No significant intervention effect from baseline to post-test (β = 7.9 [95% CI -1.5, 17.3])

Author	Sample	Design, setting & duration	Sessions	Behaviours targeted	Intervention	Control	SB measure	Results
Puder 2011[66] *Switzerland*	n=652 50% boys Mean age 5.1±0.7y	RCT Preschool 1 year	Children: four PA sessions/ week + 22 sessions on nutrition, media use and sleep parents: 3 sessions	Diet, PA, SB & sleep	Lifestyle intervention including PA program, lessons on nutrition, media use, sleep and adaption of built environment of preschool. Parents attended 3 interactive information evenings.	Usual PA program	Screen time; parent survey (TV viewing and playing video/ computer games mins/day)	Significant difference between screen time (TV, video and computer use) min/day for IV and control groups, effect estimate (95% CI): −13.4 (−25.0, -1.7), $p=0.03$
Verbestel 2013[60] *Belgium*	n=215 54% boys Mean age 15.51±2.68mo	RCT Day-care centres 1 year	n/a	Diet, PA & SB	Family-based healthy lifestyle intervention to increase parental knowledge, awareness, self-efficacy, parental modelling of the expected behaviours and availability of the healthy foods in the home environment; parents received guidelines and tips presented on a poster and a tailored feedback form for parents about their children's activity- and dietary-related behaviours	Usual care	Screen time; parent survey (usual time/day child watches TV/ video/ DVDs on weekdays and weekend days; categorised into not at all, 0.5h/day, 1h/day, 2h/day, 3h/day, 4h/day, 5h/day, ≥6h/day)	No significant differences between groups or within groups from baseline to f/u (time x condition estimate = 0.09, $p>0.05$)

Author	Sample	Design, setting & duration	Sessions	Behaviours targeted	Intervention	Control	SB measure	Results
Home setting								
Evans 2011[42] *USA*	n=524 Sex-split not reported Age range 3-7y	RCT Home 1 year f/u	One session only (duration not reported)	Diet, PA & SB	In-home counselling session (and educational/ promotional materials) on benefits of, and overcoming barriers to: eating fruits and veg, drinking water, eating low-fat dairy, limiting screen time, engaging in PA.	Usual care	Screen time; parent survey (average h/day watching TV, using video games and computer)	No significant effects of intervention observed (results not reported)
Haines 2013[39] *USA*	n=111 52.3% boys Mean age 4.1±1.1y	RCT Home 6 months	Four home visits, four phone calls	Diet, sleep, TV and TV in bedroom	Family-based intervention promoting limiting TV time and removing the TV from the child's bedroom, using motivational coaching at home and by phone, mailed educational materials, and text messages.	Mailed packages (educational material on developmental milestones)	TV viewing; parent survey (h/day watching TV on average weekday and average weekend day in the last month)	No significant differences in TV h/day change between groups overall ($\beta = -0.54$ [95% CI −1.22, 0.15] $p=0.12$) or on weekdays ($\beta = -0.31$ [95% CI −0.98, 0.37], $p=0.37$) Significant difference in TV h/day change between groups on weekend days ($\beta = -1.06$ [95% CI −1.97, −0.15], $p=0.02$)
Knowlden 2015[53] *USA*	n=57 60.7% boys control group, 32.1% boys IV group Age range 4-6y	RCT Home (online) 4 weeks	Five online educational sessions	Diet, PA & SB	Five educational sessions based designed to reify and improve five SCT constructs in mothers; one session dedicated to PA and one to screen time. Modalities included a 10- to 15-min audio-visual presentation, an interactive worksheet and a discussion board post.	Active control (knowledge-based program)	Screen time; parent survey (details of measure not reported)	Overall decrease of 39.0 mins (95% CI −65.16, −12.84) of child screen time in both groups over the duration of the intervention, but no group-by-time interaction ($p=0.37$)

Author	Sample	Design, setting & duration	Sessions	Behaviours targeted	Intervention	Control	SB measure	Results
Ostbye 2012[49] *USA*	n=400 56% boys Mean age 3.06±1.0y	RCT Home 8 months	Eight sessions	Diet, PA & SB	Mailed interactive kits including child activities and incentives reinforcing the month's topic (e.g., a rewards chart, yoga mat, pedometer, portion plate), followed each month by a 20–30 minute telephone coaching session using motivational interviewing techniques	Monthly newsletters emphasizing pre-reading skills	Actical accel (15s epoch; Evenson cut point[d]; valid data: ≥6h/day on ≥2 weekdays and ≥1 weekend day) TV viewing; parent survey (time child spends watching TV/ videos/ DVDs on a usual weekday and usual weekend day [scale ranging from 0 to ≥6h, in 30-min segments]; used to calculate average mins/day)	No significant differences between IV and control groups from baseline to post-IV (p=0.23)
Wen 2012[70] *Australia*	n=667 Sex split not reported Age at f/u 24mo	RCT Home ~24 months	Eight sessions	Infant feeding practices, child nutrition & active play, family PA & nutrition, & social support	Mothers received eight one-two hour home visits from a trained nurse who taught specific skills and knowledge in relation to healthy infant feeding practices and active play and discussed any issues and concerns; mothers also received written resources to support each key message	Usual care and home safety promotion	TV viewing; parent survey (total time child spent watching TV each day in a usual week)	IV group had a significantly lower percentage of children watching TV for >60 minutes a day than the control group (14% *v* 22%, p=0.02) post-IV

Author	Sample	Design, setting & duration	Sessions	Behaviours targeted	Intervention	Control	SB measure	Results
Yilmaz 2015[69] *Turkey*	n=412 64.8% boys control; 66.3% boys IV Mean age control: 3.49±1.22y, IV: 3.52±1.28y	RCT Home 6 weeks	One counselling phone call	SB	Parents received: printed materials and CDs with information about decreasing screen time at home, including information on harmful effects of screen time and alternative activities; a picture book depicting a family making their home screen-free; stories of families that were able to decrease screen time; one counselling call to encourage families to make their home screen-free, providing information on benefits of a screen-free home and difficulties in doing so.	Usual care	Screen time; parent survey (TV/video watching and computer/video game playing for 1 week)	IV group spent significantly less mins/day in screen time (mean = 39.48, SD = 16.36) compared to control group (mean = 86.64, SD = 21.63), t = 23.5, P < 0.001
Zimmerman 2012[50] *USA*	n=67; (exposed to >90 min TV on average day) Sex split not reported Age range 2.5-4.5y	RCT Home 4 months	n/a	SB	In-person conferences, monthly newsletters, and e-mail contact to motivate behaviour change around child TV viewing	Injury prevention and child safety education	TV viewing; 24-h time diary (on one randomly chosen weekday and one randomly chosen weekend day; 15-min segments)	Effect of IV significantly reduced TV viewing in IV group compared to control group by 37 mins/day (95% CI 5.6, 68.37)
Primary care setting								
Birken 2012[64] *Canada*	n=132 47% boys Mean age 3.1±0.2y	RCT Paediatric offices 1 year f/u	One 10-min session	SB	10-min behavioural counselling intervention on health impacts of screen time and strategies to decrease screen time	Usual care	Screen time; parent survey (total time in mins child was in a room with TV/ video/ DVD on or playing video	No significant differences between groups from baseline to f/u. Adjusted mean (95% CI) between group diff: Weekday: -7 (-38, 23), p=0.65

Author	Sample	Design, setting & duration	Sessions	Behaviours targeted	Intervention	Control	SB measure	Results
							games or using the Internet during the previous weekday and previous weekend day)	Weekend day: 2 (-16, 20), p=0.80
Taveras 2011[47] *USA*	n=475 52% boys Mean age 4.9±1.2y	RCT Paediatric offices 1 year	Four in person visits and three phone calls	Diet, TV in bedroom and TV	Intervention practices received primary care restructuring, and families received motivational interviewing by clinicians and educational modules targeting television viewing and fast food and sugar-sweetened beverage intake.	Usual care	TV viewing; parent survey (total TV and video viewing h/day)	TV mean h/day (SD) decreased significantly for IV group compared to control group; β=-0.36 (-0.64, -0.09), p=0.01
van Grieken 2014[67] *Netherlands*	n=298 (overweight) 38.1% boys Mean age 5.8±0.4y	RCT Youth health care centres 2 year f/u	One session	diet, outside play & TV	Lifestyle counselling to parent at 5 year check-up: motivational interviewing to promote development of a healthy weight incl. limiting television time to a maximum of 2 h a day	Usual care	TV viewing; parent survey (time spent in front of the screen [including DVD viewing] in hours and mins on both a weekday and weekend day; TV mins/day calculated	Proportion of children watching ≤2h/day TV decreased for both groups (IV group from 74.8% to 66.0%, control group from 75.2% to 69.0%; both p>0.05) OR (95%CI) for difference between groups 0.93 (0.53, 1.61)
Community-based setting								
Campbell 2013[54] *Australia*	n=542 53% boys Mean age 3.8mo	RCT First-time parent groups 15 months	Six 2-hour sessions	Diet, PA & SB	Parents offered six 2-hour dietitian-delivered sessions over 15 months focusing on parental knowledge, skills, and social support around infant feeding, diet, physical activity, and television viewing	Usual care from MCH nurses	TV viewing; parent survey (mins spent watching TV on a typical day)	No significant differences in TV min/day mid-intervention (child age 9mo): mean diff = -1.64 (95% CI -10.70, 7.43), p=0.72 IV children watched

Author	Sample	Design, setting & duration	Sessions	Behaviours targeted	Intervention	Control	SB measure	Results
								significantly less TV min/day than control children post-IV: mean diff = -17.12 (95% CI -26.45, -7.79), p<0.001
Hinkley 2015[55] *Australia*	n=22 60% boys control group, 67% boys IV group Age range 2-3y	RCT Sessions held at University 6 weeks	Six 1-h sessions	SB	Anticipatory guidance perspective to facilitate group-based problem solving to possible challenges, to increase knowledge about screen time recommendations and outcomes of screen time, increase awareness and implementation of strategies to participate in healthy levels of screen time, and teach families how to practice behaviour modification such as planning and monitoring	Wait-list control	activPAL accel (15s epoch; valid data: ≥6h/day on ≥3 weekdays and ≥1 weekend day) Screen time; parent time-use diary on 3 weekdays and 1 weekend day (amount of time spent watching TV, using computer, e-games and handheld devices in 15-min increments)	No significant difference between groups on % time sitting from activPALs (adjusted group mean diff = 1.0 (95% CI −7.7, 9.7), effect size = 0.11) No significant difference between groups on mins/day total screen time (adjusted mean diff = −31.2 (95% CI −71.0, 8.6), effect size = 0.70)
Skouteris 2015[57] *Australia*	n=201 52.6% boys control group; 47.3% boys IV group Mean age 2.7±0.6y	RCT Community venues or participants' homes 10 weeks	10 90-min workshops	Diet, PA & SB	Workshops relating to nutrition, PA, parenting and lifestyle behaviours. Each workshop included 3 sections: (i) 30 min of guided active play; (ii) 15 min of healthy snack time based on an evidence-based, exposure technique to promote acceptance of fruit and vegetables and (iii) 45 min of supervised creative play activities for the children while parents	Wait-list control	Screen time and SB; parent report using Physical Activity Questionnaire for pre-school-aged children (Pre-PAQ) (time child spent in activities 'yesterday' [weekday] and 'last weekend' [Saturday and Sunday]; 3-day	No significant intervention effect on either screen time (-10.26 [95% CI -26.26, 5.74], p=0.21) or SB (15.33 [95% CI -20.02, 50.68], p=0.40)

Author	Sample	Design, setting & duration	Sessions	Behaviours targeted	Intervention	Control	SB measure	Results
					attended an interactive education and skill development session.		mean calculated for both screen time and SB (average of 1 weekday, Saturday and Sunday)	

Notes: [a] Sirard sedentary cut points: 3y ≤301 counts/15s, 4y ≤363 counts/15s, 5y ≤398 counts/15s; [b] Pate sedentary cut point: <200 counts/15s; [c] De Bock sedentary cut points: boys <46 counts/15s, girls <26 counts/15s; [d] Evenson sedentary cut point: ≤15 counts/15s; [e] Pfeiffer sedentary cut point: <38 counts/15s; [f] three-armed RCT (full IV, partial IV, control) but only results from full IV and control groups used for this study as partial IV group received only nutritional content

Abbreviations: 95% CI; 95% Confidence Interval; accel. = accelerometer; BMI = body mass index; diff = difference; FMS = fundamental movement skills; f/u = follow up; h = hour; IV = intervention; LMS = locomotor skills; min = minute; PA = physical activity; RCT = randomised controlled trial; SB = sedentary behaviour; SCT = social cognitive theory; SES = socioecomic status; TV = television; y = year.

CHAPTER FOUR

Thesis aims, approach and methods

4.1 Thesis rationale and aims

As summarised in Section 2.3, there is emerging evidence that some sedentary behaviours during early childhood, particularly television viewing, are associated with unfavourable health and developmental outcomes and can track into later life. Despite these adverse outcomes, many young children are engaging in higher than recommended levels of sedentary behaviour. Therefore, there is a need for further research to understand correlates of sedentary behaviour and to investigate potential strategies to reduce young children's time spent sedentary.

The overarching aim of this thesis is to increase understanding of ecological correlates of sedentary behaviour and strategies to reduce sedentary behaviour in young children. Specifically, this thesis aimed to:

1. Investigate the individual, social and environmental level correlates of sedentary behaviour in 3- to 5-year-old children;
2. Use evidence synthesis of existing studies and an investigation of correlates to design, implement and pilot test a parent-focused intervention to reduce 2- to 4-year-old children's sedentary behaviour; and

3. Determine the acceptability, feasibility and efficacy of the pilot intervention to reduce sedentary behaviour in 2- to 4-year-old children.

4.2 Thesis approach

Developing interventions requires a systematic approach, including the use of appropriate theory, the best available evidence, and pilot testing (Craig et al. 2008). The Medical Research Council (MRC) framework for developing and evaluating complex interventions outlines steps for the development, feasibility and piloting, evaluation, and implementation phases (Craig et al. 2008). The development phase includes identifying and synthesising existing evidence (e.g., what is already known from existing interventions) and identifying and developing theory (e.g., developing a theoretical understanding of the expected process of behaviour change). The feasibility and piloting phase includes assessing acceptability, compliance, and delivery of the intervention, in addition to recruitment and retention. This thesis follows the development and feasibility and piloting phases; see Figure 4.1. The evidence synthesis has already been presented in the previous chapter (Paper One). Chapter Five (Paper Two) was the second part of the development phase, while Chapters Six and Seven (Papers Three and Four, respectively) were the feasibility and piloting phase. Full evaluation and implementation were beyond the scope of this thesis; however, it is intended that the results from the previous two phases will inform the development of a full-scale trial.

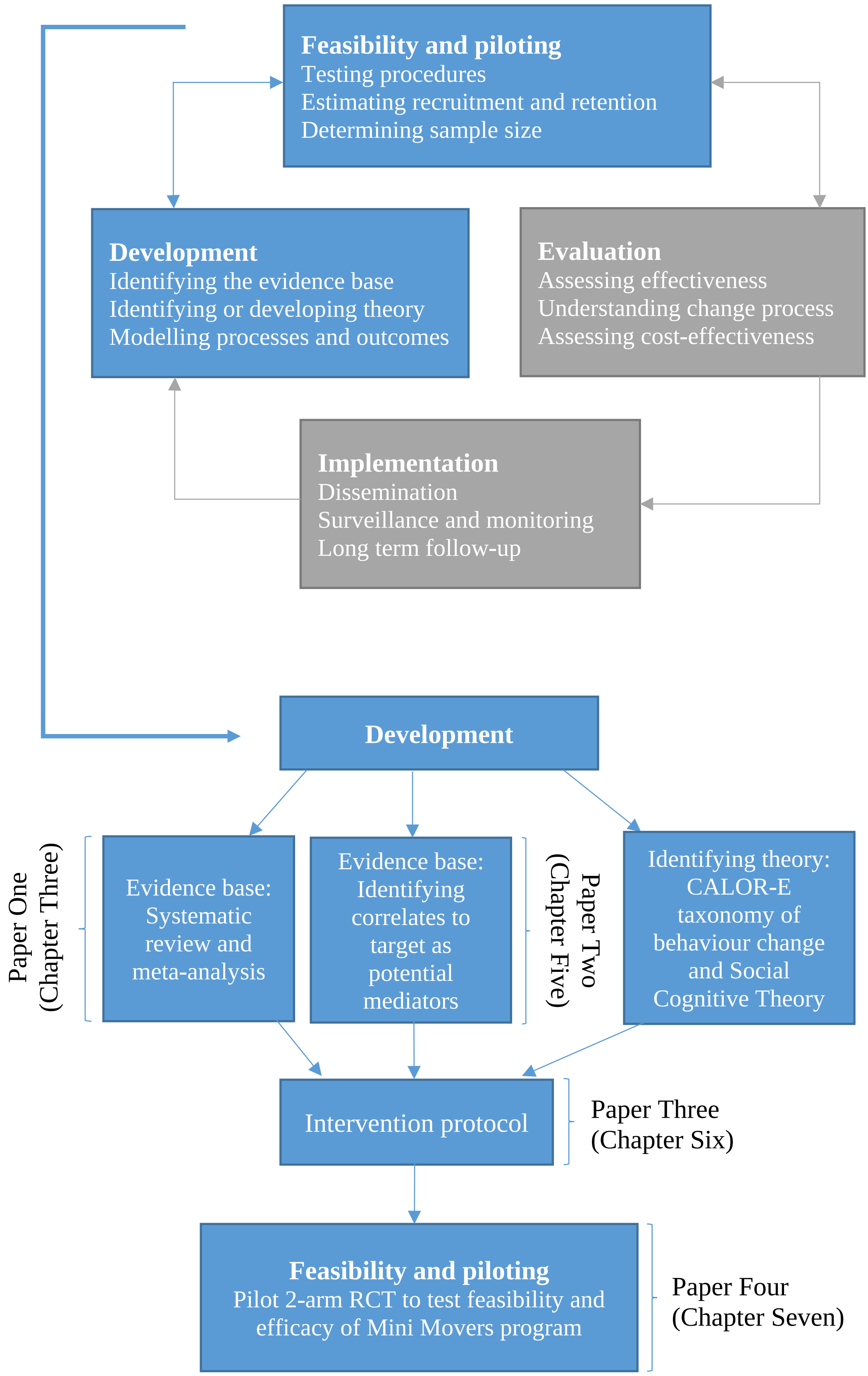

Figure 4.1 Key elements of the development and evaluation process in the MRC framework (Craig et al. 2008) that this thesis follows

4.3 Thesis context and methods overview

This thesis comprises four papers, reported in Chapters Three, Five, Six and Seven. Paper One is a systematic review and meta-analysis, Paper Two is a secondary analysis of data drawn from the Healthy Active Preschool and Primary Years (HAPPY) study, and Papers Three and Four describe the development and pilot testing of the Mini Movers randomised controlled trial (RCT).

4.3.1 The HAPPY Study

The HAPPY study was originally designed as a cross-sectional study, which aimed to investigate factors associated with preschool children's (aged 3 to 5 years) physical activity and sedentary behaviour. Data collection occurred in two waves; the first wave between August and December 2008, and the second wave between June and November 2009. Participants who provided consent to be contacted for future research were invited to take part in follow up studies three years later (from August 2011 to March 2012 [first wave] and June 2012 to April 2013 [second wave]) and six years later (from July 2014 to April 2015 [first wave] and June 2015 to April 2016 [second wave]).

Ethical approval for the HAPPY Study

Ethical approval was granted from the Deakin University Human Research Ethics Committee (EC 291-2007) and the Department of Education and Early Childhood Development (2008/196). Parents provided written, informed consent for their children to participate. Children provided verbal assent to participate. Ethical approvals for the HAPPY study are shown in Appendix C.

Recruitment of HAPPY Study participants

Participants were recruited using a two-stage stratified random sampling procedure. Firstly, six local government areas within the Melbourne metropolitan region were randomly selected, two each from low, medium and high socioeconomic position (SEP) areas. Local government area SEP was determined using the Australian Bureau of Statistics Socio-Economic Indexes for Areas (SEIFA) Index of Advantage/Disadvantage (Australian Bureau of Statistics 2011). In each wave of data collection, 10 childcare centres and 10 preschools were randomly selected in each of the medium and high SEP local government areas. As response rates are typically lower in low SEP areas (Johnson et al. 1994; Madigan et al. 2000; Sheikh & Mattingly 1981), 16 childcare centres and 16 preschools were randomly selected in each of the low SEP local government areas. Invitation letters were sent to each of the randomly selected centres and preschools. Follow-up phone calls were made one week later, with interested centres and preschools signing written consent forms. Consenting centres and preschools were screened for non-English speaking parents; if more than 50% of parents were non-English speaking the centre or preschool was excluded from the study. Centres and preschools that were excluded or declined to participate were replaced with the next randomly selected centre or preschool in that local government area. This approach was repeated until recruitment was completed. Of the 146 childcare centres and 124 preschools invited to participate in this study, 79 (54.1%) and 65 (52.4%) consented to participate, respectively.

All parents of children aged 3 to 5 years attending participating centres and preschools were invited to participate in the study. Leaflets explaining the background and purpose of the study, plain language statements and consent forms were distributed into child ‘pockets’ or folders, or to centre staff for distribution to parents. Reminder slips were distributed one week later. Interested parents consented by completing their consent form and returning it to a sealed box at the centre. In total, 1032 parents consented to participate; an overall response rate of 10.5%. Of the 1032 participants, 485 were recruited through childcare centres (9.0% response) and 547 through preschools (12.4% response).

Candidate’s role in the HAPPY Study

Prior to commencing my candidature, I was employed as a research assistant for three years (2011-2014) on the second follow-up of the HAPPY study. Although I was not directly involved with the project at baseline, my Honours project (in 2010) utilised HAPPY baseline data and, as such, I assisted with follow-up of outstanding parent surveys and data cleaning for the 2009 group. In my role as a research assistant on the follow-up study, I was involved with all aspects of the project, including participant recruitment, scheduling of visits to schools and homes, data collection (child height, weight and waist measurements and fitting with ActiGraph and *activ*PAL™ accelerometers), and data management and cleaning. For the purposes of this thesis, only baseline data from the HAPPY study were utilised; I was responsible for data manipulation and analyses (Chapter Five, Additional file 1 describes potential correlates included in analyses and

Appendix D shows internal reliability results for summed items). The HAPPY study baseline survey is shown in Appendix E.

4.3.2 The Mini Movers Program

The Mini Movers program was a two-arm pilot RCT aiming to support parents to minimise their children's sedentary behaviour. The methods are described in detail in Paper Three (Chapter Six).

Ethical approval for Mini Movers

Ethical approval was granted from the Deakin University Human Research Ethics Committee (2016-103). Parents provided written, informed consent for their children to participate. Children provided verbal assent to participate. Ethical approval for Mini Movers is shown in Appendix F.

Recruitment of Mini Movers participants

Participant recruitment for Mini Movers is described in detail in Papers Three and Four (Chapters Six and Seven). Appendices G and H contain the recruitment flyer and plain language statement and consent form, respectively.

Candidate's role in Mini Movers

I was involved in all aspects of the Mini Movers program. In consultation with my supervisors, I conceived the program and designed the intervention materials (booklet and goal-checking magnet; see Appendix I for intervention materials provided to parents) and baseline and post-intervention surveys (shown in Appendices J and K, respectively). Most of the items included in the surveys were based on existing questionnaires with previously established reliability (Campbell et al. 2013; Hinkley et al. 2012a); however, some items were purpose-developed for Mini Movers. The reliability of these new items was tested in a separate sample of participants; methods and results for the test-retest study are described in Appendix L. Although recruitment for the test-retest study was undertaken by research assistants (recruitment was combined with test-retest surveys for similar studies), I undertook the analyses.

I also designed and made the pouches and leggings for the *activ*PAL™ accelerometers (Appendix M). The *activ*PAL™ instruction booklet for parents is shown in Appendix N. I managed all aspects of participant recruitment, data collection and intervention delivery (including sending/receiving text messages). I was also responsible for managing the budget for the program. Data cleaning, manipulation and analyses were all undertaken in consultation with my supervisors and/or a statistician. A subsample of participants in the intervention arm of the Mini Movers RCT participated in qualitative interviews (Appendix O shows the invitation and plain language statement/consent form for this component of the study). I designed the interview questions (Appendix P) and undertook the recruitment and scheduling of telephone interviews. I was also responsible for analysing the qualitative data. Appendix Q shows additional methods and results for the qualitative interviews.

The following three chapters contain the original research components of this thesis. Each chapter contains a paper either published or under review in a peer-reviewed journal. The papers are prepared in accordance to the structure, formatting and referencing guidelines specified by the journal in which it is published.

CHAPTER FIVE

Paper Two: Do the correlates of screen time and sedentary time differ in preschool children?

5.1 Introduction

As discussed in Chapter Two (Section 2.8), a number of studies were identified that report correlates of young children's sedentary behaviour; however, most correlates have been investigated in only a small number of studies. Moreover, the majority of variables have been investigated only as correlates of television viewing or screen time, with few studies reporting the correlates of overall sedentary time. It is important to investigate screen time and sedentary time as separate behaviours, as they have different health risks (LeBlanc et al. 2012), are likely to have distinct factors that promote and inhibit participation, and subsequently, potentially require different strategies in interventions. Additionally, identifying common correlates of these behaviours may be beneficial for multi-behaviour intervention development. Finally, most studies to date have neglected to consider variables across levels of the ecological model (i.e., individual, social and physical environment factors (Bronfenbrenner 1979)). It is important to consider multilevel correlates simultaneously to determine the relative contribution of correlates across multiple levels. When developing intervention strategies to reduce time in sedentary behaviour it is particularly important to understand correlates to identify where to focus intervention efforts. Therefore, the following chapter presents an original investigation of correlates of screen and sedentary time in preschool children, across multiple levels of the ecological model. Previous studies investigating correlates of accelerometer-assessed physical activity (Hinkley et al. 2012c) and compliance with screen time recommendations (Hinkley et al. 2013) in the current sample have found that correlates differ for boys and girls; hence, analyses were stratified by child sex. This paper has been published in BMC Public Health (Impact Factor: 2.265) as:

Downing KL, Hinkley T, Salmon J, Hnatiuk JA, Hesketh KD. Do the correlates of screen time and sedentary time differ in preschool children? BMC Public Health. 2017:17;285.

The Authorship Statement for this manuscript is contained in Appendix R.

Downing et al. BMC Public Health (2017) 17:285
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RESEARCH ARTICLE Open Access

Do the correlates of screen time and sedentary time differ in preschool children?

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Abstract

Background: Preschool children can spend up to 12 h a day in sedentary time and few meet current recommendations for screen time. Little is known about ecological correlates that could be targeted to decrease specific versus total sedentary behaviour. This study examined whether the correlates of screen time and sedentary time differ in preschool boys and girls.

Methods: Parents participating in the HAPPY Study in 2008/09 in Melbourne, Australia reported their child's usual screen time and potential individual, social and physical environment correlates. Children wore ActiGraph GT1M accelerometers for eight days to objectively assess sedentary time (<100 counts.min^{-1}). Multivariable linear regression analyses were performed, stratified by sex and controlling for child age, preschool/childcare attendance and clustering by centre of recruitment. Correlates significantly associated with screen time or sedentary time in individual models ($p < 0.05$) were included in final combined models.

Results: Children were sedentary for 301.1 (SD 34.1) minutes/day and spent 108.5 (SD 69.6) minutes/day in screen time. There were no sex differences in screen or sedentary time. In the final models, sleep duration was inversely associated with girls' sedentary time and boys' screen time. The only other consistent correlates for boys and girls were parental self-efficacy to limit screen time and screen time rules, which were inversely associated with screen time for both sexes. Parents reporting that they get bored watching their child play was inversely associated and maternal television viewing was positively associated with boys' screen time. Paternal age was positively associated with boys' sedentary time. Maternal ethnicity was inversely associated and paternal education, child preferences for sedentary behaviour, and parental concerns about child's physical activity and sedentary behaviour were positively associated with girls' screen time.

Conclusions: The modifiable correlates of total sedentary and screen time identified in this study could be targeted in interventions to reduce these behaviours. With correlates differing for screen and sedentary time, and between boys and girls, interventions may also benefit from including behaviour- and sex-specific strategies.

Keywords: Sedentary behaviour, Sedentary time, Screen time, Preschool children, Paediatric, Accelerometry, Television viewing

Background

Sedentary behaviour, defined as any seated, waking behaviours requiring ≤1.5 Metabolic Equivalent of Tasks (METs) to perform [1], can include watching television, playing electronic games and reading. Sedentary behaviour research to date has generally focused on screen time (i.e., the sum of time spent viewing television, playing electronic games, and using a computer or other electronic devices) and, to a lesser extent, sedentary time (objectively assessed, e.g., by accelerometry). Sedentary behaviours have their genesis in early childhood (birth through 5 years of age) [2]. While there is currently no evidence for negative health consequences of sedentary time in early childhood [3], excessive screen time has been associated with poorer cognitive development and well-being, and increased risk of overweight and obesity [4–6].

A recent systematic review found that preschool children (roughly 3 to 5 years) spend up to 12 h per day in total (objectively measured) sedentary time [7].

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Additionally, research suggests that preschool children spend an average of two hours per day engaging in screen time [8–11], with approximately one quarter meeting current recommendations of less than one hour of screen time per day [8, 9, 12]. Given the low level of compliance with screen time recommendations and high levels of sedentary time, it is important to identify the factors that are associated with specific and sedentary time in young children in order to inform the development of appropriate intervention strategies.

A systematic review of correlates of sedentary behaviour in preschool children found that studies investigating potential correlates of sedentary behaviour have largely examined television viewing only, with very few investigating correlates of overall screen time or sedentary time [13]. That review also found few consistent correlates of screen and sedentary time. A more recent review examining correlates of energy balance-related behaviours in preschool children found that parental body mass index (BMI), family size, higher energy intake, consumption of high energy drinks, consumption of savoury snacks, parental television viewing time, the presence of a television in the bedroom, having a cable subscription and the day of the week (weekdays) were positively associated with screen time, while fruit consumption and living in an urban region were inversely associated with screen time, with no differences in correlates between sexes reported [14]. However, that review focused exclusively on screen time, with correlates of sedentary time not reported. Studies investigating sedentary time in preschool children have reported that girls are significantly more sedentary than boys [15, 16]. Further, television/video games and physical activity equipment in the home were also shown to be positively associated with sedentary time for boys, while child BMI z-scores and parent-reported athletic coordination were significantly associated with sedentary time for girls [15].

No studies have been identified that examine the correlates of screen time and sedentary time in preschool children in the same sample; however, recent research of this nature in 9- to 11-year-old children has shown that the correlates of these behaviours differ [17, 18]. This suggests that there is a need to investigate screen time and sedentary time as separate behaviours, potentially requiring different strategies to decrease time in those behaviours. Moreover, research has shown that correlates of sedentary behaviours differ between the sexes in preschool [15, 19] and school-aged [17, 18] children, suggesting that correlates should be investigated separately for boys and girls. The aim of this study was to investigate whether the correlates of screen time and sedentary time differ in 3- to 5-year-old boys and girls.

Methods

Recruitment and participants

This study used baseline data (from 2008/09) drawn from the Healthy Active Preschool and Primary Years (HAPPY) Study when children were 3 to 5 years old. HAPPY is a cohort study, conducted in Melbourne, Australia, that investigates multi-domain correlates of physical activity and sedentary behaviour. Recruitment and data collection for this study have previously been described [20]. Briefly, two local government areas (LGAs) within each of the lowest, middle and highest socioeconomic quintiles in metropolitan Melbourne were randomly selected (six in total). Within each of those LGAs, once permission was granted, 124 preschools and 146 childcare centres were randomly selected and invited to participate. All parents (n = 9794) of children aged 3 to 5 years at consenting preschools and childcare centres were then invited to participate in the study. Data were collected from 1002 children and their parents (11% response rate). The final sample included 937 children (n = 504 boys) with valid screen time data and 724 children (n = 397 boys) with valid accelerometry data. The Deakin University Human Research Ethics Committee and the Department of Education and Early Childhood Development approved the study.

Measures and data management

Outcome variables

Children were fitted with ActiGraph GT1M uniaxial accelerometers (Pensacola, FL, USA) on an elastic belt at the right iliac crest and instructed to wear them during waking hours for 8 consecutive days to objectively assess sedentary time. ActiGraph accelerometers have established validity and reliability in preschool-aged children [21]. Data were collected in 15-s epochs [22, 23] to account for the sporadic nature of young children's physical activity. Non-wear time was determined as ≥10 min of consecutive zero counts [24]. Sedentary time was classified using Evenson et al. [25] cut points of ≤25 counts per 15-s epoch. To be included in the analyses, children were required to have data recorded for at least 6 h per day on at least 4 days (including at least 1 weekend day) [24]. To account for variations in children's accelerometer wear time, sedentary time was standardized using the residuals obtained when regressing sedentary time on wear time [26].

During the week that children wore the accelerometer, parents completed surveys reporting their child's usual television/video/DVD time, computer use, and sedentary electronic game use (in hours and minutes) on weekdays (i.e., total time from Monday to Friday) and on weekend days (i.e., total time on Saturday and Sunday). Responses were converted to minutes, then weekday and weekend responses were summed and divided by seven to give average daily minutes of screen time.

Explanatory variables

Explanatory variables in this study were derived from three levels of the ecological model (individual, social and physical environment) [27]. Children's height (m) and weight (kg) were measured using standardized measurement procedures by trained researchers with a Wedderburn Seca portable rigid stadiometer and Wedderburn Tanita portable digital scales respectively [28, 29]. Parents self-reported their height and weight and that of their partner (where applicable); BMI was calculated (kg/m^2) for children and parents. Child BMI categories were determined using age- and sex-specific international cut-off points [30, 31] and WHO classifications [32] were used for parents.

Parents reported individual domain correlates (n = 29) including biological and demographic variables (e.g., parent's age, country of birth, education; child's sleep duration, number of siblings); child behavioural variables (e.g., participation in organized activities, outdoor play time); and psychological variables (e.g., child preferences for physical activity and screen time). Social domain correlates (n = 26) included parental variables (e.g., parental constraints to supporting physical activity, parental rules and regulations regarding physical activity and screen time) and broader social variables (e.g., role-modelling of physical activity and screen time, social gatherings). Physical environment domain correlates (n = 12) included home environment variables (e.g., number of televisions in the home, indoor play spaces), and broader neighbourhood variables (e.g., park and playground availability and quality, frequency of visits to active play spaces). Only survey items with established test-retest reliability were included in analyses: for categorical items Kappa >0.60 and/or per cent agreement >60%; and for continuous variables ICC >0.50 [33]. See (Additional file 1: Table S1) for a full list of potential correlates included in analyses.

Data analysis

Analyses were performed in Stata 13.0 (StataCorp, Texas, USA). Descriptive statistics were used to characterize the sample and t-tests were used to determine differences in sedentary and screen time between boys and girls. Multivariable linear regression models were used to identify correlates of sedentary time and screen time. Initially, each potential correlate was included in individual models with each of the two outcomes. Variables that were significant in individual models ($p < 0.05$) were included in combined models. Collinearity of variables included in the combined models was tested using tolerance and variance inflation factors (VIFs); no issues with collinearity were identified. Given that child age was positively associated with sedentary time for both boys (β = 8.33, 95% CI 4.46, 12.20) and girls (β = 7.93, 95% CI 2.78, 13.07), all models controlled for child age. Additionally, given that in Australian children have varying preschool/childcare hours, all models controlled for hours of preschool/childcare attendance per week. Models also controlled for clustering by centre of recruitment and were performed separately by child sex.

Results

Descriptive data have previously been reported [8, 20]. Respondent parents (93.7% female) had a mean (SD) age of 37.3 (5.2) years and 69.8% were born in Australia. Children had a mean (SD) age of 4.5 (0.7) years. Boys spent a mean (SD) of 109.8 (69.8) minutes per day and girls spent a mean (SD) of 107.0 (69.4) minutes per day in screen time ($p > 0.05$). Accelerometry data showed that boys were sedentary for a mean (SD) of 303.0 (34.6) minutes per day while girls spent a mean (SD) of 298.8 (33.4) minutes per day sedentary ($p > 0.05$).

Table 1 shows individual model results for screen and sedentary time, stratified by child sex. Individual models showed that 22 variables (six, 11 and five from the individual, social and physical environment domains, respectively) were significantly associated with boys' screen time, while 28 variables (10, 12 and six from the individual, social and physical environment domains, respectively) were significantly associated with girls' screen time. For sedentary time, five potential correlates (two, one and two from the individual, social and physical environment domains, respectively) were identified in the individual models for boys and five (four, zero and one from the individual, social and physical environment domains, respectively) were identified for girls.

Table 2 presents the results of the combined models for correlates of screen and sedentary time, stratified by child sex. In the combined model, for boys, five correlates remained significantly associated with screen time and one correlate remained significantly associated with sedentary time. For girls, seven correlates remained significantly associated with screen time and one variable remained significantly associated with sedentary time. No common correlates of screen and sedentary time were identified for either boys or girls.

In the combined model, for each additional hour of sleep, boys spent 7.5 min less per day in screen time. For every unit increase in parental self-efficacy to limit screen time and their actual rules to limit screen time, boys spent 6.5 min and 5.2 min less per day in screen time, respectively. If parents reported that they get bored watching their child play, boys spent 14.4 min less per day in screen time. Conversely, maternal television viewing was positively associated with boys' screen time, such

Table 1 Individual regression models[a] for all potential correlates of screen time and sedentary time for boys and girls

Variable	Screen time mins/day				Sedentary time mins/day			
	Boys (n = 504)		Girls (n = 433)		Boys (n = 394)		Girls (n = 323)	
	% or mean (SD)[b]	β (95% CI)	% or mean (SD)[b]	β (95% CI)	% or mean (SD)[b]	β (95% CI)	% or mean (SD)[b]	β (95% CI)
Individual level								
Demographic and family profile								
Child disability/poor health	10.3%	4.57 (−17.79, 26.93)	5.6%	39.18 (−4.82, 83.18)	9.9%	−10.93 (−21.99, 0.12)	5.6%	**14.38 (0.64, 28.13)**
Child's birth parents live together	86.9%	−5.90 (−30.42, 18.63)	89.3%	−10.91 (−40.22, 18.40)	88.1%	9.71 (−0.63, 20.05)	90.0%	−1.60 (−14.50, 11.30)
Child sleep duration (hours)	11.1 (1.1)	**−13.96 (−22.40, −5.52)**	11.0 (1.1)	**−10.24 (−16.91, −3.57)**	11.1 (1.0)	**−7.09 (−11.35, −2.82)**	11.0 (1.1)	**−6.52 (−9.20, −3.84)**
Child has siblings	84.9%	−0.98 (−17.83, 15.88)	82.3%	−8.30 (−24.40, 7.81)	86.6%	−4.63 (−16.17, 6.91)	83.5%	1.79 (−9.37, 12.96)
Child BMI category[c]								
Underweight/healthy weight (ref)	82.5%	0	80.8%	0	83.3%	0	80.0%	0
Overweight/obese	17.5%	2.64 (−14.22, 19.51)	19.2%	2.19 (−14.84, 19.21)	16.7%	−1.30 (−12.00, 10.02)	20.0%	6.94 (−3.84, 17.72)
Maternal age (years)	37.1 (5.3)	−0.13 (−1.65, 1.40)	37.1 (5.1)	−1.22 (−2.53, 0.09)	37.0 (5.1)	0.57 (−0.06, 1.21)	37.1 (5.2)	−0.30 (−1.07, 0.48)
Mother born in Australia	70.1%	**−17.00 (−32.69, −1.32)**	68.1%	**−26.60 (−42.88, −10.32)**	72.6%	−7.75 (−16.18, 0.69)	68.1%	−0.61 (−8.89, 7.67)
Maternal BMI category[d]								
Healthy weight (ref)	62.1%	0	60.9%	0	62.1%	0	62.8%	0
Overweight	22.7%	11.13 (−1.70, 23.96)	21.8%	7.28 (−8.60, 23.16)	23.4%	5.69 (−2.98, 14.37)	19.2%	**9.99 (0.51, 19.47)**
Obese	15.2%	17.04 (−8.42, 42.49)	17.3%	**26.78 (7.91, 45.65)**	14.6%	−8.80 (−18.27, 0.68)	18.0%	7.98 (−1.32, 17.28)
Mother in paid employment[e]	55.3%	−6.29 (−20.24, 7.66)	52.5%	−9.49 (−22.72, 3.74)	55.5%	5.63 (−2.12, 13.38)	50.8%	3.91 (−2.83, 10.65)
Maternal disability/poor health	3.4%	7.72 (−28.30, 43.75)	4.4%	33.04 (−3.77, 69.86)	2.5%	−17.05 (−35.42, 1.32)	4.6%	**19.32 (5.72, 32.92)**
Maternal education								
Year 10 or equivalent (ref)	10.6%	0	11.2%	0	9.9%	0	11.2%	0
Year 12/trade/diploma	31.7%	−6.72 (−34.83, 21.38)	36.3%	−10.37 (−34.49, 13.75)	31.0%	−7.21 (−21.03, 6.61)	34.7%	6.71 (−9.16, 22.57)
University degree/post-graduate	57.7%	−17.11 (−45.00, 10.78)	52.6%	**−34.98 (−57.46, −12.49)**	59.0%	−1.83 (−13.93, 10.28)	54.2%	−6.23 (−18.96, 6.49)
Low income status (health care/pension card)	20.4%	13.72 (−4.88, 32.33)	18.1%	**23.91 (3.92, 43.90)**	17.7%	−4.05 (−14.67, 6.57)	17.7%	4.40 (−5.70, 14.5)
Paternal age (years)	39.1 (5.7)	−0.65 (−1.74, 0.43)	39.2 (5.5)	−0.58 (−1.99, 0.83)	38.9 (5.5)	**0.85 (0.21, 1.50)**	39.0 (5.3)	−0.27 (−1.14, 0.59)
Father born in Australia	68.3%	−8.24 (−22.90, 6.42)	66.9%	**−19.14 (−35.97, −2.32)**	71.3%	−6.46 (−15.31, 2.39)	69.5%	−2.25 (−11.36, 6.86)
Paternal BMI category[d]								
Healthy weight (ref)	38.6%	0	34.0%	0	36.7%	0	36.5%	0
Overweight	45.2%	1.91 (−11.26, 15.08)	48.7%	4.62 (−11.62, 20.87)	46.9%	−0.38 (−9.41, 8.66)	47.0%	−3.47 (−11.23, 4.28)
Obese	16.2%	**18.84 (2.21, 35.48)**	17.3%	18.97 (−2.31, 40.24)	16.3%	8.57 (−2.73, 19.86)	16.5%	6.99 (−4.81, 18.80)
Father in paid employment[e]	88.9%	10.16 (−7.81, 28.13)	90.8%	−16.27 (−42.18, 9.64)	89.7%	1.96 (−11.21, 15.12)	90.9%	−10.51 (−27.72, 6.71)

Table 1 Individual regression models[a] for all potential correlates of screen time and sedentary time for boys and girls *(Continued)*

Paternal disability/poor health	4.9%	32.13 (−6.56, 70.83)	4.4%	38.40 (−10.43, 87.23)	4.5%	14.39 (−3.29, 32.08)	4.8%	4.17 (−9.92, 18.26)
Paternal education								
Year 10 or equivalent (ref)	9.6%	0	9.5%	0	9.9%	0	7.8%	0
Year 12/trade/diploma	39.9%	−8.63 (−29.07, 11.82)	42.4%	0.26 (−25.22, 25.74)	39.2%	−4.91 (−16.47, 6.65)	41.8%	−8.10 (−26.21, 10.01)
University degree/post-graduate	50.5%	−14.67 (−33.75, 4.42)	48.1%	**−28.92 (−52.31, −5.53)**	51.0%	0.95 (−9.83, 11.73)	50.3%	−9.01 (−25.08, 7.06)
Child PA and SB								
Usual frequency of active transport per week (e.g., ride a bike to kinder)	4.6 (3.9)	−0.22 (−1.79, 1.35)	4.3 (4.1)	**−3.01 (−4.53, −1.49)**	4.4 (3.6)	−0.73 (−1.65, 0.19)	4.2 (3.9)	−0.10 (−1.28, 1.07)
Usual frequency of non-organised activities per week (e.g., play in the backyard)	22.7 (9.8)	−0.51 (−1.20, 0.19)	22.8 (10.4)	−0.35 (−0.80, 0.09)	22.3 (9.7)	−0.28 (−0.65, 0.09)	22.3 (10.4)	−0.18 (−0.56, 0.19)
Number of organised activities per week (e.g., swimming, tennis)	0.9 (0.8)	−3.75 (−12.14, 4.63)	1.2 (0.8)	**−17.67 (−25.95, −9.39)**	0.9 (0.8)	0.93 (−3.81, 5.67)	1.2 (0.8)	−3.29 (−7.79, 1.21)
Child attends playgroup[f]	24.3%	4.98 (−8.96, 18.92)	20.8%	1.52 (−16.25, 19.30)	24.1%	0.27 (−7.36, 7.90)	20.1%	−3.88 (−11.64, 3.88)
Average outdoor play time hours/day (week and weekend day)	4.3 (2.7)	0.11 (−2.60, 2.82)	3.8 (2.5)	1.18 (−1.27, 3.63)	4.2 (2.6)	−0.27 (−1.77, 1.24)	3.7 (2.5)	−0.75 (−2.33, 0.83)
Child personality, preferences and constraints								
Child active co-participation preferences (e.g., active by him/herself, active with his/her friends)	1.8 (1.5)	0.42 (−2.82, 3.65)	1.6 (1.4)	−0.78 (−5.74, 4.19)	1.8 (1.5)	−0.59 (−3.43, 2.25)	1.5 (1.4)	−1.92 (−4.60, 0.77)
Child is active for longer with someone else	79.2%	**−20.57 (−40.06, −1.08)**	78.3%	14.43 (−2.48, 31.34)	78.9%	−6.32 (−16.18, 3.55)	78.5%	−1.70 (−11.41, 8.00)
Child is competitive with other children when being active	66.2%	11.48 (−1.00, 23.96)	51.9%	−1.21 (−14.28, 11.86)	66.9%	2.75 (−3.41, 8.90)	51.3%	0.33 (−7.44, 8.09)
Child prosocial PA behaviour (e.g., asks for opportunities to be active)	12.8 (2.8)	0.29 (−2.17, 2.76)	12.6 (2.9)	−0.43 (−2.58, 1.73)	12.8 (2.7)	−0.24 (−1.40, 0.92)	12.5 (2.8)	−0.01 (−1.60, 1.58)
Child preferences for SB (e.g., more likely to watch TV than be active)	4.1 (1.6)	**10.07 (5.98, 14.16)**	4.4 (1.4)	**14.51 (9.71, 19.32)**	4.1 (1.6)	0.89 (−1.42, 3.20)	4.5 (1.4)	1.08 (−2.37, 4.53)
Child constraints to PA (e.g., too tired to do more PA)	−12.1 (4.5)	**1.60 (0.11, 3.09)**	−11.9 (4.4)	1.28 (−0.07, 2.63)	−12.2 (4.4)	−0.48 (−1.21, 0.25)	−11.8 (4.5)	−0.33 (−1.12, 0.46)
Social level								
Parental influence								
Parental concerns about child's PA/SB	-3.9 (3.3)	**4.59 (2.51, 6.66)**	−4.4 (3.1)	**7.47 (4.90, 10.04)**	−3.8 (3.3)	0.57 (−0.44, 1.57)	−4.3 (3.0)	0.59 (−0.69, 1.87)
Parental constraints to child's PA	6.9 (3.1)	**2.87 (0.36, 5.38)**	6.7 (3.2)	**5.05 (3.19, 6.92)**	6.9 (3.0)	0.14 (−1.01, 1.28)	6.8 (3.1)	0.94 (−0.19, 2.07)
Parent likes to participate in outdoor play	73.5%	4.70 (−8.72, 18.12)	70.8%	7.03 (−7.35, 21.41)	73.0%	3.65 (−3.37, 10.67)	70.0%	−5.31 (−13.37, 2.75)
Parent prefers to be social with other parents	36.7%	−5.65 (−17.2, 5.90)	39.1%	11.65 (−1.77, 25.07)	35.6%	−0.68 (−7.52, 6.15)	36.8%	−2.02 (−10.21, 6.16)
Parent gets bored watching child playing in outdoor spaces	11.8%	**−22.01 (−36.87, −7.15)**	12.5%	5.81 (−18.58, 30.19)	11.5%	−0.71 (−8.44, 7.02)	12.7%	−7.79 (−18.44, 2.86)
Parent likes child to do activities of older children	24.0%	−10.26 (−24.05, 3.52)	22.5%	12.73 (−2.27, 27.73)	24.7%	1.18 (−6.7, 9.07)	22.0%	6.29 (−2.93, 15.50)
Parent likes child to do activities they did as a child	34.3%	5.27 (−9.72, 20.26)	33.0%	1.79 (−12.19, 15.76)	34.4%	−0.71 (−7.41, 5.99)	34.1%	−0.01 (−8.59, 8.58)
Parent gets bored going to the same place	12.8%	5.71 (−21.47, 32.88)	10.9%	7.73 (−17.83, 33.29)	10.7%	−0.83 (−10.72, 9.06)	11.2%	−6.60 (−16.29, 3.09)
Parent believes it's important to be active as a family	90.8%	**−26.67 (−48.93, −4.42)**	86.9%	−14.56 (−34.31, 5.19)	90.6%	−0.22 (−12.23, 11.80)	86.8%	−6.87 (−19.39, 5.65)

Table 1 Individual regression models[a] for all potential correlates of screen time and sedentary time for boys and girls *(Continued)*

Parental self-efficacy to support PA	5.9 (1.7)	**−3.62 (−7.02, −0.23)**	5.9 (1.8)	**−8.07 (−11.75, −4.38)**	5.9 (1.7)	0.06 (−2.00, 2.12)	5.8 (1.8)	−0.54 (−2.60, 1.53)
Parental self-efficacy to limit screen time	8.7 (2.3)	**−9.15 (−11.68, −6.62)**	8.9 (2.5)	**−8.25 (−10.98, −5.52)**	8.8 (2.3)	−0.20 (−1.86, 1.46)	9.0 (2.4)	−0.89 (−2.43, 0.66)
Parental health knowledge/beliefs of child's PA	1.5 (2.2)	−4.19 (−8.74, 0.36)	1.3 (2.2)	**−5.65 (−8.87, −2.44)**	1.6 (2.1)	−0.08 (−1.72, 1.56)	1.3 (2.2)	0.46 (−1.31, 2.23)
Rules and boundaries								
Parental rules to limit screen time	2.1 (1.6)	**−11.40 (−16.32, −6.48)**	2.2 (1.5)	**−14.20 (−18.24, −10.16)**	2.2 (1.6)	−0.64 (−2.65, 1.37)	2.2 (1.5)	−1.90 (−4.46, 0.66)
Parental rules about games inside (e.g., no throwing balls inside)	−0.2 (2.1)	1.13 (−2.50, 4.76)	−0.2 (2.1)	1.13 (−2.50, 4.76)	−0.2 (2.1)	−0.16 (−1.90, 1.58)	−0.1 (2.1)	1.16 (−0.73, 3.05)
Parental rules about PA for stranger danger, traffic, injury	2.3 (1.5)	−1.23 (−6.15, 3.70)	2.3 (1.6)	1.27 (−2.65, 5.19)	2.3 (1.5)	−1.73 (−4.17, 0.71)	2.3 (1.5)	−0.31 (−3.17, 2.54)
Parent allows child to play freely in backyard/ street	−0.1 (1.2)	−6.29 (−13.74, 1.16)	−0.1 (1.2)	**−7.11 (−12.49, −1.73)**	−0.1 (1.1)	−2.67 (−6.09, 0.75)	−0.04 (1.2)	−0.97 (−3.99, 2.05)
Parent switches off screen entertainment	2.7 (1.4)	3.19 (−0.62, 7.00)	2.6 (1.3)	3.26 (−1.76, 8.28)	2.7 (1.4)	−0.27 (−2.80, 2.26)	2.7 (1.3)	−0.83 (−3.35, 1.69)
Social interaction and support								
Child is active at social gatherings	6.0 (1.0)	5.26 (−1.42, 11.95)	6.0 (1.2)	1.05 (−5.88, 7.97)	6.0 (1.0)	−0.54 (−5.45, 4.37)	5.9 (1.2)	−1.86 (−4.50, 0.77)
Maternal PA emotional support for child	5.5 (2.1)	**4.32 (1.74, 6.90)**	5.4 (2.1)	1.20 (−1.84, 4.24)	5.5 (2.1)	**−1.75 (−3.46, −0.04)**	5.4 (2.1)	−0.92 (−2.55, 0.71)
Paternal PA emotional support for child	4.7 (2.4)	**4.29 (1.89, 6.70)**	4.6 (2.4)	1.86 (−0.95, 4.66)	4.7 (2.4)	−1.25 (−2.77, 0.28)	4.6 (2.4)	−0.73 (−2.43, 0.97)
Modelling of PA								
Maternal time in PA (hours/week)	5.4 (4.2)	−0.01 (−1.72, 1.69)	5.0 (4.0)	−1.28 (−3.01, 0.45)	5.3 (4.0)	−0.17 (−0.79, 0.45)	4.9 (3.9)	0.46 (−0.54, 1.45)
Paternal time in PA (hours/week)	5.4 (4.7)	0.24 (−0.93, 1.40)	5.2 (4.6)	**−2.12 (−3.65, −0.59)**	5.0 (4.3)	−0.47 (−1.17, 0.22)	5.2 (4.5)	0.35 (−0.53, 1.23)
Maternal TV viewing (hours/week)	8.6 (6.8)	**3.87 (1.81, 5.93)**	9.0 (6.5)	**2.62 (1.56, 3.68)**	8.6 (6.1)	−0.14 (−0.74, 0.46)	9.2 (6.6)	0.10 (−0.46, 0.66)
Paternal TV viewing (hours/week)	9.6 (6.6)	**1.91 (0.96, 2.85)**	9.8 (7.0)	**2.26 (1.23, 3.29)**	9.8 (6.4)	0.16 (−0.39, 0.71)	9.6 (6.9)	−0.01 (−0.48, 0.46)
Maternal role modelling of PA (times/week)	3.2 (2.0)	−0.63 (−4.49, 3.23)	3.0 (2.0)	**−3.67 (−6.97, −0.38)**	3.3 (2.0)	−0.29 (−1.94, 1.35)	3.0 (2.0)	−1.03 (−3.27, 1.22)
Paternal role modelling of PA (times/week)	2.8 (2.0)	−1.82 (−4.88, 1.24)	2.6 (2.0)	**−4.68 (−7.73, −1.63)**	2.8 (1.9)	−0.21 (−2.01, 1.60)	2.7 (2.0)	−0.28 (−2.26, 1.69)
Physical environment level								
Dog ownership	32.3%	3.35 (−9.64, 16.34)	32.2%	−1.44 (−14.89, 12.00)	32.1%	0.90 (−6.43, 8.22)	31.2%	4.94 (−2.91, 12.79)
Number of pieces of toys/ equipment to be physically active with at home (e.g., swings, slide)	13.3 (3.5)	−1.62 (−3.25, 0.001)	13.1 (3.7)	**−2.37 (−4.15, −0.60)**	13.4 (3.5)	−0.12 (−1.17, 0.93)	13.1 (3.7)	−0.69 (−1.89, 0.52)
Lives on medium/large block	86.1%	1.16 (−14.99, 17.30)	85.2%	−8.11 (−26.65, 10.43)	86.1%	−1.06 (−12.25, 10.13)	84.5%	−6.63 (−18.48, 5.21)
Number of features at home (e.g., front fence, covered outdoor areas)	1.9 (0.9)	**−11.00 (−20.38, −1.62)**	1.9 (0.9)	**−11.48 (−17.82, −5.14)**	2.0 (0.8)	2.02 (−2.10, 6.14)	1.9 (0.8)	−3.14 (−8.23, 1.95)
Lives on a cul-de-sac	24.1%	**24.23 (7.27, 41.19)**	29.6%	13.57 (−1.66, 28.79)	23.3%	−5.76 (−13.49, 1.97)	28.0%	0.31 (−7.40, 8.01)
Number of pieces of electronic equipment at home (e.g., DVD player, PlayStation)	5.1 (1.2)	3.83 (−2.76, 10.41)	5.1 (1.1)	2.89 (−2.67, 8.46)	5.1 (1.1)	1.01 (−2.89, 4.91)	5.0 (1.1)	1.58 (−2.33, 5.49)
Number of TVs at home	2.2 (1.2)	**7.31 (1.89, 12.74)**	2.2 (1.1)	**14.08 (7.61, 20.55)**	2.2 (1.1)	−0.80 (−3.60, 2.00)	2.2 (1.0)	**4.10 (1.00, 7.20)**
TV in child's bedroom	10.6%	**23.51 (4.75, 42.28)**	9.5%	**50.01 (23.84, 76.18)**	10.0%	0.02 (−11.97, 12.01)	7.1%	12.36 (−1.91, 26.63)
Computer/e-games in child's bedroom	4.2%	11.34 (−28.46, 51.15)	4.2%	5.86 (−22.70, 34.41)	4.1%	17.37 (−9.11, 43.85)	3.7%	15.80 (−1.21, 32.81)

Table 1 Individual regression models[a] for all potential correlates of screen time and sedentary time for boys and girls *(Continued)*

Neighbourhood playground suitability (e.g., equipment, shade, safety)	5.5 (4.4)	**−2.98 (−5.30, −0.66)**	5.2 (4.4)	**−2.71 (−4.15, −1.28)**	5.6 (4.2)	**−0.92 (−1.65, −0.19)**	5.5 (4.5)	−0.31 (−1.13, 0.52)
Neighbourhood constraints to active transport (e.g., busy roads)	4.9 (4.4)	−1.46 (−3.19, 0.28)	4.8 (4.6)	**−2.06 (−3.50, −0.62)**	5.0 (4.4)	**−0.65 (−1.28, −0.01)**	5.0 (4.4)	−0.42 (−1.34, 0.50)
Total frequency of visiting active places per week	6.5 (3.2)	0.64 (−1.58, 2.85)	5.9 (3.0)	0.24 (−2.62, 3.10)	6.4 (3.2)	−0.77 (−1.90, 0.37)	5.9 (3.1)	−0.35 (−1.60, 0.90)

Abbreviations: BMI body mass index, *CI* confidence interval, *e-games* electronic games, *PA* physical activity, *SB* sedentary behaviour, *TV* television
[a]All models adjusted for age, preschool/childcare attendance and clustering by centre of recruitment; [b] Reported as % for binary/categorical variables and mean (SD) for continuous variables; [c] Directly measured height and weight, calculated using Cole et al. classifications; [d] Parents' self-reported height and weight, calculated using WHO classifications; [e] Includes part- and full-time paid employment; [f] In Australia, playgroups are informal gatherings for parents (and caregivers) and their children prior to the commencement of school; bolded data indicates significance ($p < 0.05$); – indicates variable not included in combined model

that boys spent an additional 2.3 min per day in screen time for each additional hour in maternal television viewing. For sedentary time, boys spent an additional 0.7 min per day sedentary for every additional year of paternal age.

For girls, results from the combined model show that if mothers were born in Australia, girls spent 15.7 min less per day in screen time. For every unit increase in parental self-efficacy to limit screen time and rules to limit screen time, girls spent 6.5 min and 2.6 min less per day in screen time, respectively. Paternal education, child preferences for sedentary behaviour (e.g. child is more likely to watch television than be active), and parental concerns about their child's physical activity and sedentary behaviour were positively associated with girls' screen time. If fathers had a year 12/trade/diploma level of education, girls spent 23.3 min more per day in screen time compared to fathers with a year 10 or equivalent level of education. Girls also spent 7.1 min per day more in screen time for each unit increase in parent-reported child preferences for sedentary behaviour, and 3.1 min more per day in screen time for every unit increase in parental concerns about their child's physical activity and sedentary behaviour. For sedentary time, girls spent 5.8 min less per day sedentary for every additional hour of sleep time.

Discussion

The aim of this study was to identify whether correlates of screen time and sedentary time in preschool children differ. Results identified a greater number of correlates of screen time than sedentary time in this population. No common correlates of screen and sedentary time were identified for either boys or girls. The larger number of correlates of screen time than sedentary time is consistent with research in older children [17, 18]. This may be because in this study both screen time and potential correlates were parent-reported, whereas sedentary time was objectively measured, hence there may have been consistent reporting biases that influenced associations for screen time. Additionally, many of the correlates measured focus directly on screen time (e.g., parents limiting screen time) rather than sedentary time (e.g., strategies to reduce overall sitting). They may therefore be less relevant to sedentary time which, when measured by accelerometry, captures many more types of sedentary behaviour in addition to screens (e.g., reading, craft, quiet play) across many domains (e.g., in the car, at preschool, in the home). Most research to date has focused only on screen time [14], which is often used as a proxy for sedentary time [34]. However, results from the current study suggest that the correlates of these behaviours differ, and therefore behaviour-specific strategies may be required to reduce screen time and sedentary time.

Children's total sleep time (including daytime naps) was significantly inversely associated with girls' sedentary time and boys' screen time. The association between sedentary time and sleep has not previously been investigated in preschool children, but research in older children supports this inverse association [17]. Previous research has found that increased sleep time is associated with decreased television viewing in five-year-old children [35]. In the current study it is not possible to determine whether children are engaging in higher levels of screen time and sedentary time due to less sleep, or whether the higher levels of sedentary time and screen time disrupt sleep. However, screen time at age two years has been longitudinally inversely associated with sleep duration at age five years [36], suggesting that encouraging parents to decrease their child's screen time to improve sleep could be an appealing strategy for parents.

The only other common correlates for boys' and girls' screen time were parental self-efficacy to limit screen time and their actual rules to limit screen time. For every unit increase in the summed score for parental self-efficacy to limit screen time, boys and girls spent around six and three minutes less per day in screen time, respectively. Similarly, for every unit increase in parental rules, boys and girls both spent around five minutes less per day in screen time. Parental self-efficacy to limit screen time and their actual rules have

Table 2 Combined regression models[a] for correlates of screen time and sedentary time for boys and girls

Variable	Screen time mins/day		Sedentary time mins/day	
	Boys (n = 504)	Girls (n = 433)	Boys (n = 394)	Girls (n = 323)
	β (95% CI)	β (95% CI)	β (95% CI)	β (95% CI)
Individual level				
Demographic and family profile				
Child disability/poor health	-	-	-	10.18 (−3.03, 23.40)
Child sleep duration (hours)	**−7.49 (−13.46, −1.52)**	−5.67 (−11.57, 0.23)	−3.97 (−7.95, 0.01)	**−5.76 (−8.83, −2.69)**
Mother born in Australia	0.99 (−11.45, 13.42)	**−15.66 (−28.97, −2.35)**	-	-
Maternal BMI category[c]				
Healthy weight (ref)	-	0	-	0
Overweight	-	1.56 (−12.22, 15.34)	-	8.55 (−0.90, 18.00)
Obese	-	15.11 (−4.11, 34.32)	-	5.20 (−4.05, 14.45)
Maternal disability/poor health	-	-	-	10.97 (−5.36, 27.30)
Maternal education				
Year 10 or equivalent (ref)	-	0	-	-
Year 12/trade/diploma	-	−3.39 (−27.86, 21.09)	-	-
University degree/post-graduate	-	−2.62 (−30.91, 25.66)	-	-
Low income status (health care/pension card)	-	−4.22 (−23.18, 14.74)	-	-
Paternal age (years)	-	-	**0.73 (0.10, 1.35)**	-
Father born in Australia	-	−3.93 (−17.82, 9.95)	-	-
Paternal BMI category[c]				
Healthy weight (ref)	0	-	-	-
Overweight	−1.15 (−13.03, 10.74)	-	-	-
Obese	2.79 (−12.80, 18.37)	-	-	-
Paternal education				
Year 10 or equivalent (ref)	-	0	-	-
Year 12/trade/diploma	-	**23.26 (0.11, 46.41)**	-	-
University degree/post-graduate	-	9.66 (−16.33, 35.65)	-	-
Child PA and SB				
Usual frequency of active transport per week (e.g., ride a bike to kinder)	-	**−1.72 (−3.14, −0.30)**	-	-
Number of organised activities per week (e.g., swimming, tennis)	-	−7.54 (−15.72, 0.64)	-	-
Child personality, preferences and constraints				
Child is active for longer with someone else	−10.63 (−23.18, 1.93)	-	-	-

Table 2 Combined regression models[a] for correlates of screen time and sedentary time for boys and girls *(Continued)*

Child preferences for SB (e.g., more likely to watch TV than be active)	3.52 (−1.49, 8.53)	**7.09 (2.47, 11.70)**	-	-
Child constraints to PA (e.g., too tired to do more PA)	−0.69 (−2.12, 0.75)	-	-	-
Social level				
Parental influence				
Parental concerns about child's PA/SB	1.87 (−0.05, 3.78)	**3.19 (0.62, 5.76)**	-	-
Parental constraints to child's PA	0.74 (−1.36, 2.84)	1.29 (−0.55, 3.13)	-	-
Parent gets bored watching child playing in outdoor spaces	**−14.43 (−27.99, −0.86)**	-	-	-
Parent believes it's important to be active as a family	6.08 (−10.86, 23.02)	-	-	-
Parental self-efficacy to support PA	0.76 (−2.78, 4.30)	1.67 (−2.23, 5.58)	-	-
Parental self-efficacy to limit screen time	**−6.52 (−9.51, −3.54)**	**−2.64 (−5.12, −0.16)**	-	-
Parental health knowledge/beliefs of child's PA	-	0.22 (−3.67, 4.11)	-	-
Rules and boundaries				
Parental rules to limit screen time	**−5.15 (−9.20, −1.11)**	**−5.20 (−9.94, −0.47)**	-	-
Parent allows child to play freely in backyard/street	-	−4.62 (−9.39, 0.16)	-	-
Social interaction and support				
Maternal PA emotional support for child	2.14 (−1.47, 5.76)	-	−1.10 (−2.84, 0.63)	-
Paternal PA emotional support for child	2.14 (−0.87, 5.14)	-	-	-
Modelling of PA				
Paternal time in PA (hours/week)	-	−0.62 (−2.29, 1.04)	-	-
Maternal TV viewing (hours/week)	**2.27 (1.09, 3.46)**	1.33 (−0.05, 2.70)	-	-
Paternal TV viewing (hours/week)	0.49 (−0.71, 1.69)	0.65 (−0.33, 1.63)	-	-
Maternal role modelling of PA (times/week)	-	0.36 (−3.27, 4.00)	-	-
Paternal role modelling of PA (times/week)	-	0.54 (−3.54, 4.61)	-	-
Physical environment level				
Number of pieces of toys/ equipment to be physically active with at home (e.g., swings, slide)	-	0.57 (−1.15, 2.29)	-	-
Number of features at home (e.g., front fence, covered outdoor areas)	−2.51 (−9.95, 4.92)	−2.34 (−9.40, 4.72)	-	-
Lives on a cul-de-sac	11.70 (−1.26, 24.66)	-	-	-
Number of TVs at home	3.65 (−2.04, 9.34)	5.15 (−1.69, 11.99)	-	2.45 (−0.79, 5.70)

Table 2 Combined regression models[a] for correlates of screen time and sedentary time for boys and girls *(Continued)*

TV in child's bedroom	−1.74 (−23.72, 20.23)	27.14 (−5.49, 59.77)	-	-
Neighbourhood playground suitability (e.g., equipment, shade, safety)	0.11 (−1.10, 1.32)	−0.69 (−2.11, 0.73)	−0.69 (−1.51, 0.12)	-
Neighbourhood constraints to active transport (e.g., busy roads)	-	0.14 (−1.29, 1.57)	−0.26 (−0.96, 0.43)	-

Abbreviations: *BMI* body mass index, *CI* confidence interval, *PA* physical activity, *SB* sedentary behaviour, *TV* television
[a] All models adjusted for age, preschool/childcare attendance and clustering by centre of recruitment; [b] Reported as % for binary/categorical variables and mean (SD) for continuous variables; [c] Parents' self-reported height and weight, calculated using WHO classifications; bolded data indicates significance ($p < 0.05$); – indicates variable not included in combined model

consistently been shown to be inversely associated with screen time in preschool children [37–43]. This suggests that interventions and public health strategies to reduce sedentary behaviour could potentially give parents strategies to implement screen time rules, and in turn increase parental self-efficacy to limit screen time.

Consistent with research in school-aged children [17], there were a higher number of parent demographic correlates of girls' compared to boys' screen time: maternal ethnicity and paternal education were both associated with girls' screen time, while there were no parent demographic correlates associated with boys' screen time. Conversely, there were a larger number of parental influences in the social level of the ecological model associated with boys' compared to girls' screen time. If parents reported that they get bored watching their child play in outdoor spaces, boys spent around 14 min less per day in screen time. It may be that these children have higher levels of physical activity (and therefore potentially lower levels of screen time) so their parents get bored watching for long periods of time.

Many of the associations identified in this study were relatively modest in magnitude e.g., a seven minutes less screen time for every additional hour of sleep. However, when considered in light of screen time recommendations for this age group (i.e., one hour or less per day), seven minutes equates to around 12% of this time. Given that there is evidence of a dose-response for increased screen time and poorer cognitive development and psychological health [4], even modest decreases in screen time may have significant health benefits in early childhood. Additionally, it is important to note that the magnitude of associations seen in the current study are the average for the sample, but across the population may be important for public health.

Consistent with previous research [15, 19], the current study found that the correlates of both screen time and sedentary time differ between boys and girls. These findings suggest that future research should recruit samples that are sufficiently large to ensure adequate power to stratify analyses by sex. Additionally, future interventions would benefit from using sex-specific strategies to reduce time in these behaviours. Despite these differences in correlates, results from this study show that preschool boys and girls spend similar amounts of time engaging in screen time and sedentary time. Previous reviews have consistently found that child sex is not associated with screen time in this population [13, 14, 44]. However, there is an indeterminate association between child sex and sedentary time, with some studies finding that preschool girls are more sedentary than boys [15, 45, 46] and others finding no association [47, 48]. Given that girls are consistently shown to be more sedentary than boys in research involving school-aged children and adolescents [49], it may be that the sex-difference in sedentary time increases as children age. This suggests that girls may particularly benefit from early intervention.

There were several strengths to this study including the use of accelerometers to objectively assess sedentary time. Additionally, this study included a wide range of potential correlates covering multiple domains of the ecological model, with the parent survey purpose-designed to cover these domains and tested for reliability [33]. Despite the low response rate (11%), the sample was large and recruited across low-, mid- and high-socioeconomic areas. Demographic characteristics were comparable with 2011 national census data; e.g., 70% of parents vs 70% of adults born in Australia, 67% of parents vs 58% of adults with post-secondary qualifications [50]. However, results may be specific to suburban Melbourne and may not be generalizable to rural areas or other cities or countries. The cross-sectional design of the study prohibits inference of causality; future studies would benefit from employing a longitudinal design to determine causality.

Future work would also benefit from including sedentary behaviours beyond just screen time. Currently, very little is known about other, non-screen based sedentary behaviours that may have positive physical, mental and cognitive health effects (e.g., reading, quiet play). Having a better understanding of the factors associated with these other types of sedentary behaviour would help inform public health messages and interventions to reduce time in unfavourable sedentary behaviours. The current study does identify a number of modifiable factors that are associated with both screen time and sedentary time in preschool children. In particular, parental factors such as self-efficacy, modelling, and screen time rules could be potential targets for future interventions.

Conclusions

Contrary to public health recommendations, preschool children are spending large amounts of time engaging in screen and sedentary time. Few common correlates exist for screen time and sedentary time suggesting that different strategies to reduce screen time and sedentary time in this population are needed. Similarly, there were a number of different correlates for boys and girls, signifying that sex-specific strategies may be required to reduce sedentary behaviours. Parental correlates (such as self-efficacy and screen time rules) identified in this study are modifiable and could potentially be targeted in interventions and public health strategies to reduce sedentary behaviour in preschool children.

Additional file

Additional file 1: Table S1. Potential correlates of sedentary time and screen time included in individual models. (DOCX 22 kb)

Abbreviations

BMI: Body mass index; CI: Confidence interval; E-games: Electronic games; HAPPY: Healthy active preschool and primary years; LGA: Local government area; MET: Metabolic equivalent of task; PA: Physical activity; SB: Sedentary behaviour; TV: Television; VIF: Variance inflation factor

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Availability of data and materials

The questionnaire and datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.

Authors' contributions

KLD provided substantial contributions to the intellectual content of the article in analysis and interpretation of the data, drafting and revision of the manuscript; TH, JS and KDH provided substantial contributions to the conception, design and implementation of the study and critically revised the article for interpretation of the data and intellectual content; JAH critically revised the article for interpretation of the data and intellectual content. All authors read and approved the final manuscript.

Competing interests

The authors declare that they have no competing interests.

Consent for publication

Not applicable.

Ethics approval and consent to participate

Ethics approval for the HAPPY Study was granted by the Deakin University Human Research Ethics Committee (EC 291–2007) and the Australian Government Department of Education and Early Childhood Development (2008/196). Participants provided written informed consent for themselves and their children to participate in the study.

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Additional file 1: Table S1 Potential correlates of sedentary time and screen time included in individual models

Variable[a]	Used in analyses
Individual domain	
Demographic and family profile	
Child disability/poor health	Binary: yes, no
Child's birth parents live together	Recoded as dichotomous: other situation (ref), parents live together
Child sleep duration (hours)	Continuous: sum of usual night time sleep and day time naps
Child has siblings	Recoded as dichotomous: child does not have siblings (ref), child has siblings
Child BMI category[b]	Dichotomous: underweight/healthy weight, overweight/obese
Maternal age (years)	Continuous
Mother born in Australia	Recoded as dichotomous: other country (ref), Australia
Maternal BMI category[c]	Categorical: normal weight, overweight, obese
Mother in paid employment	Recoded as dichotomous: not employed (ref), employed full/part time
Maternal disability/poor health	Binary: no (ref), yes
Maternal education	Recoded as categorical: year 10 or equivalent (ref), year 12/ trade/apprenticeship/diploma, university degree or higher
Low income status (health care/pension card)	Binary: no (ref), yes
Paternal age (years)	Continuous
Father born in Australia	Recoded as dichotomous: other country (ref), Australia
Paternal BMI category[c]	Categorical: normal weight, overweight, obese
Father in paid employment	Recoded as dichotomous: not employed (ref), employed full/part time
Paternal disability/poor health	Binary: no (ref), yes
Paternal education	Recoded as categorical: year 10 or equivalent (ref), year 12/ trade/apprenticeship/diploma, university degree or higher
Child PA and SB	
Usual frequency of active transport per week(e.g., ride a bike to kinder)	Continuous: times per week; summed score of 6 active transport items
Usual frequency of non-organised activities per week (e.g., play in the backyard)	Continuous: times per week; summed score of 7 non-organised activity items
Number of organised activities per week (e.g., swimming, tennis)	Continuous: times per week; summed score of 6 organised activity items
Playgroup attendance	Binary: no (ref), yes
Average outdoor play time hours/day (week and weekend day)	Continuous
Child personality, preferences and constraints	
Child active co-participation preferences (e.g., child is active by him/herself, child is active with his/her friends)	Continuous: summed score of 4 items
Child is active for longer with someone else	Recoded as dichotomous: disagree (ref), agree
Child is competitive with other children when being active	Recoded as dichotomous: disagree (ref), agree

Child prosocial physical activity behaviour (e.g., asks for opportunities to be active)	Continuous: summed score of 5 items
Child preferences for sedentary behaviour (e.g., more likely to watch TV than be active)	Continuous: summed score of 3 items
Child constraints to physical activity (e.g., too tired to do more physical activity)	Categorical: summed score of 10 items
Social level	
Parental influence	
Parental concerns about PA/SB	Continuous: summed score of 4 items
Parental constraints to child's PA	Continuous: summed score of 6 items
Prefer indoor to outdoor play spaces	Recoded as dichotomous: disagree (ref), agree
Parent likes to participate in outdoor play	Recoded as dichotomous: disagree (ref), agree
Parent prefers to be social with other parents	Recoded as dichotomous: disagree (ref), agree
Parent gets bored watching	Recoded as dichotomous: disagree (ref), agree
Parent likes child to do activities of older children	Recoded as dichotomous: disagree (ref), agree
Parent likes child to do activities they did as a child	Recoded as dichotomous: disagree (ref), agree
Parent gets bored going to the same place	Recoded as dichotomous: disagree (ref), agree
Parent believes it's important to be active as a family	Recoded as dichotomous: disagree (ref), agree
Parental self-efficacy to support PA	Continuous: summed score of 2 items
Parental self-efficacy to limit SB	Continuous: summed score of 3 items
Parental health knowledge/beliefs of child's physical activity	Continuous: summed score of 3 items
Rules and boundaries	
Parental rules to limit screen time	Continuous: summed score of 2 items
Parental rules about games inside (e.g., no throwing balls inside)	Continuous: summed score of 2 items
Parental rules about PA for stranger danger, traffic, injury	Continuous: summed score of 2 items
Parent allows child to play freely in backyard/street	Continuous: summed score of 2 items
Parent takes child outside to play if inside too long	Recoded as dichotomous: disagree (ref), agree
Parent switches off screen entertainment	Continuous: summed score of 2 items
Social interaction and support	
Child is active at social gatherings	Continuous: summed score of 3 items
Maternal PA emotional support child	Continuous (times/week)
Paternal PA emotional support child	Continuous (times/week)
Modelling of PA	
Maternal time in PA per week (hours/week)	Continuous
Paternal time in PA per week (hours/week)	Continuous
Maternal TV viewing (hours/week)	Continuous
Paternal TV viewing (hours/week)	Continuous
Maternal role modelling for child PA	Continuous (times/week)
Paternal role modelling for child PA	Continuous (times/week)
Physical environment level	
Dog ownership	Binary: no (ref), yes
Number of pieces of toys/equipment to be physically active with at home (e.g., swings, slide)	Continuous
Lives on medium/large block	Recoded as dichotomous: small/none (ref), medium/large

Number of features at home (e.g., front fence, covered outdoor areas)	Continuous
Lives on a cul-de-sac	Binary: no (ref), yes
Number of pieces of electronic equipment at home (e.g., DVD player, PlayStation)	Continuous
Number of TVs at home	Continuous
TV in child's bedroom	Binary: no (ref), yes
Computer/e-games in child's bedroom	Binary: no (ref), yes
Neighbourhood playground suitability (e.g., equipment, shade, safety)	Continuous: summed score of 6 items
Neighbourhood constraints to active transport (e.g., busy roads)	Continuous: summed score of 7 items
Total frequency of visiting active places per week	Continuous: summed score of 10 items

Notes: [a] Unless otherwise stated, all measures are assessed by parental proxy-report survey; [b] Directly measured height and weight, calculated using Cole et al. classifications; [c] Parents' self-reported height and weight, calculated using WHO classifications

Abbreviations: BMI = body mass index; e-games = electronic games; PA = physical activity; SB = sedentary behaviour; TV = television

CHAPTER SIX

Paper Three: A mobile technology intervention to reduce sedentary behaviour in 2- to 4-year-old children (Mini Movers): study protocol for a randomised controlled trial

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6.1 Introduction

Chapter Three identified a number of gaps in the existing literature describing interventions to reduce sedentary behaviour in early childhood. For example, few interventions have been conducted outside the preschool/childcare setting. In addition, findings from that study suggest that parental involvement in interventions with young children seems to be important for behaviour change.

Many of the interventions included in that review also had limited potential for scalability. The use of text messages, or short message services (SMS), may help to overcome this limitation. Text messages offer a wide-reaching, low-cost channel for the delivery of behaviour change interventions (Fjeldsoe, Marshall &

Miller 2009). Text message interventions have previously focused predominantly on preventative health behaviours in adults (e.g., smoking cessation) (Fjeldsoe, Marshall & Miller 2009). Recently, text message interventions have focused more on behaviour change, e.g., to improve health behaviours (diet and physical activity) of pregnant women (Willcox et al. 2017) and to increase physical activity in postnatal women (Fjeldsoe, Miller & Marshall 2010). Children's behaviour change interventions utilising text messaging have focused largely on older children/adolescents and clinical populations (e.g., children with type 1 diabetes) (Militello, Kelly & Melnyk 2012). The feasibility of using text messages in interventions targeting parents of school-aged children has been reported in studies aiming to increase physical activity (Newton et al. 2014), to reduce child body mass index (BMI; by targeting sugar-sweetened beverage reduction, increased physical activity, eating meals at home, and increased vegetable consumption) (Armstrong et al. 2017), and for monitoring health behaviours (i.e., diet, screen time and physical activity (Shapiro et al. 2008).

Only one pilot intervention using text messages has been identified that targets parents of preschool children. The intervention, delivered largely via text messages to parents of overweight and obese preschoolers (focusing on healthy lifestyles), showed significant improvements in parental knowledge around nutrition and physical activity (Militello et al. 2016). Additionally, it was reported to be feasible and acceptable for parents, suggesting that this delivery mode may hold promised for parents of young children. A qualitative study with low socio-economic mothers in urban and regional areas in Victoria, Australia found that the majority of mothers would be happy to receive text messages with information about children's play and screen time (Downing et al. 2016a).

Chapter Five utilised data from a large cohort of preschool children to identify correlates of screen time and sedentary time, which may be targeted as potential mediators of behaviour change in future interventions. Examples of the modifiable correlates identified in that study include parental self-efficacy to limit screen time and rules around screen time. As such, incorporating the findings from Chapters Three and Five, a novel intervention was developed to support parents in reducing the amount of time their 2- to 4-year-old child spends in a range of sedentary behaviours.

The following chapter introduces the Mini Movers program and describes in detail the rationale and methodology. This protocol paper has been published in Trials (Impact factor: 1.969) as:

Downing KL, Salmon J, Hinkley T, Hnatiuk JA, Hesketh KD. A mobile technology intervention to reduce sedentary behaviour in 2- to 4-year-old children (Mini Movers): study protocol for a randomised controlled trial. Trials 2017:18(1);97.

The Authorship Statement for this manuscript is contained in Appendix S.

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Trials

STUDY PROTOCOL Open Access

A mobile technology intervention to reduce sedentary behaviour in 2- to 4-year-old children (Mini Movers): study protocol for a randomised controlled trial

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Abstract

Background: Sedentary behaviour (e.g. television viewing, sitting time) tracks over time and is associated with adverse health and developmental outcomes across the lifespan. Young children (5 years or younger) spend up to 12 h/day sedentary, of which around 2 h is spent in screen time (e.g. watching television). Interventions to reduce sedentary behaviour in early childhood report mixed results and many have limited potential for scalability. Mobile phones offer a wide-reaching, low-cost avenue for the delivery of health behaviour programmes to parents but their potential to reduce young children's sedentary behaviour has not been widely tested. This study aims to test the feasibility and efficacy of a parent-focused, predominantly mobile telephone-delivered intervention to support parents to minimise the amount of time their child spends using screens and in overall sitting time.

Methods/design: Mini Movers is a pilot randomised controlled trial recruiting 100 parents and children. Inclusion criteria include having a child aged between 2 and 4 years, being able to speak, read and write English, and smartphone ownership. Participants will be randomised to the intervention or a wait-list control group at a 1:1 ratio. Intervention group parents will receive printed materials including a content booklet and goal-checking magnet and will participate in a one-on-one discussion with the interventionist to plan two goals to reduce their child's sedentary behaviour. Subsequently, the intervention will be delivered over 6 weeks via personalised and interactive text messages promoting positive health behaviours (strategies for decreasing screen time and overall sitting time), goal setting and self-monitoring. Outcomes to be assessed include intervention feasibility and children's screen time and objectively-assessed sitting time.

Discussion: Few studies have used mobile phone technology to deliver health behaviour programmes to parents of young children. Findings will inform the development of larger-scale interventions to reduce sedentary behaviour during early childhood.

Trial registration: Australian New Zealand Clinical Trials registry, identifier: ACTRN12616000628448. Prospectively registered on 16 May 2016.

Keywords: Sedentary behaviour, Screen time, Television viewing, Sitting time, Early childhood, Randomised controlled trial, mHealth, Text messaging, SMS

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Background

High levels of sedentary behaviour have been associated with adverse health and developmental outcomes across the lifespan [1–4]. Some sedentary behaviours, such as television viewing, have been shown to track over time [5, 6], with early childhood (i.e. birth through 5 years) being recognised as a critical period in which sedentary behaviour habits are established [7]. Guidelines for sedentary behaviour in Australia and internationally recommend that children aged 2 to 5 years should have less than 1 h per day of screen time [8, 9]. Additionally, it is recommended that situations that restrict movement, i.e. in a car seat, stroller or high chair, should be minimised for children aged 5 years and younger [8–10]. Research has shown that 2- to 5-year-old children are spending on average 2 h per day in screen time [11–14], with only around a quarter of these children meeting current recommendations of 1 h or less per day [11, 12, 15]. Children of this age are also spending up to 12 h per day in any form of sedentary behaviour when assessed objectively [16], and approximately 2 h per day in situations that restrict movement [17]. This suggests that there is considerable scope to reduce sedentary behaviour in young children. Feasible, acceptable and effective interventions are required during the early childhood period, prior to the establishment of less than optimal levels of sedentary behaviour.

A recent review of interventions to reduce screen time in children younger than 12 years identified 47 studies, of which only 13 targeted children under the age of 6 years [18]. All of the studies targeting young children were conducted in the United States and the majority (11 studies) were delivered in either preschools or clinic- and Women, Infant and Children (WIC)-based (federally assisted programs for low-income mothers and children in the United States) settings, with the remaining two conducted in the home [18]. Schmidt et al. noted that the largest reductions in television viewing across all studies (i.e. all age groups) were seen in home-based settings, and suggested that high levels of parental involvement are important for intervention effectiveness [18]. An earlier review of obesity-prevention interventions during early childhood similarly suggested that the lack of parental involvement in preschool interventions may explain the lack of significant results [19]. Findings from Schmidt et al. [18] highlight the relative paucity of interventions in early childhood, and also the need for interventions that are scalable and have large reach.

Given the rapid and wide adoption of mobile phone usage across most adult age and demographic groups [20], health behaviour programmes are increasingly being delivered by mobile phone technology [21]. In particular, text messages, or short message services (SMS), are considered to be a wide-reaching, low-cost channel for the delivery of health behaviour programs [22]. Text messages are also instantaneous and convenient, in that individuals can read them in their own time. Moreover, they can be individually tailored, which has been shown to have positive effects on behaviour change and reduces attrition [22]. However, to date, text message interventions have largely focused on preventative health behaviours in adults, such as smoking cessation, and clinical care [22]. Few studies have used text messages in programs targeting child and adolescent health behaviours [23]. However, a recent pilot intervention delivered largely via text messages to parents, that focused on healthy lifestyle behaviours for overweight and obese preschoolers, showed significant improvements in parental knowledge around nutrition and physical activity [24]. Moreover, the intervention was found to be both feasible and acceptable for parents of young children [24] suggesting such delivery modes hold promise in this population group. Thus, the aim of this study is to test the feasibility and efficacy of a parent-focused, predominantly mobile telephone-delivered intervention to support parents to minimise the amount of time that their 2–4-year-old children spend in sedentary behaviour.

Methods/design

Overview

This protocol describes a two-armed, pilot randomised controlled trial (RCT) to evaluate the feasibility and efficacy of a parent-focused, predominantly mobile phone-delivered intervention to reduce sedentary behaviour in 2- to 4-year-old children. The protocol is guided by the Standard Protocol Items: Recommendations for Interventional Trials (SPIRIT) statement [25] and the Consolidated Standards of Research Trials (CONSORT) – EHEALTH guidelines [26, 27]; Additional file 1: shows the completed SPIRIT Checklist (see Additional file 1). Figure 1 provides an overview of the schedule for enrolment, interventions and assessments [25].

Recruitment

Participants will be recruited in Melbourne, Australia through existing playgroups, parent-focused websites and social media, and snowball sampling.

Playgroups

In Australia, playgroups are informal gatherings for parents, caregivers and their children prior to the commencement of primary school [28]. In addition to providing opportunities for children to interact, play and develop, playgroups also provide a supportive environment for parents to share experiences about parenting [28]. Hence, they may provide an ideal setting for recruiting parents for child behaviour interventions, as parents may be more receptive in a setting where other child or

	Enrolment	Baseline	Allocation	Intervention	Close-out
TIMEPOINT	*0*	t_1			t_2
ENROLMENT:					
Eligibility screen	X				
Informed consent	X				
Allocation			X		
INTERVENTIONS:					
Mini Movers Program					
ASSESSMENTS:					
Sample demographics, child sitting and screen time, parent behaviours, knowledge and self-efficacy		X			
Child sitting and screen time, parent behaviours, knowledge and self-efficacy		X			X

Fig. 1 Schedule of enrolment, interventions and assessments

parenting issues are usually discussed. The Playgroup Victoria public website (http://www.playgroup.org.au) provides names and contact details for the lead parents and/or playgroup leaders of playgroups across the state. Playgroups within a 10-km radius from the study site (Deakin University, Burwood Campus, Melbourne, Australia) will be identified via the website and randomly selected. Lead parents/playgroup leaders will be contacted by email and/or phone initially to gauge interest in the intervention programme and determine if the families attending the playgroup meet the inclusion criteria for the study. If the leader expresses interest and families appear to be eligible, a researcher will visit the playgroup to explain the study to the parents and provide them with plain language statements, Consent Forms and contact details of the research team. Parents will be able to provide written consent on the day of the recruitment visit, or will be able to return their consent form by email, post or in person at the baseline visit the following week. Alternatively, for more structured playgroups where a recruitment visit may not be possible, flyers with brief programme information will be delivered for playgroup leaders to hand out to parents. Interested parents will then be able to contact the research team directly for more information.

Websites and social media

Individuals and organisations that provide services to, or work, volunteer or collaborate with, the target population (i.e. parents with young children; e.g. reputable parenting blogs) will be contacted and asked to post information about the study on their website, community groups, blog or social media (e.g. Twitter, Facebook). Information on websites and social media will be the same as that included on the flyer and will instruct parents who are interested in participating to contact the research team directly for more information.

Snowball sampling

Parents participating in the programme will be asked to pass on the details of the study and research team to any friends that may be interested in participating. Interested parents will be able to contact the research team directly for more information.

Inclusion criteria

Parents will be eligible to participate if they have a child aged 2 through 4 years, are able to freely give informed consent, can speak, read and write fluent English and own a mobile phone.

Sample size

As this is a pilot study, a sample of 100 participants will be recruited. This sample size will provide feasibility data for the critical recruitment and compliance parameters and also for the estimation of the standard deviation of sitting time and screen time (both continuous variables) [29].

Randomisation

Participants will be randomised to the intervention or wait-list control at a 1:1 ratio after baseline data collection. If more than one parent is recruited in a playgroup, randomisation will occur at the group level to avoid potential contamination. A computer-generated random number schedule will be developed by a researcher (not part of the research team) who has no contact with the participants. Allocation will be concealed by sealed, opaque envelopes, which will be opened and revealed to the researcher and participant(s) after baseline data collection to minimise selection and measurement bias.

Mini Movers intervention

Intervention content

The intervention content for Mini Movers was developed based on evidence-based guidelines for sedentary behaviour and active play in early childhood [8], and guided by the CALO-RE taxonomy of behaviour change techniques [30] and Social Cognitive Theory [31]. The intervention comprises a content booklet, a one-on-one goal-setting discussion with the interventionist, and regular, personalised text messages for a period of 6 weeks. Intervention strategies focus on increasing parental knowledge, building self-efficacy, setting goals and providing reinforcement. Table 1 presents intervention strategies mapped to theoretical constructs.

Intervention materials After baseline measures have been completed and randomisation has taken place, participants in the intervention group will receive their intervention materials, including a content booklet, goal-checking magnet and a Move and Play Every Day: National Physical Activity Recommendations for Child 0–5 Years brochure [8]. The content booklet provides an overview of the Mini Movers programme and text messages that parents will receive, suggests ideas for reducing sedentary behaviour and increasing active play, and introduces goal setting. At this time, participants will have a one-on-one discussion with the interventionist to set their goals. Participants will be asked to set two goals around their child's sedentary behaviour; specifically, one screen time goal (e.g. to limit their child's screen time to 60 min per day) and one overall sedentary behaviour goal (e.g. to walk to local destinations without the pram on 3 days per week). The interventionist will assist participants in identifying and setting SMART (Specific, Measurable, Attainable, Relevant and Time-bound) goals. The goal-checking magnet provided to participants was designed to help track their progress with their two goals for the duration of the programme (6 weeks).

Text messages Personalised, interactive text messages will be the main mode of delivery for the intervention. Participants will receive four text messages per week for 6 weeks (24 texts in total). The text messages will include ideas for limiting and displacing their child's screen and sitting time, active play ideas, and monitoring and encouraging achievement of individual goals. Some text messages will include links to reputable websites for further information.

The text messages will be tailored to the participant's name, child's name, behaviour goals and the

Table 1 Intervention strategies mapped to theoretical constructs

Strategies	Theoretical constructs
Provide parents with evidence-based guidelines for sedentary behaviour	SCT: Knowledge
Provide parents with ideas for minimising sedentary behaviour (e.g. changing activities such as drawing or painting from sitting down to standing up, setting screen time rules, removing screens from bedrooms, leading by example)	SCT: Self-efficacy CALO-RE: Provide instruction on how to perform the behaviour CALO-RE: Environmental restructuring CALO-RE: Prompt identification as role model/position advocate
Provide parents with alternatives to sedentary behaviour (e.g. new activities to try, providing practical ideas for entertaining children when cooking dinner)	SCT: Knowledge SCT: Self-efficacy SCT: Access CALO-RE: Provide information on *where and when* to perform the behaviour CALO-RE: Provide instruction on how to perform the behaviour
Assist parents to set goals to reduce screen time and overall sitting time (e.g. to limit their child's screen time to 30 min per day)	SCT: Goal setting CALO-RE: Goal setting (behaviour)
Educate parents about benefits of reducing sedentary behaviour and increasing active play (e.g. detrimental effects of screen time on sleep, benefits of active play on development)	SCT: Knowledge CALO-RE: Provide information on consequences of behaviour in *general*
Provide parents with a goal-checking magnet to monitor their progress with their goals	CALO-RE: Prompt self-monitoring of behaviour
Send weekly goal-check SMS	CALO-RE: Prompt review of behavioural goals
Provide parents with positive reinforcement and suggest rewards (e.g. an afternoon in the park with their child) when goals are met	CALO-RE: Prompt rewards contingent on effort or progress towards behaviour SCT: Reinforcement

SCT social cognitive theory, *SMS* short message service interventionist's name, as evidence suggests that personalisation of text message programs encourages behaviour change and reduces attrition [22]. Text messages will be sent on specific dates at specific times. Participants will be asked to nominate a preferred time of day to receive messages (e.g. early morning, late afternoon); however, some text messages are designed to be delivered at specific times of the day to coincide with specific activities (e.g. ideas for keeping their child entertained without screens whilst cooking dinner). Examples of the text messages include: "Hi «parent». We know that entertaining «child» can be difficult sometimes without using the TV or other screens. Check out this picture for some ideas! «link». Mini Movers"; and "«Parent», get «child» to help make some playdough! Here's a great recipe with no cooking required: «link». Remember, encourage «child» to stand up while playing with it! Mini Movers". Two-way texting will be used for the goal monitoring. This will require participants to respond to the message enquiring as to whether they met their goal, to which the researchers will reply with a predefined response, depending on whether the goals were achieved or not.

Wait-list control

Participants randomised to the wait-list control group will receive the full intervention (i.e. goal-setting discussion, content booklet, goal-checking magnet and text messages) after post-intervention assessments have been completed.

Measures

The primary outcome of this trial is feasibility, which will be measured with programme metrics, recruitment, and participant self-reported data post-intervention. The secondary outcomes are children's objectively measured sitting time and parent-reported screen time, and parent behaviours, knowledge and self-efficacy for limiting their child's sedentary behaviour assessed pre and post intervention (Fig. 2). Children's sitting time will be measured objectively using *activ*PAL™ accelerometers worn pre and post intervention. All other secondary outcomes, potential mediators and demographics (apart from the

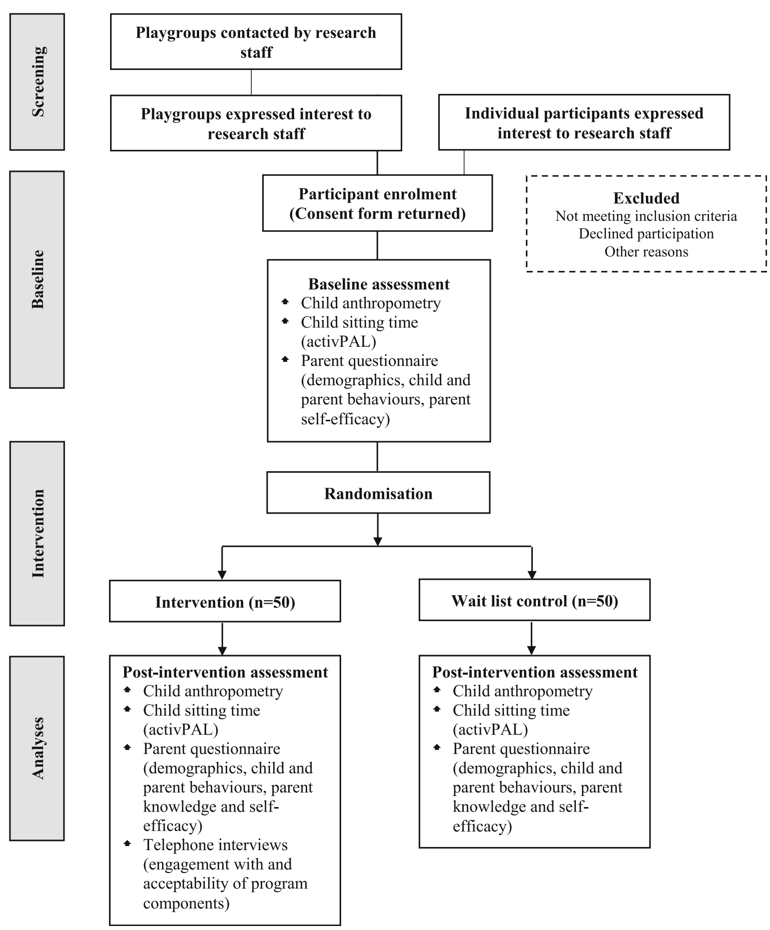

Fig. 2 Trial flow diagram

child's Body Mass Index (BMI)) will be parental proxy-reported using an online survey delivered by Qualtrics (Qualtrics Labs, Provo, UT, USA), completed pre and post intervention.

Primary outcome

Feasibility will be measured by recruitment numbers, programme metrics and self-reported participant data, as described below. The process evaluation is informed by the Process-Evaluation Plan for Assessing Health Programme Implementation [32] and the e-CONSORT guidelines [27].

1. *Recruitment and retention.* Recruitment will be measured by: the proportion of playgroups interested in the study (i.e. the proportion of playgroups allowing a visit by the research team or distribution of flyers); the proportion of eligible parents within playgroups consenting; the number of parents recruited via social media and snowball sampling; and the time taken to recruit the sample. Retention will be measured by the proportion of participants providing measures at the end of the study
2. *Intervention delivery and fidelity.* Intervention delivery and fidelity, i.e. successful delivery to protocol, will be measured by system reports (e.g. delivered text messages), reports of technological difficulties (e.g. parent self-report of mobile phone downtimes, lack of Internet access) and auditing of protocol compliance in delivery of one-on-one goal-setting discussions by a single researcher
3. *Dose delivered and engagement in the intervention.* Dose and engagement will be measured by the number of replies to messages received from participants and participant self-reported usage of and engagement with different components of the intervention (reported in the post-intervention survey). A subsample of participants in the intervention group will also be invited to participate in qualitative telephone interviews (with a researcher other than the interventionist). Qualitative interviews will gain more insight into what components of the intervention parents found useful and what they liked or disliked about components of the program

Secondary outcomes

Children's objectively assessed sitting time Children will wear an *activ*PAL™ for seven consecutive days pre and post intervention to objectively measure sitting time. The *activ*PAL™ has been shown to be valid, reliable and feasible in young children [33]. The *activ*PAL™ will be worn in the middle of the anterior aspect of the right thigh; the monitors will be sewn into purpose-made pouches affixed to leggings/bike shorts with Velcro, to be worn underneath normal clothes. Data will be collected in 15-s epochs and non-wear time will be defined as 10 min of consecutive zero counts and removed from daily wear time [34]. Participants will be required to have at least 6 h of wear time on at least 4 days, including one weekend day [34]. Where possible, participants will be asked to re-wear the *activ*PAL™ if they have insufficient data.

Parent-reported sedentary behaviour and screen time Parents will report their child's usual time in the last week in a range of sedentary behaviours including sitting down for reading/quiet play/craft activities and situations that restrict movement (e.g. in a car seat or stroller). They will also be asked to report their child's usual time engaging in a range of screen-based behaviours (i.e. television viewing, computer use, electronic game use, smartphone and tablet computer use). Responses will be open (i.e. h/day and/or min/day) and the majority of items have previously established reliability [35].

Parent behaviours, knowledge and self-efficacy Parents will be asked to report their own frequency and duration in physical activity in the previous week using the Active Australia Survey [36] and their usual week and weekend day television viewing [37]. Parents will also report their co-participation in physical activity and sedentary behaviour with their child, knowledge around physical activity and sedentary behaviour in early childhood, self-efficacy for promoting physical activity and limiting sedentary behaviour for their child, and an audit checklist of the home physical activity and sedentary behaviour environment [35, 38].

Sample demographics Parents will be asked to report their own, their partner's (if applicable) and their child's demographic information (e.g. date of birth, parent education, parent employment status). Children's height and weight will be measured at baseline by trained researchers using a Wedderburn portable rigid stadiometer, Wedderburn Tanita portable digital scales, and standardised measurement procedures [39, 40]. BMI will be calculated by standard formula (weight in kilograms divided by height in meters squared); BMI categories (healthy weight, overweight, obese) will be determined using age- and sex-specific international cut-off points [41].

Statistical analysis

Analyses will be conducted using Stata 14 (StataCorp, College Station, TX, USA). Descriptive statistics will be used to describe the baseline characteristics of the sample. Feasibility and acceptability will be assessed using percentages and by analysing qualitative data, as appropriate. Linear and logistic regression will be used to determine the effect of the intervention on the secondary outcomes, controlling for potential confounders (e.g. child sex, age, BMI), baseline values and clustering by playgroup. Given the small sample size, effect sizes (Cohen's *d* and Hedges' *g*) will be calculated.

Discussion

This paper presents the protocol for a pilot RCT to determine the feasibility and efficacy of a parent-focused, predominantly mobile phone-delivered intervention to reduce sedentary behaviour in 2- to 4-year-old children. Existing interventions to reduce sedentary behaviour in early childhood are scarce and report mixed results; few have been conducted with parents outside the preschool setting and many have limited potential for scalability [18]. Mobile phones have been rapidly adopted across most demographic groups [20], and offer a wide-reaching, low-cost channel for the delivery of health behaviour programs. However, they have not been extensively used in health behaviour programs for parents of young children [23]. Hence, small-scale RCTs are required to determine whether interventions delivered in this way are acceptable, feasible and practical for both participants and researchers [42].

Strengths of the current pilot study include the use of an objective measure of children's sitting time and the large range of specific sedentary behaviours assessed (encompassing screen time, time spent restrained). In addition, the use of mobile phone technology to deliver the majority of the intervention content affords the potential for the intervention to be scaled-up and widely disseminated.

The findings of this study will be used to inform the development of larger-scale, mobile technology RCTs to support parents to minimise the amount of time their children spend in sedentary behaviour. Moreover, findings will contribute to the limited medical literature on interventions designed to support health behaviour during early childhood.

Trial status

The trial commenced recruitment in June 2016. There are 59 participants enrolled, with the trial due to be completed in March 2017.

Additional file

Additional file 1: SPIRIT Checklist. (DOCX 48 kb)

Abbreviations

BMI: Body Mass Index; CONSORT: Consolidated Standards of Research Trials; RCT: Randomised controlled trial; SMS: Short message services; SPIRIT: Standard Protocol Items: Recommendations for Interventional Trials

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Availability of data and materials

Not applicable.

Authors' contributions

KLD conceived the study, composed the content for the intervention, drafted the manuscript and is the project manager/interventionist. JS, TH, JAH and KDH provided substantial contributions to the conception, design and content of the study and reviewed and critically appraised the manuscript. All authors read and approved the final manuscript.

Competing interests

The authors declare that they have no competing interests.

Consent for publication

Not applicable.

Ethics approval and consent to participate

The study has been approved by the Deakin University Human Research Ethics Committee (2016-103). Written, informed consent from parents and verbal assent from children will be received.

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SPIRIT

STANDARD PROTOCOL ITEMS: RECOMMENDATIONS FOR INTERVENTIONAL TRIALS

SPIRIT 2013 Checklist: Recommended items to address in a clinical trial protocol and related documents*

Section/item	Item No	Description	Addressed on page number
Administrative information			
Title	1	Descriptive title identifying the study design, population, interventions, and, if applicable, trial acronym	1
Trial registration	2a	Trial identifier and registry name. If not yet registered, name of intended registry	3
	2b	All items from the World Health Organization Trial Registration Data Set	n/a
Protocol version	3	Date and version identifier	n/a
Funding	4	Sources and types of financial, material, and other support	4
Roles and responsibilities	5a	Names, affiliations, and roles of protocol contributors	4
	5b	Name and contact information for the trial sponsor	n/a
	5c	Role of study sponsor and funders, if any, in study design; collection, management, analysis, and interpretation of data; writing of the report; and the decision to submit the report for publication, including whether they will have ultimate authority over any of these activities	n/a
	5d	Composition, roles, and responsibilities of the coordinating centre, steering committee, endpoint adjudication committee, data management team, and other individuals or groups overseeing the trial, if applicable (see Item 21a for data monitoring committee)	n/a

Introduction			
Background and rationale	6a	Description of research question and justification for undertaking the trial, including summary of relevant studies (published and unpublished) examining benefits and harms for each intervention	4-5
	6b	Explanation for choice of comparators	n/a
Objectives	7	Specific objectives or hypotheses	5
Trial design	8	Description of trial design including type of trial (eg, parallel group, crossover, factorial, single group), allocation ratio, and framework (eg, superiority, equivalence, noninferiority, exploratory)	6
Methods: Participants, interventions, and outcomes			
Study setting	9	Description of study settings (eg, community clinic, academic hospital) and list of countries where data will be collected. Reference to where list of study sites can be obtained	6
Eligibility criteria	10	Inclusion and exclusion criteria for participants. If applicable, eligibility criteria for study centres and individuals who will perform the interventions (eg, surgeons, psychotherapists)	8
Interventions	11a	Interventions for each group with sufficient detail to allow replication, including how and when they will be administered	9-11
	11b	Criteria for discontinuing or modifying allocated interventions for a given trial participant (eg, drug dose change in response to harms, participant request, or improving/worsening disease)	n/a
	11c	Strategies to improve adherence to intervention protocols, and any procedures for monitoring adherence (eg, drug tablet return, laboratory tests)	11
	11d	Relevant concomitant care and interventions that are permitted or prohibited during the trial	n/a
Outcomes	12	Primary, secondary, and other outcomes, including the specific measurement variable (eg, systolic blood pressure), analysis metric (eg, change from baseline, final value, time to event), method of aggregation (eg, median, proportion), and time point for each outcome. Explanation of the clinical relevance of chosen efficacy and harm outcomes is strongly recommended	11-14
Participant timeline	13	Time schedule of enrolment, interventions (including any run-ins and washouts), assessments, and visits for participants. A schematic diagram is highly recommended (see Figure)	Figure 1

Sample size	14	Estimated number of participants needed to achieve study objectives and how it was determined, including clinical and statistical assumptions supporting any sample size calculations	8
Recruitment	15	Strategies for achieving adequate participant enrolment to reach target sample size	6-7
Methods: Assignment of interventions (for controlled trials)			
Allocation:			
Sequence generation	16a	Method of generating the allocation sequence (eg, computer-generated random numbers), and list of any factors for stratification. To reduce predictability of a random sequence, details of any planned restriction (eg, blocking) should be provided in a separate document that is unavailable to those who enrol participants or assign interventions	8
Allocation concealment mechanism	16b	Mechanism of implementing the allocation sequence (eg, central telephone; sequentially numbered, opaque, sealed envelopes), describing any steps to conceal the sequence until interventions are assigned	8
Implementation	16c	Who will generate the allocation sequence, who will enrol participants, and who will assign participants to interventions	8
Blinding (masking)	17a	Who will be blinded after assignment to interventions (eg, trial participants, care providers, outcome assessors, data analysts), and how	n/a
	17b	If blinded, circumstances under which unblinding is permissible, and procedure for revealing a participant's allocated intervention during the trial	n/a
Methods: Data collection, management, and analysis			
Data collection methods	18a	Plans for assessment and collection of outcome, baseline, and other trial data, including any related processes to promote data quality (eg, duplicate measurements, training of assessors) and a description of study instruments (eg, questionnaires, laboratory tests) along with their reliability and validity, if known. Reference to where data collection forms can be found, if not in the protocol	12-14
	18b	Plans to promote participant retention and complete follow-up, including list of any outcome data to be collected for participants who discontinue or deviate from intervention protocols	n/a

Data management	19	Plans for data entry, coding, security, and storage, including any related processes to promote data quality (eg, double data entry; range checks for data values). Reference to where details of data management procedures can be found, if not in the protocol	Covered in ethics submission and consent form
Statistical methods	20a	Statistical methods for analysing primary and secondary outcomes. Reference to where other details of the statistical analysis plan can be found, if not in the protocol	15
	20b	Methods for any additional analyses (eg, subgroup and adjusted analyses)	15
	20c	Definition of analysis population relating to protocol non-adherence (eg, as randomised analysis), and any statistical methods to handle missing data (eg, multiple imputation)	n/a
Methods: Monitoring			
Data monitoring	21a	Composition of data monitoring committee (DMC); summary of its role and reporting structure; statement of whether it is independent from the sponsor and competing interests; and reference to where further details about its charter can be found, if not in the protocol. Alternatively, an explanation of why a DMC is not needed	DMC is comprised of the authors
	21b	Description of any interim analyses and stopping guidelines, including who will have access to these interim results and make the final decision to terminate the trial	No stopping guidelines with low-risk trial
Harms	22	Plans for collecting, assessing, reporting, and managing solicited and spontaneously reported adverse events and other unintended effects of trial interventions or trial conduct	No risk of harm is foreseen
Auditing	23	Frequency and procedures for auditing trial conduct, if any, and whether the process will be independent from investigators and the sponsor	12
Ethics and dissemination			
Research ethics approval	24	Plans for seeking research ethics committee/institutional review board (REC/IRB) approval	6

Protocol amendments	25	Plans for communicating important protocol modifications (eg, changes to eligibility criteria, outcomes, analyses) to relevant parties (eg, investigators, REC/IRBs, trial participants, trial registries, journals, regulators)	Modifications will be reported to trial registry, ethics committee and participants
Consent or assent	26a	Who will obtain informed consent or assent from potential trial participants or authorised surrogates, and how (see Item 32)	16
	26b	Additional consent provisions for collection and use of participant data and biological specimens in ancillary studies, if applicable	n/a
Confidentiality	27	How personal information about potential and enrolled participants will be collected, shared, and maintained in order to protect confidentiality before, during, and after the trial	Covered in consent form
Declaration of interests	28	Financial and other competing interests for principal investigators for the overall trial and each study site	17
Access to data	29	Statement of who will have access to the final trial dataset, and disclosure of contractual agreements that limit such access for investigators	Covered in ethics submission and consent form
Ancillary and post-trial care	30	Provisions, if any, for ancillary and post-trial care, and for compensation to those who suffer harm from trial participation	n/a
Dissemination policy	31a	Plans for investigators and sponsor to communicate trial results to participants, healthcare professionals, the public, and other relevant groups (eg, via publication, reporting in results databases, or other data sharing arrangements), including any publication restrictions	Covered in ethics submission and consent form
	31b	Authorship eligibility guidelines and any intended use of professional writers	17
	31c	Plans, if any, for granting public access to the full protocol, participant-level dataset, and statistical code	n/a
Appendices			
Informed consent materials	32	Model consent form and other related documentation given to participants and authorised surrogates	n/a

Biological specimens	33	Plans for collection, laboratory evaluation, and storage of biological specimens for genetic or molecular analysis in the current trial and for future use in ancillary studies, if applicable	n/a

CHAPTER SEVEN

Paper Four: Feasibility and efficacy of Mini Movers: a parent-focused, text message delivered pilot randomised controlled trial to reduce sedentary behaviour in 2- to 4-year-old children

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7.1 Introduction

Chapter Six described the rationale and protocol for a pilot randomised controlled trial (RCT) to test the feasibility and efficacy of the Mini Movers program, designed to support parents to reduce the amount of time their children spend being sedentary.

The primary outcome of the trial was feasibility, measured by recruitment, retention, program metrics, and both quantitative and qualitative measures of participants' usage and enjoyment of the program. Secondary outcomes were child sedentary behaviour (including screen time, time spent in situations that restrict movement, and overall sitting time) and potential mediators of behaviour change (e.g., parent self-efficacy to reduce their child's sedentary behaviour). The following chapter reports the results for these outcomes. Additional methods and results for the qualitative interviews not reported in the manuscript below are presented in Appendix Q.

This manuscript is currently in the second stage of review; it has been prepared in accordance with the guidelines for the journal in which it has been submitted.

The Authorship Statement for this manuscript is contained in Appendix T.

Feasibility and efficacy of Mini Movers: a parent-focused, text message delivered pilot randomised controlled trial to reduce sedentary behaviour in 2- to 4-year-old children

Abstract

Background: Despite public health guidelines to limit sedentary behaviour, many young children spend large amounts of time sedentary (e.g., screen and sitting time) during waking hours.

Objective: The objective of this study was to test the feasibility and efficacy of a parent-focused, predominantly text message delivered intervention to support parents to reduce the amount of time their children spend in sedentary behaviour.

Methods: Mini Movers was a pilot randomised controlled trial (RCT) delivered to parents of 2- to 4-year-old children in Melbourne, Australia. Participants were recruited through playgroups, social media and snowball sampling. Eligibility criteria were: having an ambulatory child (2-4 years); English literacy; and smartphone ownership. Participants were randomised to intervention or wait-list control on a 1:1 ratio after baseline data collection. The 6-week intervention was predominantly delivered via text messages, using an online bulk text message platform managed by the interventionist. Intervention strategies focused on increasing parental knowledge, building self-efficacy, setting goals and providing reinforcement, and were underpinned by the CALO-RE taxonomy of behaviour change techniques and Social Cognitive Theory. The primary outcome was intervention feasibility, measured by recruitment, retention, intervention delivery and fidelity, process evaluation questionnaires, and qualitative interviews with a subsample of participants. Secondary outcomes were children's screen and restraint time (parent-report), sitting time (parent-report, *activ*PAL™) and potential mediators (parent-report). Linear regression models were used to determine intervention effects on secondary outcomes, controlling for child sex, age and clustering by playgroup; effect sizes (Cohen's d) were calculated.

Results: Fifty-seven participants (30 intervention; 27 wait-list control) were recruited and retention was high (93%). Process evaluation results showed the intervention was highly acceptable to parents. The majority of intervention components were reported to be useful and relevant. Compared with children in the control group, children in the intervention group had significantly less screen time post-intervention (adjusted difference [95% CI] = -35.0 [-64.1, -5.9] mins/day, Cohen's *d*=0.82). All other measures of sedentary behaviour were in the expected direction, with small to moderate effect sizes.

Conclusions: Mini Movers was shown to be a feasible, acceptable and efficacious pilot intervention for parents of young children, warranting a larger-scale RCT.

Trial Registration: Australian New Zealand Clinical Trials registry: ACTRN12616000628448. Prospectively registered: 16/05/2016.

Keywords: Screen time; television viewing; sitting time; sedentary behaviour; early childhood; mHealth; text message; SMS

Introduction

Early childhood (i.e., birth through 5 years old) is recognised as a critical period in which sedentary behaviour habits (e.g., time spent sitting, screen time) are established [1, 2]. In young children, sedentary behaviour includes screen time, quiet play and time spent in situations that restrict movement (e.g., in car seats/prams). In early childhood, there is inconsistent evidence on the health and developmental outcomes associated with objectively-assessed sedentary time (herein referred to as sedentary time) or time spent in situations that restrict movement (e.g., in a car seat or pram). Some studies report no associations between sedentary time and adiposity [3, 4] or psychosocial health [5], or between time spent restrained and motor development outcomes [6]. On the other hand, studies have reported unfavourable associations between girls' total sedentary time and waist circumference [7] and between total percent of time spent sedentary (for boys and girls) and locomotor skills [8]. For screen time, the evidence is more consistent. Television viewing, one of the most commonly studied sedentary behaviours in this age group, has been associated with unfavourable levels of adiposity and decreased psychosocial health and cognitive development [9, 10], while total screen time has been associated with poorer well-being [11].

Based on these adverse health and cognitive outcomes, and given that some sedentary behaviours track over time [2], recommendations to limit sedentary behaviour have been developed in several countries. These recommendations suggest that children aged 2 to 5 years should have less than one hour per day of screen time [12, 13], and that situations that restrict movement, e.g., in a car seat or pram, should be minimised for children aged 5 years and younger [12-14]. However, contrary to these recommendations, many young children are spending large amounts of time in these behaviours [6, 15-18]. Feasible, acceptable and effective interventions to reduce sedentary behaviours are therefore necessary during this early childhood period.

A systematic review and meta-analysis of interventions to reduce sedentary behaviour during early childhood found that previous interventions can reduce both children's screen time and sedentary time [19]. The majority of interventions included in that review were conducted in the preschool or childcare setting, with comparatively few conducted in the home or in a community-based setting. However, subgroup analyses revealed that interventions conducted in the home setting, and including parent involvement, had the largest effects on screen time outcomes [19], suggesting this may be the most effective approach for modifying children's screen behaviours. That review also highlighted the paucity of interventions targeting time spent in front of screens other than television or time spent restrained [19]. Furthermore, a limitation of existing interventions is that many, particularly those delivered to parents, have limited scalability (i.e., the ability to be widely distributed at a population level). There is therefore a need to trial interventions that include parent involvement and have the potential for scalability and broad reach.

Population strategies that incorporate access to the home environment are challenging. In recognition of its potential reach, mobile phone technology is increasingly being used to deliver health behaviour programs [20]. Text messages, or short message services (SMS), are particularly useful in this instance. They are a wide-reaching, low-cost channel for the delivery of health behaviour programs and can be individually tailored, which has been shown to have positive effects on behaviour change and to reduce attrition [21]. Few programs targeting child and adolescent health behaviours have used text messages to deliver intervention messages to parents [22], with only one targeting the early childhood population. Militello et al. [23] conducted a pilot intervention using twice-weekly text messaging that focused on healthy lifestyle behaviours for parents of overweight and obese preschoolers. Results from that study showed significant improvements in parental knowledge regarding nutrition and physical activity. Additionally, the intervention was found to be feasible and acceptable for parents of young children [23] suggesting that this delivery mode holds promise in this population group. However, that intervention did not report on changes in children's behaviours. No studies have utilised text messages to change sedentary behaviour in this population; thus, it remains to be explored whether interventions delivered via text messages are feasible and can change sedentary behaviour in this population. The current study aimed to pilot test: 1) the feasibility; and 2) the potential efficacy behaviour change strategies delivered to parents predominantly by text message to support parents to reduce the amount of time their children spend in prolonged sedentary behaviour.

Methods

Overview

This study was a two-arm pilot randomised controlled trial (RCT) to evaluate a parent-focused, predominantly text message delivered intervention to reduce sedentary behaviour in 2- to 4-year-old children. The primary outcome was feasibility of the intervention. Secondary outcomes were changes in child sedentary behaviours (objectively assessed sitting time and parent proxy-reported screen time) and potential mediators. The study protocol has previously been published [24] and is outlined briefly below. The study complied with the Consolidated Standards of Research Trials (CONSORT) – EHEALTH guidelines [25], including relevant items from the extension for pilot trials [26]. The Deakin University Human Research Ethics Committee granted ethics approval for the study (2016-103). Participants provided written, informed consent to participate on behalf of themselves and their child.

Participants and recruitment

Participants were recruited in Melbourne, Australia through playgroups, social media (namely Facebook) and snowball sampling. In Australia, playgroups are informal gatherings for parents/caregivers and their children aged birth to 5-years-old prior to the commencement of primary school. Snowball sampling included participating parents (recruited through either playgroups or on Facebook) passing on study information to friends and family (either hard copy flyers or by sharing information on Facebook). Inclusion criteria for parents were: having an ambulatory child aged 2 through 4 years (i.e., up to the age of 4.99 years); able to freely give informed consent; able to speak, read and write fluent English; and smartphone ownership. The intervention was delivered to participants individually, regardless of recruitment method.

Sample size and randomisation

As the main outcome of this study was feasibility, no sample size power calculations were undertaken. Initially, this study aimed to recruit 100 participants. Participants were randomised to the intervention or wait-list control on a 1:1 ratio after baseline data collection. If more than one parent was recruited from a particular playgroup, randomisation occurred at the group level to avoid potential contamination. A computer generated random number schedule was developed by a researcher (not part of the research team) who had no contact with the participants. Group allocation was concealed in sealed, opaque envelopes, which were opened and revealed to the researcher and participant(s) after baseline data collection to minimise selection and measurement bias. Participants were informed that they were either in Group 1 (intervention group; receiving the program immediately) or Group 2 (wait-list control group; receiving the program in seven weeks).

Mini Movers Intervention

The Mini Movers intervention was a predominantly text message delivered intervention that aimed to provide parents with information and practical support to minimise the amount of time their children spend being sedentary and in screen time. The intervention was developed based on evidence-based guidelines for sedentary behaviour in early childhood [12], and guided by the CALO-RE taxonomy of behaviour change techniques [27] and Social Cognitive Theory [28]. Intervention strategies focused on increasing parental knowledge, building self-efficacy, setting goals and providing reinforcement. Participants in the intervention group received their intervention materials, including a Mini Movers information booklet, goal-checking magnet and a Move and Play Every Day: National Physical Activity Recommendations for Children 0-5 Years brochure [12] either in person or by mail after baseline measures and allocation had been completed. The interventionist then had a one-on-one discussion with each participant individually, either in person or over the phone, to set their goals for the program. Two goals were set around reducing their child's sedentary behaviour; specifically, one screen time goal (e.g., to limit their child's screen time to 60 minutes or less per day) and one overall sedentary behaviour goal (e.g., to change an activity their child normally does sitting down, such as painting, to a standing activity). The goal-checking magnet aided participants to track their progress with their two goals for the duration of the program (six weeks).

After the materials were given to participants and the goal-setting discussion was complete, the personalised, interactive text messages (i.e., the main mode of intervention delivery) began the following day. Text messages were delivered using an online bulk text message platform, managed by the interventionist. Participants received a welcome text message at the commencement of the program, followed by three standard text messages per week for six weeks (19 texts in total). The standard text messages included two behavioural messages with practical ideas and suggestions for limiting and displacing their child's screen and sitting time, active play ideas, and monitoring and encouraging achievement of individual goals. Some text messages included links to reputable websites for further information.

The text messages were tailored to the participant's name, child's name, behaviour goals, and the interventionist's name. Participants were not required to respond to the text messages, with the exception of those texts used for goal monitoring, sent at the end of each week. These two-way goal monitoring text messages required participants to respond to let the interventionist know whether they had met their goal. Based on whether the response indicated the goals were achieved or not, parents were sent a pre-defined response encouraging them to revisit their materials and keep trying the following week (if goals were not met) or congratulating them and encouraging them to keep going (if goals were met). Multimedia Appendix 1 shows examples of the types of text messages that were sent to participants.

Wait-list control

Participants randomised to the wait-list control group received the full intervention after post-intervention assessments were completed.

Measures

Data collection occurred pre- and post-intervention. Measures included: children's height and weight (pre-intervention only), *activ*PAL™ (PAL Technologies Ltd., Glasgow, UK) accelerometers (worn for 7 days to objectively assess sitting time), and parent surveys.

Primary outcome

Intervention feasibility was measured by recruitment numbers, retention of participants, program metrics and self-reported participant data, as described below.

Recruitment and retention

Recruitment was measured by: the proportion of contacted playgroups interested in the study (i.e., the proportion of playgroups allowing a visit by the research team or distribution of flyers); the number of eligible parents within playgroups consenting; the number of parents recruited via social media and snowball sampling; and the time taken to recruit the sample. Retention was measured by the proportion of recruited participants providing measures at the end of the study.

Intervention delivery and fidelity

Intervention delivery and fidelity, i.e., successful delivery to protocol, was measured by system reports (e.g., delivered text messages) and auditing of protocol compliance in delivery of one-on-one goal-setting discussions by a single researcher.

Engagement in the intervention and acceptability

Engagement in the intervention was measured by the number of replies received from participants to the two-way goal monitoring messages and participant self-reported usage of and engagement with different components of the intervention, as reported in the post-intervention survey. A subsample of randomly selected participants in the intervention group were invited to participate in qualitative telephone interviews (with a researcher other than the interventionist) to provide more detailed feedback about what they found useful and what they liked or disliked about components of the program. These participants were contacted after the program via mail and asked to return a separate consent form. Telephone interviews were scheduled for days and times convenient to the parents. Interviews included questions such as “What did you find useful or most relevant to you about Mini Movers? How/why was that useful for you?”, “What did you think about the frequency of the text messages you received?”, and “How would you suggest we could improve the resources/materials so parents might be more likely to use them?”.

Secondary outcomes

Children’s objectively assessed sitting time

Participating children wore an *activ*PAL™ for seven consecutive days pre- and post-intervention to objectively measure sitting time. The *activ*PAL™ has been shown to be valid, reliable and feasible in young children [29]. The *activ*PAL™ was worn in the middle of the anterior aspect of the right thigh; monitors were sewn into purpose-made pouches affixed to leggings/bike shorts with Velcro®, worn underneath normal clothes. Data were collected in 15 second epochs and non-wear time was defined as 10 minutes of consecutive zero counts and removed from daily wear time. Children were asked to wear the monitors during waking hours (except for water-based activities such as bathing or swimming). To be included in analyses, children were required to have at least six hours of wear time on at least four days, including one weekend day. Non-wear time and minimum inclusion criteria were based on reliability criteria for ActiGraph (Pensacola, FL, USA) accelerometers [30], as no studies have examined reliability criteria for *activ*PAL™ accelerometers in this population. These criteria have been used previously in a pilot RCT to reduce electronic media use in 2 to 3 year old children [31].

Parent proxy-reported sedentary behaviour and screen time

During each of the weeks that the children wore the *activ*PAL™ (i.e., pre- and post-intervention), parents completed online surveys delivered via Qualtrics (Qualtrics Labs, Provo, UT). Parents with incomplete surveys (i.e., missing responses) were followed up with an email and text message to prompt them to complete their survey. Parents reported their child’s usual time in the last week in a range of sedentary behaviours including: sitting down for reading/quiet play/craft activities; situations that restrict movement (e.g., in a car seat or stroller); and screen behaviours (i.e., television viewing, computer and electronic games use, hand-held electronic games use, smartphone use, and tablet computer use). Responses were open-ended (i.e., hours and/or minutes per day). Parents also reported the number of days that their child watched television/DVDs or played video or computer games or used other electronic devices for entertainment for less than 1 hour (i.e., met screen time recommendations). A two-week test-retest reliability was conducted in a separate sample of 50 participants to test the reliability of these items (intra-class correlations [ICC] = 0.07-0.82 for continuous variables; Kappa = 0.25 and % agreement = 52.3 for meeting recommendations question). Screen behaviours were examined individually as outcomes and also summed to give average daily minutes in total screen time (ICC = 0.98).

Potential mediators

Parents were asked to report: their child's preferences for sedentary behaviour (sum of three items; 5-point Likert scale from *Never* to *Always*); their concerns about their child's screen time use (sum of four items; 4-point Likert scale from *Strongly disagree* to *Strongly agree*); their use of screens to distract or occupy their child (sum of six items; 4-point Likert scale from *Never/rarely* to *All the time*); their views about screen time occupying children (sum of four items; 4-point Likert scale from *Strongly disagree* to *Strongly agree*); their self-efficacy for limiting sedentary behaviour (sum of five items; 5-point Likert scales from *Not at all confident* to *Extremely confident*); logistic support for their child's screen time (sum of four items; 5-point Likert scale from *Never or rarely* to *Several times each day*); and their beliefs/knowledge of screen time for young children (sum of 12 items; 4-point Likert scale from *Strongly disagree* to *Strongly agree*). The majority of these individual items had previously established reliability [32, 33]. The reliability of new items was tested as described above; Kappa = 0.22-0.89 and % agreement = 33.4-97.7.

Internal reliability of all summed scores was tested using Cronbach's alpha. Scores with reliability ≥0.70 were included [34]. Eight of the 10 scales had acceptable reliability. The two remaining scales (child preferences for sedentary behaviour [0.64], and parental concerns about their child's screen time use [0.67]) had moderate reliability; however, a decision was made to still include them as they made sense conceptually. Parents also reported their own frequency and duration in moderate- to vigorous-intensity physical activity (MVPA) in the previous week using the Active Australia Survey [35] and their usual week and weekend day television viewing [36], both collapsed to average minutes per day. Mediation analyses were not undertaken due to the small sample size.

Sample characteristics and child and parent adiposity

Parents reported their own and their child's demographic information (e.g., date of birth, parent education, parent employment status) and their child's usual sleep duration (including day time naps). Parents self-reported their height and weight, while children's height and weight were measured pre-intervention by trained researchers using a Wedderburn portable rigid stadiometer, Wedderburn Tanita portable digital scales, and standardised measurement procedures [37, 38]. Body mass index (BMI) was calculated by standard formula (weight in kilograms divided by height in meters squared); BMI categories (healthy weight, overweight, obese) were determined using age- and sex-specific international cut-off points for children [39] and WHO classifications for parents [40].

Statistical analysis

All analyses were conducted using Stata 14 (StataCorp, College Station, TX, USA). Descriptive statistics were used to describe the baseline characteristics of the sample. Feasibility and acceptability were assessed using percentages and by analysing qualitative data, as appropriate. Qualitative interviews were recorded, transcribed verbatim and analysed using NVivo (QSR International, 2002) qualitative software package. Participants' responses to questions were coded to identify key themes. Linear mixed models were used to determine the effect of the intervention on the secondary outcomes (including children's sedentary behaviour and potential mediators), controlling for child sex, child age and clustering by playgroup. Given the small sample size, effect sizes (Cohen's *d*) were calculated. Values around 0.20 represent small, 0.50 moderate, and ≥0.80 large effect sizes [41].

Results

Primary outcome

Recruitment and retention

Recruitment was undertaken from June to October 2016. Figure 1 presents the flow of participants through the study. A total of 39 playgroup leaders were contacted initially. Of these, 10 leaders (25.6%) agreed to have a researcher visit the playgroup to talk to parents or put up flyers, five leaders (12.8%) declined participation, and the remainder (61.5%) did not respond (after a maximum of two emails and two phone calls). Seven of the 10 playgroups that received a recruitment visit had parents consent to participate in the study (mean number of consenting parents per group = 3.6, range = 2 to 7; n=23 parents in total). A further 34 parents were recruited via Facebook and snowball sampling, resulting in a final sample of 57 participants who provided written, informed consent to participate in the study. Due to study time constraints, recruitment was planned for a set period of time (5 months) and was closed as planned, despite the recruitment target of 100 participants not being met.

All of the 57 consenting participants provided baseline data and were randomised to the intervention (n=30) or wait-list control (n=27) groups. One participant in the intervention group was uncontactable post-baseline measures and hence did not receive the intervention. One participant from the intervention and two from the wait-list control group were uncontactable post-intervention and hence did not provide follow-up data (93% retention). Twenty intervention participants completed the acceptability questions post-intervention. Eighteen intervention (60%) and 20 (74%) control participants had complete proxy-reported child screen time data at both time points, while 19 participants from each group (63% and 70%, respectively) had valid *activ*PAL™ data at both time points and were included in efficacy analyses.

Child and parent characteristics are presented in Table 1. The average age of children was 3 years and just under half the sample were boys. One parent was the father of the child in the study and the remainder were mothers. The majority of parents were born in Australia, had a University degree, and were married/in a de facto relationship.

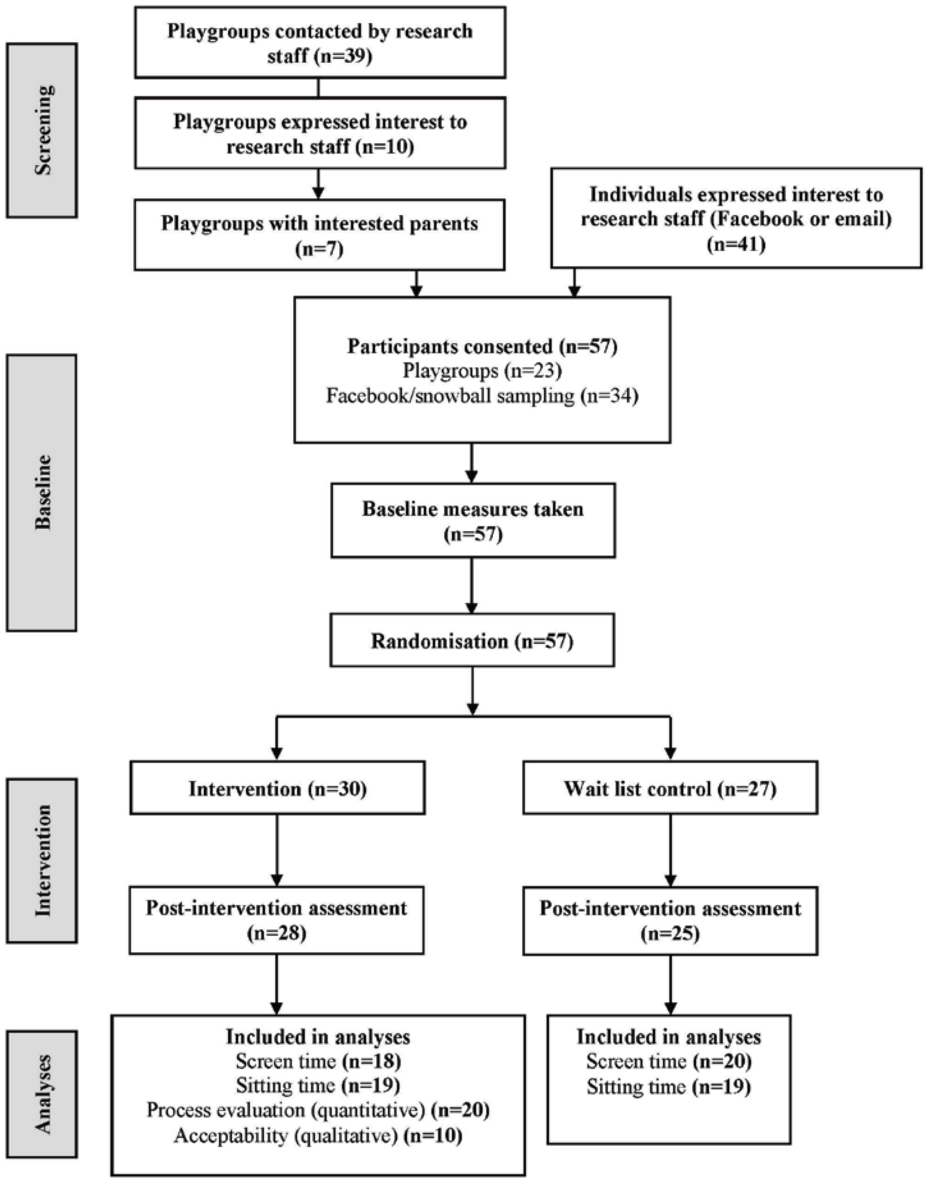

Figure 1. Trial flow diagram

Table 1. Participant baseline characteristics (% unless otherwise noted)

	Intervention (n=30)	Control (n=27)
Child characteristics		
Sex (male)	50.0	40.8
Age (mean (SD) years)	3.2 (0.8)	2.9 (0.7)
Sleep duration (mean (SD) h/day)	11.8 (1.1)	11.9 (1.0)
BMI category		
Healthy weight	80.0	74.1
Overweight	20.0	22.2
Obese	0.0	3.7
Siblings (yes)	76.9	66.7
Parent characteristics		
Relation to child		
Mother	100.0	95.8
Father	0.0	4.2
Age (mean (SD) years)	36.1 (3.9)	34.1 (3.7)
BMI category		
Healthy weight	56.0	78.3
Overweight	24.0	13.0
Obese	20.0	8.7
Born in Australia	76.9	78.3
Education level		
Year 12 or equivalent	3.9	0.0
Trade/certificate/diploma	3.9	26.1
University degree/post-graduate	92.3	73.9
Marital status		
Never married	0.0	4.4
Married/de facto	100.0	95.6
Work status		
Maternity/paternity leave	34.6	30.4
Student	3.9	0.0
Home duties full time	15.4	30.4
Part-time work	46.2	26.1
Full-time work	0.0	13.0

Abbreviations: BMI = body mass index; h = hours; SD = standard deviation

Intervention delivery and fidelity

The goal-setting discussions were all delivered; just over half (59%) were conducted in person with the remainder conducted over the phone. All of the standard text messages (i.e., one welcome text message plus two behavioural and one goal monitoring text message per participant per week; 19 text messages in total per participant) were also successfully delivered (n=551 text messages in total).

Engagement in the intervention and acceptability

Of the 174 goal monitoring text messages sent in total, 145 (83%) received a response. Results of the self-reported usage of and engagement with the text messages, as well as perceived usefulness and relevance of different components of the intervention are presented in Multimedia Appendix 2. The majority of participants (95%) reported reading at least nine of the 12 behavioural text messages. In terms of the two behavioural text messages that contained links to videos, 25% of participants reported watching none in full, 45% reported watching one of them in full, and 30% reported watching both in full. One quarter of participants reported watching at least one of the videos more than once. In terms of the five behaviour text messages containing links to images or other websites, one participant (5%)

clicked through to none, 55% of participants clicked through to at least three, and 25% clicked through to all five links. The majority of participants reported that the overall information, the goal planning, the booklet and the text messages were very or extremely useful (50-65%) and very or extremely relevant (50-60%). Slightly fewer participants reported that the links to videos or other websites were very or extremely useful or relevant (47% each).

Of the 25 intervention participants invited to participate in the qualitative interviews, 10 participants provided written, informed consent (40% response). Interviews lasted on average 17 minutes. Overall, parents were very positive about the program:

> “I thought it was fantastic. We (the playgroup) were all really keen to participate, for the children… for their awareness and for our learning and I don't have a criticism - I just thought it was lovely to promote… (an) active lifestyle and I think it's really good that those things start young for children.”

> “I thought it was a really great program. I think it had a lot of potential to really educate parents just about being aware of their kids’ activity and the consequences of inactivity… And it was very simple, like it wasn't incredibly… complex or anything.”

When asked about what components of the program they enjoyed specifically, many parents commented that the goal-setting was their favourite part. Parents thought that the goal-setting was particularly useful to keep them on track:

> “I think the thing that was most useful and I enjoyed the most was the goal-setting. So we had some goals around more physical activity in our day and also switching off the TV [television]… and so I liked being able to check off the goals and make sure that we met them every day.”

Parents were also positive about the text messages, reporting that they were an easy and convenient way to receive the information. All parents reported that the frequency of receiving the text messages was acceptable; one suggested that they would have been happy to receive more (i.e., one text message per day). Parents also like the practical ideas and suggestions received in the text messages:

> “The information you gave around very practical ideas… rather than just sort of saying you know, they shouldn't be sedentary and they shouldn't be sitting and watching TV and screen time and things like that. You actually then provided alternatives… which I think sometimes as a parent, it's not that you run out of ideas, but you do get stuck in old ways.”

When prompted about the links in the text messages, some parents reported that they only clicked through a few of them. All parents were positive about the content of the links, but some reported that they often did not have time to click through and then would forgot to go back:

> “A couple of times I couldn't (click through) at the time, on my phone, for whatever reason… but they were all quite good actually... the ones that I saw. There was a couple I certainly didn't delve into ‘cos I either forgot to go back to it… or at the time I couldn't access it so I'd sort of put it on the backburner and then… the next week evolved I suppose.”

When asked whether they thought the program had changed the way they do things in their family, parents commented that the program had made them more conscious of screen and sedentary time, and in some cases had other flow-on effects such as spending more time with their children:

> "I do tend to spend more time with the kids… because one of the goals was to reduce TV time, I have found that I do spend more time with them. So I will try and keep the TV reduced as much as possible, like switched off as long as I possibly can. And yeah, I do end up spending more time playing with them because you know, I want him to stand and I want him to move around and things like that."

> "It definitely made me re-think TV time… and use it a bit more sparingly I guess, instead of a babysitter."

> "We've definitely increased physical activity levels in our kids and we're walking to kinder, and we're walking to the shops a lot more and we're relying on the car a lot less… And... we kind of had iPads, but we've pretty much decommissioned our iPads now so they're not existing in our house anymore and we just switch off the TV a lot more. So that's definitely been a sustained effect of the program."

There were also some suggestions from parents on how to improve the program. Some parents suggested that a website or Facebook page would be beneficial as a central place for all of the information provided. One parent also suggested that Facebook would be useful for allowing parents in the program to chat to each other. Some parents also thought that re-visiting their goals half-way through the program may have been beneficial:

> "Maybe… for the first few weeks start off with a more lenient goal and then make your way to a more… a stricter goal to yourself."

Finally, some parents reported that while they liked the premise of the program, they found that the information provided was not necessarily new to them and that they already did many of the things suggested:

> "The text messages, maybe for people who weren't active, would be a good reminder to be active… (but) the suggestions weren't particularly relevant for me… like we already did a lot of that stuff."

> "I walk the dogs 7 days, every morning… she walks with me or she's in the trike, we can be gone for half an hour or an hour each morning. And then she'll come with me to the gym and then we'll do… another gym training class where mums and the kids are there in a big hall, and the kids just jump around the whole time. And then we do swimming another day… so I guess that I feel like over the week, there's activity every day... um, there's play with other children, there's awareness… there's a focus on us being out. So, I didn't feel our lives were very sedentary before the program."

Secondary outcomes

Children's sedentary behaviour

Table 2 presents the mean minutes per day parents reported their children spent in each of the individual screen behaviours, total screen time, and time spent restrained and sitting, as well as *activ*PAL™ assessed sitting time, at baseline and post-intervention. Adjusted mean differences between intervention and control groups were all in the expected direction (favouring the intervention group). Intervention participants reduced their total screen time by 30.6 mins/day (from 109.7 to 79.2 mins/day), while screen time for control participants increased by 7.5 mins/day (from 92.0 to 99.5 mins/day; d = 0.82). Reductions in individual screen behaviours resulted in small to medium effect sizes (ranging from d = 0.21 to 0.61).

Time spent restrained was reduced in the intervention group by 17.2 mins/day (from 74.7 to 57.5 mins/day) and increased in the control group by 1.0 min/day (from 63.2 to 64.3 mins/day; *d* = 0.48). Parent-reported sitting time was reduced in both the intervention and control groups, by 20.6 mins/day (from 126.7 to 106.1 mins/day) and 8.8 mins/day (from 127.3 to 118.5 mins/day), respectively (*d* = 0.15). Sitting time, as measured by *activ*PAL™, was reduced in the intervention group by 25.8 mins/day (from 281.7 to 256.0 mins/day) and in the control group by 3.7 mins/day (from 265.8 to 262.1 mins/day; *d* = 0.26).

Table 2. Baseline and post-intervention values, adjusted differences and effect sizes for sedentary behaviour outcomes

Outcome variable (all mins/day unless otherwise specified)	Baseline mean (95% CI)		Post-intervention mean (95% CI)		Adjusted mean difference (95% CI)[a]	Effect size (Cohen's *d*)
	Control	Intervention	Control	Intervention		
Parent-reported						
Total screen time[b]	92.0 (68.1, 115.9)	109.7 (78.2, 141.3)	99.5 (69.2, 129.8)	79.2 (53.2, 105.1)	-35.0 (-64.1, -5.9)	0.82
TV/DVD viewing	77.5 (57.5, 97.5)	88.1 (54.9, 121.2)	78.0 (57.4, 98.6)	69.2 (43.1, 95.2)	-15.0 (-34.3, 4.3)	0.61
Computer/e-game use	0.0 (0.0, 0.0)	0.6 (-0.6, 1.7)	0.0 (0.0, 0.0)	0.0 (0.0, 0.0)	-	-
Handheld e-game use	0.0 (0.0, 0.0)	0.0 (0.0, 0.0)	0.0 (0.0, 0.0)	0.0 (0.0, 0.0)	-	-
Smartphone use	4.8 (0.1, 9.4)	5.9 (1.3, 10.4)	5.8 (-1.0, 12.5)	3.5 (-0.5, 7.6)	-1.9 (-7.2, 3.4)	0.38
Tablet use	10.3 (0.02, 20.5)	15.0 (2.8, 27.2)	7.1 (-2.0, 16.2)	6.7 (1.5, 11.9)	-8.2 (-23.0, 6.6)	0.21
Time restrained	63.2 (39.6, 86.9)	74.7 (46.2, 103.2)	64.3 (49.7, 78.8)	57.5 (37.3, 77.7)	-16.2 (-39.3, 7.0)	0.48
Time sitting	127.3 (82.5, 172.0)	126.7 (97.8, 155.5)	118.5 (83.3, 153.7)	106.1 (75.2, 137.0)	-13.5 (-63.4, 36.4)	0.15
Days/week days child has <1h screen time	3.5 (2.4, 4.6)	3.6 (2.3, 4.9)	3.6 (2.6, 4.6)	3.4 (2.2, 4.7)	-0.1 (-1.7, 1.4)	0.11
***activ*PAL™**						
Sitting time	265.8 (212.4, 319.2)	281.7 (223.6, 339.9)	262.1 (209.6, 314.6)	256.0 (205.6, 306.3)	-22.3 (-80.8, 36.3)	0.26

[a] Adjusted for child sex, child age and clustering by playgroup; [b] Sum of individual screen behaviours
Abbreviations: CI = confidence interval; d = day; e-game = electronic game; h = hour; mins = minutes; no. = number; TV = television

Potential mediators

Changes in potential mediators from baseline to post-intervention for the intervention and control groups are reported in Table 3. The largest effect (*d* = 0.93) was seen for parental logistic support for their child's screen time (e.g., putting the television on for their child, buying DVDs). Moderate effects were also seen for parent MVPA (not in the expected direction; *d* = 0.66), parental views about the use of screen time for occupying children (*d* = 0.61) and parental self-efficacy to limit their child's sedentary behaviour (*d* = 0.43).

Table 3. Baseline and post-intervention values, adjusted differences and effect sizes for potential mediators

Outcome variable	Baseline mean (95% CI)		Post-intervention mean (95% CI)		Adjusted mean difference (95% CI)[a]	Effect size (Cohen's *d*)
	Control	Intervention	Control	Intervention		
Child preferences for SB (e.g. more likely to watch TV than be active); *possible range 0 to 12*	3.5 (2.4, 4.5)	3.8 (3.0, 4.6)	3.4 (2.6, 4.1)	3.2 (2.4, 4.1)	-0.5 (-1.6, 0.6)	0.26
Parental concerns about child's screen time (e.g. child watches too much TV); *possible range -8 to 8*[b]	-4.8 (-6.1, -3.5)	-4.0 (-5.2, -2.8)	-5.4 (-6.5, -4.3)	-5.4 (-6.3, -4.6)	-0.9 (-2.4, 0.5)	0.40
Parent use of screens to distract or occupy child (e.g. uses TV to distract child when he/she is being difficult); *possible range 0 to 18*	3.5 (2.2, 4.8)	4.4 (2.6, 6.1)	3.0 (1.7, 4.3)	3.4 (1.6, 5.3)	-0.8 (-2.1, 0.4)	0.23
Parental views about screen time occupying children (e.g. has difficulty getting child to eat without screens as distraction); *possible range 8 to 8*[c]	-4.5 (-6.1, -2.8)	-3.2 (-5.3, -1.0)	-4.7 (-6.2, -3.1)	-4.8 (-6.7, -2.9)	-1.3 (-2.8, 0.2)	0.61
Parental self-efficacy to limit child's SB; *possible range 0 to 20*	14.8 (13.6, 15.9)	12.9 (11.0, 14.9)	14.8 (13.5, 16.0)	14.2 (12.6, 15.7)	1.2 (-0.5, 2.9)	0.43
Parental logistic support of screen time (e.g. number of times in the last week parent put the TV on for child); *possible range 0 to 20*[c]	5.3 (3.8, 6.7)	5.8 (4.1, 7.6)	5.3 (3.5, 7.2)	3.9 (2.3, 5.5)	-1.7 (-3.0, -0.4)	0.93
Parental beliefs/knowledge of child screen time (e.g. TV is educational for children); *possible range -24 to 24*[d]	2.6 (-3.0, 8.2)	2.3 (-2.3, 6.8)	1.7 (-3.1, 6.5)	3.1 (-2.2, 8.4)	3.0 (-0.7, 6.8)	0.27
Parent MVPA (mins/day)	27.1 (12.0, 42.2)	38.2 (-20.3, 96.6)	43.2 (25.4, 61.1)	41.2 (-4.6, 87.0)	-16.6 (-35.7, 2.6)	0.66
Parent TV viewing (mins/day)	70.3 (38.4, 102.1)	91.8 (52.1, 131.5)	64.1 (44.9, 83.3)	83.2 (57.5, 108.9)	6.8 (-21.5, 35.2)	0.05

[a] Adjusted for child sex, child age and clustering by playgroup; [b] Lower score indicates fewer concerns; [c] Lower score indicates more favourable outcome; [d] Lower score indicates parental beliefs/knowledge consistent with evidence

Abbreviations: CI = confidence interval; mins = minutes; MVPA = moderate- to vigorous-intensity physical activity; SB = sedentary behaviour; TV = television

Discussion

This study aimed to test the feasibility and efficacy of a parent-focused, predominantly text message delivered intervention to support parents to minimise the amount of time their children spend in sedentary behaviour. Results show that the intervention was largely feasible and acceptable to parents of young children. The study also showed a statistically significant and meaningful reduction in children's total screen time in the intervention group compared with the control group, with promising results for the other secondary outcomes.

Recruitment was particularly difficult through playgroups compared with the other recruitment strategies utilised in this study (e.g., social media). Initial contact with playgroup leaders was challenging; many did not reply to multiple phone calls or emails. Leaders who declined participation (n=5) cited reasons including participation in other research, their playgroup potentially disbanding, or simply that they were not interested. Within playgroups, there was also evidence of peer influence, whereby if one or two parents were very interested initially it would often prompt other parents to read the information and potentially consent to participating. Conversely, if no-one initially expressed interest, then other parents would not consent. Future studies may benefit from exploring other recruitment avenues in this population. In particular, Facebook seemed to be a useful platform for recruiting parents in this study. An mHealth intervention delivered to parents of infants (<3 months) targeting infant feeding practices recruited more than 50% of the intervention group online (compared to around 30% recruited by practitioners and 7% recruited face-to-face by researchers) [42]. This suggests that online methods may be more appealing to parents of young children, perhaps given that they are able to read about the study and consent in their own time. Despite these difficulties, and although recruitment targets were not met, a sufficient sample was recruited for a pilot study. Previous feasibility studies targeting screen time in this population have included similar or smaller samples [31, 43]. Moreover, despite the small sample, a significant reduction in total screen time was observed and effect sizes showed favourable effects.

The acceptability of the intervention overall was high. In both the quantitative process evaluation and the qualitative phone interviews, parents reported that the goal setting and the text messages were very useful and relevant. Many parents noted that the goal planning magnet was useful to help keep them on track. It has been suggested that higher parental compliance with behaviour change techniques such as goal setting and self-monitoring results in better child outcomes [44]. It was encouraging that a number of parents reported in the qualitative interviews that they had continued to try to meet their goals, and that the changes in their families were sustained once the intervention ended. However, parents reported using the text messages containing links to images and other websites less frequently, and also reported finding them less useful and relevant, compared with the goal setting and behavioural text messages. Parents of young children are likely to be time poor and, as some parents noted in qualitative interviews, if they were not able to click through immediately they would often forget to go back. A pilot text message intervention focusing on healthy lifestyle behaviours for parents of overweight and obese preschoolers reported that parents wanted a short, easy to read, and strong message [23]. It may be that providing links to more information or to videos may not be necessary or feasible in this population.

The efficacy results are also encouraging. In addition to the statistically significant reduction and large effect in total screen time in the intervention group compared to the control group, a moderate effect was seen for television viewing. Given that television viewing constitutes around 80% of total screen time in this sample and in previous studies [15], it is important that interventions target this behaviour. An intervention conducted in preschools reported very similar results, with a significant reduction in total screen time of almost 30 mins a day, but no effect on television viewing [45]. A home-based intervention reported a significant reduction in television viewing in the intervention compared to control group of 37 mins a day; however, that intervention specifically targeted television viewing rather than total screen time [46]. Small effects were seen for smartphone use and tablet use in the current study; however, use of these screens was relatively low compared to television viewing, leaving little scope to reduce those behaviours. It may be that specific strategies are needed to target children's use of these newer devices. While the effect size was small, it was promising to see a reduction in objectively-assessed sitting time of more than 20 minutes per day in the intervention group compared with the control group. A previous intervention targeting only screen time use found no effect on objectively-assessed sitting time [31], and suggested that specific strategies should be included to target reductions in sitting time. Results from the current study support this, showing that by providing parents with strategies to reduce sitting time, potentially positive outcomes can be observed.

There was a statistically significant reduction in parental logistic support for screen time (e.g., putting the television on for the child) in the intervention group compared to the control group. This suggests that the strategies used in the intervention were effective at changing parents' behaviour around their child's screen time. Potentially the practical strategies around alternatives to screen time may have resulted in this change; in qualitative interviews some parents reported that they switched off the television more and used it less as a babysitter. Moderate effects were also seen for parental views about screen time occupying children and parental self-efficacy to limit their child's sedentary behaviour. This is particularly promising given that the intervention was theoretically based on Social Cognitive Theory [28], in which there is a strong focus on self-efficacy. Previous cross-sectional studies have reported that higher parental self-efficacy is associated with lower amounts of screen time in preschool-aged children [47-49], suggesting that future interventions would benefit from continuing to target self-efficacy as a mediator of children's screen time.

There was also a moderate effect on parent's self-reported MVPA; however, the adjusted mean difference was in the unexpected direction, in that parents in the intervention group reduced their MVPA by almost 17 mins per day compared to the control group. A possible explanation for this is that many parents set their overall sedentary behaviour goal as walking to local destinations without the pram (i.e., to decrease their child's time spent restrained). As a result, in trying to achieve this goal by having their child walk more, the parents themselves may have ended up walking more slowly than usual. Future research should consider objectively measuring parent's physical activity to examine potential changes in sedentary time and light-intensity physical activity, in addition to MVPA.

Strengths and limitations

Limitations of the current study include the small sample size and the number of participants without full outcome data. This is mostly due to parents not completing, or only partially completing, online surveys, despite reminders to do so. It may be that online surveys are not practical for parents of young children, as there is more opportunity for them to be distracted or forget to come back to it. Additionally, a number of children did not have valid *activ*PAL™ data. While the *activ*PAL™ accelerometers (sewn into a pouch and affixed to leggings) were predominantly acceptable for the children and parents, many parents noted that they often forgot to put the leggings back on after naps or bathing. This may have resulted in fewer valid hours of wear time on particular days, potentially excluding them from analyses.

It was a reasonably homogenous sample with a high percentage being very highly educated (>75% with a university degree or higher). While over-representation of higher-educated women in research is common [50, 51], the outcomes observed in this study may not have been observed in a sample of parents with lower educational attainment. Finally, intervention fidelity may have been somewhat compromised as a number of parents reported, both quantitatively and qualitatively, that they did not click through to all of the links provided in the text messages. Many parents also reported that they did not watch the videos provided in these links in full, suggesting that different strategies may be needed for some parents to increase compliance. However, given that a significant intervention effect was seen for children's screen time, the text messages alone may have been sufficient to elicit behaviour change and the links may not have been necessary.

There are also a number of strengths of the current study. Comprehensive measures of sedentary behaviour were included, including parent proxy-report of specific screen-based behaviours, time spent restrained and sitting time, in addition to children's objectively assessed sitting time. The intervention was developed based on Social Cognitive Theory [28] and targeted specific behaviour change mediators from the CALO-RE taxonomy of behaviour change techniques [27]. Interventions are more likely to be effective if they are theory-based [52] and are closely aligned with behaviour change techniques [53].

Conclusions

Mini Movers was found to be a feasible and acceptable intervention for parents of 2- to 4-year-old children. Moreover, child sedentary behaviour was reduced, suggesting that the intervention was efficacious. It will be important for future studies to measure individual screen behaviours; results from this study support previous findings that although at this age screen time consists largely of television viewing, there is some evidence of use of smartphones and tablets and thus targeting these behaviours specifically in interventions may be efficacious. The findings and learnings from this pilot study show sufficient promise to inform the development of a future large-scale trial adequately powered to determine impacts on children's sedentary behaviour and explore the mediators of behaviour change. If effective, the main delivery mode (i.e., text messages) means that this intervention has the ability to be scaled up and widely disseminated.

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Conflicts of Interest

None declared

Abbreviations

BMI – body mass index
CI – confidence interval
E-games – electronic games
MVPA - moderate- to vigorous-intensity physical activity

RCT – randomised controlled trial
SD – standard deviation
TV – television

Appendices

Multimedia Appendix 1. Examples of text messages
Multimedia Appendix 2. Parent self-reported usage of and engagement with text messages and perceived usefulness and relevance of the intervention

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Appendix 1. Examples of text messages

Type of text message	Example content[a]
Behavioural	Annie, get Josh to help make some playdough! Here’s a great recipe with no cooking required: <link to recipe>. Remember, encourage Josh to stand up while playing with it! Katherine – Mini Movers
Goal-checking	Hi Carolyn, how did you go sticking with your goals to limit Sienna’s screen time to 60 mins a day and to do puzzles standing up instead of sitting 2 days this week? Text me back YES if you achieved them or NO if you weren’t able to this week. Katherine – Mini Movers
Goal-checking – response to YES reply	Great to hear! Remember how good you feel achieving your goals – bottle that feeling & use it as motivation on tough days. Keep it up! Katherine – Mini Movers
Goal-checking – response to NO reply	It’s common to slip up sometimes Julia. The important thing is trying again next week! Use your Mini Movers Goal Checker magnet to keep you on track. Katherine – Mini Movers

[a] Names have been changed for anonymity

Appendix 2. Parent self-reported usage of and engagement with text messages and perceived usefulness and relevance of the intervention

Table 1. Self-reported usage of and engagement with behavioural text messages (n=20)

Considering the behavioural text messages…	11-12 texts n (%)	9-10 texts n (%)	7-8 texts n (%)	5-6 texts n (%)	3-4 texts n (%)	1-2 texts n (%)	None n (%)
How many did you read	17 (85.0)	2 (10.0)	0 (0.0)	0 (0.0)	1 (5.0)	0 (0.0)	0 (0.0)
How many gave you ideas that you used with your child	0 (0.0)	2 (10.0)	5 (25.0)	4 (20.0)	4 (20.0)	4 (20.0)	1 (5.0)

Table 2. Self-reported usage of and engagement with text messages containing links to videos (n=20)

Considering the text messages with links to videos…	2 texts n (%)	1 text n (%)	None n (%)
How many did you watch in full	6 (30.0)	9 (45.0)	5 (25.0)
How many did you watch in part	2 (10.0)	5 (25.0)	13 (65.0)
How many did you watch more than once	2 (10.0)	3 (15.0)	15 (75.0)
How many gave you ideas that you used with your child (n=19)	4 (21.5)	5 (26.3)	10 (52.6)

Table 3. Self-reported usage of and engagement with text messages containing links to images and other websites (n=20)

Considering the text messages with links to images or other websites…	5 texts n (%)	4 texts n (%)	3 texts n (%)	2 texts n (%)	1 texts n (%)	None n (%)
How many did you click through to the links	5 (25.0)	4 (20.0)	2 (10.0)	7 (35.0)	1 (5.0)	1 (5.0)
How many did you click through to more than once	0 (0.0)	0 (0.0)	1 (5.0)	3 (15.0)	3 (15.0)	13 (65.0)
How many gave you ideas that you used with your child	1 (5.0)	0 (0.0)	7 (35.0)	5 (25.0)	4 (20.0)	3 (15.0)

Table 4. Perceived usefulness of components of the Mini Movers intervention (n=20)

How **useful** was/were…	Extremely n (%)	Very n (%)	Moderately n (%)	Slightly n (%)	Not at all n (%)
The information overall	2 (10.0)	8 (40.0)	8 (40.0)	2 (10.0)	0 (0.0)
The goal planning	3 (15.0)	9 (45.0)	5 (25.0)	3 (15.0)	0 (0.0)
The booklet	1 (5.0)	9 (45.0)	6 (30.0)	4 (20.0)	0 (0.0)
The text messages	4 (20.0)	9 (45.0)	2 (10.0)	4 (20.0)	1 (5.0)
The links to videos (n=19)	3 (15.8)	6 (31.6)	4 (21.1)	4 (21.1)	2 (10.5)
The links to other websites (n=19)	2 (10.5)	7 (36.8)	6 (31.6)	2 (10.5)	2 (10.5)

Table 5. Perceived relevance of components of the Mini Movers intervention (n=20)

How **relevant** was/were…	Extremely n (%)	Very n (%)	Moderately n (%)	Slightly n (%)	Not at all n (%)
The information overall	2 (10.0)	8 (40.0)	7 (35.0)	2 (10.0)	1 (5.0)
The goal planning	4 (20.0)	9 (45.0)	4 (20.0)	2 (10.0)	1 (5.0)
The booklet	0 (0.0)	11 (55.0)	2 (10.0)	7 (35.0)	0 (0.0)
The text messages	2 (10.0)	8 (40.0)	3 (15.0)	6 (30.0)	1 (5.0)
The links to videos (n=19)	1 (5.3)	8 (42.1)	3 (15.8)	5 (26.3)	2 (10.5)
The links to other websites (n=19)	1 (5.3)	8 (42.1)	5 (26.3)	3 (15.8)	2 (10.5)

CHAPTER EIGHT

Thesis Discussion

This thesis makes a unique contribution to the body of literature relating to sedentary behaviour in early childhood. Following the Medical Research Council (MRC) framework (Craig et al. 2008) for developing and evaluating complex interventions (described in Chapter Four, Figure 4.1), this thesis describes the development phases of an intervention to reduce sedentary behaviour in young children. It comprises: 1) a comprehensive literature review (Chapter Two); 2) a systematic review and meta-analysis of published sedentary behaviour interventions targeting early childhood to date (Chapter Three, Paper One); 3) investigation of correlates of sedentary time and screen time across multiple domains of the ecological model to target in future behaviour change interventions (Chapter Five, Paper Two); and, 4) combining this information, the development, implementation and pilot testing of a novel intervention targeting reductions in young children's sedentary behaviour (Chapters Six and Seven, Papers Three and Four).

Early childhood (i.e., birth through 5 years) is a period of rapid growth and development, and has long been considered a time in which long-term lifestyle behaviours, including sedentary behaviour, are established (Dietz 1997; Reilly 2008). As identified in Chapter Two, a number of potential adverse health and developmental outcomes are shown to be associated with sedentary behaviour, including increased risk of overweight/obesity, poor psychosocial health and decreased cognitive development (Carson et al. 2015; Hinkley et al. 2014a; LeBlanc et al. 2012). Further, sedentary behaviour habits tend to track from early childhood into later childhood, adolescence and adulthood (Biddle et al. 2010; Jones et al. 2013). Despite government guidelines recommending limits to children's sedentary behaviour, many young children are engaging in high levels of sedentary behaviour. This suggests that it is important to investigate opportunities to reduce sedentary behaviour in early childhood, to ensure that fewer children establish detrimental sedentary behaviour habits.

Each paper included in this thesis contains a discussion of the findings related specifically to that chapter. Therefore, this chapter summarises the main findings of the thesis as a whole, considers the findings in light of existing literature, and discusses the strengths and limitations of the research. Finally, future research directions and practical implications from this thesis are discussed and an overall conclusion is provided.

8.1 Overview and discussion of findings

8.1.1 Correlates of screen time and sedentary time

An important step in intervention development is identifying factors associated with the outcome of interest, which can then be targeted as mediators of change. Previous research investigating the correlates of sedentary behaviour in preschool aged children is limited, with many studies focusing on screen time alone (Cillero

& Jago 2010; De Craemer et al. 2012; Hinkley et al. 2010) and few investigating correlates across multiple levels of the ecological model (Bronfenbrenner 1979). Additionally, no studies have comprehensively investigated correlates of screen and sedentary time across multiple levels of the ecological model in the same sample of preschool children. Building on this limited literature, Chapter Five used an ecological framework to examine correlates of screen time and sedentary time in the individual, social and physical environment level. Of the 67 variables examined, two were associated with sedentary time and 10 were associated with screen time, and many of these associations differed by sex. It is important to note that although using the ecological model allows for investigation of correlates across different levels of influence, it does not allow for understanding of the interplay (e.g., direct and indirect effects) *between* the different levels. Future research should aim to investigate this interplay to better understand the correlates of sedentary behaviour.

There was only one correlate common to both screen time and sedentary time, which was in the individual level of the ecological model. This was that children who slept for longer durations had lower levels of both behaviours. The association between sleep duration and screen time is consistent with previous research (Magee, Lee & Vella 2014; Marinelli et al. 2014; Miller et al. 2008; Xu et al. 2016b). However, research investigating the association between sleep and sedentary time in this population is scarce (Schmutz et al. 2017). A growing body of evidence supports the idea that sleep, physical activity and sedentary behaviour are mutually exclusive, i.e., they occur on a single continuum from no conscious movement (sleep) through to vigorous-intensity physical activity (Pedišić, Dumuid & Olds 2017). For example, if sleep increases, this time has to replace either physical activity or sedentary time. In this instance, replacing screen time would be the desirable substitution. Given that many parents are concerned about their child’s sleep (Milan, Snow & Belay 2007), suggesting that they may be amenable to strategies to improve it, sleep became a focus of the intervention developed later in this thesis.

The only other correlate of sedentary time, also in the individual level, was paternal age: boys with older fathers spent more time sedentary. Previous studies have not examined the association between paternal age and sedentary time. Evidence suggests that there is no association between maternal age and sedentary time in preschool children (Dolinsky et al. 2011) or toddlers (Wijtzes et al. 2013b); however, those studies did not stratify by child sex, and associations may be different for maternal and paternal age. Given that paternal age is a non-modifiable correlate, it was not targeted as a potential mediator in the intervention developed in this thesis. However, further research is required to confirm whether there is an association between paternal age and boys’ sedentary time. If there is an association, this may suggest that older fathers require additional support to reduce their sons’ time in sedentary behaviour.

There were many more factors associated with screen time than sedentary time, including four in the individual level (paternal education, maternal country of birth, child preferences for sedentary behaviours, and frequency of active transport) and five in the social level of the ecological model (parental concern about child's physical activity and screen time, parents reporting that they get bored watching their child playing in outdoor space, parental self-efficacy to limit screen time, screen time rules, and maternal television viewing). In this study, paternal education was positively associated with girls' screen time. Parental education is consistently associated with young children's television viewing (Burgi et al. 2010; Manios et al. 2009; Miller et al. 2008; Proctor et al. 2003; Truglio et al. 1996; van Rossem et al. 2012; Veldhuis et al. 2014; Yalcin et al. 2002) and total screen time (Carson & Janssen 2012; Carson, Rosu & Janssen 2014; Downing, Hinkley & Hesketh 2014; Garriguet et al. 2016; Tandon et al. 2011), but many studies have not examined correlates separately for boys and girls and have not examined maternal and paternal education separately. One study has found that paternal education (but not maternal education) is associated with preschool children's television viewing (Yalcin et al. 2002), supporting the findings from the current study. Given that maternal education is often used as a proxy for socioeconomic position, these findings suggest that paternal education should also be included in future studies. Conversely, maternal country of birth (found to be inversely associated with girls' screen time in this study) has not previously been investigated as a correlate of screen time in preschool children. However, parent race/ethnicity has been reported to have no association with television viewing (Bleakley, Jordan & Hennessy 2013) or with total screen time (Asplund et al. 2015).

Girls who preferred to watch television or play electronic games rather than be active were found to have higher levels of screen time in this thesis. This has been previously noted in preschool boys (Hinkley et al. 2013) and in school-aged children (Salmon et al. 2005). Although it is possible that preschool children may have developed preferences for some behaviours over others, it is important to note that only parent perception of children's preferences, which may be influenced by their own preferences, was measured in this study. Further, due to the cross-sectional nature of this study, causality cannot be determined. However, this finding does suggest that interventions could aim to support parents to establish their child’s preferences for physical activity (over screen time) from a young age.

In this study, usual frequency of active transport was found to be inversely associated with screen time for preschool girls. Although this association has not been previously found in preschool children, it is supported by evidence in older children (Landsberg et al. 2008). Given this finding, active transport was targeted in the intervention developed in this thesis (i.e., by encouraging parents to let their children walk to local destinations). Consistent with previous research (Hinkley et al. 2013), parents who reported that they were concerned that their child was not active enough or was engaging in too much sedentary behaviour had girls with higher levels of screen time. These findings are important as they suggest that parents may be able to determine if their child is engaging in higher than recommended levels of screen time, which may be beneficial when recruiting participants for behaviour change interventions.

An important finding from this thesis for intervention development was that parental self-efficacy to limit screen time and parental screen time rules were both inversely associated with screen time for preschool boys and girls. Both of these correlates have consistently been shown to be inversely associated with screen time in preschool children in previous literature (Barr-Anderson et al. 2011; Campbell et al. 2010; Carson & Janssen 2012; Christakis et al. 2004; Jago et al. 2013; Kuepper-Nybelen et al. 2005; Smith et al. 2010; Spurrier et al. 2008; Truglio et al. 1996; Vaughn, Hales & Ward 2013). Similar to the intervention developed in this thesis, future interventions and public health strategies to reduce sedentary behaviour could provide parents with strategies to implement screen time rules, which may in turn increase their self-efficacy to limit screen time. The positive association between maternal television viewing and preschool children's screen time is also supported by previous literature (Asplund et al. 2015; Barr-Anderson et al. 2011; Bleakley, Jordan & Hennessy 2013; Carson & Janssen 2012; Carson, Stearns & Janssen 2015; Jago et al. 2013; Jago et al. 2012; Kourlaba et al. 2009; Manios et al. 2009; Wijtzes et al. 2012; Xu et al. 2016a; Yalcin et al. 2002), suggesting that encouraging parents to reduce their own television viewing habits may have positive effects on their children's screen time.

Despite correlates of sedentary time from all three levels of the ecological model being identified in the individual analytic models (five each for boys and girls), few significant associations remained in the combined analytic models. This suggests that further research examining other potential correlates of sedentary time is required. The reasons for the lack of correlates identified are explored in detail in the discussion section of Chapter Five. Briefly, many of the correlates measured focused directly on screen time (e.g., parental rules for limiting screen time, self-efficacy to limit screen time), rather than on overall sedentary time (e.g., limiting sitting time, breaking up long periods of sedentary time). Many correlates are context and behaviour specific. Sedentary time is a measure of all time spent in any sedentary behaviours; however, sedentary behaviours may not all be ‘equal’. For example, there appears to be something unique about television viewing which may be due to concurrent eating, often of highly energy dense foods (Ford, Ward & White 2012). The correlates of television viewing would likely be different to the correlates of sitting in a car seat or beneficial sedentary behaviours such as reading. Therefore, attempting to determine correlates of the total amount of sedentary time may be challenging. Additionally, it may be that many parents are unaware of the total amount of time their children spend being sedentary. Hence, parent-reported correlates may not be relevant to or associated with total sedentary time. Evidence from qualitative interviews with parents in the randomised controlled trial (RCT) in this thesis (reported in Chapter Seven and Appendix Q) suggests that many parents believe their children are naturally active, and so limiting or breaking up sitting time was not something they had considered previously. Previous qualitative research with parents of infants and preschool children shows that many mothers believe young children are naturally active (Dwyer et al. 2008; Hesketh, Hinkley & Campbell 2012). Mothers have also been shown to overestimate their young children’s actual levels of physical activity (measured objectively) (Hesketh et al. 2013). This suggests that strategies are needed to inform parents of their child’s activity levels, as parents may not be receptive to intervention messages if they do not believe their child’s behaviour is a concern.

Importantly, correlates across multiple levels of the ecological model were identified for screen time, which helped to inform the development of intervention strategies targeting modifiable factors in the individual and social levels. Additionally, results from this study suggest that correlates of screen time and sedentary time differ in this population, and therefore behaviour-specific strategies were developed to reduce time in each of the behaviours independently.

8.1.2 Developing an evidence-based intervention

The findings from Chapter Three show that, overall, previous interventions (n=31) to reduce total sedentary time and screen time in early childhood have been effective, albeit with modest results. Results show that interventions (n=24 included in the meta-analyses) produced a significant overall difference between groups of 17 and 19 minutes per day for screen time and sedentary time, respectively. However, the studies included in the review varied greatly in their intervention objectives, settings, strategies and delivery modes, making it difficult to compare findings and draw overall conclusions. This was further highlighted in the meta-analysis by the considerable heterogeneity in the included studies, with subgroup analyses shedding little light on the types of interventions that are most effective in this population. This was likely due to the small number of studies within subgroups. Results do show that few interventions have been conducted outside the preschool setting, and emphasised the importance of parental involvement for behaviour change in interventions with young children.

The findings from Chapters Three and Five helped to inform the development of the innovative Mini Movers intervention (Chapters Six and Seven), which was designed to support parents to reduce the amount of time their young children spent in sedentary behaviour. Specifically, the intervention filled some of the gaps identified in the systematic review (e.g., the dearth of interventions delivered outside the preschool setting), and was informed by results from the meta-analyses (e.g., the importance of high parental involvement) described in Chapter Three. Although results from that meta-analysis also suggested that interventions of longer duration were more effective than shorter-duration interventions, for pragmatic reasons a six-week intervention was designed to pilot the strategies. A longer duration intervention would be considered for a full-scale RCT. Findings from the examination of preschool children's sedentary behaviour correlates in Chapter Five were utilised when designing the intervention strategies, as described in Section 8.1.1.

Overall, Mini Movers was found to be largely feasible and acceptable for parents of young children. Among a sample of 20, the vast majority of participants (at least 94% on average) reported the different components of the intervention to be useful and relevant to some degree, with at least half reporting the main components (the booklet, goal planning and text messages) to be either "very" or "extremely" useful or relevant. Further, despite being a pilot study and therefore not powered to detect significant changes in outcomes, the Mini Movers intervention showed an adjusted mean difference between groups in screen time of more than 30 minutes per day. Although the meta-analysis conducted in this thesis (Chapter Three) found that interventions to reduce screen time in this population have a significant overall effect (Downing et al. 2016b), only seven (out of 17) of the individual studies included in that analysis reported significant mean differences between groups (Campbell et al. 2013; Dennison et al. 2004; Fitzgibbon et al. 2011; Puder et al. 2011; Taveras et al. 2011; Yilmaz, Demirli Caylan & Karacan 2015; Zimmerman et al. 2012). Mean differences between groups in the effective interventions ranged from 13 (Puder et al. 2011) to 47 minutes per day (Yilmaz, Demirli Caylan & Karacan 2015). Results from the RCT presented in this thesis are especially encouraging in light of results from these previous interventions, and suggest that the strategies could be used in future interventions and public health campaigns.

There was also a significant intervention effect on one of the potential mediators measured in the RCT, parental logistic support of screen time (e.g., putting the television on for their child), which was reduced significantly in the intervention group compared to the control group. Although this has not previously examined in the literature, logistic support for physical activity has been shown to be associated with less time watching television (but not with sedentary time) (Vaughn, Hales & Ward 2013). This finding is important because parents are the “gatekeeper” for their children’s physical activity and sedentary behaviour (Welk, Wood & Morss 2003). Hence, reducing their logistic support for screen time, and increasing their logistic support for physical activity, may have important beneficial effects on their child’s time in those behaviours. However, as discussed in Section 8.3, RCTs adequately powered to perform mediation analyses are necessary to investigate this association.

This study was the first intervention aiming to decrease time in a range of sedentary behaviours to be delivered to parents of young children predominantly via text message. To date, child and adolescent interventions utilising text messaging have focused largely on older children/adolescents and clinical populations (e.g., participants with type 1 diabetes) (Militello, Kelly & Melnyk 2012). Findings from this thesis build on the growing body of evidence regarding feasible, acceptable and efficacious interventions in this population by providing a remotely delivered, low cost and effective intervention strategy that has the potential to be up-scaled into a large population level intervention.

The interviews undertaken with parents who participated in Mini Movers (described in Chapters Six and Seven and Appendix Q) drew on qualitative methodology to provide an extensive evaluation of the intervention as a whole. Results show that all parents were positive about the aim and the key message of the program. Many parents noted that they enjoyed the goal-setting component of the intervention the most. The usefulness of goal-setting has been similarly noted in a pilot online intervention focusing on dietary intake, physical activity and sedentary behaviours, with 80% of parents in that study reporting that the goal-setting was helpful (Jones et al. 2011). Parents in the RCT in this thesis were also happy to receive the information via text message. This is useful for future interventions as it could reduce the need for face-to-face contact, thereby reducing the cost and increasing potential for scalability. The high acceptability of the text messages may also highlight that this is an appropriate and ideal mode of delivery for potentially busy parents with young children. Recent evidence supports this, with findings suggesting that text message delivery in parent-focused interventions are acceptable for parents of preschool (Militello et al. 2016) and school-aged (Newton et al. 2014) children. Parents also reported that they liked that practical strategies and ideas were provided, rather than simply educational content. Parents also provided suggestions to improve the program, such as a central location for all of the materials being provided (e.g., a website), and strategies that focus on the whole family. These qualitative data provide important information for the design of future parent-focused interventions to reduce sedentary behaviour in young children.

Recruitment learnings from the intervention

Recruitment through Facebook and snowball sampling was more effective than recruitment through playgroups in the RCT, with 60% of the sample recruited through these methods. Recruitment via Facebook requires much less researcher time, and hence is also potentially more cost-effective. Further, online recruitment may be appealing to parents of young children who can read about the study and consent in their own time. Recruitment results for the RCT were similar to those observed in an mHealth (mobile-delivered) intervention targeting infant feeding practices, whereby more than 50% of the intervention group were recruited online (compared to around 30% recruited by practitioners and 7% recruited face-to-face by researchers) (Laws et al. 2016). It is important to note that in the RCT in this thesis, parents recruited via Facebook were more highly educated than parents recruited via playgroups (94% compared to 60% with a university degree or higher level of education, respectively). However, parents recruited via Facebook were more compliant in terms of completing surveys. All parents recruited via

Facebook completed their baseline survey and 82% completed their post-intervention survey, compared to 70% and 61% of parents recruited via playgroups completing their baseline and post-intervention surveys, respectively. Potentially parents recruited online were more compliant as they had seen the advertisement on Facebook and had elected to participate. On the other hand, parents recruited through playgroups were approached in person and, as discussed in Chapter Seven, were potentially influenced by peers to take part. Future interventions will need to weigh up the benefits and limitations of recruitment via these differing methods. Recruiting parents through a range of methods may be most appropriate.

This thesis adds to the body of evidence relating to correlates of preschool children's sedentary time and screen time, which contributed to the development of an intervention aiming to reduce sedentary behaviour in this population. There are a number of considerations for future research and practical implications based on the findings from both the correlates study and the RCT, which are described in Sections 8.3 and 8.4. Strengths and limitations of the current research are discussed in the following section.

8.2 Strengths and limitations

There are a number of strengths and limitations of studies presented in this thesis that should be acknowledged. A limitation of both the correlates study (Chapter Five) and the RCT (Chapter Seven) was the relatively high proportion of parents who were highly educated. In the correlates study, despite purposeful over-sampling in low socioeconomic areas, only 13% of the sample were classified as low socioeconomic position (SEP) based on maternal education. While the RCT predominantly used convenience sampling (i.e., playgroups within a certain radius of the university, social media, snowball sampling) and hence did not specifically aim to recruit low SEP parents, the sample was very highly educated (only 2% classified as low SEP). Although over-representation of women with higher levels of education is common in research (Chinn et al. 2006; Lakerveld et al. 2008), findings from both of these studies should be considered in light of this; results may not be generalisable to the wider population. Further, in both of these studies, and particularly in the RCT, it is possible that consenting parents already had a particular interest in their child's sedentary behaviour or physical activity. Results may have differed for parents without such an interest in their children's sedentary behaviours. Specifically, the RCT as delivered may not be effective in families from low socioeconomic backgrounds.

Recruiting parents for the RCT (Chapter Seven) through the playgroup setting was more difficult than anticipated. Recruitment difficulties and low response rates have been previously documented in studies with parents of young children (Carson, Rosu & Janssen 2014; Hardy et al. 2010; Oliver, Schofield & Schluter 2010). In fact, in the correlates study of this thesis (Chapter Five) the response rate was 11%. Nevertheless, a large, sociodemographically diverse sample was recruited in that study and characteristics of participating children were similar to the wider Australian population, e.g., 22% of the sample were classified as overweight/obese compared with 23% nationally (Australian Government

Department of Families Housing Community Services and Indigenous Affairs 2009). As mentioned in Section 8.1.2, recruitment through Facebook and snowball sampling seemed to be more effective than recruitment through playgroups in the intervention study, with 60% of the sample recruited through these sources. Similar to the correlates study, characteristics of participating children in the intervention were comparable to the Australian population: 23% of children in both the intervention and nationally (Australian Bureau of Statistics 2013) were classified as overweight/obese, suggesting that the sample was somewhat representative of the general population.

A major strength of the studies within this thesis was the objective measurement of sedentary behaviour in the correlates study and the RCT. However, a limitation of the correlates study is that just over 25% of the sample did not have valid accelerometry data and were therefore not included in analyses for sedentary time. Differences in associations may partially be explained by differences in the sample and reduced power for the sedentary time analyses. There are also a number of broader issues relating to the objective measurement of sedentary time in young children that warrant further investigation. A key issue is the operationalisation of young children's physical activity as any intensity (i.e., anything other than sedentary time). While sedentary behaviour is discussed in the literature as being distinct from physical inactivity (i.e., insufficient physical activity to meet recommendations), that distinction is less clear in young children given the movement continuum from sedentary time to light-intensity physical activity (LPA), particularly when measured by accelerometry. The ActiGraph accelerometer (used in the correlates study in this thesis) does not measure posture (i.e., sitting versus standing) and hence, as discussed in Section 2.5.3, sedentary time may have been misclassified as LPA in that study. Related to this, subgroup analyses in the systematic review in this thesis showed that interventions utilising a high cut point to classify sedentary time had a significant overall effect, whereas those using a low cut point did not. As discussed above, the studies using a high cut point likely included some LPA in their measure of sedentary time, which may explain the significant effect.

These limitations were overcome in the RCT by using *activ*PAL™ accelerometers, which are posture-based devices containing inclinometers and hence provide a valid and reliable measure of time spent sitting/lying (Davies et al. 2012; Janssen et al. 2013b). It is important to note that ActiGraph and *activ*PAL™ estimates of sedentary behaviour in preschool children have been shown to be similar at a group level (75% compared to 79% of waking hours spent sedentary as measured by the ActiGraph and *activ*PAL™, respectively) (Martin et al. 2011). Hence, the use of both of these tools in this thesis is appropriate. An additional strength of the RCT is that a wide range of parent-reported measures of sedentary behaviour were also assessed to provide information on the context and the different types of sedentary behaviours young children perform. These included time spent sitting down, time spent in situations that restrict movement, and time in a number of individual screen behaviours, which provides information unattainable from objective measurement tools. The inclusion of these subjective measures, in addition to an objective assessment of sitting time, means that children’s sedentary behaviour was measured comprehensively in this thesis.

A further limitation of the use of objective measures of sedentary behaviour in young children is that, as discussed in Section 2.5.3, they do not distinguish between types of sedentary behaviours or provide contextual information. Many sedentary behaviours, such as reading, drawing, and quiet play, are of crucial importance to young children's development (Carson et al. 2015; De Temple & Snow 2003; Tunks 2009) and should be encouraged. Switching from 'non-productive' sedentary behaviours (such as television viewing) to more productive ones (such as reading) may have beneficial developmental outcomes, but result in a negligible change in total sedentary time. This will be important for future research of young children's sedentary behaviour to consider.

It is also important to acknowledge that the importance of total sedentary time in young children is unclear. In addition, although evidence suggests that there are detrimental health outcomes associated with television viewing, the mechanisms through with television impacts health are unknown. The majority of sedentary behaviour research in early childhood to date has focused on television viewing as a proxy for sedentary behaviour; however, it is possible that the detrimental effect of television viewing may have little to do with its sedentary nature. Some research suggests that the dietary outcomes associated with television viewing (Ford, Ward & White 2012), or television food advertising exposure (Andreyeva, Kelly & Harris 2011), could be the mechanism to poor health. Despite this, it is still important to understand young children's sedentary behaviour (including total sedentary time). Given that sedentary behaviours have been shown to track, and are associated with numerous detrimental health outcomes later in life, it is essential to help children establish healthy habits from a young age.

A major strength of the RCT in this thesis is that the Mini Movers intervention was developed based on a comprehensive review of existing sedentary behaviour interventions (Chapter Three) and incorporated factors found to be associated with young children's sedentary behaviour from Chapter Five. Additionally, the intervention strategies were developed based on social cognitive theory (Bandura 1986) and specific behaviour change mediators from the CALO-RE taxonomy of behaviour change techniques (Michie et al. 2011) were targeted. Evidence suggests that interventions are more likely to be effective if they are theoretically grounded (King et al. 2002) and are closely aligned with behaviour change techniques (Michie et al. 2013). However, interventions in the early childhood population mostly neglect to use theory to inform their strategies (Hesketh & Campbell 2010). Thus, this study addresses an important gap in the existing literature.

A further strength of this thesis is the comprehensive process evaluation of the Mini Movers intervention. Process evaluation can help to understand how specific program elements may have impacted on outcomes (Saunders, Evans & Joshi 2005). A wide range of measures were included, covering recruitment and retention, intervention delivery and fidelity, participant engagement in the intervention, and acceptability. Qualitative interviews were undertaken to provide a more comprehensive understanding of parents' views of the intervention, some of which would not have been elicited from quantitative questions alone.

The development of a potentially scalable, wide-reaching intervention is an additional strength of the RCT. Traditionally, health promotion programs have tended to focus primarily on efficacy, with little thought given to the long term sustainability of interventions (Shediac-Rizkallah & Bone 1998). It is important for researchers to focus on designing and implementing interventions that are feasible, efficacious, and scalable in the long-term. Text messages are a wide-reaching, low-cost channel for the delivery of health behaviour programs, particularly given the rapid and wide adoption of mobile phones across most adult age and demographic groups (Atun & Sittampalam 2006). Although one-on-one goal-setting was provided in person or over the phone in this intervention, future interventions (including future iterations of this intervention) could include an online goal-setting component to minimise researcher time and cost. Online goal-setting has been used successfully in a pilot online healthy lifestyles program delivered to parents of preschool children (Jones et al. 2011). Scalability and sustainability were considered from the outset when planning and designing the intervention (e.g., by utilising mobile telephone technology), making the potential translation to a larger-scale program possible.

8.3 Future research recommendations and directions

This thesis has identified a number of key opportunities for future research in the field of early childhood sedentary behaviour, which are discussed below:

- Additional research examining sedentary behaviour other than screen time in early childhood is needed. Limiting the amount of time spent restrained is included in sedentary behaviour guidelines in a number of countries

(Australian Government Department of Health 2014; New Zealand Ministry of Health 2017; Tremblay et al. 2012b; UK Department of Health 2011) and included in the recent sedentary behaviour terminology paper (Tremblay et al. 2017). Therefore, it is necessary for future research to develop and include a validated measure of this behaviour in studies undertaken during early childhood to explore the prevalence and compliance with guidelines. Investigating potential correlates of time spent restrained that could be targeted in interventions should also be a focus of future research.

- A number of behaviours that may be performed whilst sedentary are important for children's overall cognitive development, e.g., sitting and reading (Carson et al. 2015). These should also be considered in future research of sedentary behaviours. It may be that there are different correlates of these types of sedentary behaviour, and interventions could include strategies to promote time in these behaviours which may potentially displace time spent in less beneficial sedentary behaviours.
- Future research should focus on including a wider range of potential correlates specifically related to sedentary time. Extending research and identifying additional correlates of young children's sedentary/sitting time would help improve the ability to effectively target children's sedentary time in future interventions.
- Devices available for children to engage in screen time evolve and change quickly. There will be a need for future research to ensure that measures of screen time capture this frequent change to ensure knowledge keeps pace with technology. Further, it will be important for future research to consider new technologies and their place in children's lives (e.g., in early childhood

curriculum or for video calling). Making the distinction between harmful screen time (e.g., “passive” television viewing) versus more interactive and potentially beneficial screen time (e.g., using tablet computers for reading or social interaction) will be necessary to determine the impact of specific types of uses on outcomes of interest. Future research should aim to determine the health impacts of using screens in diverse ways, to help identify which behaviours are detrimental and should be targeted in interventions.

- A full scale RCT is warranted in future. There are a number of suggestions for future interventions identified in this thesis that should be considered:

    - Future interventions should recruit larger samples and stratify recruitment across sociodemographic areas to ensure that a heterogeneous sample is recruited, to determine whether the intervention is effective for parents across a range of sociodemographic characteristics.
    - There is the need for an adequately powered RCT that allows mediation analyses to confirm which strategies explain behaviour change. Moderation analyses should also be considered to determine for whom the intervention is or is not effective.
    - Future research should include longer term follow-up to determine whether changes in behaviour are sustained (e.g., one to two years post-intervention). The impact on child health and developmental outcomes should also be considered, as well as potential broader impacts on the parents or the family as a whole.

  - It will be important for future studies to consider different strategies to increase compliance with intervention strategies among varying samples.
  - Future interventions could consider tailoring strategies to individual families. For example, strategies could be tailored depending on the number of children in the family (include strategies that target the whole family), or parent employment status (sending text messages when parents are not at work).

8.4 Practical implications from this thesis

The findings from this thesis may also be useful for parents and policy makers. Although not a focus of this thesis, some of the findings may also be applicable to early childhood practitioners (e.g., in child care centres, preschools, or other early childhood groups such as playgroups). Suggestions and recommendations are outlined below:

- Within the home environment, parents should have rules around the amount of time their young children are allowed to use screens per day, and should also consider implementing screen-free days. The amount of time their children spend engaging in screen-based behaviours should be monitored (e.g., using a chart) to ensure that the rules are adhered to.
- To increase opportunities for young children to reduce sitting time, parents should encourage children to stand up whilst doing activities traditionally done sitting down (e.g., arts and crafts, puzzles). Alternatively, making

changes to the environment, such as taking chairs away from tables, could be implemented to reduce sitting time.

- Childcare centres, preschools and playgroups are an ideal avenue through which to provide parents with educational content around screen time and other sedentary behaviours, including the health outcomes, guidelines for sedentary behaviour, and suggestions for alternative activities. Parents in the RCT in this thesis reported high usefulness and relevance of the Mini Movers booklet, suggesting that they are interested in and eager to receive this type of information.
- When safe to do so, parents of young children should minimise the use of prams/strollers and encourage children to walk, ride a bike or use a scooter to travel to local destinations as frequently as possible. In addition, other situations that restrict movement should be minimised or broken up to reduce prolonged periods of sitting.

8.5 Conclusion

The findings presented in this thesis provide insight into a growing area of research investigating sedentary behaviour in early childhood. A novel intervention was developed based on findings from previous interventions, a cross-sectional examination of correlates of sedentary behaviour in preschool children, and guided by appropriate theory. Findings from the intervention suggest that the text message delivery mode was feasible and acceptable for parents of young children, and efficacious in reducing screen time. Promising results were also demonstrated for other outcomes, including objectively-assessed sitting time which has seldom been measured in this age group. Lastly, the intervention has the ability to be scaled up and widely disseminated. There is a continued need for future research to investigate feasible, effective and scalable interventions to promote healthy sedentary behaviour habits in young children, and a need for public health programs to target these behaviours in this population at scale.

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Appendices

Appendix A: Individual, social and physical environment level correlates of sedentary behaviour identified in previous literature

Table A1. Demographic and biological correlates of sedentary behaviour

Variable	Sedentary time		TV viewing		DVD/video viewing		Electronic games		Computer use		Tablet/smartphones		Total screen time	
	Assoc.	Study ref.	Assoc.	Study ref.	Assoc.	Study ref.	Assoc.	Study ref.	Assoc.	Study ref.	Assoc.	Study ref.	Assoc.	Study ref.
Child age	0	(1-6)	+	(7-14)	+	(8, 12)	+	(8, 12)	+	(8, 15)	+	(16)	0	(15, 17[a], 18[b])
	+	(19-21)	-	(22)									+	(12, 17[c], 23, 24)
	-	(9)	0	(25-28)										
Overall assoc.	*00*		++										*?*	
Child sex (female)	0	(1, 6, 19, 20, 29-35)	0	(7, 9, 12-15, 22, 25, 27, 36, 37[d], 38-40)	0	(12, 38)	-	(12, 40[e])	0	(38)			0	(12, 17, 23, 41, 42, 43[b], 44[b])
	+	(9, 21, 38, 40, 45, 46)	+	(37[f])									-	(40, 47-49)
Overall assoc.	*00*		*00*										*00*	
Child race (non-Caucasian)	0	(4, 9, 19, 20)	+	(15, 50-53)					+	(15)			+	(54)
			-	(25)									0	(24)
			0	(9)										
Overall assoc.	*00*		++											
Child BMI	0	(3-5, 21, 32, 33, 55, 56)	0	(22, 57-61)									0	(18[b], 24, 44[b], 47, 62)
	-	(2)	+	(13, 25, 36, 63, 64)										
	+	(59)												
Overall assoc.	*00*		*?*										*00*	
Parental BMI	0	(2, 3, 6, 21)	+	(25, 26, 64, 65)									-	(48)
			0	(13)									0	(18[b])
Overall assoc.	*00*		++											

Variable	Sedentary time		TV viewing		DVD/video viewing		Electronic games		Computer use		Tablet/smartphones		Total screen time	
	Assoc.	Study ref.	Assoc.	Study ref.	Assoc.	Study ref.	Assoc.	Study ref.	Assoc.	Study ref.	Assoc.	Study ref.	Assoc.	Study ref.
Parental education	0	(3, 19, 21, 32, 35, 66, 67)	-	(13, 15, 25-27, 28[g], 66, 68)					-	(15)			-	(17, 23, 41, 44[b], 67[h])
			0	(22, 28[i], 37)					0	(69)			0	(18[b])
			+	(14)									+	(43[b])
Overall assoc.	*00*		- -										- -	
SEP	0	(5[j], 6, 70)											-	(23)
	+	(70[k])												
Overall assoc.	*?*													
Parent marital status (not married)	0	(3, 21)	0	(37, 65, 68)					-	(69)			0	(18[b], 41)
			+	(15, 25, 37)					0	(15)				
Overall assoc.			*?*											
Parent age	0	(3, 21)	-	(25, 28[g])					+	(69[l])			+	(65[m])
			0	(15, 28[i])					0	(15)			0	(18[b], 24)
Overall assoc.			*?*											
Maternal employment (employed)	+	(21, 66[n])	0	(13, 37, 65)										
			+	(71)										
			-	(64[o], 66[o], 68)										
Overall assoc.			*?*											
Waist circumference	0	(61)											0	(47)
Waist-to-height ratio	+	(72[k])												
Birth weight	0	(6, 21)												

Variable	Sedentary time		TV viewing		DVD/video viewing		Electronic games		Computer use		Tablet/smartphones		Total screen time	
	Assoc.	Study ref.	Assoc.	Study ref.	Assoc.	Study ref.	Assoc.	Study ref.	Assoc.	Study ref.	Assoc.	Study ref.	Assoc.	Study ref.
Preterm birth	0	(21)												
Child first-born status														
Child disability/ poor health	0	(6)											0	(18[b])
Breast feeding duration			-	(25)										
Breast feeding status	0	(21)												
Paternal employment	0	(21, 66)	0	(66)										
Parental employment (working)			0	(15)					0	(15)			0	(18[b])
			+	(14)										
Family income	0	(3, 21, 35)	-	(25, 64)					0	(69)			-	(17)
			0	(14)										
Family structure (single vs dual parent family)	-	(6)											0	(23)
Family size			+	(27)										
Financial difficulties/low income			0	(68)									0	(18[b])
			+	(65)										
Parent retired			0	(22)					0	(69)				
Parent studying				(25)					0	(69[j])				
									+	(69[k])				
Parent disability/ poor health													0	(18[b])

Variable	Sedentary time		TV viewing		DVD/video viewing		Electronic games		Computer use		Tablet/smartphones		Total screen time	
	Assoc.	Study ref.	Assoc.	Study ref.	Assoc.	Study ref.	Assoc.	Study ref.	Assoc.	Study ref.	Assoc.	Study ref.	Assoc.	Study ref.
Parent migrant status (migrant)	+	(66)	+	(66)									0	(18[b])
Maternal race (non-caucasian)	0	(3)												
Parent race/ethnicity			0	(14)									0	(24)
Mother's age at birth of child													0	(44)
Fundamental movement skills	0	(5, 6, 21)					0	(73)						
	-	(74)												

0 no assoc.; + positive assoc.; - negative assoc.; ? indeterminate assoc.; 00 no assoc. (≥4 studies); ++ positive assoc. (≥4 studies); -- negative assoc. (≥4 studies).
[a] 4-5y only; [b] meeting screen time recommendations; [c] 0-5y; [d] 5-6y only; [e] weekends only; [f] 3-4y only; [g] father; [h] girls only; [i] mother; [j] area-level SEP; [k] boys only; [l] >40y; [m] for ≥1h/day only, not ≥2h/day; [n] full time; [o] part time.
Abbreviations: assoc. = association; BMI = body mass index; mo = months; ref. = reference; SEP = socioeconomic position; TV = television; y = year.

Table A2 Behavioural correlates of sedentary behaviour

Variable	Total sedentary time		TV viewing		DVD/video viewing		Electronic games		Computer use		Tables/smartphones		Total screen time	
	Assoc.	Study ref.	Assoc.	Study ref.	Assoc.	Study ref.	Assoc.	Study ref.	Assoc.	Study ref.	Assoc.	Study ref.	Assoc.	Study ref.
Physical activity	-	(61[a])	-	(9, 22, 64)					0	(69)				
	+	(59)	+	(75)										
	0	(61[b])	0	(26, 59)										
Overall assoc.			*?*											
Outdoor play time	-	(6, 76)	0	(37, 50, 58)	0	(50)							0	(18[c], 62)
			-	(36)										
Overall assoc.			*?*											
Energy intake	0	(59)	+	(13, 25, 26, 59)										
Overall assoc.			++											
Consumption of energy dense/ junk foods	0	(59)	+	(25, 59, 64, 77[d])					+	(77[d])			+	(77[c])
Overall assoc.			++											
Consumption of skim milk/ fruit & veg	+	(59)	-	(13, 25, 59, 77[d])					-	(77[d])			-	(77[c])
Overall assoc.			--											
Sleep duration	0	(6)	-	(25, 78)									-	(79, 80[e])
			0	(28, 81)									0	(18[c], 62, 80[f])
Overall assoc.			*?*										*?*	
Bedtime													+	(80[f])
													0	(80[e])
Sleep latency													-	(80[g])
													0	(80[h])
Waking at night													0	(80[f])
													+	(80[e])

Variable	Total sedentary time		TV viewing		DVD/video viewing		Electronic games		Computer use		Tables/smartphones		Total screen time	
	Assoc.	Study ref.	Assoc.	Study ref.	Assoc.	Study ref.	Assoc.	Study ref.	Assoc.	Study ref.	Assoc.	Study ref.	Assoc.	Study ref.
Tummy time frequency													0	(82[i])
Tummy time commenced within 1 month of birth													0	(82[i])
Play frequency	0	(6)												
Frequency of active transport and non-organised activities	0	(6)											0	(18[c])
Participation in organised activities													0	(18[c])
Child attends swim lessons			-	(83)										
Active e-game use (e.g., Wii™)													0	(18[c])
Age child started watching TV			0	(28)										
Attendance at playgroup													0	(18[c], 82[j])
Multivitamin use			0	(25)										

0 no assoc.; + positive assoc.; - negative assoc.; ? indeterminate assoc.; ++ positive assoc. (≥4 studies).
[a] MVPA; [b] LPA & MVPA; [c] meeting screen time recommendations; [d] ≤1h/day compared to >1h/day; [e] at age 2y only; [f] at ages 3.5 & 5y only; [g] at ages 2 & 5y only; [h] at age 3.5y only; [i] at 6 months predicted screen time across 2-5y; [j] at 1y predicted screen time across 2-5y.
Abbreviations: assoc. = association; BMI = body mass index; LPA = light physical activity; mo = months; MVPA = moderate to vigorous physical activity; ref. = reference; SEP = socioeconomic position; TV = television; veg = vegetables; y = year.

Table A3 Psychological, cognitive and emotional correlates of sedentary behaviour

Variable	Total sedentary time		TV viewing		DVD/video viewing		Electronic games		Computer use		Tablet/smartphones		Total screen time	
	Assoc.	Study ref.	Assoc.	Study ref.	Assoc.	Study ref.	Assoc.	Study ref.	Assoc.	Study ref.	Assoc.	Study ref.	Assoc.	Study ref.
Child's interest in TV			+	(27)										
Child enjoys print (e.g., books)			0	(27)										
Child active by him/herself													0	(18[a])
Child requests for PA													0	(18[a])
Child preference for PA	-	(84)	-	(84)									0	(18[a])
Child constraints to PA (e.g., not enough energy)													0	(18[a])
Infant temperament	0	(21)												
Self-regulation	0	(6)												
Psychological difficulties	0	(6)												
Emotionality temperament	0	(6)												
Activity temperament	-	(6)												
Shyness temperament	0	(6)												
Cognitive performance	0	(6)												

+ positive assoc.; 0 no assoc.; - negative assoc.
[a] meeting screen recommendations
Abbreviations: assoc. = association; PA = physical activity; ref. = reference; SEP = socioeconomic position; TV = television.

Table A4. Social and cultural correlates of sedentary behaviour

Variable	Total sedentary time		TV viewing		DVD/video viewing		Electronic games		Computer use		Tablet/smartphones		Total screen time	
	Assoc.	Study ref.	Assoc.	Study ref.	Assoc.	Study ref.	Assoc.	Study ref.	Assoc.	Study ref.	Assoc.	Study ref.	Assoc.	Study ref.
Presence of siblings/ number of children in the house	0	(2, 85, 86[a])	0	(13, 14, 22, 28)									+	(17)
	-	(86[b], 87[c])												
Overall assoc.	*00*		*00*											
Single child household													-	(44[d])
													0	(18[e])
Screen time rules	0	(67, 84)	-	(27, 50, 67, 83, 84)	-	(50)	-	(50)	-	(50)			-	(48, 67)
			0	(14, 37)									0	(18[e], 24)
													+	(88)
Overall assoc.			- -										*?*	
Parental screen time/TV viewing time			+	(13, 14, 22, 28, 48, 65, 86, 89, 90)							+	(16[f])	+	(17, 24, 82[g], 91)
													-	(18[e,h])
Overall assoc.			++										++	
Parental sedentary time (obejective)	+	(92-94)												
	0	(95)												
Overall assoc.	*?*													
Use of screen time as a reward	0	(84)	-	(84)										

Variable	Total sedentary time		TV viewing		DVD/video viewing		Electronic games		Computer use		Tablet/smartphones		Total screen time	
	Assoc.	Study ref.	Assoc.	Study ref.	Assoc.	Study ref.	Assoc.	Study ref.	Assoc.	Study ref.	Assoc.	Study ref.	Assoc.	Study ref.
Use of PA as a reward	0	(84)	0	(84)										
Rules for active play indoors	-	(84)	0	(84)										
Rules for active play outdoors	0	(84)	+	(84)										
Limiting outdoor play because of weather	0	(84)	0	(84)										
Parental encouragement of TV viewing			0	(27)										
Parents limit TV advertising exposure			-	(83)										
Parental encouragement for PA	0	(9, 84)	+	(9)										
			0	(84)										
Parental discouragement for PA	0	(9)	+	(9)										
Parental stimulation to be physically active													0	(88)
Parental monitoring of activity (keeping track of amount of screen time and PA)													0	(88)

Variable	Total sedentary time		TV viewing		DVD/video viewing		Electronic games		Computer use		Tablet/smartphones		Total screen time	
	Assoc.	Study ref.	Assoc.	Study ref.	Assoc.	Study ref.	Assoc.	Study ref.	Assoc.	Study ref.	Assoc.	Study ref.	Assoc.	Study ref.
Overall parenting practices (support for PA, restrictive play rules & PA monitoring)													0	(96)
Parent perception screen time helps/is enjoyable			+	(37[d])									+	(17)
			0	(37[i])										
Parent-reported barriers to reducing screen time (e.g., societal pressure, poor weather, etc)													+	(17)
Descriptive norms (e.g., parental perception of maximum screen time for child)													+	(17)
Parental concerns (e.g., traffic danger)													0	(18[e])
Parent confidence to support healthy child behaviours													0	(18[e])

Variable	Total sedentary time		TV viewing		DVD/video viewing		Electronic games		Computer use		Tablet/smartphones		Total screen time	
	Assoc.	Study ref.	Assoc.	Study ref.	Assoc.	Study ref.	Assoc.	Study ref.	Assoc.	Study ref.	Assoc.	Study ref.	Assoc.	Study ref.
Parent perception of PA (e.g., child should do ≥1 hour of PA/day)													0	(18[e])
Parent perception of importance and value of PA	0	(84)	0	(84)										
Parent perception TV hurts			0	(37)									0	(18[e])
Parent perception that TV is of value													+	(24)
Parent perception that TV is useful													0	(24)
Parent preference for child to do activities with older siblings													0	(18[e])
Parent preference for indoor over outdoor play spaces													0	(18[e])
Parent perception child spends too much time playing e-games													+	(48)
Parent perception child watches too much TV			+	(97)										

Variable	Total sedentary time		TV viewing		DVD/video viewing		Electronic games		Computer use		Tablet/smartphones		Total screen time	
	Assoc.	Study ref.	Assoc.	Study ref.	Assoc.	Study ref.	Assoc.	Study ref.	Assoc.	Study ref.	Assoc.	Study ref.	Assoc.	Study ref.
Parental concern about child's health behaviour (i.e., PA and screen time)													-	(18[e,j])
													0	(18[e,k])
Parent constraints (e.g., too tired to support PA)													0	(18[e])
Parental role modelling of PA	0	(2, 6, 84)	0	(50)	0	(50)	0	(50)	0	(50)			0	(18[e], 96)
			-	(84)										
Parental sports club membership	-	(6)												
Parental involvement in child PA	0	(6)												
Parental smoking/ tobacco use	0	(6, 21)	+	(25)										
Parental alcohol consumption	+	(6)												
Parental TV co-viewing with child	0	(84)	+	(14, 84)										
TV on during meals	0	(84)	+	(84)										
Sibling TV viewing time			+	(28)										

Variable	**Total sedentary time**		**TV viewing**		**DVD/video viewing**		**Electronic games**		**Computer use**		**Tablet/smartphones**		**Total screen time**	
	Assoc.	**Study ref.**	**Assoc.**	**Study ref.**	**Assoc.**	**Study ref.**	**Assoc.**	**Study ref.**	**Assoc.**	**Study ref.**	**Assoc.**	**Study ref.**	**Assoc.**	**Study ref.**
Parent meets PA guideline (≥150 mins/ week)													0	(82[g])
Parental sedentary behaviour (self-report)	0	(6)												
Parental time with child			0	(13, 22)										
Frequency of social gatherings													0	(18[e])
PA of adults/ children at social gatherings													0	(18[e])
Frequency of PA interaction of parents/ others with child													0	(18[e])
Support/ reinforcement from other adults for PA	0	(84)	-	(84)										
Provision of logistic and emotional support for PA/SB	0	(84)	-	(84)									0	(18[e])
Logistic support for sports	-	(84)	-	(84)										

Variable	Total sedentary time		TV viewing		DVD/video viewing		Electronic games		Computer use		Tablet/smartphones		Total screen time	
	Assoc.	Study ref.	Assoc.	Study ref.	Assoc.	Study ref.	Assoc.	Study ref.	Assoc.	Study ref.	Assoc.	Study ref.	Assoc.	Study ref.
Logistic support for active play														
Parental knowledge of active play													0	(82[g])
Parental belief that they will be able to keep child occupied with activities													0	(82[g])
Parental knowledge of child development													0	(82[g])
Parental awareness of childhood obesity													0	(82[g])
Child is active for longer when with someone else													0	(18[e])
Child is competitive with other children when being active													0	(18[e])
Parenting style (authoritative compared to permissive, neglectful/ uninvolved or indulgent)													-	(15, 98)

Variable	Total sedentary time		TV viewing		DVD/video viewing		Electronic games		Computer use		Tablet/smartphones		Total screen time	
	Assoc.	Study ref.	Assoc.	Study ref.	Assoc.	Study ref.	Assoc.	Study ref.	Assoc.	Study ref.	Assoc.	Study ref.	Assoc.	Study ref.
PA training & education (teachers)	-	(99)												
Preschool teacher education	0	(100, 101)												
Maternal self-efficacy			-	(10[l], 90[m])									-	(17[m], 102[e,n])
			+	(90[o])										
Parental/ maternal depression			+	(39)										
			0	(14)										
Parent well-being			0	(14)							-	(16[p])		

0 no assoc.; + positive assoc.; - negative assoc.; ? indeterminate assoc.; 00 no assoc. (≥4 studies); ++ positive assoc. (≥4 studies); -- negative assoc. (≥4 studies).

[a] any younger siblings; [b] any older siblings; [c] 2 or more siblings; [d] 5-6y only; [e] meeting screen time recommendations; [f] mother's tablet use; [g] mother's pre-pregnancy screen time; [h] maternal TV viewing only; [i] 3-4y only; [j] girls only; [k] boys only; [l] self-efficacy to promote PA, displace & limit TV; [m] self-efficacy to limit screen time; [n] self-efficacy to influence PA & screen time; [o] self-efficacy to promote PA; [p] maternal personal well-being and relational well-being (relationship satisfaction, co-parenting and conflict).

Abbreviations: assoc. = association; e-games = electronic games; PA = physical activity; SB = sedentary behaviour; ref. = reference; TV = television.

Table A5. Physical environment correlates of sedentary behaviour

Variable	Total sedentary time		TV viewing		DVD/video viewing		Electronic games		Computer use		Tablet/smartphone		Total screen time	
	Assoc.	**Study ref.**	**Assoc.**	**Study ref.**	**Assoc.**	**Study ref.**	**Assoc.**	**Study ref.**	**Assoc.**	**Study ref.**	**Assoc.**	**Study ref.**	**Assoc.**	**Study ref.**
Home and neighbourhood														
TV in bedroom			0	(14, 37, 103)			+	(103)					0	(24, 48, 89)
			+	(7)									+	(17, 65)
Overall assoc.													?	
Number of TVs in home			0	(14, 28, 50)	0	(50)	0	(50)	0	(50)			0	(48[a])
													+	(24, 89[b,c])
													-	(18[d,e])
Overall assoc.													?	
Day of the week (weekday)	+	(29, 35)	0	(13, 58, 60)									+	(43[e])
	0	(32, 38)	-	(11)										
	-	(40)												
Overall assoc.	*?*		*?*											
Computer in bedroom			0	(14)									0	(17, 89)
Video games in bedroom													+	(17)
Number of pieces of game equipment in home	0	(6)											0	(18[e], 89)
Number of pieces of media equipment in home														(18[e], 89)
Playstation in home							+	(83)						

Variable	Total sedentary time		TV viewing		DVD/video viewing		Electronic games		Computer use		Tablet/smartphone		Total screen time	
	Assoc.	Study ref.	Assoc.	Study ref.	Assoc.	Study ref.	Assoc.	Study ref.	Assoc.	Study ref.	Assoc.	Study ref.	Assoc.	Study ref.
Computer/ laptop in home									-	(83)			0	(48, 89)
Video/DVD player in home													0	(48)
Cable subscription			+	(27)										
Internet connection in home			-	(83)									0	(48)
Constant TV			+	(37[f], 83)										
			0	(37[g])										
High-risk home media environment (no. of TVs, TV in bedroom, media rules, parental TV viewing)			+	(104)										
Living area per person	+	(6)												
Backyard characteristics			0	(50)	0	(50)	0	(50)	0	(50)				
Home features (e.g., front fence, covered outdoor areas)													0	(18[e])
Yard size													0	(18[e], 23)
Dog ownership	0	(6)											0	(18[e])
Number of cars in household													0	(18[e])

Variable	Total sedentary time		TV viewing		DVD/video viewing		Electronic games		Computer use		Tablet/smartphone		Total screen time	
	Assoc.	Study ref.	Assoc.	Study ref.	Assoc.	Study ref.	Assoc.	Study ref.	Assoc.	Study ref.	Assoc.	Study ref.	Assoc.	Study ref.
Neighbourhood safety	-	(6)	-	(58, 105)										
Neighbourhood characteristics (e.g., distance to closest park, walkability, green space)													0	(23)
													-	(106[c])
Neighbourhood constraints to active transport													0	(18[e])
Park characteristic (e.g., safety of park)	0	(2)	+	(107)									0	(18[e])
Frequency of visits to active play spaces (e.g., sporting facilities, playgrounds)													0	(18[e])
Frequency of visiting indoor play centres													0	(18[e])
Region of residence (urban)			+	(22)										
Holidays			+	(11)										
Season	+	(108[h])												
	0	(21, 32)												
Religion	0	(6)												

Variable	Total sedentary time		TV viewing		DVD/video viewing		Electronic games		Computer use		Tablet/smartphone		Total screen time	
	Assoc.	Study ref.	Assoc.	Study ref.	Assoc.	Study ref.	Assoc.	Study ref.	Assoc.	Study ref.	Assoc.	Study ref.	Assoc.	Study ref.
Availability of PA equipment in home	-	(2)												
Living on a cul-de-sac (no through road)													+	(18[c,e])
													0	(18[d,e])
Centre-based variables														
Attends out-of-home care	0	(21, 32, 35, 109)							0	(69)			0	(23)
													+	(41[i])
													-	(41[j])
Days per week at childcare	0	(6)												
Hours in childcare	-	(109)												
Full vs. part time care	-	(109[c])												
	0	(109[d])												
Time at daycare (vs. time not at daycare)	-	(34)												
Active opportunities	-	(99, 101)												
Recess schedule (3 vs. 2 outdoor playtimes)	0	(110)												
Indoor recreation room	-	(111)												

Variable	Total sedentary time		TV viewing		DVD/video viewing		Electronic games		Computer use		Tablet/smartphone		Total screen time	
	Assoc.	Study ref.	Assoc.	Study ref.	Assoc.	Study ref.	Assoc.	Study ref.	Assoc.	Study ref.	Assoc.	Study ref.	Assoc.	Study ref.
Outdoor play area with fixed equipment	-	(111)												
Sedentary environment	+	(99)												
Preschool attended		(19[k])												
Preschool quality	-	(100, 101)												
Preschool playground size	-	(101)												
No. of pieces of fixed playground equipment	+	(101)												
No. of pieces of portable playground equipment	-	(101)												
Preschool field trips	0	(100)												
Community involvement	0	(100)												
Preschool TV/computer time	0	(100)												
Time outdoors at preschool	0	(100, 101)												
	-	(112)												
Free time at preschool	0	(100)												

Variable	Total sedentary time		TV viewing		DVD/video viewing		Electronic games		Computer use		Tablet/smartphone		Total screen time	
	Assoc.	**Study ref.**	**Assoc.**	**Study ref.**	**Assoc.**	**Study ref.**	**Assoc.**	**Study ref.**	**Assoc.**	**Study ref.**	**Assoc.**	**Study ref.**	**Assoc.**	**Study ref.**
Preschool class size	0	(100)												

0 no assoc.; + positive assoc.; - negative assoc.; ? indeterminate assoc.
[a] ≥3 TVs only; [b] ≥4 TVs only; [c] boys only; [d] girls only; [e] meeting screen time recommendations; [f] 3-4y only; [g] 5-6y only; [h] higher in spring than in summer or autumn; [i] non-parental home-based care, e.g., relative; [j] centre-based care; [k] varies with centre.
Abbreviations: assoc. = association; e-games = electronic games; mo = month; no. = number; PA = physical activity; ref. = reference; TV = television.

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Appendix B: Authorship Statement:

Paper One

AUTHORSHIP STATEMENT

1. Details of publication and executive author

Title of Publication		Publication details
Interventions to reduce sedentary behaviour in 0-5-year-olds: a systematic review and meta-analysis of randomised controlled trials		Downing K, Hnatiuk J, Hinkley T, Salmon J, Hesketh K. Interventions to reduce sedentary behaviour in early childhood: A systematic review and meta-analysis. British Journal of Sports Medicine 2016 doi:10.1136/bjsports-2016-096634.
Name of executive author	School/Institute/Division if based at Deakin; Organisation and address if non-Deakin	Email or phone
Katherine Downing	Institute for Physical Activity and Nutrition (IPAN)	k.downing@deakin.edu.au

2. Inclusion of publication in a thesis

Is it intended to include this publication in a higher degree by research (HDR) thesis?	**Yes**	If Yes, please complete Section 3 If No, go straight to Section 4.

3. HDR thesis author's declaration

Name of HDR thesis author if different from above. (If the same, write "as above")	School/Institute/Division if based at Deakin		Thesis title
As above	Institute for Physical Activity and Nutrition (IPAN)		Intervening to reduce sedentary behaviour in early childhood
If there are multiple authors, give a full description of HDR thesis author's contribution to the publication (for example, how much did you contribute to the conception of the project, the design of methodology or experimental protocol, data collection, analysis, drafting the manuscript, revising it critically for important intellectual content, etc.)			
Conceptualised the study: 90% Performed database searches: 100% Screened titles: 100% Screened abstracts and full-text papers: 50% Extracted data: 100% Conducted quality assessment: 50% Conducted meta-analysis: 90% Drafted manuscript: 70%			
I declare that the above is an accurate description of my contribution to this paper, and the contributions of other authors are as described below.		Signature and date	Signature Redacted by Library 19/07/2017

4. Description of all author contributions

Name and affiliation of author	Contribution(s) (for example, conception of the project, design of methodology or experimental protocol, data collection, analysis, drafting the manuscript, revising it critically for important intellectual content, etc.)
Jill Hnatiuk, Deakin University	Screened abstracts and full-text papers, conducted quality assessment, critically reviewed and revised the manuscript
Trina Hinkley, Deakin University	Consulted where necessary for full-text inclusion, critically reviewed and revised the manuscript
Jo Salmon, Deakin University	Consulted where necessary for full-text inclusion, critically reviewed and revised the manuscript
Kylie Hesketh, Deakin University	Consulted where necessary for full-text inclusion, critically reviewed and revised the manuscript

5. Author Declarations

I agree to be named as one of the authors of this work, and confirm:

i. that I have met the authorship criteria set out in the Deakin University Research Conduct Policy,

ii. that there are no other authors according to these criteria,

iii. that the description in Section 4 of my contribution(s) to this publication is accurate,

iv. that the data on which these findings are based are stored as set out in Section 7 below.

If this work is to form part of an HDR thesis as described in Sections 2 and 3, I further

v. consent to the incorporation of the publication into the candidate's HDR thesis submitted to Deakin University and, if the higher degree is awarded, the subsequent publication of the thesis by the university (subject to relevant Copyright provisions).

Name of author	Signature*	Date
Jill Hnatiuk	Signature Redacted by Library	27/10/2017
Trina Hinkley	Signature Redacted by Library	27/10/2017
Jo Salmon	Signature Redacted by Library	27/10/2017
Kylie Hesketh	Signature Redacted by Library	27/10/2017

6. Other contributor declarations

I agree to be named as a non-author contributor to this work.

Name and affiliation of contributor	Contribution	Signature* and date

***** If an author or contributor is unavailable or otherwise unable to sign the statement of authorship, the Head of Academic Unit may sign on their behalf, noting the reason for their unavailability, provided there is no evidence to suggest that the person would object to being named as author

7. Data storage

The original data for this project are stored in the following locations. (The locations must be within an appropriate institutional setting. If the executive author is a Deakin staff member and data are stored outside Deakin University, permission for this must be given by the Head of Academic Unit within which the executive author is based.)

Data format	Storage Location	Date lodged	Name of custodian if other than the executive author
N/A (no original data)			

This form must be retained by the executive author, within the school or institute in which they are based.

If the publication is to be included as part of an HDR thesis, a copy of this form must be included in the thesis with the publication.

Appendix C: HAPPY Study Deakin University Human Research Ethics Committee and Department of Education and Early Childhood Development Approvals

Research Services

Office of the Deputy Vice-Chancellor (Research) (Melbourne Campus)

MEMORANDUM

TO: Prof. David Crawford — **cc:** Trina Hinkley
School of Exercise and Nutrition Sciences, Burwood

FROM: A/Executive Officer, Deakin University Human Research Ethics Committee (DU-HREC)

DATE: 20 December 2007

SUBJECT: **Project EC 291-2007** *(Please quote this project number in future communication.)*
The influence of social and physical environments on preshcool children's physical activity

---

This application was considered at the DU-HREC meeting held on 12 December 2007.

Approval has been given for Trina Hinkley, under the supervision of Prof. David Crawford, School of Exercise and Nutrition Sciences, to undertake this project for a period of three years from 20 December 2007.

The approval given by the Deakin University Human Research Ethics Committee is given only for the project and for the period as stated in the approval. It is your responsibility to contact the Executive Officer immediately should any of the following occur:

- Serious or unexpected adverse effects on the participants
- Any proposed changes in the protocol, including extensions of time.
- Any events which might affect the continuing ethical acceptability of the project.
- The project is discontinued before the expected date of completion.
- Modifications are requested by other HREC's.

In addition you will be required to report on the progress of your project at least once every year and at the conclusion of the project. Failure to report as required will result in suspension of your approval to proceed with the project.

DU-HREC may need to audit this project as part of the requirements for monitoring set out in the National Statement on Ethical Conduct in Research Involving Humans (1999).

Signature Redacted by Library

P.P Janine Truter
On behalf of DU-HREC
(03) 9251 7123

Department of Education and Early Childhood Development

50 Lonsdale Street
GPO Box 4057
Melbourne Victoria 3001
DX210081
www.dhs.vic.gov.au
Telephone: (03) 9616 7777
Facsimile: (03) 9616 8329

Our Ref: **2008/196**

15 May 2008

Professor David Crawford
Faculty of Exercise and Nutrition Sciences
Deakin University
221 Burwood Hwy,
Burwood, Vic 3125

Dear Professor Crawford

RE: Application to undertake research involving the Office for Children, Department of Human Services

I write to you concerning your application to the Office for Children Research Coordinating Committee (RCC) to undertake research entitled "*The influence of social and physical environments on preschool children's physical activity*".

I am pleased to inform you that the Office for Children RCC will support the research subject to the following conditions:

- The research is conducted in accordance with the documentation you provided to the RCC;
- The provision of a final report to the RCC at the completion of the research;
- The provision of a one page summary of the outcomes of the research and how this relates to the Office for Children;
- The provision of a seminar/presentation to Office for Children staff on the outcomes of the research – with details to be arranged with the RCC Secretariat;
- That you provide the RCC with the opportunity to review and provide comment on any materials generated from the research prior to formal publication. It is expected that if there any differences of opinion between the RCC and yourself related to the research outcomes, that these differences would be acknowledged in any publications, presentations and public forums;
- That you acknowledge the support of the Office for Children Research Coordinating Committee in any publications arising from the research; and
- The project is commenced within 12 months of this approval letter, after this time the approval lapses and extensions will need to be considered by the RCC.

If you have any further enquiries, please don't hesitate to contact the RCC Secretariat on 03 9947 1849 or via email gabriel.stacey.s@edumail.vic.gov.au. The RCC wishes you the best in your research and we look forward to seeing the results in due course.

Yours sincerely

Signature Redacted by Library

Joyce Cleary
Chair, Office for Children and Early Childhood Development Research Coordinating Committee

Appendix D: Internal reliability for summed items included in Paper Two

Table D1. Internal reliability for summed items included in Paper Two

Variable Description	Number of items	Cronbach's alpha
Child active co-participation preferences (e.g., child is active by him/herself, child is active with his/her friends)	4	0.63*
Child prosocial physical activity behaviour (e.g., asks for opportunities to be active)	5	0.60*
Child preferences for sedentary behaviour (e.g., more likely to watch TV than be active)	3	0.38*
Child constraints to physical activity	10	0.77
Parental concerns about physical activity and sedentary behaviour	4	0.80
Parental constraints to child's physical activity	6	0.70
Parental self-efficacy to support physical activity	2	0.83
Parental self-efficacy to limit sedentary behaviour	3	0.73
Parental health knowledge/beliefs of child's physical activity	3	0.77
Parental rules to limit screen time	2	0.76
Parental rules about games inside (e.g., no throwing balls inside)	2	0.73
Parental rules about physical activity for stranger danger, traffic, injury	2	0.41*
Parent allows child to play freely in backyard/street	2	0.09*
Child is active at social gatherings	3	0.12*
Neighbourhood playground suitability (e.g., equipment, shade, safety)	6	0.90
Neighbourhood constraints to active transport (e.g., busy roads)	7	0.75

Notes: *for these variables with low internal reliability, a decision was made to still include them in analyses as the constructs made sense conceptually

Appendix E: HAPPY Study questionnaire

ID: ___________

The HAPPY Study

Healthy Active Preschool Years

2009

Parent/Carer name: ___________________________

Child name: ___________________________________

If you have any questions contact Janina Chapman or Dejan Mrkic on 9244 5019

IMPORTANT INSTRUCTIONS – PLEASE READ

Thank you for taking the time to complete this survey. We would like the main carer of the child named on the front of this survey complete it. It will take you approximately 30 minutes to complete, although this may vary depending on your answers. Once you have finished your survey, please place it in the envelope provided and return it with your preschool child to the centre you collected it from by the date shown in the enclosed information.

We will refer to your child who is participating in this study as 'your preschool child'. This does not mean that your child has to attend preschool to be included in the study. In fact, we would like to include as many children as possible who do not attend preschool. We use this term to refer to children aged three to five years who have not yet started school.

Throughout this survey, 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, walking or cycling to places, sport or exercise. This includes time at playgrounds or other play spaces (including beaches and indoor play spaces), time outdoors in the backyard, and any other time inside when your preschool child is being active.
- 'your local neighbourhood' – by this we mean your suburb or the local area in which you live.
- 'preschool' – by this we mean either the preschool or kindergarten 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 is often considered to help children get ready for formal schooling, and usually only caters for children aged three to five years. This is quite different from 'childcare'.
- 'childcare' – by this we mean regular child care in a centre or family day care environment, which might be where your preschool child attends while you work or study, or do other activities without your preschool child. Childcare is often available from early morning until early evening. Childcare can cater for children from around six weeks of age until school age. Even if your child's childcare centre runs a preschool program, we still consider this to be childcare.
- 'playgroup' – by this we mean an informal session where mums, dads, grand parents, caregivers, children and babies meet together in a relaxed environment. Activities at playgroup are generally either free or low cost, and parents and caregivers stay to interact with the other adults and to play with the children. Playgroups cater for children from 0-5 years of age.

Please answer each question by ticking or circling the most suitable option. Where you are asked to write an answer please read the question carefully and answer the best you can in the space provided. If you are unsure about how to answer a question, please choose the answer that best reflects how you feel.

When marking your answers on the survey, please clearly tick or circle your response so we can easily see which answer you chose. For example:

When asked to tick your answer, please do so like this:

☐ Yes ☑ No

When asked to circle your answer, please do so like this:

Strongly disagree$_1$	Disagree$_2$	Neither agree nor disagree$_3$	Agree$_4$	Strongly Agree$_5$	Don't know$_6$	Not applicable$_7$

If you make an error, please clearly cross out the incorrect answer and choose the correct answer. For example:

Strongly disagree$_1$	~~Disagree$_2$~~	Neither agree nor disagree$_3$	Agree$_4$	Strongly Agree$_5$	Don't know$_6$	Not applicable$_7$

Section A: About you

Please write today's date: _ _ / _ _ / 200 _

A1. How old are you? _______ years

A2. What is your sex? *(Please tick ONE)*

☐1 Male ☐2 Female

A3. What country were you born in? *(Please tick ONE)*

☐1 Australia ☐2 UK or Ireland
☐3 Italy ☐4 Greece
☐5 Netherlands ☐6 Germany
☐7 New Zealand ☐8 Vietnam
☐9 Poland ☐10 Other (please specify) __________________

A4. How tall are you without shoes? (provide your best guess if you are not sure)

____________ centimetres OR _________ feet and _________ inches

A5. How much do you weigh without clothes or shoes? (Provide your best guess if you are not sure. If you are currently pregnant, please provide your pre-pregnancy weight))

______________ kilograms OR _________ stone and _________ pounds

A6. What is your highest level of schooling? *(Please tick ONE)*

☐1 No formal qualifications
☐2 Year 10 or equivalent (e.g. School Certificate)
☐3 Year 12 or equivalent (e.g. Higher School Certificate)
☐4 Trade/apprenticeship/certificate (e.g. hairdresser, chef, plumber)
☐5 Diploma (e.g. Business/Accounting)
☐6 University degree
☐7 Post-graduate qualification (e.g. Graduate Diploma, Masters,PhD)

A7. Are you currently: (Please tick the ONE you spend most time in)

- ☐1 Employed full time
- ☐2 Employed part time
- ☐3 Home-duties full time
- ☐4 A student
- ☐5 Retired
- ☐6 Unemployed
- ☐7 Other (please state) ___________________________

A8. What is your current marital status? *(Please tick ONE)*

☐1 Married	☐2 De facto/living together
☐3 Separated	☐4 Divorced
☐5 Widowed	☐6 Never married

A9. Do you own a dog? (Please tick ONE)

☐1 Yes ☐2 No

A10. How many cars are there in your household? *(Please write the number)*

_____________ cars

A11. Do you have a disability or suffer from poor health? *(Please tick ONE)*

☐1 Yes ☐2 No

If yes, please describe: _______________________________________

A12. Do you or your partner have a Health Care Card or Pension Card (from Centrelink)? *(Please tick ONE)*

☐1 Yes ☐2 No

Your free time

In this section we want you to think about the physical activities you do in your free time in a typical week. These questions are about that time when you are NOT WORKING OR DOING CHORES.

A13. In a TYPICAL WEEK **HOW MANY TIMES** do you usually do **vigorous** physical activity which makes you breathe harder or puff and pant, for at least 10 minutes continuously? (eg tennis, jogging, cycling) *(Please write the number)*

________________ times

A14. Please estimate the **TOTAL AMOUNT OF TIME** that you usually spend doing vigorous physical activity in a TYPICAL WEEK *(Please write the number)*

________________ hours and _______________ minutes

A15. In a TYPICAL WEEK, **HOW MANY TIMES** do you usually walk or do other **moderate** physical activity, for at least 10 minutes continuously? (eg gardening, walking the dog, golf, lap swimming) *(Please write the number)*

________________ times

A16. Please estimate the **TOTAL AMOUNT OF TIME** that you usually spend doing moderate physical activity in a TYPICAL WEEK *(Please write the number)*

________________ hours and _______________ minutes

A17. Please estimate the **TOTAL AMOUNT OF TIME** you usually spend **watching TV and DVDs/videos** during a TYPICAL WEEK. This is when it is the main activity you are doing (eg you would not include time when the TV was switched on and you were preparing a meal) *(Please write the number)*

________________ hours and _______________ minutes

Section B: Your partner

B1. Do you have a partner (husband/wife or de facto) who you live with? *(Please tick ONE)*

☐1 Yes ☐2 No – *Please go to Section C*

If you are not sure of the answers to any of these questions, you can ask your partner to help you.

B2. How old is your partner? ________ years

B3. What is your partner's sex? *(Please tick ONE)*

☐1 Male ☐2 Female

B4. Where was your partner born? *(Please tick ONE)*

☐1 Australia ☐2 UK or Ireland
☐3 Italy ☐4 Greece
☐5 Netherlands ☐6 Germany
☐7 New Zealand ☐8 Vietnam
☐9 Poland ☐10 Other (please specify) _________________

B5. How tall is your partner without shoes? *(provide your best guess if you are not sure)*

_____________ centimetres OR ________ feet and _________ inches

B6. How much does your partner weigh without clothes or shoes? *(Provide your best guess if you are not sure. If your partner is currently pregnant, please provide her pre-pregnancy weight.)*

_____________ kilograms OR ________ stone and _________ pounds

B7. What is your partner's highest level of schooling? *(Please tick ONE)*

☐1 No formal qualifications
☐2 Year 10 or equivalent (e.g. School Certificate)
☐3 Year 12 or equivalent (e.g. Higher School Certificate)
☐4 Trade/apprenticeship/certificate (e.g. hairdresser, chef, plumber)
☐5 Diploma (e.g. Business/Accounting)
☐6 University degree
☐7 Post-graduate qualification (e.g. Graduate Diploma, Masters,PhD)

B8. Is your partner currently: *(Please tick the ONE they spend most time in)*

- ☐$_1$ Employed full time
- ☐$_2$ Employed part time
- ☐$_3$ Home-duties full time
- ☐$_4$ A student
- ☐$_5$ Retired
- ☐$_6$ Unemployed
- ☐$_7$ Other (please state) ____________________________

B9. Does your partner have a disability or suffer from poor health? *(Please tick ONE)*

☐$_1$ Yes ☐$_2$ No

If yes, please describe: ____

Your partner's free time

In this section we want you to think about the physical activities that your partner does in his/her free time in a typical week. These questions are about that time when he/she is NOT WORKING OR DOING CHORES.

B10. In a TYPICAL WEEK **how many times** does your partner usually do **vigorous** physical activity which makes him/her breathe harder or puff and pant, for at least 10 minutes continuously? (eg tennis, jogging, cycling) *(Please write the number)*

________________ times

B11. Please estimate the **total time** that he/she usually spends doing **vigorous** physical activity in a TYPICAL WEEK *(Please write the number)*

________________ hours and _______________ minutes

B12. In a TYPICAL WEEK, **how many times** does your partner usually walk or do other **moderate** physical activity, for at least 10 minutes continuously? (eg gardening, walking the dog, golf, lap swimming) *(Please write the number)*

________________ times

B13. Please estimate **the total time** that he/she usually spends doing these activities in a TYPICAL WEEK *(Please write the number)*

________________ hours and _______________ minutes

B14. Please estimate the **total time** your partner usually spends **watching TV and DVDs/videos** during a TYPICAL WEEK. This is when it is the main activity he/she is doing (eg you would not include time when the TV was switched on and he/she was preparing a meal) *(Please write the number)*

________________ hours and _______________ minutes

Section C: Your preschool child

Please think about your preschool child
as you answer these questions.

C1. What is your preschool child's date of birth?

(day/month/year) ________/________/ 20______

C2. What is the sex of your preschool child? *(Please tick ONE)*

☐1 Male ☐2 Female

C3. How many hours per night does your preschool child usually sleep at the moment? *(Please write the number)*

Write the number here: _________ hours

C4. How many hours does your preschool child usually sleep/nap for during the day at the moment? *(Please write the number. If your preschool child does not usually have a daytime nap, please write '0'.)*

Write the number here: _________ hours

C5. Does your preschool child have a disability or suffer from poor health (including asthma)? *(Please tick ONE)*

☐1 Yes ☐2 No

If yes, please describe: ______________________________________

C6. What relation are you to the preschool child involved in this study? *(Please tick ONE)*

☐1 Mother ☐2 Father
☐3 Stepmother ☐4 Stepfather
☐5 Grandparent ☐6 Guardian
☐7 Other (please specify): ______________________

C7. Thinking about your preschool child, which of the following applies to their family situation? *(Please tick ONE)*

- ☐1 Both the child's birth parents live together
- ☐2 The child's birth parents live apart
- ☐3 Other family situation. *Please describe:* ___________________________

  ____

C8. Which of the following best describes your preschool child's living arrangements? *(Please tick ONE)*

My preschool child lives with me:

- ☐1 All or most of the time
- ☐2 About half of the time
- ☐3 Less than half of the time

C9. How many **other** children aged under 18 years currently live in your house? (NOT including the child in this study.)

Write the number here: ____________

What are their ages and sex?

Age (years)	Sex (M/F)
_____________	M / F
_____________	M / F
_____________	M / F
_____________	M / F
_____________	M / F
_____________	M / F

Being a child

C10. Please tell us how much you agree or disagree with these statements. *(Please circle ONE response on each* line*)*

a. My preschool child is active by him/herself	Strongly disagree$_1$	Disagree$_2$	Neither agree or disagree$_3$	Agree$_4$	Strongly agree$_5$	
b. My preschool child is active with his/her siblings (e.g. outdoor play, rough-and-tumble)	Strongly disagree$_1$	Disagree$_2$	Neither agree or disagree$_3$	Agree$_4$	Strongly agree$_5$	My child has no siblings$_6$
c. My preschool child is active with his/her friends(e.g. outdoor play, rough-and-tumble)	Strongly disagree$_1$	Disagree$_2$	Neither agree or disagree$_3$	Agree$_4$	Strongly agree$_5$	
d. My preschool child is active with his/her pets	Strongly disagree$_1$	Disagree$_2$	Neither agree or disagree$_3$	Agree$_4$	Strongly agree$_5$	We have no pets$_6$
e. My preschool child is active for longer when with someone else than when on his/her own	Strongly disagree$_1$	Disagree$_2$	Neither agree or disagree$_3$	Agree$_4$	Strongly agree$_5$	
f. My preschool child is competitive with other children when being physically active	Strongly disagree$_1$	Disagree$_2$	Neither agree or disagree$_3$	Agree$_4$	Strongly agree$_5$	

C11. Please tell us how often your preschool child might do the following things. *(Please circle ONE response on each line)*

a. My preschool child asks for me/my partner to be active with him/her	Never$_1$	Rarely$_2$	Sometimes$_3$	A lot or most of the time$_4$	Always$_5$	I do not have a partner$_6$
b. My preschool child asks his/her siblings to be active with him/her	Never$_1$	Rarely$_2$	Sometimes$_3$	A lot or most of the time$_4$	Always$_5$	My child has no siblings$_6$
c. My preschool child asks people outside our immediate family to be active with him/her (e.g. uncles, parents' friends)	Never$_1$	Rarely$_2$	Sometimes$_3$	A lot or most of the time$_4$	Always$_5$	
d. My preschool child asks for opportunities to be active (eg going to the park/indoor play centre)	Never$_1$	Rarely$_2$	Sometimes$_3$	A lot or most of the time$_4$	Always$_5$	
e. My preschool child likes to help out with active things around the home like gardening	Never$_1$	Rarely$_2$	Sometimes$_3$	A lot or most of the time$_4$	Always$_5$	
f. My preschool child is more likely to watch TV than be active	Never$_1$	Rarely$_2$	Sometimes$_3$	A lot or most of the time$_4$	Always$_5$	We don't have a TV$_6$
g. My preschool child is more likely to play electronic games than be active	Never$_1$	Rarely$_2$	Sometimes$_3$	A lot or most of the time$_4$	Always$_5$	We don't have e-games$_6$
h. My preschool child is more likely to play inside/draw/do craft than be active	Never$_1$	Rarely$_2$	Sometimes$_3$	A lot or most of the time$_4$	Always$_5$	

C12. 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? *(Please circle ONE response on each line)*

a. My preschool child already does a lot of physical activity	Strongly disagree$_1$	Disagree$_2$	Neither agree or disagree$_3$	Agree$_4$	Strongly agree$_5$
b. My preschool child doesn't have enough energy to do more physical activity	Strongly disagree$_1$	Disagree$_2$	Neither agree or disagree$_3$	Agree$_4$	Strongly agree$_5$
c. My preschool child doesn't have enough time to do physical activity	Strongly disagree$_1$	Disagree$_2$	Neither agree or disagree$_3$	Agree$_4$	Strongly agree$_5$
d. My preschool child doesn't have anyone to be physically active with	Strongly disagree$_1$	Disagree$_2$	Neither agree or disagree$_3$	Agree$_4$	Strongly agree$_5$
e. My preschool child just doesn't enjoy being physically active	Strongly disagree$_1$	Disagree$_2$	Neither agree or disagree$_3$	Agree$_4$	Strongly agree$_5$
f. The right facilities are not available for my preschool child to do more physical activity	Strongly disagree$_1$	Disagree$_2$	Neither agree or disagree$_3$	Agree$_4$	Strongly agree$_5$
g. My preschool child is too overweight to participate in physical activity	Strongly disagree$_1$	Disagree$_2$	Neither agree or disagree$_3$	Agree$_4$	Strongly agree$_5$
h. My preschool child feels uncomfortable with groups of children	Strongly disagree$_1$	Disagree$_2$	Neither agree or disagree$_3$	Agree$_4$	Strongly agree$_5$
i. My preschool child doesn't have good enough skills (eg kicking, throwing, catching) to do more physical activity	Strongly disagree$_1$	Disagree$_2$	Neither agree or disagree$_3$	Agree$_4$	Strongly agree$_5$
j. My preschool child will have more freedom and opportunities to be active when he/she is older and more mature	Strongly disagree$_1$	Disagree$_2$	Neither agree or disagree$_3$	Agree$_4$	Strongly agree$_5$

Things your preschool child does

C13. This question is about some of the physical activities that your preschool child might do.

THINKING ABOUT THE LAST MONTH, how often does your preschool child USUALLY do the following physical activities during a typical WEEK**?** *(Please circle one response for each item)*

a. Walk to kinder/school	Never/ Rarely$_1$	Less than once a week$_2$	1-2 times a week$_3$	3-4 times a week$_4$	5-6 times a week$_5$	Daily$_6$	
b. Walk to other destinations	Never/ Rarely$_1$	Less than once a week$_2$	1-2 times a week$_3$	3-4 times a week$_4$	5-6 times a week$_5$	Daily$_6$	
c. Walk for exercise, fun or pleasure	Never/ Rarely$_1$	Less than once a week$_2$	1-2 times a week$_3$	3-4 times a week$_4$	5-6 times a week$_5$	Daily$_6$	
d. Ride a bike/scooter to kinder/school	Never/ Rarely$_1$	Less than once a week$_2$	1-2 times a week$_3$	3-4 times a week$_4$	5-6 times a week$_5$	Daily$_6$	
e. Ride a bike/scooter to other destinations	Never/ Rarely$_1$	Less than once a week$_2$	1-2 times a week$_3$	3-4 times a week$_4$	5-6 times a week$_5$	Daily$_6$	
f. Ride a bike/scooter for fun	Never/ Rarely$_1$	Less than once a week$_2$	1-2 times a week$_3$	3-4 times a week$_4$	5-6 times a week$_5$	Daily$_6$	
g. Walk the dog	Never/ Rarely$_1$	Less than once a week$_2$	1-2 times a week$_3$	3-4 times a week$_4$	5-6 times a week$_5$	Daily$_6$	We don't have a dog$_7$
h. Play with the dog	Never/ Rarely$_1$	Less than once a week$_2$	1-2 times a week$_3$	3-4 times a week$_4$	5-6 times a week$_5$	Daily$_6$	We don't have a dog$_7$
i. Play in the backyard	Never/ Rarely$_1$	Less than once a week$_2$	1-2 times a week$_3$	3-4 times a week$_4$	5-6 times a week$_5$	Daily$_6$	
j. Play on a trampoline, swings or other equipment	Never/ Rarely$_1$	Less than once a week$_2$	1-2 times a week$_3$	3-4 times a week$_4$	5-6 times a week$_5$	Daily$_6$	
k. Use toys/ equipment such as bats & balls in his/her play	Never/ Rarely$_1$	Less than once a week$_2$	1-2 times a week$_3$	3-4 times a week$_4$	5-6 times a week$_5$	Daily$_6$	
l. Swim in a pool	Never/ Rarely$_1$	Less than once a week$_2$	1-2 times a week$_3$	3-4 times a week$_4$	5-6 times a week$_5$	Daily$_6$	
m. Dance to the television or music	Never/ Rarely$_1$	Less than once a week$_2$	1-2 times a week$_3$	3-4 times a week$_4$	5-6 times a week$_5$	Daily$_6$	

The following questions are about ORGANISED sports, games or activities that your preschool child does during the week and on weekends. Please think about a normal week. By organised sports or activities, we mean attending a session at a particular time with a coach, teacher, or trainer. Organised sports or activities may or may not involve competition.

C14. **THINKING ABOUT THE LAST MONTH,** has your preschool child participated in any of the following structured activities? Please tick 'Yes' or 'No' for each activity. Please also complete how many times a week your child participates in this activity.

a.	Swimming	☐1 Yes	☐2 No	____________	times per week
b.	Kindy gym/gymbaroo	☐1 Yes	☐2 No	____________	times per week
c.	Dance/callisthenics	☐1 Yes	☐2 No	____________	times per week
d.	Auskick/football	☐1 Yes	☐2 No	____________	times per week
e.	Soccer	☐1 Yes	☐2 No	____________	times per week
f.	Other (please specify below)				
		________________		____________	times per week
		________________		____________	times per week

C15. During a typical week does your preschool child attend **playgroup**? (please tick one response)

☐1 Yes ☐2 No – *please go to question C16*

If yes, how many times per week does your preschool child attend playgroup?

____________ times

C16. **Thinking about the last month,** which of the following indoor LEISURE activities does your preschool child USUALLY do during a typical WEEK?

For this question, please think about the time your child is not at preschool or childcare.

Please circle either '*Yes*' or '*No*' for each item.

For items you have circled '*Yes*', please write the TOTAL time your preschool child participates in the activity for the WHOLE working/school week (that is, Monday to Friday). Please also write the TOTAL time your preschool child participates in the activity for the WHOLE weekend (that is, Saturday & Sunday).

If you circle '*Yes*' for an activity and your child only participates in that activity during either the working/ school week or the weekend, please write '0' in the TOTAL hours 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?	Does your preschool child usually do this activity? (please circle ONE answer for each)	**TOTAL** hours/minutes Monday-Friday	**TOTAL** hours/minutes Saturday & Sunday
TV/videos/DVDs	Yes$_1$ No$_2$	*15hrs*	*6hrs 30mins*
Playstation© / Nintendo©/ X-Box©/ Gameboy©/ computer games	Yes$_1$ No$_2$	*0*	*2hrs 0mins*

During a typical WEEK what leisure activities does your preschool child usually do?	Does your preschool child usually do this activity? (please circle ONE answer for each)	**TOTAL** hours/minutes Monday-Friday	**TOTAL** hours/minutes Saturday & Sunday
a. TV/videos/DVDs	Yes$_1$ No$_2$		
b. Playstation© / Nintendo©/ X-Box©/ Gameboy©/ computer games	Yes$_1$ No$_2$		
c. Wii™/Eye Toy	Yes$_1$ No$_2$		
d. Computer / internet (excluding games)	Yes$_1$ No$_2$		
e. Quiet play (e.g. Lego™, books, train set, dolls, board games, craft)	Yes$_1$ No$_2$		
f. Imaginary games (e.g. dress ups, imitating TV characters)	Yes$_1$ No$_2$		

Your preschool child's outdoor playtime

Please think about a typical week for your preschool child. This might be different to today or any other days this week, for instance, if your preschool child has been ill or you have been on holidays.

C17. Think for a moment about a TYPICAL **WEEKDAY** (Monday – Friday) for your preschool child IN THE LAST MONTH. **How much time** would you say your preschool child spends playing outdoors on a **typical weekday**? *(Please write how much time in total)*

_______________Hours ______________Minutes

C18. Now think about a TYPICAL **WEEKEND DAY** (Saturday – Sunday) for your preschool child IN THE LAST MONTH. **How much time** would you say your preschool child spends playing outdoors on a **typical weekend day**? *(Please write how much time in total)*

_______________Hours ______________Minutes

You're about half-way through and doing well.

This might be a good time to have a cuppa . . . .

Section D: Being a parent

Please answer these questions with your preschool child in mind.

D1. This question is about concerns you might have for your preschool child. Please indicate how much you agree or disagree with the following concerns. *(Please circle one response on each line)*

a. I am concerned that my preschool child is overweight	Strongly disagree$_1$	Disagree$_2$	Neither agree or disagree$_3$	Agree$_4$	Strongly agree$_5$
b. I am concerned about my preschool child becoming overweight in the future	Strongly disagree$_1$	Disagree$_2$	Neither agree or disagree$_3$	Agree$_4$	Strongly agree$_5$
c. I am concerned about my preschool child having a traffic accident when he/she is being physically active in our neighbourhood	Strongly disagree$_1$	Disagree$_2$	Neither agree or disagree$_3$	Agree$_4$	Strongly agree$_5$
d. I am concerned about stranger danger when my preschool child is being physically active in our neighbourhood	Strongly disagree$_1$	Disagree$_2$	Neither agree or disagree$_3$	Agree$_4$	Strongly agree$_5$
e. I am concerned about my preschool child getting hurt (e.g. falling out of a tree) when he/she is being physically active	Strongly disagree$_1$	Disagree$_2$	Neither agree or disagree$_3$	Agree$_4$	Strongly agree$_5$
f. I am concerned about my preschool child not getting enough physical activity	Strongly disagree$_1$	Disagree$_2$	Neither agree or disagree$_3$	Agree$_4$	Strongly agree$_5$
g. I am concerned that my preschool child watches too much TV/videos/DVDs	Strongly disagree$_1$	Disagree$_2$	Neither agree or disagree$_3$	Agree$_4$	Strongly agree$_5$
h. I am concerned that my preschool child spends too much time on the computer	Strongly disagree$_1$	Disagree$_2$	Neither agree or disagree$_3$	Agree$_4$	Strongly agree$_5$
i. I am concerned that my preschool child spends too much time playing electronic games (such as X-Box, Playstation, GameBoy)	Strongly disagree$_1$	Disagree$_2$	Neither agree or disagree$_3$	Agree$_4$	Strongly agree$_5$

D2. Please state how often the following statements apply to you and your family situation. *(Please circle one response on each line)*

a. I am too tired to support my preschool child to be active (e.g. play outside with him/her, take him/her to park)	Never$_1$	Rarely$_2$	Sometimes$_3$	A lot or most of the time$_4$	Always$_5$	
b. I have enough money to support my preschool child to be active (e.g. take him/her places, pay for activities)	Never$_1$	Rarely$_2$	Sometimes$_3$	A lot or most of the time$_4$	Always$_5$	
c. The time I spend doing housework stops me from supporting my preschool child to be active	Never$_1$	Rarely$_2$	Sometimes$_3$	A lot or most of the time$_4$	Always$_5$	
d. The time I spend working stops me from supporting my preschool child to be active	Never$_1$	Rarely$_2$	Sometimes$_3$	A lot or most of the time$_4$	Always$_5$	I don't work$_6$
e. Looking after my other child/ren stops me from supporting my preschool child to be active	Never$_1$	Rarely$_2$	Sometimes$_3$	A lot or most of the time$_4$	Always$_5$	I don't have other children$_6$

f. I always have a car available when I want to take my preschool child somewhere to be active	$Never_1$	$Rarely_2$	$Sometimes_3$	A lot or most of the $time_4$	$Always_5$
g. It is difficult to get to places for my preschool child to be active	$Never_1$	$Rarely_2$	$Sometimes_3$	A lot or most of the $time_4$	$Always_5$
h. I feel confident that I have the skills to support my preschool child to be active	$Never_1$	$Rarely_2$	$Sometimes_3$	A lot or most of the $time_4$	$Always_5$
i. No matter how I feel, I always make sure I give my preschool child opportunities to be active	$Never_1$	$Rarely_2$	$Sometimes_3$	A lot or most of the $time_4$	$Always_5$

D3. This question is about some of your preferences for the types of physical activities your preschool child does. *(Please circle one response on each line)*

a. I prefer to take my preschool child to indoor play centres than to outdoor play spaces	Strongly $disagree_1$	$Disagree_2$	Neither agree or $disagree_3$	$Agree_4$	Strongly $agree_5$	
b. I take my preschool child to different places for him/her to be active in because I like the variety even if he/she is happy to go to the same place all the time	Strongly $disagree_1$	$Disagree_2$	Neither agree or $disagree_3$	$Agree_4$	Strongly $agree_5$	
c. I am happy to sit and watch my preschool child play in outdoor play spaces for as long as he/she wants to be there	Strongly $disagree_1$	$Disagree_2$	Neither agree or $disagree_3$	$Agree_4$	Strongly $agree_5$	
d. I like to participate with my preschool child when he/she is playing in outdoor play spaces	Strongly $disagree_1$	$Disagree_2$	Neither agree or $disagree_3$	$Agree_4$	Strongly $agree_5$	
e. I prefer to be social with other parents when my preschool child is playing in outdoor play spaces	Strongly $disagree_1$	$Disagree_2$	Neither agree or $disagree_3$	$Agree_4$	Strongly $agree_5$	
f. I get bored watching my preschool child play in outdoor play spaces if there is nothing else for me to do	Strongly $disagree_1$	$Disagree_2$	Neither agree or $disagree_3$	$Agree_4$	Strongly $agree_5$	
g. I like my preschool child to do the activities my older children do/did	Strongly $disagree_1$	$Disagree_2$	Neither agree or $disagree_3$	$Agree_4$	Strongly $agree_5$	Not $applicable_6$
h. I like my preschool child to do the activities I did as a child	Strongly $disagree_1$	$Disagree_2$	Neither agree or $disagree_3$	$Agree_4$	Strongly $agree_5$	
i. I get bored going to the same place for my preschool child to be active	Strongly $disagree_1$	$Disagree_2$	Neither agree or $disagree_3$	$Agree_4$	Strongly $agree_5$	
j. It is important to me that we spend time being physically active together as a family	Strongly $disagree_1$	$Disagree_2$	Neither agree or $disagree_3$	$Agree_4$	Strongly $agree_5$	

D4. How confident are you that you could do the following over the next year? *(Please circle one response in each line)*:

a. Get my preschool child to participate in at least one hour of physical activity every day over the next year	Not at all confident$_1$	Slightly confident$_2$	Moderately confident$_3$	Very confident$_4$	Extremely confident$_5$
b. Get my preschool child to participate in a range of physical activities over the next year	Not at all confident$_1$	Slightly confident$_2$	Moderately confident$_3$	Very confident$_4$	Extremely confident$_5$
c. Get my preschool child to be active when he/she is asking to watch TV/video/DVD over the next year	Not at all confident$_1$	Slightly confident$_2$	Moderately confident$_3$	Very confident$_4$	Extremely confident$_5$
d. 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$_1$	Slightly confident$_2$	Moderately confident$_3$	Very confident$_4$	Extremely confident$_5$
e. Limit my preschool child's screen-based entertainment (TV/video/DVD/computer/electronic games) to less than 2 hours on any day over the next year	Not at all confident$_1$	Slightly confident$_2$	Moderately confident$_3$	Very confident$_4$	Extremely confident$_5$
f. Say no to my preschool child's requests to play on the computer or electronic games over the next year	Not at all confident$_1$	Slightly confident$_2$	Moderately confident$_3$	Very confident$_4$	Extremely confident$_5$

Your beliefs and behaviours

D5. Please tell us how much you agree or disagree with the following statements. *(Please circle one response in each line)*:

a. I think that my preschool child should do at least one hour of activity every day	Strongly disagree$_1$	Disagree$_2$	Neither agree or disagree$_3$	Agree$_4$	Strongly agree$_5$
b. I am satisfied with the amount of physical activity my preschool child does	Strongly disagree$_1$	Disagree$_2$	Neither agree or disagree$_3$	Agree$_4$	Strongly agree$_5$
c. I would like my preschool child to do more physical activity	Strongly disagree$_1$	Disagree$_2$	Neither agree or disagree$_3$	Agree$_4$	Strongly agree$_5$
d. My preschool child does enough physical activity to keep him/her healthy	Strongly disagree$_1$	Disagree$_2$	Neither agree or disagree$_3$	Agree$_4$	Strongly agree$_5$
e. My preschool child does enough physical activity from preschool/kinder/childcare for the whole day on days when he/she attends, even if he/she is only there for a few hours	Strongly disagree$_1$	Disagree$_2$	Neither agree or disagree$_3$	Agree$_4$	Strongly agree$_5$
f. The amount of TV my preschool child watches would not affect his/her health	Strongly disagree$_1$	Disagree$_2$	Neither agree or disagree$_3$	Agree$_4$	Strongly agree$_5$

D6. This question is about some of the boundaries that you might have for your preschool child. *(Please circle one response on each line)*

a. I limit how much time my preschool child is allowed to spend watching TV	Strongly disagree$_1$	Disagree$_2$	Neither agree or disagree$_3$	Agree$_4$	Strongly agree$_5$
b. I limit how much time my preschool child is allowed to spend using computer and electronic games	Strongly disagree$_1$	Disagree$_2$	Neither agree or disagree$_3$	Agree$_4$	Strongly agree$_5$
c. My preschool child is not allowed to throw balls or play ball-games inside the house	Strongly disagree$_1$	Disagree$_2$	Neither agree or disagree$_3$	Agree$_4$	Strongly agree$_5$
d. My preschool child is not allowed to play rough games, like rough-and-tumble or running, inside the house	Strongly disagree$_1$	Disagree$_2$	Neither agree or disagree$_3$	Agree$_4$	Strongly agree$_5$
e. I have rules about physical activity to protect my preschool child from other people (eg not allowed outside the home yard on his/her own)	Strongly disagree$_1$	Disagree$_2$	Neither agree or disagree$_3$	Agree$_4$	Strongly agree$_5$
f. I have rules about physical activity to stop my preschool child from hurting him/herself (eg no climbing trees)	Strongly disagree$_1$	Disagree$_2$	Neither agree or disagree$_3$	Agree$_4$	Strongly agree$_5$
g. I have rules about physical activity to protect my preschool child from accidents with traffic (eg always holding adult hand near roads)	Strongly disagree$_1$	Disagree$_2$	Neither agree or disagree$_3$	Agree$_4$	Strongly agree$_5$

h. My preschool child is able to play freely in the backyard whenever he/she wants to	Strongly disagree$_1$	Disagree$_2$	Neither agree or disagree$_3$	Agree$_4$	Strongly agree$_5$
i. My preschool child is able to play freely in the street whenever he/she wants to	Strongly disagree$_1$	Disagree$_2$	Neither agree or disagree$_3$	Agree$_4$	Strongly agree$_5$
j. I take my preschool child outside to play if I think he/she has been inside for too long	Strongly disagree$_1$	Disagree$_2$	Neither agree or disagree$_3$	Agree$_4$	Strongly agree$_5$

D7. This question is about how much you let your preschool child choose their own activities. Please think about the types of things you might do or the things you might let your preschool child do, when answering this question. *(Please circle one response on each line)*

a. I switch off the TV if I think my preschool child is watching too much	Strongly disagree$_1$	Disagree$_2$	Neither agree or disagree$_3$	Agree$_4$	Strongly agree$_5$	Not necessary for my child$_6$
b. I switch off the computer/internet if I think my preschool child is using it too much	Strongly disagree$_1$	Disagree$_2$	Neither agree or disagree$_3$	Agree$_4$	Strongly agree$_5$	Not necessary for my child$_6$
c. I switch off electronic games if I think my preschool child is playing too much	Strongly disagree$_1$	Disagree$_2$	Neither agree or disagree$_3$	Agree$_4$	Strongly agree$_5$	Not necessary for my child$_6$
d. If I did not guide or regulate my preschool child's activity levels, he/she would not be as active as he/she should be	Strongly disagree$_1$	Disagree$_2$	Neither agree or disagree$_3$	Agree$_4$	Strongly agree$_5$	
e. If I did not guide or regulate my preschool child's TV watching, he/she would watch too much	Strongly disagree$_1$	Disagree$_2$	Neither agree or disagree$_3$	Agree$_4$	Strongly agree$_5$	

Section E: Friends and family

E1. How often do you attend social gatherings where other adults and children (in addition to those in your immediate family) are present? These may be at your home, someone else's home, in a park or playground or other venue. *(Please tick one response)*

- ☐ 1 Never *(go to question E3)*
- ☐ 2 Once a month or less
- ☐ 3 Once every fortnight
- ☐ 4 Once a week
- ☐ 5 Two or more times a week

E2. This question is about what happens at social gatherings you attend. *(Please circle one response on each line)*

a. When we are at social gatherings (friends, family) children and adults are usually active together	Never/ rarely$_1$	Sometimes$_2$	A lot or most of the time$_3$	Always$_4$
b. When we are at social gatherings (friends, family) children are usually active with each other while adults are not active	Never/ rarely$_1$	Sometimes$_2$	A lot or most of the time$_3$	Always$_4$
c. When we are at social gatherings (friends, family) no one is usually active	Never/ rarely$_1$	Sometimes$_2$	A lot or most of the time$_3$	Always$_4$

E3. How often are the following people **physically active with** your preschool child? *(Please circle one response on each line.)*

Person		**How often the person plays with your preschool child**					
a. You	Never/ Rarely$_1$	Less than once a week$_2$	1-2 times a week$_3$	3-4 times a week$_4$	5-6 times a week$_5$	Daily$_6$	
b. Your partner	Never/ Rarely$_1$	Less than once a week$_2$	1-2 times a week$_3$	3-4 times a week$_4$	5-6 times a week$_5$	Daily$_6$	I do not have a partner$_7$
c. Siblings	Never/ Rarely$_1$	Less than once a week$_2$	1-2 times a week$_3$	3-4 times a week$_4$	5-6 times a week$_5$	Daily$_6$	My preschool child does not have siblings$_7$
d. Whole family together	Never/ Rarely$_1$	Less than once a week$_2$	1-2 times a week$_3$	3-4 times a week$_4$	5-6 times a week$_5$	Daily$_6$	
e. Cousins	Never/ Rarely$_1$	Less than once a week$_2$	1-2 times a week$_3$	3-4 times a week$_4$	5-6 times a week$_5$	Daily$_6$	My preschool child does not have cousins$_7$
f. Uncles and/or aunts	Never/ Rarely$_1$	Less than once a week$_2$	1-2 times a week$_3$	3-4 times a week$_4$	5-6 times a week$_5$	Daily$_6$	My preschool child does not have uncles or aunts$_7$

g. Grandparents	Never/ Rarely$_1$	Less than once a week$_2$	1-2 times a week$_3$	3-4 times a week$_4$	5-6 times a week$_5$	Daily$_6$	My preschool child does not have grandparents$_7$
h. Your or your partner's friends	Never/ Rarely$_1$	Less than once a week$_2$	1-2 times a week$_3$	3-4 times a week$_4$	5-6 times a week$_5$	Daily$_6$	
i. Children of your or your partner's friends	Never/ Rarely$_1$	Less than once a week$_2$	1-2 times a week$_3$	3-4 times a week$_4$	5-6 times a week$_5$	Daily$_6$	My and my partner's friends do not have children$_7$
j. Children in the neighbourhood/ your preschool child's friends (when not at preschool/ kinder/childcare)	Never/ Rarely$_1$	Less than once a week$_2$	1-2 times a week$_3$	3-4 times a week$_4$	5-6 times a week$_5$	Daily$_6$	
k. Other (please state relationship to your preschool child ______________)	Never/ Rarely$_1$	Less than once a week$_2$	1-2 times a week$_3$	3-4 times a week$_4$	5-6 times a week$_5$	Daily$_6$	
l. Other (please state relationship to your preschool child ______________)	Never/ Rarely$_1$	Less than once a week$_2$	1-2 times a week$_3$	3-4 times a week$_4$	5-6 times a week$_5$	Daily$_6$	

E4. How often do the following people provide **practical support** for your preschool child to be physically active? (e.g. take him/her to places to be active, provide money for participation, buy sports clothing/equipment/toys). *(Please circle one response on each line.)*

Person	**How often the person provides practical support to your preschool child**						
a. You	Never/ Rarely$_1$	Less than once a week$_2$	1-2 times a week$_3$	3-4 times a week$_4$	5-6 times a week$_5$	Daily$_6$	
b. Your partner	Never/ Rarely$_1$	Less than once a week$_2$	1-2 times a week$_3$	3-4 times a week$_4$	5-6 times a week$_5$	Daily$_6$	I do not have a partner$_7$
c. Other (please state relationship to your preschool child ______________)	Never/ Rarely$_1$	Less than once a week$_2$	1-2 times a week$_3$	3-4 times a week$_4$	5-6 times a week$_5$	Daily$_6$	
d. Other (please state relationship to your preschool child ______________)	Never/ Rarely$_1$	Less than once a week$_2$	1-2 times a week$_3$	3-4 times a week$_4$	5-6 times a week$_5$	Daily$_6$	

E5. How often do the following people provide **praise or encouragement** to your preschool child for being physically active? (e.g. say positive or encouraging things to him/her, seem happy that he/she does something active). *(Please circle one response on each line.)*

Person	**How often the person provides praise or encouragement to your preschool child**						
a. You	Never/ Rarely$_1$	Less than once a week$_2$	1-2 times a week$_3$	3-4 times a week$_4$	5-6 times a week$_5$	Daily$_6$	
b. Your partner	Never/ Rarely$_1$	Less than once a week$_2$	1-2 times a week$_3$	3-4 times a week$_4$	5-6 times a week$_5$	Daily$_6$	I do not have a partner$_7$
c. Other (please state relationship to your preschool child ______________)	Never/ Rarely$_1$	Less than once a week$_2$	1-2 times a week$_3$	3-4 times a week$_4$	5-6 times a week$_5$	Daily$_6$	
d. Other (please state relationship to your preschool child ______________)	Never/ Rarely$_1$	Less than once a week$_2$	1-2 times a week$_3$	3-4 times a week$_4$	5-6 times a week$_5$	Daily$_6$	

E6. Please tell us how your preschool child sees other people being physically active. *(Please circle one response on each line)*

a. My preschool child sees me being active	Never/ rarely$_1$	Once a fortnight or less$_2$	Once a week$_3$	2-3 times a week$_4$	4-5 times a week$_5$	6 or more times a week$_6$	
b. My preschool child sees my partner being active	Never/ rarely$_1$	Once a fortnight or less$_2$	Once a week$_3$	2-3 times a week$_4$	4-5 times a week$_5$	6 or more times a week$_6$	I don't have a partner$_7$
c. My preschool child sees his/her older siblings being active	Never/ rarely$_1$	Once a fortnight or less$_2$	Once a week$_3$	2-3 times a week$_4$	4-5 times a week$_5$	6 or more times a week$_6$	My child doesn't have older siblings$_7$
d. My preschool child sees other children (e.g. friends, cousins) being active	Never/ rarely$_1$	Once a fortnight or less$_2$	Once a week$_3$	2-3 times a week$_4$	4-5 times a week$_5$	6 or more times a week$_6$	
e. My preschool child sees other adults (e.g. uncles/ aunts, teachers) being active	Never/ rarely$_1$	Once a fortnight or less$_2$	Once a week$_3$	2-3 times a week$_4$	4-5 times a week$_5$	6 or more times a week$_6$	
f. My preschool child sees people being active on the TV/video/DVD (e.g. dancing, sport)	Never/ rarely$_1$	Once a fortnight or less$_2$	Once a week$_3$	2-3 times a week$_4$	4-5 times a week$_5$	6 or more times a week$_6$	

You're doing really well . . . just a few more questions . . .

Section F: Your home

F1. Please think about the types of toys and equipment that your preschool child has available at home to be physically active with. *(Please circle ONE response for each item.)*

a. Balls (footballs, basketballs, tennis balls, baseballs)	yes_1	no_2	n. Scooter	yes_1	no_2
b. Basketball ring	yes_1	no_2	o. Skateboard	yes_1	no_2
c. Bats, racquets, golf clubs	yes_1	no_2	p. Skipping rope	yes_1	no_2
d. Billy cart	yes_1	no_2	q. Slide	yes_1	no_2
e. Bowls (ten pin, skittles)	yes_1	no_2	r. Soft balls and other toys for active indoor play	yes_1	no_2
f. Climbing equipment/trees suitable for climbing	yes_1	no_2	s. Swimming/wading pool	yes_1	no_2
g. Cubby house	yes_1	no_2	t. Swings	yes_1	no_2
h. Frisbee	yes_1	no_2	u. Table tennis table, bats & balls	yes_1	no_2
i. Gardening tools (appropriate for child to use)	yes_1	no_2	v. Trampoline	yes_1	no_2
j. Pool or beach toys	yes_1	no_2	w. Tricycle/bicycle	yes_1	no_2
k. Roller blades or roller skates	yes_1	no_2	x. Volleyball/badminton net	yes_1	no_2
l. Safety equipment for activities (eg bike helmet, knee guards, etc)	yes_1	no_2	y. Other (Please specify ____________________)	yes_1	no_2
m. Sand pit	yes_1	no_2	z. Other (Please specify ____________________)	yes_1	no_2

Please tell us about your yard where your preschool child is able to play. This may be your front yard, your back yard, or your combined front and back yards.

F2. How big is your yard? *(Please tick ONE)*

- ☐$_1$ no yard at all
- ☐$_2$ no private yard
- ☐$_3$ a small yard (eg unit or courtyard)
- ☐$_4$ a medium yard (eg standard block of land)
- ☐$_5$ a large yard (eg ¼ acre block or larger)

F3. Which of the following do you have at your home? *(Please tick as many as apply)*

- ☐$_1$ front fence
- ☐$_2$ covered area outdoors (eg patio, decked area, garage, carport)
- ☐$_3$ indoor play areas (eg rumpus room, family room)
- ☐$_4$ none of the above

F4. Do you live on a cul-de-sac, court or no-through road? *(Please tick ONE)*

☐$_1$ yes ☐$_2$ no

Please think about the electronic equipment you have in your home.

F5. Which of the following do you have in your home? *(please circle one response for each item)*

Equipment/toy	Do you have this toy/ equipment	
a. Video/DVD player	yes$_1$	no$_2$
b. TV	yes$_1$	no$_2$
c. Desktop (PC or Macintosh) computer	yes$_1$	no$_2$
d. Laptop computer	yes$_1$	no$_2$

Equipment/toy	Do you have this toy/ equipment	
e. Internet access	yes$_1$	no$_2$
f. Wii/eye-toy	yes$_1$	no$_2$
g. Playstation©/X-Box©/ Gameboy©/Nintendo©	yes$_1$	no$_2$
h. Other electronic equipment *(please specify)* ____________________	yes$_1$	no$_2$

F6. How many functioning TVs do you have in your house? *(Please write the number.)*

____

F7. Does your preschool child have a TV in his/her bedroom? *(Please tick ONE)*

☐$_1$ Yes ☐$_2$ No

F8. Does your preschool child have a computer or electronic games (e.g. Playstation©/X-box©) in his/her bedroom? *(Please tick ONE)*

☐$_1$ Yes ☐$_2$ No

Section G: Your local neighbourhood

For this section, please think about
your suburb or the local area where you live

G1. Think about the **playgrounds** in your local neighbourhood. How much do you agree or disagree with the following statements? *(Please circle ONE response on each line.)*

a. There are many playgrounds in our local neighbourhood that are suitable for my preschool child to play in	Strongly disagree$_1$	Disagree$_2$	Neither agree or disagree$_3$	Agree$_4$	Strongly agree$_5$
b. The playgrounds in our local neighbourhood have a variety of equipment so my preschool child doesn't get bored	Strongly disagree$_1$	Disagree$_2$	Neither agree or disagree$_3$	Agree$_4$	Strongly agree$_5$
c. The playgrounds in our local neighbourhood have equipment suitable for my preschool child's age and abilities	Strongly disagree$_1$	Disagree$_2$	Neither agree or disagree$_3$	Agree$_4$	Strongly agree$_5$
d. The playgrounds in our local neighbourhood have play equipment that is safe for my preschool child to play on	Strongly disagree$_1$	Disagree$_2$	Neither agree or disagree$_3$	Agree$_4$	Strongly agree$_5$
e. The playgrounds in our local neighbourhood have adequate facilities (such as shade, seating, fences)	Strongly disagree$_1$	Disagree$_2$	Neither agree or disagree$_3$	Agree$_4$	Strongly agree$_5$
f. The playgrounds in our local neighbourhood are free from things such as litter, graffiti, vandalism and dog droppings	Strongly disagree$_1$	Disagree$_2$	Neither agree or disagree$_3$	Agree$_4$	Strongly agree$_5$
g. The playgrounds in our local neighbourhood are well used by other children	Strongly disagree$_1$	Disagree$_2$	Neither agree or disagree$_3$	Agree$_4$	Strongly agree$_5$
h. My preschool child is safe from strangers in playgrounds in our neighbourhood	Strongly disagree$_1$	Disagree$_2$	Neither agree or disagree$_3$	Agree$_4$	Strongly agree$_5$

G2. This question is about moving around your local neighbourhood. How much do you agree or disagree with the following statements? *(Please circle one response on each line.)*

a. There are major barriers to walking/ cycling that make it hard for my preschool child and I to get from place to place (eg major roads, steep hills)	Strongly disagree 1	Disagree 2	Neither agree or disagree 3	Agree 4	Strongly agree 5
b. My preschool child and I would have to cross a busy road/major highway to get to areas where he/she can play	Strongly disagree 1	Disagree 2	Neither agree or disagree 3	Agree 4	Strongly agree 5
c. There are no lights/crossings/ pedestrian overpasses for my preschool child and I to use	Strongly disagree 1	Disagree 2	Neither agree or disagree 3	Agree 4	Strongly agree 5
d. There are no footpaths in our neighbourhood for my preschool child and I to use	Strongly disagree 1	Disagree 2	Neither agree or disagree 3	Agree 4	Strongly agree 5
e. My neighbourhood has walking/cycling trails suitable for my preschool child and I to use	Strongly disagree 1	Disagree 2	Neither agree or disagree 3	Agree 4	Strongly agree 5
f. My neighbourhood is safe for children to walk/cycle around in the daytime	Strongly disagree 1	Disagree 2	Neither agree or disagree 3	Agree 4	Strongly agree 5
g. My neighbourhood is safe for children	Strongly disagree 1	Disagree 2	Neither agree or disagree 3	Agree 4	Strongly agree 5

G3. 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 would usually go there. If your preschool child never visits a particular place, please circle “never" on that line. (*Please circle one response on each line.)*

Here is an example

Venue	Please circle how often your preschool child visits this type of venue						
Local playground	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
Playground in another area	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

Venue	Please circle how often your preschool child visits this type of venue						
a. Local playground	Never$_1$	Once a month or less$_2$	Twice a month$_3$	Once a week$_4$	Twice a week$_5$	3-4 times a week$_6$	5 or more times a week$_7$
b. Playground in another area	Never$_1$	Once a month or less$_2$	Twice a month$_3$	Once a week$_4$	Twice a week$_5$	3-4 times a week$_6$	5 or more times a week$_7$
c. Parks/ovals (no play equipment)	Never$_1$	Once a month or less$_2$	Twice a month$_3$	Once a week$_4$	Twice a week$_5$	3-4 times a week$_6$	5 or more times a week$_7$
d. Sports venue (eg swimming pool)	Never$_1$	Once a month or less$_2$	Twice a month$_3$	Once a week$_4$	Twice a week$_5$	3-4 times a week$_6$	5 or more times a week$_7$
e. Specialist outdoor activity venues (eg Traffic School, Zoo)	Never$_1$	Once a month or less$_2$	Twice a month$_3$	Once a week$_4$	Twice a week$_5$	3-4 times a week$_6$	5 or more times a week$_7$
f. Indoor play centre	Never$_1$	Once a month or less$_2$	Twice a month$_3$	Once a week$_4$	Twice a week$_5$	3-4 times a week$_6$	5 or more times a week$_7$
g. Family restaurant with play area	Never$_1$	Once a month or less$_2$	Twice a month$_3$	Once a week$_4$	Twice a week$_5$	3-4 times a week$_6$	5 or more times a week$_7$
h. Shopping centre	Never$_1$	Once a month or less$_2$	Twice a month$_3$	Once a week$_4$	Twice a week$_5$	3-4 times a week$_6$	5 or more times a week$_7$
i. Other venue (please specify) ____________________	Never$_1$	Once a month or less$_2$	Twice a month$_3$	Once a week$_4$	Twice a week$_5$	3-4 times a week$_6$	5 or more times a week$_7$
j. Other venue (please specify) ____________________	Never$_1$	Once a month or less$_2$	Twice a month$_3$	Once a week$_4$	Twice a week$_5$	3-4 times a week$_6$	5 or more times a week$_7$

ID ____________

Thank you for your time

We hope to conduct similar research to this in the future, examining children's physical activity patterns.

If you agree to us contacting you in the future, please provide your details below, and the contact details of two close friends or relatives, not living with you, who we can contact in the event that you move house. By providing these details you are not agreeing to participate in future research; you are giving permission for us to contact you to inform you about future research and invite you to participate.

☐ **Yes I agree to have my details recorded for future research, and give permission for Deakin research staff to contact me or the nominated person below to inform me about future research. (Please tick)**

My name: ______________________________

My address: __________ ______________________________
Unit/House number Street name

______________________________ __________
Suburb Postcode

My phone number:

Home: ____________________ Business: ____________________

Mobile: ____________________

Email: ____

Primary school/centre your child will attend (if known): ______________________________

Suburb: ______________________________

Name of two close friends or relatives (in the event I move and cannot be contacted):

1) Name: ____________________	2) Name: ____________________
Address: ____________________	Address: ____________________
____________________	____________________
____________________	____________________
Phone: ____________________	Phone: ____________________
Email: ____________________	Email: ____________________
Relationship to you: ______________	Relationship to you: ______________

Appendix F: Mini Movers Deakin University Human Research Ethics Committee Approval

Human Research Ethics

Deakin Research Integrity
Burwood Campus
Postal: 221 Burwood Highway
Burwood Victoria 3125 Australia
Telephone 03 9251 7123
research-ethics@deakin.edu.au

Memorandum

To: A/Prof Kylie Hesketh
School of Exercise and Nutrition Sciences

B

cc: Miss Katherine Downing

From: Deakin University Human Research Ethics Committee (DUHREC)

Date: 02 June, 2016

Subject: 2016-103
Pilot testing a program to reduce young children's sedentary behaviour

Please quote this project number in all future communications

The application for this project was considered at the DU-HREC meeting held on 18/04/2016.

Approval has been given for Miss Katherine Downing, under the supervision of A/Prof Kylie Hesketh, School of Exercise and Nutrition Sciences, to undertake this project from 2/06/2016 to 2/06/2020.

The approval given by the Deakin University Human Research Ethics Committee is given only for the project and for the period as stated in the approval. It is your responsibility to contact the Human Research Ethics Unit immediately should any of the following occur:

- Serious or unexpected adverse effects on the participants
- Any proposed changes in the protocol, including extensions of time.
- Any events which might affect the continuing ethical acceptability of the project.
- The project is discontinued before the expected date of completion.
- Modifications are requested by other HRECs.

In addition you will be required to report on the progress of your project at least once every year and at the conclusion of the project. Failure to report as required will result in suspension of your approval to proceed with the project.

DUHREC may need to audit this project as part of the requirements for monitoring set out in the National Statement on Ethical Conduct in Human Research (2007).

Human Research Ethics Unit
research-ethics@deakin.edu.au
Telephone: 03 9251 7123

Appendix G: Mini Movers flyer

IPAN
INSTITUTE FOR PHYSICAL ACTIVITY AND NUTRITION

We are seeking parents to take part in an exciting new program!

mini movers

What is the Mini Movers program?
This program aims to support parents to reduce the amount of time their young children spend in sedentary behaviour (e.g. TV viewing) and increase active play.

Who can join the program?
Any parent with a child aged 2 to 4 years.

What are we asking you to do?
- Complete an online **survey** at the start and the end of the study
- Your child would be weighed and measured at the start of the study and would wear an **activity monitor** (similar to a pedometer) for a week at the start and the end of the study
- You would receive a **booklet and text messages** with simple, practical ideas for reducing sedentary behaviour and engaging your child in active play

You will receive a report of your child's activity and a $20 voucher

For more information please contact Katherine on 9244 6088 or k.downing@deakin.edu.au

Institute for Physical Activity and Nutrition (IPAN), School of Exercise and Nutrition Sciences
Deakin University, 221 Burwood Highway, Burwood, VIC 3125
Tel 03 9244 6613 email ipan@deakin.edu.au www.deakin.edu.au/research/ipan
Deakin University CRICOS Provider Code: 00113B

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Appendix H: Mini Movers Plain Language Statement and Consent Form

PLAIN LANGUAGE STATEMENT AND CONSENT FORM

Plain Language Statement

Date: 2016

Full Project Title: Mini Movers Program

Principal Researcher: Assoc Prof Kylie Hesketh

Student Researcher: Ms Katherine Downing

Associate Researchers: Prof Jo Salmon, Dr Trina Hinkley, Dr Jill Hnatiuk

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Dear Parent,

We would like to invite you take part in our Mini Movers program which aims to support you to help your child develop healthy habits such as active play. This program will help us to understand how we can best support parents to learn skills that will promote children's health. It is being conducted by Ms Katherine Downing (PhD Candidate), Assoc Prof Kylie Hesketh, Prof Jo Salmon, Dr Trina Hinkley (all from Deakin University) and Dr Jill Hnatiuk (from Western Sydney University). This research will contribute towards Ms Downing achieving her PhD qualification.

What can I expect if I agree to participate?
At the start of the program we will measure your child's height and weight. We will ask you to complete an online survey at the start of the program, and again about 6 weeks later. The survey will take around 20-30 minutes to complete, and will ask for background information (e.g., your age), and about your and your child's physical activity and sedentary behaviour (e.g., sitting, watching TV). At both times we will also ask your child to wear an activity monitor for one week. Activity monitors are small devices, about the size of a matchbox, sewn into a pocket on the leg of a pair of bike shorts. They help us to measure when your child is sitting or lying down and are completely harmless.

After completing the first survey and other measures, you will be randomly (i.e., you can't choose) assigned to one of two groups. Group One will take part in the Mini Movers program immediately, while Group Two will participate in the same program, starting about 8 weeks later. At the start of the program you will receive your printed program materials and have a brief (5 minute) one-on-one discussion with a researcher during your usual playgroup time. Following this initial discussion, the program will be completely online and via text messages. You can expect to receive about 3 text messages per week over the 6 week program. The printed materials, online content and text messages will focus on strategies and tips to help decrease sedentary behaviour and increase active play time for your child.

Has this program been approved? Will it be monitored?
The program has been approved by the Deakin University Human Research Ethics Committee (DUHREC; 2016-103) and has the consent of Playgroup Victoria. The researchers will monitor the program's progress and will report to the DUHREC and Playgroup Victoria.

Who will see the information that I provide?
All aspects of the program, including results, will be strictly confidential and only the researchers will have access to information on participants. To maintain confidentiality, identifying information such as your name and address will be kept separately from the completed survey and activity monitor data. Only a number will identify these data. All of this information will be stored at Deakin University in a locked filing cabinet and all electronic information will be password protected and stored on a secure server. Storage of collected data will adhere to University regulations; it will be kept in secure storage for at least 6 years, after which time it will be securely destroyed.

Where will the results be published?
The results of this program will be published in Ms Downing's thesis. Results may also be published in research journals and presented at research conferences. However, individual participants or playgroups will never be identified and only aggregate data will be reported (that is, information from all parents in the program will be combined and reported as a group).

Are there any risks for my child or me if we agree to take part in this program?
We do not anticipate any risk or discomfort will be experienced by taking part in this research.

What are the possible benefits for my child or me from taking part in this program?
You will gain some simple and practical ideas about how you can reduce sedentary time and increase physical activity in your family. As thanks for your time in taking part, you will receive a $20 gift card at the end of the program. You can also request to receive a summary of your child's physical activity and sedentary behaviour levels as recorded by the activity monitor at the end of the program.

What if I decide <u>not</u> to consent to take part in this program?
This program is completely voluntary and you are under no obligation to participate. If you do agree to take part and later change your mind, you may withdraw at any stage, for any reason, without consequence.

If you have any questions about this program or require further information, please contact Katherine Downing on 9244 6088 or k.downing@deakin.edu.au.

Kind regards,

Signature Redacted by Library

Signature Redacted by Library

Katherine Downing
PhD Candidate
Institute for Physical Activity and Nutrition
School of Exercise and Nutrition Sciences
Deakin University

Kylie Hesketh
Associate Professor
Institute for Physical Activity and Nutrition
School of Exercise and Nutrition Sciences
Deakin University

Complaints
If you have any complaints about any aspect of the project, the way it is being conducted or any questions about your rights as a research participant, then you may contact:

The Manager, Ethics and Biosafety, Deakin University, 221 Burwood Highway, Burwood Victoria 3125, Telephone: 9251 7129, research-ethics@deakin.edu.au
Please quote project number [2016-103].

Consent Form

Full Project Title: Mini Movers Program

Reference Number: 2016-103

I agree to take part in the Deakin University research program specified in the Plain Language Statement.

I have had the program explained to me, and I have read and understand the Plain Language Statement, which I will keep for my records.

The researcher has agreed not to reveal my identity and personal details, including where information about this program is published, or presented in any public form.

☐ **By checking this box I indicate my consent for me and my child to participate in the Mini Movers Program.**

Today's date: ___/___/___

My full name: ____ My DOB: ___/___/___

My child's full name: ______________________________________ My child's DOB: ___/___/___

Postal address: ____

Suburb: _________________________________ Postcode: ____________

Email address: ____

Mobile phone number: ____

Home phone number: ____

I would like to receive my child's physical activity/sedentary behaviour results: ☐ Yes ☐ No

If you have any questions or concerns, please contact Katherine Downing on 9244 6088 or k.downing@deakin.edu.au.

Please complete this consent form and return it in to the research team in person, via post, or save it and email to k.downing@deakin.edu.au.

Appendix I: Mini Movers intervention materials

- Mini Movers booklet
- Mini Movers goal checker magnet
- Australian Physical Activity and Sedentary Behaviour Recommendations brochure

mini movers

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Katherine Downing, Project Manager, is supported by a National Medical Health and Research Council (NHMRC) Postgraduate Scholarship.

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Katherine Downing, Project Manager
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www.deakin.edu.au/research/ipan

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mini movers

We probably don't need to convince you about the benefits of being active throughout life, but sometimes it gets hard with the abundance of screens and technology in our lives to prioritise activity, even for the littlies. mini movers is a program designed by researchers in the Institute for Physical Activity and Nutrition (IPAN) at Deakin University to help you help your child to be more active and less sedentary, to ensure they get the best possible start to life.

We will guide you through the mini movers program at your group session.

If you have any questions about the program please contact:
Katherine Downing
9244 6088 or 0473 361 897
k.downing@deakin.edu.au

Planning your mini movers program

In your group session we will talk to you about:

- What the mini movers program involves
- Healthy habits for you and your child
- Active play ideas for you and your child
- Setting goals to develop healthy habits

Text messages from mini movers

You will receive regular texts from mini movers for the next 6 weeks (2-3 per week) to touch base on the information listed above, and to check how you are going with your goals.

You will receive a text in the next day or so confirming your mobile number. Please make sure you respond to this text to let us know that we've got the right number.

If you don't receive a text message from us in the next week, please phone Katherine (details on the front of this booklet).

What time of day would you prefer to receive messages?

Early morning (7-9am) ☐	Late afternoon (3-5pm) ☐
Late morning (9am-12pm) ☐	Early evening (5-7pm) ☐
Early afternoon (12-3pm) ☐	

What is sedentary behaviour?

Sedentary behaviour refers to activities undertaken in a sitting position, requiring very little energy expenditure. Examples of sedentary behaviours include watching TV, playing electronic games, using a computer, using smartphones and tablets, reading, and sitting activities such as arts and crafts. It also includes any time when a child's movement is restricted, for example in a car seat or stroller. Some types of sedentary behaviour (such as screen use) are worse for your child's health and development than others. However, sitting for long periods of time throughout the day in any type of sedentary behaviour is not recommended.

What is active play?

Active play refers to physical activities that toddlers and young children do, which involve bursts of high energy. Active play should raise a child's heart rate and make them "huff and puff". For very young children, this might include things like chasing after balls or bubbles, or dancing. For preschool-aged children, active play might involve more structured play, such as obstacle courses, hide-and-seek, or riding a bike.

Physical activity guidelines for young children

Australia has national physical activity and sedentary behaviour guidelines for children from birth through 5 years. We have included a copy of the brochure with your program information pack.

Sedentary behaviour

The sedentary behaviour recommendations state that:

- Children under 2 years of age **should not spend any time** watching TV or using other electronic media (DVDs, computer, electronic games, smartphones and tablets).
- Children aged 2 to 5 years **should spend no more than 1 hour per day** sitting and watching TV or using other electronic media.
- All children from birth to 5 years **should not be sedentary, restrained, or kept inactive, for more than 1 hour at a time**, with the exception of sleeping.

Physical activity

The physical activity guidelines recommend that children aged 1 to 5 years should be physically active every day **for at least 3 hours**, spread throughout the day. Remember, more is always better!

Ideas for getting your child active

Over the next 3 pages you'll find some tips and ideas to help decrease your child's sedentary behaviour and increase the amount of time they spend being active...

Instead of sitting down to paint or draw, change this to a **standing activity**. Easels are great for getting kids standing up, or just take the chairs away and let them stand at the table!

Have a **treasure hunt** inside or out. For younger children, ask them to find objects you've hidden or things in nature (a pink flower). For older children, ask them to find things starting with a letter of your choosing.

Go for a pram-free walk and let your child explore and discover nature's 'treasures' along the way.

Play some ball games...
Rolling, catching, and kicking, using both large and small balls are all great for developing your child's motor skills.

Blow lots of bubbles and watch your child's joy as they chase them and try to pop them!

Make your child's bedroom a **screen-free zone**. Using screen entertainment before bed can lead to poorer sleep.

Create an **obstacle course** inside or out. Get your child involved and use things you already have lying around, such as ropes and buckets.

Set screen time rules and stick to them! For example:

- No screens at meal times
- Set a timer to 15 minutes
- iPads only allowed on weekends

mini movers myth busters

It seems that news stories about screen time are everywhere these days, often with conflicting advice. We're here to bust some of the more common myths for you!

Myth #1: Screen time is okay for young children, as long as the content is educational

There is currently no evidence that any type of screen time provides benefits to children's learning, development, health or school readiness. Of course, if your child is using screens we always encourage educational content over non-educational (particularly violent) content; however, less screen time is always better!

Myth #2: Children are naturally physically active so it doesn't matter how long they spend in front of screens

Screen time should be limited for children, regardless of how active they are. Any time that children spend in front of a screen takes away from time when they can be active, engaged and learning. We often think of young children as being naturally active but actually, they're not as active as they could be. If you compare what your child does to what you used to do, it's easy to see they have fewer opportunities for active play and so many more technology options than we had.

Myth #3: TV is useful to help children unwind before bed

Watching TV (or using any screens) in the hours leading up to bedtime actually has a detrimental effect on children's sleep (it takes them longer to fall asleep and their sleep quality throughout the night is not as good). This is because the content stimulates the brain and the bright light emitted by the screens increases alertness and disrupts the sleep cycle. Research suggests that screen time should be avoided completely in the hour or two leading up to bedtime.

Take the mini movers quiz to test your knowledge!

1) How many hours of physical activity do young children (up to 5 years of age) need every day (at a minimum)? ____ **hours**

2) What is the maximum amount of screen time children aged 0 to 2 years should have per day? ____ **hours**

3) What is the maximum amount of screen time children aged 2 to 5 years should have per day? ____ **hours**

4) It's okay for children to exceed the screen time guidelines as long as they do enough physical activity throughout the day
   ☐ **True**
   ☐ **False**

5) All children under 5 years should not be kept sedentary, restrained, or inactive (e.g., in a pram, car seat, or highchair) for more than 1 hour at a time, with the exception of sleeping
   ☐ **True**
   ☐ **False**

The following are recommendations for children up to 5 years: **1)** 3 hours; see p. 4. **2)** 0 hours (i.e., no screen time); see p. 4. **3)** 1 hour; see p. 4. **4)** False. It's still important to limit screen time no matter how active they are; see p. 8. **5)** True. Time spent restrained should be limited to less than 1 hour at a time; see p. 4.

Making changes to your child's habits

In your group session, we will ask you to set two goals around your child's sedentary behaviour (see the next page for the mini movers Goal Planner).

We will text you every week to check in and see how you went with your goals for that week. Let us know by replying, and make sure you celebrate your successes! If you don't reach your goals one week, don't give up, try again the next week!

What makes a good goal?

SMART Goals
Specific
Measurable
Attainable
Relevant
Time-bound

Setting a good goal can be tricky. An example of a good goal would be *"Over the next 6 weeks I will aim to ensure my child has 3 screen-free days per week."* This is specific (identifies who, what and when), measurable, attainable, relevant, and time-bound. On the other hand, an example of a poor goal would be *"I will limit my child's screen time"*.

It's also important to **rate your confidence** in achieving your goal. Once you have chosen your goals, rate your confidence in sticking to them out of 10, where 1 = not at all confident and 10 = totally confident.

If you rate your confidence 7 or more, you have chosen realistic and achievable goals. If you rate your confidence less than 7, you may need to reassess your goals and work out a more realistic plan. Remember to also not set a goal that is too easy (something that you would meet anyway!).

mini movers Goal Planner

Please use the mini movers Goal Planner to choose **ONE** screen and **ONE** activity goal from the list below (or create your own!) to focus on during this program.

You can track your progress using the fridge magnet planner given to you in the first session.

Over the next 6 weeks I will aim to *(please choose ONE screen goal and ONE activity goal)*:

Screen goals

- ☐ Limit my child's screen time to less than ________ mins/day
- ☐ Ensure my child has ________ screen-free days/week
- ☐ ____
  ____

Activity goals

- ☐ Walk to local destinations (e.g., shops, friend's house, preschool) without the pram ________ days/week
- ☐ Modify an activity that my child usually does sitting down (e.g., painting) to a standing activity ________ times/day
- ☐ ____
  ____

Please rate below how confident you are that you can stick to your chosen goals: _____/10

References, sources and thanks

- Active Alphabet for Toddlers. Queensland Government.
- Kids at Play: Active Play Everyday. ACT Government.
- Move and Play Every Day: National Physical Activity Recommendations for Children 0-5 Years. Australian Government Department of Health.
- Screen Sense: Setting the Record Straight. Research-Based Guidelines for Screen Use for Children Under 3 Years Old. Lerner C & Barr R. ZERO TO THREE.

Images from flickr.com and pixabay.com

mini movers

Weekly Goal Checker

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Goal 1:

Goal 2:

WEEK	Monday		Tuesday		Wednesday		Thursday		Friday		Saturday		Sunday	
	Goal 1	Goal 2	Goal 1	Goal 2	Goal 1	Goal 2	Goal 1	Goal 2	Goal 1	Goal 2	Goal 1	Goal 2	Goal 1	Goal 2
e.g.	✓	✗	✓	✗	✓	✓	✗	✗	✓	✓	✓	✓	✓	✓
1														
2														
3														
4														
5														
6														

What about TV and computer games?

TV, DVDs and computer games may be popular with kids, but they usually involve sitting for long periods. Children will benefit more from talking, singing, reading, listening to music or playing with a family member or a friend.

Regardless of how active kids may be at other times, it is still important to limit screen time.

RECOMMENDATIONS

Children aged 2 to 5 years

For children 2 to 5 years of age, sitting and watching television and the use of other electronic media (DVDs, computer and other electronic games) should be limited to less than one hour per day.

Children aged less than 2 years

Children younger than 2 years of age should not spend any time watching television or using other electronic media (DVDs, computer and other electronic games).

A variety of TV programs have been created for children under 2 years, however it is questionable whether TV enhances development in the first two years of life. For more information on the evidence in this area you may wish to visit *www.healthyactive.gov.au*. For healthy development, kids need regular activity and plenty of interaction with others.

TIPS AND IDEAS

Reducing screen time for all children

- Make meal time your family time and turn off the TV.
- Turn the TV off after the program has finished.
- Set limits and have rules around screen time.
- Make your kids' bedrooms TV and computer free.
- Play music or stories on CDs instead.

What about time spent sitting or being inactive?

RECOMMENDATION

All children (Birth to 5 years)

Infants, toddlers and pre-schoolers should not be sedentary, restrained, or kept inactive, for more than one hour at a time, with the exception of sleeping.

'Sedentary behaviour' refers to time spent being physically inactive. All children need some 'down time' but they are not naturally inactive for long periods of time.

Sitting in strollers, highchairs and car seats (being restrained) for long periods isn't good for children's health and development and goes against their natural tendency to be active and play.

The use of baby jumpers and baby walkers is also discouraged. The evidence shows they can restrict the muscle development required for independent walking and may cause injuries.

TIPS AND IDEAS

All children

- Take breaks on long car trips – stop at a park or rest area.
- Give kids a break from the stroller and let them walk for some of the journey.
- Try walking, pedalling or using a scooter for short trips.

What can I do?

Get involved! Remember you are the most important role model in your child's life. By being active with your child you can encourage their lifelong enjoyment of physical activity – and benefit your own health at the same time.

Don't forget that along with lots of play and activity, kids need a variety of good foods for healthy growth and development. For more information on healthy eating for kids see the nutrition resources outlined below.

Healthy living resources for all ages

- Get Up & Grow – Healthy Eating and Physical Activity for Early Childhood (for centre based care, family day care and pre-schools)
- Australia's Physical Activity Recommendations for 5-12 year olds
- Australia's Physical Activity Recommendations for 12-18 year olds
- National Physical Activity Guidelines for Adults
- Choose Health: Be Active – a physical activity guide for older Australians
- Food for Health – Dietary Guidelines for Australians (Adults, Children and Adolescents)
- Australian Guide to Healthy Eating

To order resources, free of charge ph 1800 020 103.

FOR MORE INFORMATION, VISIT
www.healthyactive.gov.au

Australian Government
Department of Health and Ageing

Move and Play Every Day

NATIONAL PHYSICAL ACTIVITY RECOMMENDATIONS FOR CHILDREN 0-5 YEARS

These recommendations are for children who haven't started school yet. If your child has started school, please refer to the National Physical Activity Recommendations for 5-12 year olds.

Children love to play and be active!

Being physically active every day is important for the healthy growth and development of infants, toddlers and pre-schoolers.

Physical activity for children includes both structured activities and unstructured free play, and can be done indoors or out.

THE BENEFITS FOR YOUR CHILD

Being physically active every day is fun and can:

- Help achieve and maintain a healthy weight.
- Build strong bones and muscles.
- Improve balance, movement and co-ordination skills.
- Promote social skills through interactions with people.
- Support brain development.
- Encourage self-confidence and independence.

Whatever their level of ability, children need to be active.

The National Physical Activity Recommendations provide you with support and guidance in relation to your child's physical activity, play, sedentary behaviour (sitting) and television viewing. While meeting these recommendations may seem like a challenge at times, tips and ideas have been provided to help you include more activity in your child's day.

What physical activity does my infant need?

RECOMMENDATION

Infants (Birth to 1 year)

For healthy development in infants, physical activity – particularly supervised floor-based play in safe environments – should be encouraged from birth.

Before infants begin to crawl, physical activity includes reaching and grasping, pulling and pushing, moving their head, body and limbs during daily routines, and supervised floor play, including tummy time.

Once your infant is mobile, encourage them to be as active as possible in a safe, supervised and nurturing play environment.

TIPS AND IDEAS

Infants (Birth to 1 year)

- Encourage them to reach and grasp by placing toys just out of reach.
- Play push and pull games with balls and soft toys.
- Play music to encourage playful movements.
- Encourage movement and play during bath time.

How much physical activity does my toddler or pre-schooler need?

RECOMMENDATION

Toddlers (1 to 3 years) & Pre-schoolers (3 to 5 years)

Toddlers and pre-schoolers should be physically active every day for at least three hours, spread throughout the day.

You'd be surprised by how many opportunities there are throughout the day for toddlers and pre-schoolers to be active. Remember that kids don't need to do their three hours of physical activity all at once. It can be accumulated throughout the day and can include light activity like standing up, moving around and playing.

TIPS AND IDEAS

Toddlers (1 to 3 years) & Pre-schoolers (3 to 5 years)

- Play with different sized balls.
- Twirl and run with streamers.
- Play with balloons – punch, kick or throw them to keep them off the ground.
- Blow bubbles and chase them through the air.
- Play games – try hide-and-seek, obstacle courses, follow the leader, stuck in the mud, or tip/tag games.
- Move to music or try action songs like 'Ring-A-Ring-A-Rosie' or 'Head-Shoulders-Knees and Toes'.
- Walk barefoot on different surfaces – try grass, carpet, concrete or sand.
- Pretend to move like different animals.
- Play dress ups and act out different roles.
- Walk to places rather than driving or using the stroller.

WITH SO MANY OPPORTUNITIES TO BE ACTIVE, YOUR CHILD CAN REACH THREE HOURS BEFORE YOU KNOW IT!

Tips for active play!

- Choose 'active' toys. For infants, choose boxes, pots, pans, streamers, hoops and toys that encourage reaching, stretching, crawling and moving. Play materials don't need to be expensive and can be found around the house.
- For toddlers and pre-schoolers, choose toys and play materials that encourage movement and help develop skills like running, kicking, throwing and catching, such as balls, bats, tricycles and kites.
- When you can, involve all of the family – try walking to the park, a visit to the zoo for a special treat, or playing soccer in the backyard.
- Being outdoors is best – just make sure kids have sun protection, such as sunscreen, hats and shade. If the weather is no good, head indoors and build cubby houses or play hide and seek.
- Encourage children to be independent and to explore the world around them. Allow them the freedom to create, imagine and direct their own play, while maintaining a safe environment. This will help your child's confidence grow!
- Competitive sport is not recommended for children under 5 years. Some great alternatives include structured activities like water familiarisation, recreational gymnastics and dance taught by qualified instructors.

Active play is the best way for kids to be physically active.

For more tips, visit
www.healthyactive.gov.au

Appendix J: Mini Movers baseline questionnaire

Default Question Block

mini movers

Parent Survey 1

IMPORTANT INSTRUCTIONS - PLEASE READ

Thank you for taking the time to complete this survey. It will take you approximately 30 minutes to complete, although this might vary depending on your answers.

Throughout this survey, we will refer to your "child". By this we mean your child who is aged between 2 and 4 years and is participating in this study. Although you may have other children, it is important that you answer these questions in relation to that child only.

Please answer each question by choosing the most suitable option. Where you are asked to write an answer please read the question carefully and answer as best you can. If you are unsure about how to answer a question, please choose the answer that best reflects how you feel.

SECTION A: ABOUT YOUR CHILD

A1. Today's date (automatic)

(dd/mm/yyyy)

A2. What is your child's date of birth?

(dd/mm/yyyy)

A3. Is your child a boy or a girl?

- Boy
- Girl

A4. What relation are you to the child involved in this program?

- Mother/stepmother
- Father/stepfather
- Grandparent
- Guardian
- Other (please specify):

A5. Does your child have a disability or suffer from poor health (including asthma)?

- No
- Yes (please describe):

A6. How many other children aged under 18 years currently live in your house? (NOT including the child in this study. If there are no other children please choose "0".)

What are their ages and sex?

	Age (years)	Sex	
		Male	Female
Child 1			

What are their ages and sex?

	Age (years)	Sex	
		Male	Female
Child 1			
Child 2			

What are their ages and sex?

	Age (years)	Sex	
		Male	Female
Child 1			
Child 2			
Child 3			

What are their ages and sex?

	Age (years)	Sex	
		Male	Female
Child 1			

	Age (years)	Sex	
		Male	Female
Child 2			
Child 3			
Child 4			

What are their ages and sex?

	Age (years)	Sex	
		Male	Female
Child 1			
Child 2			
Child 3			
Child 4			
Child 5			

What are their ages and sex?

	Age (years)	Sex	
		Male	Female
Child 1			
Child 2			
Child 3			
Child 4			
Child 5			
Child 6			

What are their ages and sex?

	Age (years)	Sex	
		Male	Female
Child 1			
Child 2			
Child 3			
Child 4			
Child 5			
Child 6			
Child 7			

SECTION B: YOUR CHILD'S BEHAVIOUR & ACTIVITIES

B1. **<u>On an average day</u>** in the last week, about how many hours and minutes did your child sleep in total during the **<u>NIGHT</u>**?

Hours ▼

Minutes ▼

B2. **<u>On an average day</u>** in the last week, about how many hours and minutes did your child sleep in total during the **<u>DAY</u>**?

Hours ▼

Minutes ▼

B3. The following statements are about your child's sleep habits. Please think about the past week when you answer the questions. If last week was unusual for a specific reason (such as your child had an ear infection and did not sleep well), choose the most recent typical week.

Answer USUALLY if something occurs **5 or more times** in a week.
Answer SOMETIMES if something occurs **2-4 times** in a week.
Answer RARELY if something occurs **never or 1 time** in a week.

	Usually (5-7)	Sometimes (2-4)	Rarely (0-1)
a. Child goes to bed at the same time at night	○	○	○
b. Child falls asleep within 20 minutes after going to bed	○	○	○
c. Child falls asleep alone in own bed	○	○	○
d. Child falls asleep in parent's or sibling's bed	○	○	○
e. Child needs parent in the room to fall asleep	○	○	○
f. Child struggles at bedtime (cries, refuses to stay in bed, etc)	○	○	○
g. Child is afraid of sleeping alone	○	○	○

We are interested in finding out how your child spends a usual day (24 hour period).

The following questions ask you to tell us how much time your child usually spends doing a range of activities on an average day. We understand that this will vary from day to day, but ask you to give your best guess of what your child usually does.

An hour and a half would be recorded as 1 hour and 30 minutes. If your child DOES NOT do an activity, please choose '0' (zero) in both hours and minutes.

B4. **<u>On an average day</u>** in the last week, how much time did your child spend doing the following?

a. Being physically active (any time moving around and not sitting or standing still)

Hours ▼

Minutes ▼

b. Playing active games with an adult (e.g. catch, chasey)

Hours ▼

Minutes ▼

c. In a stroller or pram

Hours ▼

Minutes ▼

d. In a car seat

Hours ▼

Minutes ▼

e. Sitting down on a chair or on the floor doing activities (reading, drawing, arts and crafts, etc.)

Hours ▼

Minutes ▼

f. Outside

Hours ▼

Minutes ▼

g. Watching or in front of the TV

Hours ▼

Minutes ▼

h. Playing on a computer (desktop or laptop) or game player that hooks up to a TV (e.g. PlayStation/Nintendo/XBox)

Hours ▼

Minutes ▼

i. Playing on hand held electronic devices (e.g. GameBoy/Nintendo DS)

Hours ▼

Minutes ▼

j. Playing active electronic games (e.g. Wii/Eye Toy/XBox Kinect)

Hours ▼

Minutes ▼

k. Using/playing on a smart phone (e.g. iPhone, Android)

Hours ▼

Minutes ▼

I. Using/playing on a digital tablet (e.g. iPad, Samsung Galaxy)

Hours ▼

Minutes ▼

B5. The following questions ask about your child's physical activity and screen time behaviours.

On **how many of the past 7 days** did your child:

	0 days	1 day	2 days	3 days	4 days	5 days	6 days	7 days
a. Engage in physical activity or active play for a total of **at least 3 hours** across the day? Some examples include playing outside, walking or running around, dancing or any activity in which they were moving	○	○	○	○	○	○	○	○
b. Watch TV/DVDs, play video or computer games or other electronic devices for entertainment for **less than 1 hour**?	○	○	○	○	○	○	○	○

B6. The following statements ask about how often your asks certain people to be active with him/her.

	Never	Rarely	Sometimes	A lot or most of the time	Always	N/A
a. My child asks for me/my partner to be active with him/her	○	○	○	○	○	○
b. My child asks his/her siblings to be active with him/her	○	○	○	○	○	○
c. My child asks people **outside** our immediate family to be active with him/her (e.g. uncles, parents' friends)	○	○	○	○	○	○

B7. The following statements ask about how often your child does certain things.

	Never	Rarely	Sometimes	A lot or most of the time	Always
a. My child asks for opportunities to be active (e.g. going to the park/indoor play centre)	○	○	○	○	○
b. My child likes to help out with active things around the home (e.g. gardening, cleaning, etc)	○	○	○	○	○
c. My child is more likely to watch TV than be active	○	○	○	○	○
d. My child is more likely to play electronic games than be active	○	○	○	○	○
e. My child is more likely to play inside/draw/do craft than be active	○	○	○	○	○

B8. The following statements ask about your child's general well-being and behaviour. Please think about how your child has been feeling and behaving during the past week.

In the **past week:**

	Never	Seldom	Sometimes	Often	All the time
a. My child was moody and whined a lot	○	○	○	○	○
b. My child had a healthy appetite	○	○	○	○	○

	Never	Seldom	Sometimes	Often	All the time
c. I managed to show patience and understanding towards my child					
d. My child felt under pressure					
e. My child slept soundly					
f. My child romped around and was very active					
g. My child kept bursting into tears					
h. My child was cheerful and in a good mood					
i. My child was alert and able to concentrate well					
j. My child was easily distracted and absent-minded					
k. My child enjoyed being with other children					
l. I had to give my child a telling-off					
m. I praised my child					
n. My child had problems with teachers, kindergarten staff of other child-minders					
o. My child was nervous and fidgety					
p. My child was lively and energetic					
q. My child complained of being in pain					
r. My child was sociable and out-going					
s. My child succeeded at everything he/she set out to do					
t. My child became dissatisfied easily					
u. My child cried bitterly					
v. My child lost his/her temper quickly					

SECTION C: YOUR BELIEFS/BEHAVIOURS

C1. The following statements ask about concerns you might have for your child. Please indicate how much you agree or disagree with the following concerns.

	Strongly disagree	Disagree	Agree	Strongly agree
a. I am concerned that my child is overweight				
b. I am concerned about my child having a traffic accident when he/she is being physically active in our neighbourhood				
c. I am concerned about stranger danger when my child is being physically active in our neighbourhood				
d. I am concerned about my child getting hurt (e.g. falling out of a tree) when he/she is being physically active				
e. I am concerned about my child not getting enough physical activity				
f. I am concerned that my child watches too much TV/DVDs				
g. I am concerned that my child spends too much time on the computer				
h. I am concerned that my child spends too much time playing electronic games (e.g. X-Box, PlayStation, GameBoy)				
i. I am concerned that my child spends too much time using smartphones and tablets				

C2. The following statements ask about your behaviours with your child.

	Never/ rarely	Sometimes	Often	All the time
a. I use TV to distract my child when he/she is being difficult	◯	◯	◯	◯
b. I use a computer/tablet/smartphone to distract my child when he/she is being difficult	◯	◯	◯	◯
c. I use TV to keep my child occupied so that I can get things done	◯	◯	◯	◯
d. I use a computer/tablet/smartphone to keep my child occupied so that I can get things done	◯	◯	◯	◯
e. I have the TV on while my child is eating	◯	◯	◯	◯
f. I allow my child to use a computer/tablet/smartphone while eating	◯	◯	◯	◯

C3. The following statements ask about some of the activities that you might limit for your child.

We understand that this will vary from day to day, but ask you to give your best guess of what you usually do.

a. I limit how much time my child is allowed to spend watching TV

◯ Yes

◯ No

What is the MAXIMUM time your child spends watching TV **per day**?

Hours ▼

Minutes ▼

b. I limit how much time my child is allowed to spend using computer and electronic games

◯ Yes

◯ No

What is the MAXIMUM time your child spends using computer and electronic games **per day**?

Hours ▼

Minutes ▼

c. I limit how much time my child is allowed to spend using smartphones/tablets

◯ Yes

◯ No

What is the MAXIMUM time your child spends using smartphones/tablets **per day**?

Hours ▼

Minutes ▼

d. I limit how much time my child spends sitting down

- Yes
- No

What is the MAXIMUM time your child spends sitting down **per day**?

Hours ▼

Minutes ▼

e. I limit how much time my child spends in situations that restrict his/her movement (e.g. in a car seat, stroller, shopping trolley seat)

- Yes
- No

What is the MAXIMUM time your child spends in situations that restrict his/her movement **per day**?

Hours ▼

Minutes ▼

C4. The following statements ask about your views on a number of things around children's activities.

	Strongly disagree	Disagree	Agree	Strongly agree
a. I have difficulty getting my child to eat if I don't use the TV/computer/tablet/smartphone to distract him/her				
b. I don't know what activities and games I should play with my child to help his/her development				
c. An active child is difficult for me to manage				
d. I think it's safer for my child to be in a stroller/pram than free to move about				
e. A placid and inactive child is easier to look after than an active one				
f. I wouldn't know how to keep my child entertained if I didn't use the TV/computer/tablet/smartphone				
g. I don't think I will be able to get anything done if I don't use the TV/computer/tablet/smartphone to keep my child entertained				
h. The toys and games I give my child to play with will affect his/her motor development and activity levels in the future				
i. Having a TV in my child's bedroom affects how much TV he/she watches				
j. Children are more likely to enjoy sports and active play if they see their parents doing them				
k. Children need help and encouragement to be active				

C5. How confident are you that you could do the following **over the next 2 months**?

	Not at all confident	Slightly confident	Moderately confident	Very confident	Extremely confident

a. Get my child to participate in at least 3 hours of physical activity/active play every day	○	○	○	○	○
b. Get my child to participate in a range of physical activities	○	○	○	○	○
c. Get my child to be active when he/she is asking to watch TV	○	○	○	○	○
d. Get my child to be active when he/she wants to play on the computer or play electronic games	○	○	○	○	○
e. Get my child to be active when he/she wants to play a smartphone/tablet	○	○	○	○	○
f. Limit my child's screen-time to less than 1 hour every day	○	○	○	○	○
g. Limit the amount of time my child spends sitting down	○	○	○	○	○
h. Limit the amount of time my child spends in situations that restrict movement (e.g. in a car seat, stroller, shopping trolley seat)	○	○	○	○	○
i. Say no to my child's requests to play on the computer or electronic games	○	○	○	○	○
j. Say no to my child's requests to play on a smartphone/tablet	○	○	○	○	○

C6. Thinking about the **LAST WEEK**, how often did you do the following things?

	Less than once a week	1-2 days per week	3-4 days per week	5-6 days per week	Every day	Several times per day
a. Put the TV/DVD on for my child to watch	○	○	○	○	○	○
b. Give my child a smartphone/tablet to play with	○	○	○	○	○	○
c. Have the TV/DVD on in the room, even if my child wasn't watching it	○	○	○	○	○	○
d. Have the TV/DVD on during dinner	○	○	○	○	○	○
e. Engage in active play with my child (e.g. dancing, chasing, playing with a ball, tickling games)	○	○	○	○	○	○
f. Take my child for a walk in the pram/pusher/stroller	○	○	○	○	○	○
g. Take my child for a walk: child walking, **NOT** in the pram/pusher/stroller	○	○	○	○	○	○
h. Encourage my child to do something active (e.g. dance, run, ride on their bike/push-along)	○	○	○	○	○	○
i. Encourage my child to go outside to play	○	○	○	○	○	○
j. Do an activity to help my child's skill development (e.g. kick a ball, play catch)	○	○	○	○	○	○
k. Encourage my child to stand up while doing craft activities (e.g. painting, drawing, playdough)	○	○	○	○	○	○

C7. The following statements ask about your views regarding young children's (0-5 years of age) physical activity.

	Strongly disagree	Disagree	Agree	Strongly agree
a. Children get all the activity they need naturally	○	○	○	○
b. Parents need to encourage their children to be physically active	○	○	○	○
c. Children need at least 3 hours of active play every day	○	○	○	○
d. Children need some planned active play every day (e.g. rolling a ball to each other)	○	○	○	○
e. Except when sleeping, children should not spend prolonged periods of time in restrained seating (like highchairs, pushers & car seats)	○	○	○	○
f. Children need help to learn skills like jumping and throwing a ball	○	○	○	○
g. TV/DVDs are educational for children	○	○	○	○

	Strongly disagree	Disagree	Agree	Strongly agree
h. Children should be allowed to watch TV/DVDs	◯	◯	◯	◯
i. TV/DVDs are helpful for children's development (e.g. language skills)	◯	◯	◯	◯
j. TV/DVDs are useful for keeping children occupied	◯	◯	◯	◯
k. Computer/electronic games are educational for children	◯	◯	◯	◯
l. Children should be allowed to use computer/electronic games	◯	◯	◯	◯
m. Computer/electronic games are helpful for children's development (e.g. language skills)	◯	◯	◯	◯
n. Computer/electronic games are useful for keeping children occupied	◯	◯	◯	◯
o. Tablets (e.g. iPad) are educational for children	◯	◯	◯	◯
p. Children should be allowed to use tablets	◯	◯	◯	◯
q. Tablets are helpful for children's development (e.g. language skills)	◯	◯	◯	◯
r. Tablets are useful for keeping children occupied	◯	◯	◯	◯

SECTION D: ABOUT YOU

D1. What is your date of birth?

(dd/mm/yyyy)

[ ]

D2. What is your sex?

◯ Male

◯ Female

D3. How tall are you without shoes?

*(Please select **ONE** height measurement and type your answer. Please provide your best guess if you are not sure.)*

Centimetres (cm) (e.g. 167cm) [ ]

Feet and inches (e.g. 5 feet 6 inches) [ ]

D4. How much do you weigh without clothes or shoes?

*(Please select **ONE** weight measurement and type your answer. Please provide your best guess if you are not sure. If you are currently pregnant, please provide your pre-pregnancy weight.)*

Kilograms (kg) (e.g. 68kg) [ ]

Stone and pounds (e.g. 10 stones 9 pounds) [ ]

D5. In what country were you born?

- Australia
- UK
- Italy
- Greece
- Netherlands
- Germany
- New Zealand
- Vietnam
- Poland
- Other (please specify):

D6. What is the main language you usually speak at home?

- English
- Other (please specify):

D7. What is the highest level of schooling you have completed?

- No formal qualifications
- Year 10 or equivalent (e.g. School Certificate)
- Year 12 or equivalent (e.g. Higher School Certificate)
- Trade/apprenticeship/certificate (e.g. hairdresser, chef, plumber)
- Diploma (e.g. business/accounting)
- University degree
- Postgraduate qualification (e.g. Graduate Diploma, Masters, PhD)

D8. What is your current marital status?

- Married
- De facto/living together
- Separated
- Divorced
- Widowed
- Never married

D9. Are you currently (please choose the one that you spend the MOST time in):

- On maternity/paternity leave
- In paid work full-time
- In paid work part-time

- Unemployed
- A student
- Retired
- Home duties full time
- Other

D10. How many days and hours did you spend in a paid job(s) in the ***last week***?

a) Approximately how many **DAYS** did you work in paid employment?

b) How many **HOURS** did you work on an average day?

SECTION E: YOUR OWN ACTIVITIES

E1. On a usual **weekday** (Monday through to Friday), about how many hours do you usually spend sitting down and watching TV/DVDs?

Hours

Minutes

E2. On a usual **weekend day** (Saturday or Sunday), about how many hours do you usually spend sitting down and watching TV/DVDs?

Hours

Minutes

In the following questions we want you to think about the physical activities that you have done in the last week.

E3. In the ***last week***, how many times have you walked continuously, for at least 10 minutes, for recreation, exercise or to get to or from places?

(If you did not do any walking, please choose “0 times”.)

E4. What do you estimate was the total time that you spent walking in this way in the ***last week***?

Hours

Minutes

E5. In the ***last week***, how many times did you do any vigorous gardening or heavy work around the yard, which made you breathe harder or puff and pant?

(If you did not do any vigorous gardening, please choose “0” times.)

▼

E6. What do you estimate was the total time that you spent doing vigorous gardening or heavy work around the yard in the ***last week***?

Hours ▼

Minutes ▼

The next questions exclude household chores, gardening or yard work:

E7. In the ***last week***, how many times did you do any vigorous physical activity which made you breathe harder or puff and pant? (e.g. jogging, cycling, aerobics, competitive tennis).

(If you did not do any vigorous physical activity, please choose “0 times”.)

▼

E8. What do you estimate was the total time that you spent doing this vigorous physical activity in the ***last week***?

Hours ▼

Minutes ▼

E9. In the ***last week***, how many times did you do any other more moderate physical activities that you have not already mentioned? (e.g. gentle swimming, social tennis, golf).

(If you did not do any moderate physical activity, please choose “0 times”.)

▼

E10. What do you estimate was the total time that you spent doing these activities in the ***last week***?

Hours ▼

Minutes ▼

SECTION F: YOUR HOME

F1. The following question asks about **TV, electronic games and computer equipment you may have in your home**.

	Yes	No
a. TV	◯	◯
b. DVD player	◯	◯
c. Hard disk recorder	◯	◯
d. Pay TV (e.g. Foxtel, Optus)	◯	◯
e. Nintendo Wii	◯	◯
f. Nintendo (any other variety)	◯	◯
g. XBox	◯	◯
h. Sega	◯	◯
i. Gameboy	◯	◯
j. PlayStation	◯	◯
k. Laptop computer	◯	◯
l. Desktop (PC or Apple Mac) computer	◯	◯
m. Internet access	◯	◯
n. Tablet computer (iPad or similar)	◯	◯
o. Smart phone (iPhone or similar)	◯	◯

F2. The following question asks about the types of **toys and equipment that your child has available at home to be physically active with**.

	Yes	No
a. Balls (footballs, basketballs, tennis balls, etc.)	◯	◯
b. Basketball/netball ring	◯	◯
c. Bats, racquets, golf clubs	◯	◯
d. Bicycle/tricycle	◯	◯
e. Climbing equipment/trees suitable for climbing	◯	◯
f. Cubby house	◯	◯
g. Hover board	◯	◯
h. Roller blades/skates	◯	◯
i. Sand pit	◯	◯
j. Scooter/skateboard	◯	◯
k. Skipping rope	◯	◯
l. Soft balls and other toys for indoor use	◯	◯
m. Swimming/wading pool	◯	◯
n. Slide	◯	◯
o. Swing	◯	◯
p. Trampoline	◯	◯

F3. The following question asks about TV, electronic games and computer equipment **your child may have in his/her bedroom PERMANENTLY**.

	Yes	No
a. TV	◯	◯
b. Laptop computer	◯	◯
c. Desktop (PC or Macintosh) computer	◯	◯

	Yes	No
d. Electronic games (e.g. XBox, PlayStation)	○	○

F4. The following question asks about portable electronic games and computer equipment **your child may TAKE in to his/her bedroom**.

	Yes	No
a. Laptop computer	○	○
b. Portable electronic games (e.g. Gameboy, PlayStation Portable)	○	○
c. Electronic games (e.g. XBox, PlayStation)	○	○
d. Tablet computer (iPad or similar)	○	○
e. Smart phone (iPhone or similar)	○	○

Appendix K: Mini Movers post-intervention questionnaire

Default Question Block

mini movers

Parent Survey 2

IMPORTANT INSTRUCTIONS - PLEASE READ

Thank you for taking the time to complete this second survey. It will take you approximately 30 minutes to complete, although this might vary depending on your answers.

Throughout this survey, we will refer to your “child”. By this we mean your child who is aged between 2 and 4 years and is participating in this study (the child who you answered the first survey about). Although you may have other children, it is important that you answer these questions in relation to that child only.

Please answer each question by choosing the most suitable option. Where you are asked to write an answer please read the question carefully and answer as best you can. If you are unsure about how to answer a question, please choose the answer that best reflects how you feel.

Are you the person who completed the first Mini Movers survey (approximately 7 weeks ago)?

- Yes
- No **(if possible, please ask the person who completed the first survey to complete this one)**

SECTION A: ABOUT YOUR CHILD

A1. Today's date (automatic)

(dd/mm/yyyy)

A2. What is your child's date of birth?

(dd/mm/yyyy)

A3. What relation are you to the child involved in this program?

- Mother/stepmother
- Father/stepfather
- Grandparent
- Guardian
- Other (please specify):

SECTION B: YOUR CHILD'S BEHAVIOUR & ACTIVITIES

B1. **On an average day** in the last week, about how many hours and minutes did your child sleep in total during the **NIGHT**?

Hours ▼

Minutes ▼

B2. **On an average day** in the last week, about how many hours and minutes did your child sleep in total during the **DAY**?

Hours ▼

Minutes ▼

B3. The following statements are about your child's sleep habits. Please think about the past week when you answer the questions. If last week was unusual for a specific reason (such as your child had an ear infection and did not sleep well), choose the most recent typical week.

Answer USUALLY if something occurs **5 or more times** in a week.
Answer SOMETIMES if something occurs **2-4 times** in a week.
Answer RARELY if something occurs **never or 1 time** in a week.

	Usually (5-7)	Sometimes (2-4)	Rarely (0-1)
a. Child goes to bed at the same time at night			
b. Child falls asleep within 20 minutes after going to bed			
c. Child falls asleep alone in own bed			
d. Child falls asleep in parent's or sibling's bed			
e. Child needs parent in the room to fall asleep			
f. Child struggles at bedtime (cries, refuses to stay in bed, etc)			
g. Child is afraid of sleeping alone			

We are interested in finding out how your child spends a usual day (24 hour period).

The following questions ask you to tell us how much time your child usually spends doing a range of activities on an average day. We understand that this will vary from day to day, but ask you to give your best guess of what your child usually does.

An hour and a half would be recorded as 1 hour and 30 minutes. If your child DOES NOT do an activity, please choose '0' (zero) in both hours and minutes.

B3. **On an average day** in the last week, how much time did your child spend doing the following?

a. Being physically active (any time moving around and not sitting or standing still)

Hours ▼

Minutes ▼

b. Playing active games with an adult (e.g. catch, chasey)

Hours ▼

Minutes ▼

c. In a stroller or pram

Hours ▼

Minutes ▼

d. In a car seat

Hours ▼

Minutes ▼

e. Sitting down on a chair or on the floor doing activities (reading, drawing, arts and crafts, etc.)

Hours ▼

Minutes ▼

f. Outside

Hours ▼

Minutes ▼

g. Watching or in front of the TV

Hours ▼

Minutes ▼

h. Playing on a computer (desktop or laptop) or game player that hooks up to a TV (e.g. PlayStation/Nintendo/XBox)

Hours ▼

Minutes ▼

i. Playing on hand held electronic devices (e.g. GameBoy/Nintendo DS)

Hours
Minutes

j. Playing active electronic games (e.g. Wii/Eye Toy/XBox Kinect)

Hours
Minutes

k. Using/playing on a smart phone (e.g. iPhone, Android)

Hours
Minutes

l. Using/playing on a digital tablet (e.g. iPad, Samsung Galaxy)

Hours
Minutes

B5. The following questions ask about your child's physical activity and screen time behaviours.

On **how many of the past 7 days** did your child:

	0 days	1 day	2 days	3 days	4 days	5 days	6 days	7 days
a. Engage in physical activity or active play for a total of **at least 3 hours** across the day? Some examples include playing outside, walking or running around, dancing or any activity in which they were moving	○	○	○	○	○	○	○	○
b. Watch TV/DVDs, play video or computer games or other electronic devices for entertainment for **less than 1 hour**?	○	○	○	○	○	○	○	○

B6. The following statements ask about how often your asks certain people to be active with him/her.

	Never	Rarely	Sometimes	A lot or most of the time	Always	N/A
a. My child asks for me/my partner to be active with him/her	○	○	○	○	○	○
b. My child asks his/her siblings to be active with him/her	○	○	○	○	○	○
c. My child asks people **outside** our immediate family to be active with him/her (e.g. uncles, parents' friends)	○	○	○	○	○	○

B7. The following statements ask about how often your child does certain things.

	Never	Rarely	Sometimes	A lot or most of the time	Always
a. My child asks for opportunities to be active (e.g. going to the park/indoor play centre)	○	○	○	○	○

	Never	Rarely	Sometimes	A lot or most of the time	Always
b. My child likes to help out with active things around the home (e.g. gardening, cleaning, etc)					
c. My child is more likely to watch TV than be active					
d. My child is more likely to play electronic games than be active					
e. My child is more likely to play inside/draw/do craft than be active					

B8. The following statements ask about your child's general well-being and behaviour. Please think about how your child has been feeling and behaving during the past week.

In the **past week:**

	Never	Seldom	Sometimes	Often	All the time
a. My child was moody and whined a lot					
b. My child had a healthy appetite					
c. I managed to show patience and understanding towards my child					
d. My child felt under pressure					
e. My child slept soundly					
f. My child romped around and was very active					
g. My child kept bursting into tears					
h. My child was cheerful and in a good mood					
i. My child was alert and able to concentrate well					
j. My child was easily distracted and absent-minded					
k. My child enjoyed being with other children					
l. I had to give my child a telling-off					
m. I praised my child					
n. My child had problems with teachers, kindergarten staff of other child-minders					
o. My child was nervous and fidgety					
p. My child was lively and energetic					
q. My child complained of being in pain					
r. My child was sociable and out-going					
s. My child succeeded at everything he/she set out to do					
t. My child became dissatisfied easily					
u. My child cried bitterly					
v. My child lost his/her temper quickly					

SECTION C: YOUR BELIEFS/BEHAVIOURS

C1. The following statements ask about concerns you might have for your child. Please indicate how much you agree or disagree with the following concerns.

	Strongly disagree	Disagree	Agree	Strongly agree

a. I am concerned that my child is overweight	○	○	○	○
b. I am concerned about my child having a traffic accident when he/she is being physically active in our neighbourhood	○	○	○	○
c. I am concerned about stranger danger when my child is being physically active in our neighbourhood	○	○	○	○
d. I am concerned about my child getting hurt (e.g. falling out of a tree) when he/she is being physically active	○	○	○	○
e. I am concerned about my child not getting enough physical activity	○	○	○	○
f. I am concerned that my child watches too much TV/DVDs	○	○	○	○
g. I am concerned that my child spends too much time on the computer	○	○	○	○
h. I am concerned that my child spends too much time playing electronic games (e.g. X-Box, PlayStation, GameBoy)	○	○	○	○
i. I am concerned that my child spends too much time using smartphones and tablets	○	○	○	○

C2. The following statements ask about your behaviours with your child.

	Never/ rarely	Sometimes	Often	All the time
a. I use TV to distract my child when he/she is being difficult	○	○	○	○
b. I use a computer/tablet/smartphone to distract my child when he/she is being difficult	○	○	○	○
c. I use TV to keep my child occupied so that I can get things done	○	○	○	○
d. I use a computer/tablet/smartphone to keep my child occupied so that I can get things done	○	○	○	○
e. I have the TV on while my child is eating	○	○	○	○
f. I allow my child to use a computer/tablet/ smartphone while eating	○	○	○	○

C3. The following statements ask about some of the activities that you might limit for your child.

We understand that this will vary from day to day, but ask you to give your best guess of what you usually do.

a. I limit how much time my child is allowed to spend watching TV

○ Yes

○ No

What is the MAXIMUM time your child spends watching TV **per day**?

Hours ▼

Minutes ▼

b. I limit how much time my child is allowed to spend using computer and electronic games

○ Yes

○ No

What is the MAXIMUM time your child spends using computer and electronic games **per day**?

Hours ▼

Minutes ▼

c. I limit how much time my child is allowed to spend using smartphones/tablets

- Yes
- No

What is the MAXIMUM time your child spends using smartphones/tablets **per day**?

Hours ▼

Minutes ▼

d. I limit how much time my child spends sitting down

- Yes
- No

What is the MAXIMUM time your child spends sitting down **per day**?

Hours ▼

Minutes ▼

e. I limit how much time my child spends in situations that restrict his/her movement (e.g. in a car seat, stroller, shopping trolley seat)

- Yes
- No

What is the MAXIMUM time your child spends in situations that restrict his/her movement **per day**?

Hours ▼

Minutes ▼

C4. The following statements ask about your views on a number of things around children's activities.

	Strongly disagree	Disagree	Agree	Strongly agree
a. I have difficulty getting my child to eat if I don't use the TV/computer/tablet/smartphone to distract him/her	○	○	○	○
b. I don't know what activities and games I should play with my child to help his/her development	○	○	○	○
c. An active child is difficult for me to manage	○	○	○	○
d. I think it's safer for my child to be in a stroller/pram than free to move about	○	○	○	○

	Strongly disagree	Disagree	Agree	Strongly agree
e. A placid and inactive child is easier to look after than an active one	○	○	○	○
f. I wouldn't know how to keep my child entertained if I didn't use the TV/computer/tablet/smartphone	○	○	○	○
g. I don't think I will be able to get anything done if I don't use the TV/computer/tablet/smartphone to keep my child entertained	○	○	○	○
h. The toys and games I give my child to play with will affect his/her motor development and activity levels in the future	○	○	○	○
i. Having a TV in my child's bedroom affects how much TV he/she watches	○	○	○	○
j. Children are more likely to enjoy sports and active play if they see their parents doing them	○	○	○	○
k. Children need help and encouragement to be active	○	○	○	○

C5. How confident are you that you could do the following **over the next 2 months**?

	Not at all confident	Slightly confident	Moderately confident	Very confident	Extremely confident
a. Get my child to participate in at least 3 hours of physical activity/active play every day	○	○	○	○	○
b. Get my child to participate in a range of physical activities	○	○	○	○	○
c. Get my child to be active when he/she is asking to watch TV	○	○	○	○	○
d. Get my child to be active when he/she wants to play on the computer or play electronic games	○	○	○	○	○
e. Get my child to be active when he/she wants to play a smartphone/tablet	○	○	○	○	○
f. Limit my child's screen-time to less than 1 hour every day	○	○	○	○	○
g. Limit the amount of time my child spends sitting down	○	○	○	○	○
h. Limit the amount of time my child spends in situations that restrict movement (e.g. in a car seat, stroller, shopping trolley seat)	○	○	○	○	○
i. Say no to my child's requests to play on the computer or electronic games	○	○	○	○	○
j. Say no to my child's requests to play on a smartphone/tablet	○	○	○	○	○

C6. Thinking about the **LAST WEEK**, how often did you do the following things?

	Less than once a week	1-2 days per week	3-4 days per week	5-6 days per week	Every day	Several times per day
a. Put the TV/DVD on for my child to watch	○	○	○	○	○	○
b. Give my child a smartphone/tablet to play with	○	○	○	○	○	○
c. Have the TV/DVD on in the room, even if my child wasn't watching it	○	○	○	○	○	○
d. Have the TV/DVD on during dinner	○	○	○	○	○	○
e. Engage in active play with my child (e.g. dancing, chasing, playing with a ball, tickling games)	○	○	○	○	○	○
f. Take my child for a walk in the pram/pusher/stroller	○	○	○	○	○	○
g. Take my child for a walk: child walking, **NOT** in the pram/pusher/stroller	○	○	○	○	○	○
h. Encourage my child to do something active (e.g. dance, run, ride on their bike/push-along)	○	○	○	○	○	○
i. Encourage my child to go outside to play	○	○	○	○	○	○

	Less than once a week	1-2 days per week	3-4 days per week	5-6 days per week	Every day	Several times per day
j. Do an activity to help my child's skill development (e.g. kick a ball, play catch)	○	○	○	○	○	○
k. Encourage my child to stand up while doing craft activities (e.g. painting, drawing, playdough)	○	○	○	○	○	○

C7. The following statements ask about your views regarding young children's (0-5 years of age) physical activity.

	Strongly disagree	Disagree	Agree	Strongly agree
a. Children get all the activity they need naturally	○	○	○	○
b. Parents need to encourage their children to be physically active	○	○	○	○
c. Children need at least 3 hours of active play every day	○	○	○	○
d. Children need some planned active play every day (e.g. rolling a ball to each other)	○	○	○	○
e. Except when sleeping, children should not spend prolonged periods of time in restrained seating (like highchairs, pushers & car seats)	○	○	○	○
f. Children need help to learn skills like jumping and throwing a ball	○	○	○	○
g. TV/DVDs are educational for children	○	○	○	○
h. Children should be allowed to watch TV/DVDs	○	○	○	○
i. TV/DVDs are helpful for children's development (e.g. language skills)	○	○	○	○
j. TV/DVDs are useful for keeping children occupied	○	○	○	○
k. Computer/electronic games are educational for children	○	○	○	○
l. Children should be allowed to use computer/electronic games	○	○	○	○
m. Computer/electronic games are helpful for children's development (e.g. language skills)	○	○	○	○
n. Computer/electronic games are useful for keeping children occupied	○	○	○	○
o. Tablets (e.g. iPad) are educational for children	○	○	○	○
p. Children should be allowed to use tablets	○	○	○	○
q. Tablets are helpful for children's development (e.g. language skills)	○	○	○	○
r. Tablets are useful for keeping children occupied	○	○	○	○

SECTION D: ABOUT YOU

D1. What is your date of birth?

(dd/mm/yyyy)

D2. Are you currently (please choose the one that you spend the MOST time in):

- ○ On maternity/paternity leave
- ○ In paid work full-time
- ○ In paid work part-time
- ○ Unemployed

- A student
- Retired
- Home duties full time
- Other

D3. How many days and hours did you spend in a paid job(s) in the ***last week***?

a) Approximately how many **DAYS** did you work in paid employment?

b) How many **HOURS** did you work on an average day?

SECTION E: YOUR OWN ACTIVITIES

E1. On a usual **weekday** (Monday through to Friday), about how many hours do you usually spend sitting down and watching TV/DVDs?

Hours

Minutes

E2. On a usual **weekend day** (Saturday or Sunday), about how many hours do you usually spend sitting down and watching TV/DVDs?

Hours

Minutes

In the following questions we want you to think about the physical activities that you have done in the last week.

E3. In the ***last week***, how many times have you walked continuously, for at least 10 minutes, for recreation, exercise or to get to or from places?

(If you did not do any walking, please choose "0 times".)

E4. What do you estimate was the total time that you spent walking in this way in the ***last week***?

Hours

Minutes

E5. In the ***last week***, how many times did you do any vigorous gardening or heavy work around the yard, which made you breathe harder or puff and pant?

(If you did not do any vigorous gardening, please choose "0" times.)

▼

E6. What do you estimate was the total time that you spent doing vigorous gardening or heavy work around the yard in the ***last week***?

Hours ▼

Minutes ▼

The next questions exclude household chores, gardening or yard work:

E7. In the ***last week***, how many times did you do any vigorous physical activity which made you breathe harder or puff and pant? (e.g. jogging, cycling, aerobics, competitive tennis).

(If you did not do any vigorous physical activity, please choose "0 times".)

▼

E8. What do you estimate was the total time that you spent doing this vigorous physical activity in the ***last week***?

Hours ▼

Minutes ▼

E9. In the ***last week***, how many times did you do any other more moderate physical activities that you have not already mentioned? (e.g. gentle swimming, social tennis, golf).

(If you did not do any moderate physical activity, please choose "0 times".)

▼

E10. What do you estimate was the total time that you spent doing these activities in the ***last week***?

Hours ▼

Minutes ▼

SECTION F: YOUR HOME

F1. The following question asks about **TV, electronic games and computer equipment you may have in your home**.

	Yes	No

a. TV	○	○
b. DVD player	○	○
c. Hard disk recorder	○	○
d. Pay TV (e.g. Foxtel, Optus)	○	○
e. Nintendo Wii	○	○
f. Nintendo (any other variety)	○	○
g. XBox	○	○
h. Sega	○	○
i. Gameboy	○	○
j. PlayStation	○	○
k. Laptop computer	○	○
l. Desktop (PC or Apple Mac) computer	○	○
m. Internet access	○	○
n. Tablet computer (iPad or similar)	○	○
o. Smart phone (iPhone or similar)	○	○

F2. The following question asks about the types of **toys and equipment that your child has available at home to be physically active with**.

	Yes	No
a. Balls (footballs, basketballs, tennis balls, etc.)	○	○
b. Basketball/netball ring	○	○
c. Bats, racquets, golf clubs	○	○
d. Bicycle/tricycle	○	○
e. Climbing equipment/trees suitable for climbing	○	○
f. Cubby house	○	○
g. Hover board	○	○
h. Roller blades/skates	○	○
i. Sand pit	○	○
j. Scooter/skateboard	○	○
k. Skipping rope	○	○
l. Soft balls and other toys for indoor use	○	○
m. Swimming/wading pool	○	○
n. Slide	○	○
o. Swing	○	○
p. Trampoline	○	○

F3. The following question asks about TV, electronic games and computer equipment **<u>your child may have in his/her bedroom PERMANENTLY</u>**.

	Yes	No
a. TV	○	○
b. Laptop computer	○	○
c. Desktop (PC or Macintosh) computer	○	○
d. Electronic games (e.g. XBox, PlayStation)	○	○

F4. The following question asks about portable electronic games and computer equipment **<u>your child may TAKE in to his/her bedroom</u>**.

	Yes	No
a. Laptop computer	○	○
b. Portable electronic games (e.g. Gameboy, PlayStation Portable)	○	○
c. Electronic games (e.g. XBox, PlayStation)	○	○
d. Tablet computer (iPad or similar)	○	○
e. Smart phone (iPhone or similar)	○	○

SECTION G: YOUR FEEDBACK

This section asks for your feedback on different components of the Mini Movers program. Your feedback will help us to make the program resources as useful as they can be to parents in the future. Thank you for taking the time to complete this; your input is valuable.

G1. Thinking about the Mini Movers program overall, what do you think the <u>main messages of the program were?</u>

G2. Thinking about the information you received in the Mini Movers program, how <u>USEFUL</u> did you find each of the following?

	Not at all useful	Slightly useful	Moderately useful	Very useful	Extremely useful
a. The information overall	○	○	○	○	○
b. The goal planning	○	○	○	○	○
c. The booklet	○	○	○	○	○
d. The text messages	○	○	○	○	○
e. The YouTube videos (links in text messages)	○	○	○	○	○
f. The other websites (links in text messages)	○	○	○	○	○

G3. Thinking about the information you received in the Mini Movers program, how <u>RELEVANT</u> to your family did you find each of the following?

	Not at all relevant	Slightly relevant	Moderately relevant	Very relevant	Extremely relevant
a. The information overall	○	○	○	○	○
b. The goal planning	○	○	○	○	○
c. The booklet	○	○	○	○	○

	Not at all relevant	Slightly relevant	Moderately relevant	Very relevant	Extremely relevant
d. The text messages	○	○	○	○	○
e. The YouTube videos (links in text messages)	○	○	○	○	○
f. The other websites (links in text messages)	○	○	○	○	○

G4. Considering the 12 *informative text messages* (that is, the text messages with play ideas or tips for reducing screen time) you received during the 6 weeks this study:

	None	1-2 texts	3-4 texts	5-6 texts	7-8 texts	9-10 texts	11-12 texts
a. How many did you read?	○	○	○	○	○	○	○
b. How many gave you ideas that you used with your child?	○	○	○	○	○	○	○

G5. Considering the 2 text messages we sent you with links to the *YouTube videos*:

	None	1 video	2 videos
a. How many did you watch in full?	○	○	○
b. How many did you watch in part?	○	○	○
c. How many did you watch more than once?	○	○	○
d. How many gave you ideas that you used with your child?	○	○	○

G6. Considering the 5 text messages we sent you with links to *images* or other *websites*:

	None	1 text	2 texts	3 texts	4 texts	5 texts
a. How many did you click through to the links?	○	○	○	○	○	○
b. How many did you click through to more than once?	○	○	○	○	○	○
c. How many gave you ideas that you used with your child?	○	○	○	○	○	○

Appendix L: Test-retest results for purpose-developed items in Mini Movers questionnaires

Mini Movers: Test-retest study to assess reliability of purpose developed questionnaire items

Introduction

The baseline and post-intervention questionnaires utilised in the Mini Movers program (described in Chapters Five and Six) were largely based on existing questionnaires with previously established reliability (1, 2). However, some items in the questionnaires were purpose-developed for this study. The reliability of these items was tested in a separate sample of participants; methods and results for this test-retest study are described below.

Methods

Recruitment and participants

Participants were recruited via a number of convenience sampling methods. A university-wide email was sent to all staff at Deakin University and flyers were posted around campus. Staff members were also asked to forward the information to friends or acquaintances who had children of the appropriate age for the study. Finally, notices were posted on websites and Facebook pages providing information for parents (with approval from the owners of the websites/pages as appropriate). Potential participants were asked to express interest via email. Information about the study was then emailed back to participants, including a link to the baseline survey (delivered online via Qualtrics), which included consent. The follow-up survey was emailed directly to participants two weeks after completing the first survey.

Measures

The items included in the test-retest questionnaire are described below in Table L2.

Statistical analyses

Analyses were undertaken in Stata 14 (StataCorp, College Station, TX, USA). Descriptive statistics were used to describe the sample. Test-retest reliability of items was determined by comparing the agreement between responses from the first and second surveys. Levels of agreement for categorical variables were determined using Kappa coefficients and percent agreement; Kappa coefficients were defined as poor/slight (κ = 0.00–0.20), fair (κ = 0.21–0.40), moderate (κ = 0.41–0.60), substantial (κ = 0.61–0.80) and almost perfect (κ = 0.81–1.00). Some items had negative or very low Kappa values despite showing high percent agreement, which can occur when items have a high percent of responses in one category, creating instability in the Kappa statistic. Therefore, an item with κ > 0.60 and/or percent agreement ≥60% was considered to have acceptable reliability. Reliability of continuous variables (including any summed scores) was assessed using intra-class correlations (ICC). An ICC value of less than 0.50 indicated poor reliability; ICC values of 0.50–0.74 indicated moderate reliability; and an ICC of 0.75 or higher indicated a good level of agreement. In addition to test-retest reliability, internal reliability of all summed scores was tested using Cronbach’s alpha. Scores with reliability ≥0.70 were included (3).

Results

Participant characteristics

Fifty parents were recruited to take part in the test-retest study and completed the first survey; 44 of those parents (88%) completed the second survey two weeks later. Characteristics of participating parents and their children are presented in Table L1.

Table L1. Participant characteristics

Characteristic	Mean (SD) or %
Parent characteristics	
Age, mean (SD) years	35.2 (3.9)
Sex, %	
Male	4.0%
Female	96.0%
Child characteristics	
Age, mean (SD) years	2.9 (1.1)

Reliability

Test-retest reliability results for individual items and test-retest and internal reliability for summed scores (where applicable) are presented in Table L2 below.

Table L2. Test-retest reliability results for purpose-developed items

Individual items	Question number	Kappa (% agreement) for categorical variables	ICC for continuous variables	Details and ICC for summed scores (if applicable)	Cronbach's alpha for summed scores (if applicable)
Average daily time spent in a stroller/pram*	B2d	-	0.61	B2d and B2e summed to give total time spent restrained: ICC = 0.22	-
Average daily time spent in a car seat*	B2e	-	0.16		
Average daily time spent watching or in front of the TV*	B2h	-	0.71	B2h, B2i, B2j, B2m, B2n and B2l summed to give total screen time: ICC = 0.96	-
Average daily time spent playing on a computer or game player that hooks up to a TV*	B2i	-	0.00†		
Average daily time spent playing hand held electronic devices*	B2j	-	0.14		

Individual items	Question number	Kappa (% agreement) for categorical variables	ICC for continuous variables	Details and ICC for summed scores (if applicable)	Cronbach's alpha for summed scores (if applicable)
Average daily time spent using/playing on a smart phone*	B2m	-	0.82		
Average daily time spent using/playing on a digital tablet*	B2n	-	0.76		
Average daily time spent sitting down on a chair or on the floor doing activities*	B2l	-	0.07	-	
Days in the last week child watched TV/DVDs or played video or computer games or other electronic devices for entertainment for < 1 hour*	B4b	0.22 (24.7)	-	-	
TV is educational for children	B3g	0.69 (63.6)	-		0.92

Individual items	**Question number**	**Kappa (% agreement) for categorical variables**	**ICC for continuous variables**	**Details and ICC for summed scores (if applicable)**	**Cronbach's alpha for summed scores (if applicable)**
Children should be allowed to watch TV	B3i	0.89 (78.1)	-	B3g, B3i, B3j, B3k, B3l B3m, B3n, B3o, B3p, B3q, B3r, B3s summed to create 'Parental beliefs/ knowledge of child screen time' variable: ICC = 0.79	
TV is helpful for children's development (e.g. language skills)	B3j	0.51 (58.7)	-		
TV is useful for keeping children occupied	B3k	0.38 (81.6)	-		
Computer/electronic games are educational for children	B3l	0.47 (52.3)	-		
Children should be allowed use computer/electronic games	B3m	0.55 (54.1)	-		
Computer/electronic games are helpful for children's	B3n	0.32 (50.0)	-		

Individual items	**Question number**	**Kappa (% agreement) for categorical variables**	**ICC for continuous variables**	**Details and ICC for summed scores (if applicable)**	**Cronbach's alpha for summed scores (if applicable)**
development (e.g. language skills)					
Computer/electronic games are useful for keeping children occupied	B3o	0.59 (61.4)	-		
Tablet computers (e.g. iPad) are educational for children	B3p	0.59 (61.4)	-		
Children should be allowed to use tablet computers	B3q	0.72 (59.3)	-		
Tablet computers are helpful for children's development (e.g. language skills)	B3r	0.47 (52.5)	-		
Tablet computers are useful for keeping children occupied	B3s	0.72 (67.5)	-		

Individual items	Question number	Kappa (% agreement) for categorical variables	ICC for continuous variables	Details and ICC for summed scores (if applicable)	Cronbach's alpha for summed scores (if applicable)
I use a computer/tablet/smartphone to distract my child when s/he is being difficult	B5c	0.44 (63.4)	-	B5c, B5d, B5e summed with items with previously established reliability (ICC not available)	0.74 (including other items not listed here)
I use a computer/tablet/smartphone to keep my child occupied so that I can get things done	B5d	0.61 (53.7)	-		
I allow my child to use a computer/ tablet/smartphone while eating	B5e	0.85 (85.3)	-		
I wouldn't know how to keep my child entertained if I didn't use the TV/computer/tablet/ smartphone	B6b	0.00 (97.7)	-	B6b, B6c, B6d, B6e summed to create 'Parental views about screen time occupying children' variable: ICC = 0.71	0.73
I don't think I will be able to get anything done if I don't use the	B6c	0.39 (70.3)	-		

Individual items	Question number	Kappa (% agreement) for categorical variables	ICC for continuous variables	Details and ICC for summed scores (if applicable)	Cronbach's alpha for summed scores (if applicable)
TV/computer/tablet/smartphone to keep my child entertained					
I am concerned that my child spends too much time using smartphones and tablets	B6d	0.73 (74.8)	-		
I have difficulty getting my child to eat if I don't use the TV/ computer/tablet/smartphone to distract him/her	B6e	0.85 (85.3)	-		
Confident to limit my child's screen-time to less than 1 hour every day	C2c	0.22 (36.3)	-	C2c, C2d, C2e, C2f summed with one other item with previously	0.72 (including other item not listed here)

Individual items	Question number	Kappa (% agreement) for categorical variables	ICC for continuous variables	Details and ICC for summed scores (if applicable)	Cronbach's alpha for summed scores (if applicable)
Confident to limit the amount of time my child spends sitting down	C2d	0.40 (54.6)	-	established reliability (ICC not available)	
Confident to limit the amount of time my child spends in situations that restrict movement (e.g. in a car seat, stroller, shopping trolley seat)	C2e	0.39 (55.1)	-		
Confident to say no to my child's requests to play on a smartphone/tablet	C2f	0.36 (67.8)	-		
Put the TV/DVD on for my child to watch	C3a	0.66 (33.4)	-	C3a, C3b, C3c, C3d summed to create	0.63

Individual items	Question number	Kappa (% agreement) for categorical variables	ICC for continuous variables	Details and ICC for summed scores (if applicable)	Cronbach's alpha for summed scores (if applicable)
Give my child a smartphone/tablet to play with	C3b	0.73 (57.9)	-	'Parental logistic support of screen time' variable: ICC = 0.88	
Have the TV/DVD on in the room, even if my child wasn't watching it	C3c	0.71 (52.4)	-		
Have the TV/DVD on during dinner	C3d	0.80 (55.3)	-		

Notes: * These items assess behaviours in the 'last week', so responses would be expected to vary by week; † The majority (~87%) of participants reported no time in this activity at both time points.

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Appendix M: Design of pouch and leggings for *activ*PAL™ accelerometers

Design of pouch and leggings for activPAL™ accelerometers

Introduction

The *activ*PAL™ accelerometer and inclinometer is a posture-based device, worn on the midline anterior aspect of the upper thigh, that measures sitting/lying, standing and stepping (PAL Technologies Ltd, Glasgow, Scotland). In adults, *activ*PAL™ monitors are commonly affixed to the thigh using adhesive pads (e.g., PALstickies™ available from the manufacturer), and either removed for water-based activities or waterproofed (e.g., with Tegaderm™ tape) (1). Few studies have measured habitual sedentary behaviour in children using *activ*PAL™ accelerometers. De Decker et al. (2) compared the *activ*PAL™ and the hip-worn ActiGraph for measuring sedentary time in preschoolers. Fifty-two children wore an *activ*PAL™, affixed to the thigh with hypoallergenic Tegaderm™ tape, for five consecutive days (three weekdays and two weekend days). Although 70% of parents reported that their child found wearing both devices (i.e., the *activ*PAL™ and ActiGraph) either 'pleasant' or 'very pleasant', 10% reported that their child found wearing the *activ*PAL™ 'very unpleasant' and 38% reported that that their child experienced skin irritation due to wearing the waterproof *activ*PAL™ (2). Davies et al. (3) examined the practical utility of the *activ*PAL™ in 20 preschool children. The monitor was attached to the thigh with a PALstickie™ and parents were provided with Tegaderm™ tape for additional security if required. Children wore the monitors for seven consecutive days, but parents were instructed to remove the monitor each day for bathing and to reattach it afterwards. While the overall practical utility was reported to be acceptable, some parents reported that their child found it somewhat uncomfortable or painful to wear, and that input was required to ensure that it was kept on correctly (3).

Ridgers et al. (4) examined the agreement between the *activ*PAL™ and ActiGraph accelerometers for assessing sedentary time school-aged children (8-12 years). Children wore both monitors for two consecutive school days; the *activ*PAL™ monitor was enclosed in a small pocket in an adjustable, elasticised belt, worn on the child's thigh. Acceptability of this method was not measured; however, the authors reported 100% compliance with the inclusion criteria (two complete school days, i.e., 9am to 3:30pm), suggesting that acceptability was likely high. Within our research group, this method of enclosing the monitor in a pocket in an elasticised belt has been utilised with young children (aged 3 years) (5). However, parents of children in that study reported anecdotally that the belts were uncomfortable or would constantly slip down. As a result of this, only around 50% of the sample had valid *activ*PAL™ data (unpublished data). Potentially this method is practical for use in older children, but not in younger children given the small size of their legs (which may cause the belt to slip down). Therefore, for the purposes of the Mini Movers intervention in this thesis, we aimed to develop a method for wearing the *activ*PAL™ that would increase wear compliance in young children.

Methods

The design for the leggings with a detachable pouch for the *activ*PAL™ monitor was conceived because we wanted something that could be worn underneath the child's clothing so that they were not visible (to others or to the child). The detachable pouch was designed so that parents were able to wash the leggings after each wear, without damaging the monitor.

Firstly, pouches slightly larger than the *activ*PAL™ (~40cm x 55cm) were sewn, with one side of Velcro® sewn onto the back (see Image 1).

Image 1. Front and back view of *activ*PAL™ pouch

The other side of the Velcro® was sewn onto leggings in sizes ranging from 1 to 6 (i.e., for children aged 1 through 6 years) and in a range of colours. The leggings were cut so that they would be knee length, to enable them to be worn under most items of clothing. Prior to data collection, the initialised *activ*PAL™ monitors were sewn into the pouches (to ensure children were not able to remove them) and the pouches were then affixed to leggings (see Images 2 and 3). Parents were given two or three pairs of leggings to allow for washing during the week. Approximately 100 pouches were sewn and 100 leggings were altered by the candidate for use in the Mini Movers study.

Image 2. *Activ*PAL™ sewn into pouch

Image 3. Child wearing *activ*PAL™ leggings

Although parents were not specifically asked for their feedback on the leggings, the majority commented that their children enjoyed wearing them. Additionally, some parents commented on the leggings unprompted during the qualitative interviews (see Appendices O and P). The feedback received from these parents was predominantly positive:

“My daughter liked wearing her "monster leggings" and it was nice to go to our mothers group where everybody else was wearing them.”

“My son was extremely enthusiastic ‘cos I think he thought that these, um, robot things he got to stick on his leg made him go faster. He was very enthusiastic in terms of being, you know, there was no issue in terms of putting on leggings and stuff underneath. He was actually quite excited by all of that… I was unsure with him, just being a boy, if he'd actually put leggings on... but he did. And it wasn't too much hassle from my end, in terms of putting on the clothes.”

“It was very easy to participate in… my daughter's first problem was that she didn't get pink leggings! Um, so if there was more variety in colours of leggings, maybe… that was the only thing, we had a little breakdown for it. But, other than that it was extremely easy to put the leggings on and go.”

“I think the way you measured with the legging thing that was all appropriate and I mean, for his age, he was happy to sort of wear them, it wasn't a battle for his to get them on. He was convinced they made him jump higher!”

One mother commented that it was difficult initially, but that her son eventually got used to it:

“The only thing that was slightly difficult was… keeping that monitor on my son. Like he was a bit resistant to it. He didn't really enjoy wearing it, um, sometimes. So that was, you know, it was the start of the program and he eventually like, towards the end of the week got used to it.”

It appears that this method for wearing the *activ*PAL™ is feasible and acceptable for both parents and children, suggesting that future research may benefit from similar methods.

References

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Appendix N: Instruction booklet for parents for *activ*PAL™ accelerometers

ID: Child name:

mini movers

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Activity Monitor Instructions

The activity monitor leggings need to be worn during all waking hours, except for water activities (e.g. baths, showers, swimming), for the next 7 days.

- The monitor has been sewn into the pouch. It is important that it is not taken out of the pouch at any time.
- Your child can wear the leggings under their usual clothes or by themselves. **We recommend under usual clothes** so they are less tempted to play with or remove the pouch.
- You have received 2 pairs of leggings with Velcro on the right leg. This is so you can wash the leggings if needed (we know how messy kids can be!). Please **make sure you remove the pouch** before putting the leggings in the machine. *It is very important that the monitors do not get wet.* Remember to re-attach the pouch to the next, clean pair of leggings.
- Please ensure the pouch is **not submerged in water** (take leggings off for baths, showers, swimming). Don't worry if the pouch gets dirty. If needed you can wipe it with a damp cloth.

PLEASE REMEMBER THE MONITORS ARE EXPENSIVE TO REPLACE.

If you have any questions about the monitor please contact
Katherine: 9244 6088 or 0473 361 897
k.downing@deakin.edu.au

Activity Record Sheet

If the activity monitor is removed during the day **FOR 10 MINUTES OR MORE** for any reason (including if you forget to put the leggings on), we need to know what your child was doing during that time. Please write below **WHAT** your child was doing (e.g. having a shower), **WHEN** he/she did it (e.g. 7.30 am) and for **HOW LONG** (e.g. 15 minutes).

Date	What was your child doing?	Time removed	Duration
E.g. 23/9/16	*Swimming lesson*	*4.30 pm*	*45 mins*

Date	What was your child doing?	Time removed	Duration

Childcare/Preschool Attendance

Please also tell us which days and times your child attended childcare or preschool during the week that he/she wore the activity monitor. This might be different from any other week, for instance, if your child was sick or you had other activities to do.

Day of attendance	Type of care	Start time	Finish time
E.g. 23/9/16	*Childcare*	*8.30 am*	*4.30 pm*

Please ensure your child wears the leggings as shown in the picture below. The pouch should sit on the front of the right thigh, with the smiley faces facing the right way up for other people looking at them. Please ensure the leggings are always on the right way.

Tips and tricks for getting your child to wear the activity monitor…

Put the leggings on every morning as part of getting dressed so they become just another item of clothing.

Make the leggings into 'superhero' leggings.

Excite them with a favourite character: "You're like a transformer!", "Dora the explorer would love to wear these!"

Make them feel like one of a kind: "You're only one of just a few kids who gets to wear these cool leggings!"

At the end of the day, we understand that getting kids to do some things can be almost impossible! We just ask that you try your best to get them to wear the leggings as much as possible for the 7 days ☺

Appendix O: Mini Movers qualitative interviews invitation letter, Plain Language Statement and Consent Form

ID:

[Parent first name] [Parent surname]
[Street address]
[Suburb] [Postcode]

[Date]

Dear [Parent first name],

We would like to take this opportunity to thank you again for your participation in the Mini Movers Program. The research team is extremely grateful to all the families who have been involved. As you know, the program is now finished, however, we are keen to find out more about parents' experiences of Mini Movers.

You are invited to participate in a telephone interview which will take about 30 minutes. During the interview you will be asked about: your thoughts on the program generally; aspects of the program that you enjoyed; and things that you feel could have been improved. The interview will be scheduled at a time convenient to you.

If you would like to participate, please read the enclosed Plain Language Statement, complete the consent form, and return the consent form either via post in the reply-paid envelope enclosed or via email to k.downing@deakin.edu.au.

If you do not wish to participate, please tick the 'no' box on the consent form and return it via post or email as above.

If you have any questions about this study, please contact Katherine on 9244 6088. Thank you for your consideration, and we look forward to hearing from you.

Kind regards,

Signature Redacted by Library

Katherine Downing
Project Manager/PhD Candidate
Mini Movers Program

PLAIN LANGUAGE STATEMENT AND CONSENT FORM

Plain Language Statement

Date: 2016

Full Project Title: Parent perceptions of the Mini Movers Program

Principal Researcher: Assoc Prof Kylie Hesketh

Student Researcher: Ms Katherine Downing

Dear Parent,

As you know, we have recently finished delivering the Mini Movers program to parents around Melbourne. Now that the formal program is finished, the research team is keen to find out more about parents' experiences of this program.

In the next 2 months, we will be conducting a study with a small number of parents who participated in Mini Movers. The aim of this study is to learn about parents' views of the program. We will ask you about aspects of Mini Movers that you enjoyed, things that you feel could have been improved and what you learnt about promoting healthy habits such as active play for your child.

What can I expect if I agree to participate?

Participation in this study will involve one telephone interview that will take about 30 minutes. Interviews will be scheduled at a time convenient for you. With your permission, the interview will be audio-taped, and the key points recorded in writing. Please be assured that all the information you provide will be de-identified, will remain completely confidential and will be used for research purposes only.

Who will see the information that I provide?

The results of this program will be published in Ms Downing's thesis. Results may also be published in research journals and presented at research conferences. However, individual participants or playgroups will never be identified and only aggregate data will be reported (that is, information from all parents in the program will be combined and reported as a group). Data will be used for no other purposes and will not be released to other parties. Storage of the data collected will adhere to the University regulations. Data will be kept in secure storage for at least 6 years.

Are there any risks for me if I agree to take part in this study?

We do not anticipate any risk or discomfort will be experienced by participating in this research.

What are the possible benefits for me from taking part in this program?

As thanks for your time in taking part, you will receive a $10 gift card after participating in the telephone interview. This is in addition to the $20 gift card you have already received for your participation in the program.

What if I decide not to consent to take part in this program?

As this study is completely voluntary, you are under no obligation to consent to participation and you may withdraw at any stage, for any reason. If you withdraw from the study, any information obtained from you will not be used and will be destroyed. You are also free to avoid answering questions that you feel are too personal or intrusive. If you have any questions about participating in this project, please feel free to contact the researchers at any time.

If you agree to participate in this study, please complete the consent form, and return the consent form either via post in the reply-paid envelope enclosed or via email to k.downing@deakin.edu.au. If you do not wish to participate in this study, please tick 'no' on the enclosed consent form, and return via post or email as above.

Kind regards,

Signature Redacted by Library

Katherine Downing
PhD Candidate
School of Exercise and Nutrition Sciences
Deakin University

Signature Redacted by Library

Kylie Hesketh
Associate Professor
School of Exercise and Nutrition Sciences
Deakin University

Complaints

If you have any complaints about any aspect of the project, the way it is being conducted or any questions about your rights as a research participant, then you may contact:

The Manager, Ethics and Biosafety, Deakin University, 221 Burwood Highway, Burwood Victoria 3125, Telephone: 9251 7129, research-ethics@deakin.edu.au
Please quote project number [2016-103].

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Consent Form

Full Project Title: Parent perceptions of the Mini Movers Program

Reference Number: 2016-103

I agree to take part in the Deakin University research project specified in the Plain Language Statement.

I have had the project explained to me, and I have read and understand the Plain Language Statement, which I will keep for my records.

The researcher has agreed not to reveal my identity and personal details, including where information about this project is published, or presented in any public form.

I agree to participate in a telephone interview asking me about my experience of the Mini Movers program. ☐ **YES** ☐ **NO**

Today's date: _______________

My full name: ____

Email address: ____

Mobile phone number: _______________________________________

If you ticked "YES" above:
Times I am available to be contacted: *please tick as many as possible*

Day/Time	Monday	Tuesday	Wednesday	Thursday	Friday
Early morning 7-9am					
Morning 9am-12pm					
Afternoon 12-5pm					
Evening 5-7pm					
Other time (e.g. weekend), please specify:					

We will contact you once we receive this form to confirm your interview time.

If you have any questions or concerns, please contact Katherine Downing on 9244 6088 or k.downing@deakin.edu.au.

Please complete this consent form and return it in to the research team in person, via post, or save it and email to k.downing@deakin.edu.au.

Appendix P: Interview script and questions for Mini Movers qualitative interviews

Introduction:
Hi <parent>, this is <researcher> calling from the Mini Movers Program at Deakin University. I'm calling today as arranged to ask you a few questions about your participation in Mini Movers. Is now still a good time to chat?

If NO → *arrange another time to call back*

If YES → Great! Just a reminder that this phone call will be recorded and later transcribed. Is that still ok with you? We won't store your name with the recording or transcription so anything you say will be completely anonymous. I'll also be taking some notes during our talk. We are keen to find out about your experiences as part of this program, things you liked, things you didn't like and any suggestions you have for improving the program or making it easier for parents to participate. We would really value your honest opinions about both positive and negative aspects of the program so that we can improve the program. There are no right or wrong answers to the questions I am about to ask you, we just want to know what you think.

Ok, I'm just going to turn the recorder on now…

START RECORDING

… for administrative purposes this is interview number <participant ID>.

1a) Tell me what you thought about the Mini Movers program overall.

1b) What things did you enjoy about participating in Mini Movers? *Prompts: the goal-setting, the booklet, the text messages…*

1c) What things did you not enjoy about participating in Mini Movers? *Prompts as above*

2a) What did you find useful or most relevant to you about Mini Movers? How/why was that useful for you? *(Asking about CONTENT)*

> *(repeat until no more responses)* What else about Mini Movers did you find useful/relevant? How was that useful for you?

2b) What information provided in Mini Movers did you think was not useful or relevant? Why/how was that not useful? *(Asking about CONTENT)*

> *(repeat until no more responses)* What else about Mini Movers did you think was not useful? Why was that not useful?

2c) In what ways could we have made Mini Movers more relevant or useful to you and your family?

I'm going to ask you some more specific questions about the program now, so apologies if we've already covered some of this!

3a) What did you think about receiving the text messages from Mini Movers?
3b) What did you think about the frequency of the text messages you received? (Should the frequency have been more/less often?)

3c) What did you think about the links we included in the text messages? Did you click through to these links?

4a) What did you think about the goal setting component of Mini Movers?

4b) Did you find the goal setting useful?

4c) Did you find it difficult to set goals?

4d) Did you find it difficult to stick to your goals?

5a) Which of the Mini Movers resources/materials (the things we've given you as part of the program, including the booklet and the videos and infographic you received via text), have you used?

5b) Which, if any, of these resources/materials do you think you would use in the future, as your child (who has participated in Mini Movers) gets older?

5c) Which, if any, of these resources/materials do you think you would use in the future, with other children?

5d) How would you suggest we could improve the resources/materials so parents might be more likely to use them?

6) Do you think the program overall was useful for your family? Do you think it made you change the way you do things?

7) Do you have any other thoughts about Mini Movers that you'd like to share?
Prompt: Have you talked to anyone else about Mini Movers? What sort of things have you told them?

Conclusion:
Thank you very much for your time today, we really appreciate your input! You should receive your additional $10 voucher in the post in the next couple of weeks.

Appendix Q: Additional methods and results for Mini Movers qualitative interviews

Additional methods and results for Mini Movers qualitative interviews

Methods

A subsample of randomly selected participants in the intervention group were invited to participate in qualitative telephone interviews. These participants were contacted after the program had concluded via mail and asked to return a separate consent form (see Appendix O). Participants were sent a maximum of one reminder email and one text message to return their consent form if interested. Once consent was received, telephone interviews were scheduled for days and times convenient to the parents. Interview questions are presented in Appendix P.

As the candidate was responsible for delivering the intervention, the interviews were conducted by a trained research assistant to minimise participant social desirability. All interviews were digitally recorded and brief notes were taken by the interviewer. The recordings were transcribed verbatim by the candidate, using InqScribe digital media transcription software (Inquirium, Chicago, Illinois, USA). Transcripts were analysed using NVivo (QSR International, 2002) qualitative software package. Participants' responses to questions were coded to identify key themes.

Results

Of the 25 intervention participants invited to participate in the qualitative interviews, 10 participants provided written, informed consent (40% response). All participants were mothers, with a mean age of 36.6 years (SD 4.6). All were highly educated (university degree or higher) and married/living in a de facto relationship. Fewer than half (40%) were classified as healthy weight, 70% were born in Australia, and 70% were in either part- or full-time paid employment. There was an even split (50% each) of mothers of boys and girls. Additional results from the interviews not reported in Chapter Seven (Paper Four) are described below.

When asked about their thoughts on the program overall, parents commented that they liked tips and ideas for new activities and reminders to do activities that they may have forgotten about:

“It was a really good idea... I enjoyed knowing what [child’s] activity level was and then finding… new ways to increase it. Like I hadn't really thought about her walking places, I always just put her in the push chair, so that was good for me realising her capability… of what she was actually able to do.”

“I think some of the strategies were really great, that you offered, I mean it was things that perhaps you sort of know already as a parent, but it was just that little reminder... sometimes I was sort of like "yeah, you know… that's a good thing to do".”

This was reiterated when parents were asked what they found most useful or relevant from the program. The two most common responses to this question were related to the reminders for activities to do with children and the goal-setting:

“I think that I knew a lot of the information, but I think as you kind of get busy with kids, you forget it a little bit, so it was useful in terms of reminding me of some useful activities to do with the kids. Like I remember… a prompt about you know, getting them involved in cooking and I think over time, cos it was my third child that participated, you kind of forget. You just kind of go "it's easy to cook without them". But actually, when you stop and get reminded to do that kind of thing, then you involve them again and they really do enjoy it. So it was kind of useful in that way to remind me and get me back to kind of, my roots of parenting I think.”

“Having clear goals that you work towards as a team, like that kind of is very useful as well… it keeps you in check as well. Like "did we meet our goals this week?", if we didn't, "why didn't we? And how can we fix that next time?". So it's kind of a… visual thing as well. It's on the fridge so the kids would tick it off and stuff so... it was useful in that sense.”

When asked what they enjoyed specifically about the program, in addition to the goal-setting (reported in Chapter Seven), many parents commented that they enjoyed receiving the text messages:

“It was great to have those encouraging text messages as well, that sort of, I guess, just reinforced that there was someone there… you know, supporting you.

And yeah it was, it was just simple, like it wasn't something difficult. And it wasn't something that you had to spend a lot of time on. It was just something you could incorporate into what you were doing each day."

Parents were also asked what components of the program they did not enjoy, more than half of the parents (60%) reported that there was nothing they did not enjoy. Other parents reported that the one thing they did not enjoy was that it was sometimes difficult to stick to their goals:

"There were times that it was difficult as well to keep the goals going. Especially because I've got two kids, one has just turned 1 so… it was hard to manage trying to keep, trying to do all the activities that they recommended and trying to keep my toddler busy and you know, away from the things that he's used to."

The same proportion of parents (60%) reported that there was nothing they did not find useful or relevant. Other parents thought that some of the ideas provided were not practical or relevant for them:

"I have to say I found a lot of the text messages with activity ideas were just impractical… she's my third (child)… I just found it quite impractical lots of the suggestions and particularly ones like "go to the park with a friend" and we didn't really have anyone nearby, and kind of to... follow through with some of the suggestions, it just didn't work for our family."

An interesting theme that emerged when asked how the program could be improved to make it more useful or relevant was to focus on the whole family (rather than just an individual child):

“I guess the only thing is because the intervention only focussed on my youngest, I mean we did involve the kids, but if you could have a more holistic program where you're not just targeting the youngest child but your goals centre around everyone in the family. That probably would have been a bit more relevant. I mean we did that anyway. But if you did that from the outset, like made it family goal rather than just an individual child goal – that would work. Particularly because I think that the goals that we set around physical activity are useful to everyone in the family, not just the one child... we've sustained some of the goals because of that. And the kids kind of became our change champions… my oldest son he would often say, you know we would have friends over and they would want to watch TV and he would say "no, it's a screen-free day today".”

When asked specifically what they thought about the goal-setting component of the study, all parents were positive about it overall. One parent suggested that it would have been useful to re-visit the goals half way through the program. All but one parent reported that they found the goal-setting useful:

“Yeah I think so, cos it was something that basically kept you… focused on something and you know, you could have been all over the place trying to do lots of different things but it kept you sort of focused on one area of improvement and… I did. I found it useful.”

The majority of parents (80%) reported that they did not find it difficult to set goals; however, some parents reported that they (or others in the family) found it difficult to stick to them:

“It was easy to set goals, difficult to achieve them… like one was watching TV and the other was walking to kinder, we only managed to walk to kinder once, so I think I should have maybe thought about that goal a bit more.”

“Certain family members found it more difficult than others. I personally didn't find it difficult, because I'm at home more with the kids. But certainly my husband… particularly around switching off the TV, he found it very difficult to stick to because quite often, he just… goes to do that on the weekend. And he can kind of get some stuff done. But I didn't have trouble.”

When asked which of the Mini Movers resources or materials they had used, the two most common response were the booklet and the goal-checking magnet:

“I think I've used all of it. I read through the booklet… the things that they recommended there.”

“The tick box, to say whether we achieved the goal or not, that's still on my fridge. And still something that we will look at.”

The goal-checking magnet was also noted to be the thing that many parents would continue to use in the future. Additionally, some parents commented that it was more the concepts and principles from the program rather than resources that they would continue to use:

“I think more just the concepts and ideas that came out of it… the way you approach your activities or you know, how you might balance it out, or even the goal-setting I think… doing it sort of more consciously, doing that with my 2-year-old… getting her to do things, standing up and… she's at the other end of my spectrum now with the others at school at kinder, I can probably take her on walks or do those things. I've got more time on my hands.”

Parents were asked whether the program overall was useful for their family and had made them change the way they do things. All parents reported that it was useful overall, even if just to make them more aware:

“I think it's very useful and I think in this day and age… it's almost essential for many families. I thought that I had a lot of that knowledge because of the area that I work, but it did sort of surprise me that I did get more out of it than I thought I would and it made me realise what I needed to do in our life to change that. There's definitely things in place to try and improve those outcomes… which I think has probably stemmed from doing the Mini Movers (program). I'm certainly much more aware, even though I thought I was aware previously, but I think it made me even more aware.”

However, some parents commented that it may only be useful in the short-term:

“In terms of trying to do it on a daily basis, or on a long period of time, like on every day… that is where I find it difficult. So if it was just like a short program, like how we had it, like a 6 week program, maybe we can do it… but I personally would find it difficult to keep doing it every day.”

Finally, when asked if they had any final thoughts on the program, no clear themes emerged. However, one parent had an interesting suggestion for the up-scaling of the program:

“I think if the program were to continue, like be rolled out in the real world, it is really good to get that feedback around how much activity your child is doing. And I don't know whether that's just going to be a short-term research thing but it is nice to know that your child is tracking better on certain things. So if that can still be incorporated as it gets rolled out, that would be ideal. I mean, they don't necessarily need to wear a monitor, but if you're able to give feedback to parents that "you walked an hour today with your child, that's equivalent to this much activity or this many steps", just knowing that is quite useful.” n you can find on the web, these days.

In summary, parents (n=10) who participated in the qualitative interviews were positive about many aspects of the program. In particular, the goal-setting, in conjunction with the goal-checking magnet, was reported to be very useful and relevant. Parents also provided some insightful suggestions that may be useful in the development of future interventions.

Appendix R: Authorship Statement: Paper Two

AUTHORSHIP STATEMENT

1. Details of publication and executive author

Title of Publication		Publication details
Do the correlates of screen time and sedentary time differ in preschool children?		Downing KL, Hinkley T, Salmon J, Hnatiuk JA, Hesketh KD. Do the correlates of screen time and sedentary time differ in preschool children? BMC Public Health. 2017. doi: 10.1186/s12889-017-4195-x
Name of executive author	School/Institute/Division if based at Deakin; Organisation and address if non-Deakin	Email or phone
Katherine Downing	Institute for Physical Activity and Nutrition (IPAN)	k.downing@deakin.edu.au

2. Inclusion of publication in a thesis

Is it intended to include this publication in a higher degree by research (HDR) thesis?	**Yes**	If Yes, please complete Section 3 If No, go straight to Section 4.

3. HDR thesis author's declaration

Name of HDR thesis author if different from above. (If the same, write "as above")	School/Institute/Division if based at Deakin		Thesis title
As above	Institute for Physical Activity and Nutrition (IPAN)		Intervening to reduce sedentary behaviour in early childhood
If there are multiple authors, give a full description of HDR thesis author's contribution to the publication (for example, how much did you contribute to the conception of the project, the design of methodology or experimental protocol, data collection, analysis, drafting the manuscript, revising it critically for important intellectual content, etc.)			
Conceived study: 70% Data analysis: 80% Drafted manuscript: 70% Revised manuscript for important intellectual content: 60%			
I declare that the above is an accurate description of my contribution to this paper, and the contributions of other authors are as described below.		Signature and date	Signature Redacted by Library 19/07/2017

4. Description of all author contributions

Name and affiliation of author	Contribution(s) (for example, conception of the project, design of methodology or experimental protocol, data collection, analysis, drafting the manuscript, revising it critically for important intellectual content, etc.)
Trina Hinkley, Deakin University	Conception, design and implementation of the study, data collection, critically revised the article for interpretation of the data and intellectual content
Jo Salmon, Deakin University	Conception, design and implementation of the study, critically revised the article for interpretation of the data and intellectual content

Jill Hnatiuk, Deakin University	Critically revised the article for interpretation of the data and intellectual content
Kylie Hesketh, Deakin University	Conception, design and implementation of the study, critically revised the article for interpretation of the data and intellectual content

5. Author Declarations

I agree to be named as one of the authors of this work, and confirm:

i. that I have met the authorship criteria set out in the Deakin University Research Conduct Policy,

ii. that there are no other authors according to these criteria,

iii. that the description in Section 4 of my contribution(s) to this publication is accurate,

iv. that the data on which these findings are based are stored as set out in Section 7 below.

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v. consent to the incorporation of the publication into the candidate's HDR thesis submitted to Deakin University and, if the higher degree is awarded, the subsequent publication of the thesis by the university (subject to relevant Copyright provisions).

Name of author	Signature*	Date
Trina Hinkley	Signature Redacted by Library	27/10/2017
Jo Salmon	Signature Redacted by Library	27/10/2017
Jill Hnatiuk	Signature Redacted by Library	27/10/2017
Kylie Hesketh	Signature Redacted by Library	27/10/2017

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I agree to be named as a non-author contributor to this work.

Name and affiliation of contributor	Contribution	Signature* and date

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Data format	Storage Location	Date lodged	Name of custodian if other than the executive author
Hard-copy	Locked cupboards, building J, Burwood campus Archived (Deakin)	04/2017 04/2017	Kylie Hesketh
Electronic	SENS Research drive	2008/2009	Kylie Hesketh

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If the publication is to be included as part of an HDR thesis, a copy of this form must be included in the thesis with the publication.

Appendix S: Authorship Statement: Paper Three

AUTHORSHIP STATEMENT

1. Details of publication and executive author

Title of Publication		Publication details
A mobile technology intervention to reduce sedentary behaviour in 2- to 4-year-old children (Mini Movers): study protocol for a randomised controlled trial.		Downing KL, Salmon J, Hinkley T, Hnatiuk JA, Hesketh KD. A mobile technology intervention to reduce sedentary behaviour in 2- to 4-year-old children (Mini Movers): study protocol for a randomised controlled trial. Trials 2017:18(1);97.
Name of executive author	School/Institute/Division if based at Deakin; Organisation and address if non-Deakin	Email or phone
Katherine Downing	Institute for Physical Activity and Nutrition (IPAN)	k.downing@deakin.edu.au

2. Inclusion of publication in a thesis

Is it intended to include this publication in a higher degree by research (HDR) thesis?	**Yes**	If Yes, please complete Section 3 If No, go straight to Section 4.

3. HDR thesis author's declaration

Name of HDR thesis author if different from above. (If the same, write "as above")	School/Institute/Division if based at Deakin		Thesis title
As above	Institute for Physical Activity and Nutrition (IPAN)		Intervening to reduce sedentary behaviour in early childhood
If there are multiple authors, give a full description of HDR thesis author's contribution to the publication (for example, how much did you contribute to the conception of the project, the design of methodology or experimental protocol, data collection, analysis, drafting the manuscript, revising it critically for important intellectual content, etc.)			
Conceived project: 80% Designed content for intervention: 80% Drafted manuscript: 70%			
I declare that the above is an accurate description of my contribution to this paper, and the contributions of other authors are as described below.		Signature and date	Signature Redacted by Library 19/07/2017

4. Description of all author contributions

Name and affiliation of author	Contribution(s) (for example, conception of the project, design of methodology or experimental protocol, data collection, analysis, drafting the manuscript, revising it critically for important intellectual content, etc.)
Jo Salmon, Deakin University	Provided substantial contribution to the conception, design & content of the study, reviewed & critically appraised the manuscript
Trina Hinkley, Deakin University	Provided substantial contribution to the conception, design & content of the study, reviewed & critically appraised the manuscript

Jill Hnatiuk, Deakin University	Provided substantial contribution to the conception, design & content of the study, reviewed & critically appraised the manuscript
Kylie Hesketh, Deakin University	Provided substantial contribution to the conception, design & content of the study, reviewed & critically appraised the manuscript

5. Author Declarations

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Jo Salmon	Signature Redacted by Library	27/10/2017
Trina Hinkley	Signature Redacted by Library	27/10/2017
Jill Hnatiuk	Signature Redacted by Library	27/10/2017
Kylie Hesketh	Signature Redacted by Library	27/10/2017

6. Other contributor declarations

I agree to be named as a non-author contributor to this work.

Name and affiliation of contributor	Contribution	Signature* and date

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N/A (protocol paper – no original data)			

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Appendix T: Authorship Statement: Paper Four

AUTHORSHIP STATEMENT

1. Details of publication and executive author

Title of Publication		Publication details
Feasibility and efficacy of Mini Movers: a parent-focused, text message delivered pilot randomised controlled trial to reduce sedentary behaviour in 2- to 4-year-old children		(not yet published)
Name of executive author	School/Institute/Division if based at Deakin; Organisation and address if non-Deakin	Email or phone
Katherine Downing	Institute for Physical Activity and Nutrition (IPAN)	k.downing@deakin.edu.au

2. Inclusion of publication in a thesis

Is it intended to include this publication in a higher degree by research (HDR) thesis?	**Yes**	If Yes, please complete Section 3 If No, go straight to Section 4.

3. HDR thesis author's declaration

Name of HDR thesis author if different from above. (If the same, write "as above")	School/Institute/Division if based at Deakin	Thesis title
As above	Institute for Physical Activity and Nutrition (IPAN)	Investigating sedentary behaviour in early childhood
If there are multiple authors, give a full description of HDR thesis author's contribution to the publication (for example, how much did you contribute to the conception of the project, the design of methodology or experimental protocol, data collection, analysis, drafting the manuscript, revising it critically for important intellectual content, etc.)		
Conceived project: 80% Designed content for intervention: 80% Data collection: 100% Data analyses: 90% Drafted manuscript: 70%		
I declare that the above is an accurate description of my contribution to this paper, and the contributions of other authors are as described below.	Signature and date	Signature Redacted by Library 19/07/2017

4. Description of all author contributions

Name and affiliation of author	Contribution(s) (for example, conception of the project, design of methodology or experimental protocol, data collection, analysis, drafting the manuscript, revising it critically for important intellectual content, etc.)
Jo Salmon, Deakin University	Provided substantial contribution to the conception, design & content of the study, reviewed & critically appraised the manuscript
Trina Hinkley, Deakin University	Provided substantial contribution to the conception, design & content of the study, reviewed & critically appraised the manuscript
Jill Hnatiuk, Deakin University	Provided substantial contribution to the conception, design & content of the study, reviewed & critically appraised the manuscript
Kylie Hesketh, Deakin University	Provided substantial contribution to the conception, design & content of the study, reviewed & critically appraised the manuscript

5. Author Declarations

I agree to be named as one of the authors of this work, and confirm:

i. that I have met the authorship criteria set out in the Deakin University Research Conduct Policy,

ii. that there are no other authors according to these criteria,

iii. that the description in Section 4 of my contribution(s) to this publication is accurate,

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Jo Salmon	Signature Redacted by Library	27/10/2017
Trina Hinkley	Signature Redacted by Library	27/10/2017
Jill Hnatiuk	Signature Redacted by Library	27/10/2017
Kylie Hesketh	Signature Redacted by Library	27/10/2017

6. Other contributor declarations

I agree to be named as a non-author contributor to this work.

Name and affiliation of contributor	Contribution	Signature* and date

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7. Data storage

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Hard-copy	Locked filing cabinets, building J, Burwood campus	06/2016	
Electronic	SENS Research drive	06/2016	

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