Active Play and Sedentary Behaviour in Preschool Children. From Patterns to Intervention.

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A thesis submitted in partial fulfilment of the requirements of Liverpool John Moores University for the degree of Doctor of Philosophy

May 2012

FIGURE 1.1 PAGE 9 AND CONTACT DETAILS ON PAGES 167,174,182,186 AND188 NOT SCANNED ON INSTRUCTION FROM THE UNIVERSITY

Abstract

Increasing physical activity (PA) and reducing the time spent sedentary can favourably impact the health and wellbeing of preschool aged children. Despite the importance of regular PA, objective monitoring studies suggest that young children do not accumulate enough PA to benefit their health. Furthermore, relatively few interventions to promote PA in children under 5 have been rigorously evaluated and intervention studies to date have generated mixed results. The aims of this thesis were to a) assess within-day variability of objectively measured moderate-to-vigorous physical activity (MVPA) during weekdays and weekend days among preschool children; b) investigate the effect of a curricular Active Play intervention on children's sedentary and PA behaviours; and, c) investigate the effect of a family focused Active Play intervention on children's weekday and weekend day sedentary time and total PA.

Study 1

Background: Identifying periods of the day which are susceptible to varying levels of PA may help identify key times to intervene and potentially change preschool children's PA behaviours. This study assessed variability of objectively measured MVPA during weekdays and weekend days among preschool children.

Method: One hundred and eighty-eight children (aged 3-5 years; 53.2% boys) from a northwest English city wore uni-axial accelerometers for 7 consecutive days.

Results: Higher levels of MVPA were recorded in boys, particularly those who attended preschool for a half day. Children who attended preschool for a full day engaged in 11.1 minutes less MVPA than children who attended for a half day. After-school hours were characterised by a decrease in activity for all groups. Patterns of activity during the weekend were smoother with less variability.

Conclusion: This study identified discrete segments of the week, specifically afterschool and during the weekend, when preschoolers engage in low levels of PA. Higher levels of MVPA among children who attended preschool for less time each day suggests that the structured preschool environment is related to decreased activity. Consequently, there is a need for interventions in young children to focus on school and home environments.

Study 2

Background: Early childhood is a critical time for the promotion of healthy lifestyle behaviours such as physical activity. Cross-sectional studies suggest that preschool children are not sufficiently active to benefit their health. Few studies have investigated the effect of interventions on physical activity levels and time spent being sedentary in this population. The aim of this study was to investigate the effect of a school-based active play intervention on preschool children's physical activity and sedentary time.

Method: Two hundred and forty children were recruited from 12 randomly selected preschools in the North West of England. Six schools were randomly assigned to either an intervention (n=6) or a current practice comparison group (n=6). One teacher in each intervention school received training in the delivery of a 6-week

active play programme including active play resources. The training programme was delivered by experienced active play professionals. Comparison schools received the active play resources (but not the training) and were asked to deliver their usual active play provision. Children wore a uni-axial accelerometer for 7 days at baseline, post-test and at 6 months follow up. Whole week sedentary time and physical activity adjusted for pupil- and school- level covariates were analysed using multilevel analyses.

Results: No significant intervention effects were observed for sedentary time or physical activity. Sex and hours spent at school were significant predictors of physical activity in this age group, with boys engaging in less sedentary time and more light intensity activity than girls. Children who spent fewer hours at school were significantly more active than those who spent more time at school. BMI, maternal education, child's ethnicity and accelerometer wear time were not associated with activity levels.

Conclusion: Physical activity during intervention classes was high. However the six teacher training intervention sessions did not increase physical activity or decrease sedentary time over a week. Specific covariates were identified as having a significant effect on the outcome measures. Moreover, children who spend more time at pre-school were less active suggesting that this setting was not as conducive to physical activity engagement as other environments.

Study 3

Background: Early childhood provides a window of opportunity for the promotion of physical activity. Given the limited effectiveness of interventions to date, new approaches are needed. Socio-ecological models suggest that involving parents as intervention targets may be effective in fostering healthier lifestyles in children. This study describes the effectiveness of a family-focused 'Active Play' intervention in decreasing sedentary time and increasing total physical activity in preschool children.

Method: Seventy-seven families were recruited from 8 randomly selected SureStart children's centres in the North West of England. Centres were randomly assigned to either an intervention (n=4) or a comparison group (n=4). Parents and children in the intervention group received a 10-week active play programme delivered by trained active play professionals; this included an activity and educational component. Families in the comparison group were asked to maintain their usual routine. Each participating parent and child wore a uni-axial accelerometer for 7 days at baseline and post-test. Week and weekend day sedentary time and total physical activity adjusted for child- and home- level covariates were analysed using multilevel analyses.

Results: Significant intervention effects were observed for sedentary time and physical activity for both week and weekend days. Children in the intervention group engaged in 1.5% and 4.3% less sedentary time during week and weekend days, respectively and 4.5% and 13.1% more physical activity during week and weekend days, respectively than children in the comparison group. Parent's participation in sport and their physical activity levels, child's sex, availability of media in the home and attendance at organised activities were significant predictors of sedentary time and physical activity in this age group.

Conclusion: A 10-week family focused active play intervention produced positive changes in sedentary time and total physical activity levels in preschool children. Specific covariates were identified as having a significant effect on the outcome measures. Moreover, children whose parents were active engaged in less sedentary time and more physical activity suggesting that parent's activity habits are mediators of physical activity engagement in this age group.

Acknowledgements

This Ph.D was funded by the Neighbourhood Renewal Fund, Liverpool Children's Services and Liverpool John Moores University. I would like to acknowledge the support of a number of individuals:

My Director of Studies, Professor Gareth Stratton for providing me with this fantastic opportunity to undertake a Ph.D in an area I truly feel passionate about. His knowledge and guidance have been pivotal to my development as a researcher. I sincerely thank Dr. Zoe Knowles who has gone above and beyond the call of duty, especially in the final months, and Professor Stuart Fairclough for his encouragement over the past 3 years. Their contributions have been invaluable throughout the Ph.D.

Dr. Nicola Ridgers who was present during the early development of this project and most notably for her advice and feedback concerning multilevel modeling.

Dr. Lawrence Foweather, for his critical eye and significant contribution to the Ph.D especially during the long data collection days back in 09/10.

Dr. Paula Watson, a colleague and dear friend, who has been tremendous in terms of encouragement and fun and Anna Sharp, a superb symbiotic housemate and intervention agony aunt! Here's to future Irish interventions.

Gillian Kingston, a fellow researcher – for her constant positivity. She has been a great friend and support over the last number of years.

My friends and colleagues at LJMU - their encouragement, reassurance, positivity and extremely fun times have made this journey a great one.

The SportsLinx & Active Play crew and all the schools, children and parents who took part in this research project, as well as the students and volunteers who assisted with the data collection over the past three years.

I would like to thank my family and friends back home for their exceptional love and support especially my Mam, Dad and Darrell– thank you all very much.

And last but certainly not least, Evan. Your love and support is something I will never be able to put down in words. This is for you.

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Glossary of Terms

Infants	Children aged between birth and 1 year.
Toddlers	Children aged between 1 and 3 years.
Preschoolers	Children aged between 3 and 5 years.
Sedentary behaviour	No unanimous definition exists for sedentary behaviour. It has been described as the absence of physical activity and involves the intentional engagement in mostly seated activities that require minimal and low energy expenditure (Biddle, 2010, Reilly and McDowell, 2003). Within this thesis, sedentary behaviour will be objectively quantified using age specific accelerometer cut-points (Sirard, 2005).
Physical activity	Defined as 'any bodily movement produced by skeletal muscles resulting in energy expenditure' (Casperson et al. 1985, p.126).
Play	No common definition exists for play. It has been defined as activity done for its own sake, characterised by means rather than ends (the process is more important than any end point or goal), flexibility (objects are put in new combinations or roles are acted out in new ways), and positive affect (children often smile, laugh, and say they enjoy it) (Pellegrini and Smith, 1998).
Active play	Active play may involve symbolic activity or games with rules; children may participate in active play in a group or by themselves, but the unique characteristics of the activity are its playful context, combined with activity that is significantly above resting metabolic rate (Simons-Morton et al., 1990a).
Light intensity physical activity	Corresponds to energy expenditure between 1 and 3 times that used at rest, or 1 and 3 metabolic equivalents (Freedson et al., 1998).
Moderate intensity physical activity	Activity usually equivalent to brisk walking, which might be expected to leave the participant feeling warm and slightly out of breath. Corresponds to energy expenditure between 3 and 6 metabolic equivalents (Freedson et al., 1998).
Vigorous intensity physical activity	Defined as 'activity usually equivalent to at least slow jogging, which might be expected to leave the participant feeling out of breath and sweaty'. Corresponds to energy expenditure between 6 and 9 metabolic equivalents

	(Freedson et al., 1998).
Very vigorous intensity physical activity	Corresponds to energy expenditure 9 metabolic equivalents or greater.
Moderate to vigorous intensity physical activity	Physical activity of intensity equivalent to or greater than moderate intensity (≥ 3 metabolic equivalents) (Freedson et al., 1998).
Total physical activity	Physical activity of intensity equivalent to or greater than moderate intensity (≥ 1 metabolic equivalent) (Freedson et al., 1998).

Chapter 1

Introduction

1.1 The research problem

The prevalence of obesity is high and increasing in all age groups and most countries worldwide (World Health Organisation, 1999), with these trends being observed from early in life (Wang and Lobstein, 2006). Obesity is a serious problem that affects children from both industrialised and developing countries. In recent years its prevalence has reached epidemic proportions and it is estimated that 10% of the world's children are currently overweight or obese (Lobstein et al., 2004). The problem is not confined to school-age children; twenty-two million children <5 years of age are now estimated to be overweight or obese (World Health Organisation, 2004). Recent evidence suggests that in obese children most of their excess weight is gained before the age of 5 years (Gardner et al., 2009) and that adiposity tracks into later childhood (Nader et al., 2006). This situation is a major concern for public health because weight gained before puberty has a strong association with risk factors for cardiovascular disease, which are typically seen in adulthood but are becoming apparent in children as young as 4 years of age (Cali and Caprio, 2008). These risk factors are also known to track to adulthood (Berenson, 2002) with major implications for long-term health. Early childhood is therefore a key period for the development of obesity and an important target for intervention (Flynn et al., 2006).

Evidence suggests that increased physical activity (PA) reduces the risk of obesity in preschool children (Mo-suwan et al., 1998, Metallinos-Katsaras et al., 2007, Klesges et al., 1995, Jago et al., 2005). One cross-sectional study has shown that children with lower PA are approximately four times (3.8 [95% CI: 1.4, 10.6]) more likely to have increased body fat (Moore et al., 1995). The effect size of PA on obesity could possibly be substantial. For example, in Thailand preschool children reported to have low exercise levels have been shown to have >2-fold risk of obesity compared with

children with a normal exercise level (Mo-suwan and Geater, 1996). The intensity of PA may be principally important in influencing obesity risk. For example, one study has shown that overweight children spend approximately 9 min less time (22.9 min v. 32.1 min, $P<0.05$) in vigorous PA daily compared with normal weight children (Metallinos-Katsaras et al., 2007). Although the extent of the contribution of PA to preschool obesity is unclear, adopting a physically active lifestyle is crucial for long-term health promotion. Aside from obesity prevention and treatment; participation in PA has other important health benefits. Regular PA among young children can contribute to social, psychological and fundamental movement skill development and maintain bone health (Timmons et al., 2007, Oliver et al., 2007, Reilly et al., 2008, Ward et al., 2010, Okely et al., 2009). Despite these benefits and an increasing awareness of the importance of PA, research suggests that preschool children are not sufficiently active to benefit their health (Finn et al., 2002, Reilly, 2010, Taylor et al., 2009, Okely et al., 2009). A systematic review of studies found that 54% of preschool children were sufficiently active to positively impact their health (Tucker, 2008) A similar story exists for the PA levels of children attending childcare, a recent review of the evidence on volume of PA and amount of moderate- to vigorous-intensity PA (MVPA) in preschool children within child care centers, (Reilly, 2010) concluded that levels of objectively measured PA were low within childcare, and most studies also reported very high levels of objectively measured sedentary behaviour. However, there is scant evidence of successful trials to increase PA in children. This is supported by PA intervention reviews (Kriemler et al., 2011, van Sluijs et al., 2007, Salmon et al., 2007) which also report that the evidence base within this age group is preliminary. Furthermore, few studies have investigated the patterns of preschool children PA levels. Now that there is a growing evidence base

surrounding the prevalence and rates of PA in preschool children, evidence surrounding patterns of PA would inform the potential timing of PA interventions in this age group.

Childcare settings (centre based care and preschools) have been identified as a promising setting for the delivery of interventions to increase PA among children during early childhood (Trost et al., 2010, Dowda et al., 2009, Finn et al., 2002). First, childcare services provide access to a large and growing number of children for prolonged periods each day (Ward et al., 2010). Second, childcare services have existing infrastructure which can be used to facilitate child PA (Story et al., 2006). Third, childcare service staff appear amenable to interventions which aim to enhance children's activity (British Heart Foundation National Centre, 2011). Lastly, descriptive research suggests that service policies and practices and the physical environment of childcare services are important influences on children's PA behaviours (Bower et al., 2008, Trost et al., 2010). Working with staff within childcare settings may provide a sustainable solution for the low levels of PA reported during childcare. Additionally, in terms of intervention design it has been suggested that attempts to increase children's PA should target the whole family (Gortmaker et al., 1999, Timperio et al., 2004, Norton et al., 2003). Parents can strongly influence children's PA behaviours through role-modeling and direct involvement, and these influences may last beyond adolescence (Oliver et al., 2010, Norton et al., 2003). Given their potential as an agent of behaviour change, research involving parents is required to investigate the effectiveness of directly involving them in PA interventions.

It must be noted that there are important differences in PA between young children and older children and adolescents. Firstly, the type and purpose of PA participated

in varies with age. During the preschool and early primary school years basic movement patterns are developed which form the foundation for activity at later ages (Strong et al., 2005). Secondly, children's PA rarely involves sustained activity but is characterised by intermittent short duration (<5 minutes) bursts of all-out activity alternated with periods of rest and recovery (Pangrazi, 2000). Thirdly, the correlates and determinants of PA differ between children and adolescents. The Health Survey for England 2002 (Department of Health, 2003) found 'active play' to be the most common type of activity reported by boys and girls on at least five days. Paradigm examples of active play include running, climbing, chasing, and play fighting, the latter being a component of rough-and-tumble play (Pellegrini and Smith, 1998). These activities may occur in informal settings (e.g. gardens, public open spaces) or as part of more formal settings (e.g. nurseries, play groups, pre-schools, school recess time). There is little evidence surrounding the use of active play as a component of PA interventions, and, the effects of active play on PA and sedentary behaviour. In addition, few studies have investigated the PA levels of young children whilst participating in active play. Quantifying PA during active play will inform whether this type of activity contributes to daily PA recommendations of young children.

1.2 Theoretical framework to increase preschooler's physical activity

PA behaviour and the factors influencing it are very complex. Theoretical frameworks are used to provide a model to understand the numerous factors and behaviours that enable or act as barriers to PA participation. They are used to understand a specific problem in a particular setting or context. They help researchers understand and identify factors related to PA participation therefore enabling the design of more effective interventions. In the context of PA, the term

intervention is used to describe a strategy, program or policy that is designed to have an impact on PA participation (Marcus et al., 2006). Theories or conceptual models can be used to drive the effective development and implementation of intervention programmes to increase PA in young children. For PA promotion, a theory or conceptual model should be created based on research identifying correlates or determinants of behaviour change in a targeted population (Paxton et al., 2008). Correlates of PA in young children have been identified across a number of settings and contexts. For instance, characteristics of the child's demographic and biological characteristics, social and physical environments have all been shown to be associated with young children's sedentary time (ST) and PA (Hinkley et al., 2012, Dolinsky et al., 2011, Hinkley et al., 2008). This will be discussed in more depth in section 2.7 below. Findings from such studies support the use of ecological models of behaviours that indicate personal, social and physical environmental factors influence behaviour (Sallis, 1999). Human behaviour is difficult to change, especially in an environment that does not support change. In order to increase PA, efforts need to focus on the behaviour choices of each individual but also on factors that influence those choices. Social ecological models help identify opportunities to promote participation in PA by recognising the multiple factors that influence an individual's behaviour. Efforts to change behaviour are more likely to be successful when the multiple levels of influence are addressed at the same time and a coherent theoretical basis is utilised to guide intervention development (Medical Research Council, 2008, Stokols et al., 1996).

Health behaviours, including PA participation, are thought to be improved when environments and policies support healthy choices, and individuals are motivated and educated to make those choices (World Health Organisation, 1996). Social

ecological approaches acknowledge the multiple interrelated influences across social, cultural, and environmental domains. One such theory is Bronfenbrenners theory of ecological development (Bronfenbrenner, 1979) (Figure 1.1). For almost thirty years, this has been one of the most generally used theories to analyse the phenomena of early childhood education. This theoretical framework adopts a social-cognitive approach to changing behaviours and attitudes of those with the greatest influence on preschool children (i.e. the parents and children's centre staff). Further ecological models provide a comprehensive framework within which to examine children's active free-play (Sallis et al., 1997). Social ecological frameworks aim to influence children's PA and sedentary behaviour through the manipulation of moderators and mediators across their social environment (Golley et al., 2011, Oliver et al., 2010).

The studies within this thesis are based on Bronfenbrenners theory of ecological development, which places emphasis on both the immediate and broader environment as important for child development. In this conceptual framework the family, school, community and broader society, as well as the children's own attributes, are seen to contribute to the child's development in complex interacting ways over time (Sanson, 2002). Bronfenbrenner's ecological model of human development was adopted at the outset of this thesis to underpin the design and development of the interventions. Bronfenbrenner's model emphasises the contexts in which people develop as well as the ability for change. This model can be viewed as well as differentiated and complete account of contextual influences on development (Lerner, 2006). This theory (Bronfenbrenner, 1979, Bronfenbrenner, 1998, Bronfenbrenner, 2006) notes the bidirectional nature of interactions between the individual and the context in which they develop. An individual's dispositions, aptitudes, and demands on the environment all shape the course of their

development. Changes in life events can be imposed on the child, or arise from the child as they themselves select, create and modify their own experiences.

This ecological framework views development as influenced by five environmental systems, ranging from proximal contexts of direct interaction with people to broad based contexts of culture, all occurring over time. The five systems are the microsystem, mesosystem, exosystem, macrosystem and chronosystem. Any relations between a child and their immediate environment occur within *microsystem* (Bronfenbrenner, 1979). This includes the child's family, peers, school, and neighbourhood. The *mesosystem* refers to the interrelationships among two or more microsystems in which an individual actively participates, for example the relation of family experiences (a microsystem) to their school (another microsystem). A social setting that affects a child but does not directly impinge on them is referred to as an *exosystem*. Exosystems include parent's place of employment, parent's social networks, and government and social policy. The *macrosystem* refers to the attitudes, beliefs and ideologies of the child's culture (e.g. a culture's values concerning child-rearing). The *chronosystem* refers to the pattern of the environmental events and transitions over time (Bronfenbrenner, 1998, Bronfenbrenner, 2006). In essence the model says that child development results from interactions between the child and their families, schools, communities and their broader society over time. In the model the historical time and place of an individual, the timing of transitions and events occurring during their lives and historical events are all important in determining a person's life course. All of these relationships and interactions between individuals and their environments are viewed as "mutually shaping". Brofenbrenner saw the individual's experience "as a set of nested structures, each inside the next, like a set of Russian dolls" (Bronfenbrenner 1979, p. 22).

1.3 Organisation of the thesis

The central theme of the thesis is to examine the effects of active play when promoted within a school and family context, on ST and the PA levels of preschool aged children. **Chapter 2** provides a review of the literature. The key topics addressed are the measurement and prevalence of PA in preschool children, the relative contribution towards daily PA guidelines, and the effect of interventions on children's PA levels and sedentary behaviour. Through this review, highlighted limitations and gaps in the literature will provide a rationale for the one cross-sectional study and two clustered randomised controlled trials designed for this thesis. Few studies have investigated the patterns of PA. **Chapter 3** examines this

issue in preschool children. Little research exists on the promotion of physically active play within a preschool context. **Chapter 4** evaluates the short- and long term effects of a curricular Active Play intervention on whole week ST and moderate-to-vigorous PA. Involving parents as an agent of change in preschool PA interventions has not been extensively studied. **Chapter 5** evaluates the effect of a family focused Active Play intervention on preschool children's weekday and weekend day ST and total PA. To conclude, **Chapter 6** synthesises results from the 3 empirical studies and their implications in relation to the major themes in the thesis. Directions for future research are also suggested.

1.4 Authors contribution to the research project

It is important to note that this PhD sits within a wider research project. The author of this PhD was responsible for the design, data collection and analyses of all three empirical studies. However, other researchers must be acknowledged for their contribution throughout, namely Prof. Gareth Stratton, Prof. Stuart Fairclough, Dr. Zoe Knowles, Dr. Lawrence Foweather and Dr. Nicola Ridgers.

Chapter 2

Literature Review

"Our children from their earliest years must take part in all the more lawful forms of play, for if they are not surrounded with such an atmosphere they can never grow up to be well conducted and virtuous citizens"

--Plato, 380 BC

2.1 Introduction

The purpose of this chapter is to review the literature associated with PA and sedentary behaviours of preschool children, and to examine a range of evidence surrounding the importance of participation in PA, specifically active play. Specifically, guidelines for sedentary behaviour and PA, measurement procedures, correlates of PA and intervention based research will be reviewed using evidence from cross-sectional, longitudinal and experimental research to inform the basis of rationale for each thesis study.

The purpose of the literature review is to: (i) define PA, active play and sedentary behaviour, (ii) discuss how PA and sedentary behaviour impacts the health of preschool children, (iii) identify the recommended guidelines for sedentary behaviour and PA, (iv) review the methods for assessing sedentary behaviour and PA, (v) describe the levels and patterns of PA for this age group, (vi) review the key correlates of PA in preschool children, (vii) discuss interventions that have been implemented with this age group. Finally, I will lead into the aims of the thesis and the associated objective's.

2.2 Physical activity, active play and health in young children

PA is central to leading a healthy lifestyle and is defined as "*any bodily movement produced by skeletal muscles that result in caloric expenditure*" (Casperson et al. 1985, p.126). Preventable lifestyle diseases continue to be major contributors to the

burden of disease internationally, and physical inactivity is among the top five risk factors contributing to global mortality. Interventions during the early years of development are required to ensure health promoting behaviours, such as PA, are established (Department of Health, 2011). Despite young children being seen as the most active segment of the population, monitoring studies (Hinkley et al., 2010, Vale et al., 2010, Pfeiffer et al., 2009, Reilly, 2010) suggest that a high proportion of this population are insufficiently active to benefit their health.

PA is typically categorised into a range of intensities and measured in metabolic equivalents (METs; where 1 MET is equivalent to rest) (Sallis, 1999). Light intensity physical activities (1.5 – 2.9 METs) for young children includes for example dressing up in costumes, standing and painting and slow walking. Moderate-to-vigorous physical activities (3-8 METs) include higher intensity activity, such as running, jumping, and playing ball games. Sedentary behaviours (<1.5 METs) are characterised by sitting or lying down, and include watching television, using a computer, reading and drawing (Ainsworth et al. 2011). Young children's natural activity patterns are described as being intermittent, and are characterised by periods of intense bursts of activity followed by periods of rest or lower intensity activity (Reilly, 2010).

PA is one of a number of factors which influence the healthy growth and development of children (Hills et al., 2007). The value of PA for young children is now beyond doubt, and a lack of sufficient PA during the early years of life is viewed as having negative consequences on children's health. Participating in regular PA contributes to the prevention of obesity (Moore et al., 2003) and reduces cardiovascular disease risk factors (Sääkslahti et al., 2004, Alpert et al., 1990), contributes to adequate bone health (Janz et al., 2010), motor development (Williams

et al., 2008), and positive cognitive and social development (Burdette and Whitaker, 2005). Research also suggests that children's PA patterns also appear to track during childhood (Pate et al., 1996), and from childhood and adolescence into adulthood (Telama et al., 2005) thus suggesting that early life experiences of PA may influence later behaviours and subsequent health. Given that early childhood is a critical period for the establishment of both eating and activity behaviour (Trost et al., 2003); prevention strategies to ensure that children develop healthy PA behaviour should start as early in life as possible.

Participation in PA can provide important health benefits such as preventing unhealthy weight gain, reducing blood pressure and enhancing mental health (Boreham and Riddoch, 2001, Strong et al., 2005). A moderate association between PA and adiposity has been established with a number of cohort studies showing that children who were more active at baseline had smaller gains in fatness at follow up (Klesges et al., 1995, Moore et al., 2003, Moore et al., 1995, Jago et al., 2005). In a series of cross-sectional studies a significant inverse relationship between adiposity and PA was reported (Trost et al., 2003, Janz et al., 2002, Jouret et al., 2007). This relationship was stronger when PA was quantified using an objective measurement protocol. A limited association between PA and blood pressure, musculoskeletal health and motor development has also been found. In a prospective cohort study conducted by Shea et al. (1994), it was reported that participants with higher increases in PA had smaller increases in systolic and diastolic blood pressure. Janz et al. (2001); Litmanovitz et al. (2007) and Aly et al. (2004) have identified associations between PA and musculoskeletal health however studies by both Litmanovitz et al. (2007) and Aly et al. (2004) used a non-representative sample of preschool children who were born pre-term and with a consequential low birth

weight. A cross-sectional study conducted by Janz et al. (2001) showed that vigorous intensity PA was significantly associated with bone mineral density and bone mineral health. Research also shows that there is a consistent relationship, albeit cross-sectional, between PA and motor development (Williams et al., 2008, Fisher et al., 2005). Other studies have reported positive associations between the PA and motor development (Cliff et al., 2009a, Trevlas et al., 2003). Although these studies have reported positive results in general, the absence of potential confounders such as different assessment procedures and the individual child's developmental status make it difficult to draw reliable and comparable conclusions from the research. Evidence surrounding the relationship between PA and blood lipids remains inconclusive for this age group. In terms of blood lipids, one study has described an inverse relationship between PA and total cholesterol (Sääkslahti, 1999), whilst other studies have reported a positive association between PA and high-density-lipoprotein cholesterol (Sääkslahti et al., 2004, Parízková et al., 1986).

The same inclusivity exists with the relationship between PA and emotional development. Two studies; one cross-sectional and one experimental in design investigated the relationship between PA and social competence. In these studies, participation in a dance based intervention (Labo et al., 2005) or participating in more time playing with peers of the same sex (Colwell and Lindsey, 2005) resulted in increased social competence. Lindsey et al. (2005) investigated the relationship between PA and emotional development and concluded that time spent in PA was related to teacher-rated emotional competence in boys but not girls. Overall, contrasting evidence for the positive association of PA with health benefits in preschool children has been consistently presented in the literature. Challenges when measuring PA in this age group, the inconsistency in global PA recommendations,

small and underpowered samples in many studies; and the fact that young children are often healthy and free from risk factors for chronic disease are possible explanations for the lack of compelling evidence. Although there is an agreement that the more PA young children participate in, the better (Institute of Medicine, 2005, Strong et al., 2005), there is insufficient evidence of the precise dose and intensity of PA required for adequate health and development for preschool children (Reilly, 2010). Guidelines for the preschool years have recently been developed in several countries, but there are notable inconsistencies in the amount of PA regarded as sufficient for preschool children (Skouteris et al. 2010). PA recommendations for this age group are discussed further on in the literature review.

Much of the data regarding children's PA is limited to active travel, before and after school sports clubs, physical education classes and adult organised activities (Veitch et al., 2006) A somewhat neglected area of research, albeit recently gaining popularity, is that of PA obtained through playing (Pellegrini and Smith, 1998). The benefits of participating in play related activity go beyond the benefits of PA as outlined earlier. Similar to the psychosocial benefits of participating in PA, playing allows children to develop a sense of wellbeing (Lester, 2007), develop their emotional responses (Pellis and Pellis, 2007) and improve their interpersonal skills (Russ, 2004). Playing involves exploring and being creative (Howard-Jones et al., 2002), which in turn assists children to think flexibly (Frederickson, 2006), developing their creative process, language skills (Lewis et al., 2000) and learning and problem solving skills (Rogers, 1988). Although there is a lack of agreement within the literature on the definition of 'play', descriptive words and phrases such as 'freely chosen', 'personally directed', 'intrinsically motivated' and 'spontaneous' are often used to describe its characteristics (Garvey, 1990). Much of the PA that young

children participate in takes the form of a more vigorous type of play, referred to as 'PA play', 'active play', 'locomotor play', or 'exercise play' (Pellegrini and Smith, 1998). This type of play involves large body activity and is generally thought to support the physical training of muscles for strength, endurance and skill. This type of play increases from toddlers to preschoolers and peaks at early primary school age when the neural and muscular basis of physical coordination and healthy growth is important and vigorous play obviously provides good opportunities for this (Byers and Walker, 1995); as children grow older, this type of play declines. There is evidence in the literature to support active playground type breaks which can help young children concentrate better at subsequent inactive tasks (Pellegrini and Smith, 1998), consistent with the cognitive immaturity hypothesis that the need to exercise helps young children to space out cognitive demands for which they have less mature capacities (Bjorklund, 1992). Active play takes on many forms and is therefore challenging to define per se. Active play may involve symbolic activity or games with rules; children may participate in active play in a group or by themselves, but the unique characteristics of the activity are its playful context, combined with activity that is significantly above resting metabolic rate (Simons-Morton et al., 1990a). Active play tends to occur sporadically, with frequent rest periods (Bailey et al., 1995) which makes it difficult to capture and measure. Comparatively, in an older group of UK children (10-11 year olds), recent research has found active play to be associated with moderate to vigorous PA, particularly during the after school period (Brockman et al., 2010).

2.3 Sedentary behaviour and health in young children

Sedentary behaviour (from the Latin *sedere* – 'to sit') is the term now used to describe activity for which energy expenditure is only marginally above resting

levels and is typically characterised by sitting which can occur at school, in transit, at home, and during leisure time. Hence, the terms 'sitting time' and 'sedentary time' are often used interchangeably – each referring to the unit of time spent participating in sedentary behaviour measured using objective measurement tools such as accelerometers, which will be discussed further in section 2.4.

Early childhood has been identified as a critical time in the development of sedentary behaviours as these behaviours track reliably into childhood and adolescence (Janz et al., 2006, Zimmerman and Christakis, 2005). Certain activities which are categorised as sedentary in nature are important for child development (e.g. play based activities; making a puzzle or playing with dolls). Such activities are not the primary focus of this thesis. An increasing amount of research exists concerned with screen based entertainment and other electronic media. At this point it is important to note that sedentary behaviour is not the "opposite" of PA; and just because a child is physically active does not mean he/ she doesn't spend excessive time being sedentary (Marshall SJ, 2008). Sedentary behaviour researchers do not accept the position that sedentary behaviour is simply that defined as a lack of PA. In fact sedentary behaviour is defined in respect of individual behaviours associated with sitting or lying as the dominant mode of posture and where energy expenditure is very low (Biddle, 2010). Biddle and colleagues describes these behaviours as varied ranging from screen time (television, watching DVDs, computers), motorised transportation, and sitting to read or complete homework. The majority of sedentary behaviour research has focused on television viewing (Hinkley et al., 2010, Department of Health, 2010, Biddle, 2010) and while this is an important sedentary behaviour in itself, it is only one of many that can be over used. It is becoming increasingly apparent from the literature that it is the total time spent in sedentary

behaviour, and the length and number of bouts spent being sedentary, that are important risk factors in adults (Dunstan et al., 2010, Healy et al., 2008) and adolescents (Ekelund et al., 2006, Ekelund et al., 2007). Research concerning the correlates of sedentary behaviours during the early years of life is still very much in its infancy with much of the findings being indeterminate (Hinkley et al., 2010). Prior to 2010, Australia were the only developed country to have evidence based national recommendations for sedentary behaviour for children under the age of 5 years within the United Kingdom and Canada drafting similar recommendations in the last year. Although guidelines for time spent sedentary are not widespread globally, a number of recommendations which have been endorsed by organisations (American Academy of Pediatrics, 2001). However, these guidelines are based on expert opinion rather than robust scientific evidence. Evidence is increasing across a range of longitudinal studies, meta-analysis and cross sectional studies which demonstrate that the amount of time children spend being sedentary is positively associated with excess body fat (Hancox et al., Jago et al., 2005, Spinks et al., 2007). More specifically, two studies have reported that preschool children who spent more than 2 $h \cdot d^{-1}$ watching television were more likely to become overweight as children (Dennison et al., 2004, Viner and Cole, 2005). Research from the Avon Longitudinal Study cohort found that children who watched more than 2 $h \cdot d^{-1}$ of television were almost twice as likely to develop asthma by 11 ½ years than those watching <2 hours TV per day (1.8 [95% CI:1.2 to 2.6]) (Sherriff et al., 2009). Conversely, preschool children who did not exceed 2 $h \cdot d^{-1}$ television viewing were shown to have more bone accrual at age 7 years than their counterparts who exceeded 2 $h \cdot d^{-1}$ (Wosje et al. 2009). Matheson and colleagues reported that 16.6 ± 16.4% of third grade children's total daily energy was consumed during television viewing on weekdays,

and 26.2 ± 30.6% of total daily energy was consumed during television viewing on weekend days (Matheson et al., 2004). These percentages were even higher for fifth grade children (age 10-11). In terms of children's cognitive functioning, research has shown that children's exposure to television during the preschool years is predictive of academic outcomes during adolescence (Anderson et al., 2001). Debate exists surrounding the type of television parents allow their children to watch due to proposed educational benefits associated with certain types of programmes or channels (e.g. Brainy Babies or Baby Einstein). Studies of educational television have however found benefits for young children. For example, *Sesame Street* (probably the most studied and acclaimed children's television programme of all time) has been shown to have a variety of benefits for preschool children, including increases in vocabulary, ability to count, and general school readiness (Garrison, 2005). However, while television may capture the attention of preschool children and aid development of some skills, there is little evidence to suggest it facilitates meaningful learning and in contrast has been associated with lower levels of language development in very young children (Zimmerman and Christakis, 2007), reading difficulties (Vandewater et al., 2005) and attention disorders (Christakis et al., 2004). It has been noted that adults must make sensible, informed decisions about the television viewing habits of the children in their care (choosing developmentally appropriate programmes, removing televisions from bedrooms to family areas and establishing family rules surround screen time) which can create a sense of balance for all the family (Diehl and Toelle, 2011).

2.4 Measurement of physical activity in young children

To accurately assess PA levels and time spent engaging in sedentary behaviours in children, it is necessary to use measures that are valid, reliable and appropriate for

this population. Many measures of PA used with older populations are inappropriate for preschool children given their age and inability to comply with the measurement procedure (Pate et al., 2010). PA is an infinite variable, which is both complex and unstable (Harro, 2000) and no perfect criterion measure exists (Troiano, 2009). The dimensions of PA include; frequency, intensity, duration and type. According to Welk (Welk, 2002) over thirty different methods are available for measuring PA, but no single method can capture all dimensions of activity behaviour. The difficulties associated with the accurate measurement of PA and ST are often amplified in children due to the cognitive, physiological, and biomechanical changes that they undergo during growth and development (Corder et al., 2008). Capturing sedentary behaviour and PA is even more challenging with very young children. As noted previously, PA in 0 – 5 year olds is sporadic, unstructured and intermittent in nature (Cliff et al., 2009b). In contrast to older children and adults, young children's PA consists of short bursts of moderate-to-vigorous PA punctuated by periods of lower intensity activity such as walking or resting with up to 96% of activity bouts captured being shorter than 10 seconds in duration. (Bailey et al., 1995, Baquet et al., 2007). Additionally, given their age preschool children tend to take periodic day time naps which can range from 0.5 – 3.0 hours in duration (Acebo et al., 2005). The complexity of accurately measuring these unique PA patterns of preschool children has stalled progress in this area. The most commonly used methods of quantifying PA in this age group are direct observation, parent proxy self-report and motion sensors e.g. accelerometers.

2.4.1 Direct observation

Two direct observation systems that have been used extensively with young children are the Children's Activity Rating Scale (CARS) (Puhl et al., 1990) and the

Children's Physical Activity Form (CPAF) (O'Hara et al. 1989). Both of these systems solely record PA intensity across 4 and 5 categories, respectively. Other systems of direct observation which record intensities as well as other PA domains including environment, group sizes and interactions include Behaviours of Eating and Activity for Child Health: Evaluation System (BEACHES) (McKenzie et al., 1992), The Observational System for Recording Activity in Children – Preschool Version (OSRAC-P) (Brown et al., 2006) and System for Observing Children's Activity and Relationships during Play (SOCARP) (Ridgers et al., 2010b). These systems of observation have been validated against indirect calorimetry (Puhl et al., 1990), heart rate and energy expenditure (McKenzie et al., 1992) and accelerometry (Ridgers et al., 2010b). Such instruments can provide information on both the *intensity* of the activity and the *context* surrounding the behaviour. These systems can be used both in the home (McKenzie et al., 1992) but are more suitable in more confined environments e.g. school and childcare settings (Ridgers et al., 2010b, Oliver et al., 2007, Brown et al., 2006). However, the main disadvantage of direct observation is the associated training required up skill those collecting data to achieve acceptable levels of reliability. This process is both time intensive and burdensome requiring extensive time in the field (Pate et al., 2010)

2.4.2 Self report

Another form of subjectively monitoring PA and sedentary behaviour is through self-report. Self-reports are inappropriate for preschool aged children to complete and parent-proxy reports have inherent biases (Oliver et al., 2007, Trost et al., 2008) . However, some PA studies in preschool children do not have the resources needed to successfully implement direct observation or an objective measure of PA (Pate et al., 2010). For these studies, proxy reports by adults serve as an alternative option.

Burdette et al., (2004) designed a checklist allowing parents to log the amount of time their children spent outdoors over two weekdays and one weekend day. When compared with accelerometry, time spent outdoors was positively correlated with total PA. More recently a questionnaire has been developed by as a parent proxy tool which aimed to measure population estimates of activity in young children in their home environment. The Preschool-age Children's Physical Activity Questionnaire' (Pre-PAQ) (Dwyer et al., 2011) has been found to have generally good to very good reliability and adequate validity. In contrast, young children's PA does not occur in easily distinguishable non-discrete blocks of exercise those who complete these types of tools are usually asked to recall 3 days of activity therefore the results should be interpreted with care (Pate et al., 2010). Interview-administered recall affords higher validity than parent proxy questionnaires; however this approach requires substantial training, is labour intensive and can only be conducted with a limited number of participants (Harro, 2000).

2.4.3 Motion sensors

Motion sensors such as pedometers and accelerometers represent objective measures of PA. The disadvantages of pedometers are their inability to record non-locomotor activities e.g. riding a tricycle; are susceptible to child tampering; and are unable to determine the intensity of the activity (Dale, 2002). As a result of these limitations, pedometers have been superseded by accelerometers (Figure 2.1) which are used widely as an objective monitor of PA in preschool children. Accelerometers are small and unobtrusive devices, typically worn on an elastic belt on the right side of the hip (Toschke et al., 2007, Kelly et al., 2007, Pate et al., 2004). These instruments can quantify the intensity and frequency of movement in a specific plane (uni-axial) or in multiple dimensions (tri-axial) and are therefore capable of determining

patterns and intensity of ST, PA as well as total volume of activity. Within the hard plastic casing exists a piezoelectric sensor which detects accelerations, these accelerations are converted from an analog signal to a digital signal, typically within a range (0.1–3.6 Hz). This signal is integrated over a specific time sampling period known as an epoch, then summed and stored as 'counts' in the units internal memory. The epoch can be set to record from every second to several minutes, but is typically set at 5 seconds in preschool research (Ward et al., 2010, Corder et al., 2008) in an attempt to capture their sporadic activity (Cliff et al., 2009b). A disadvantage of accelerometers is that they do not provide information on the type of activity being performed. In addition, accelerometers are limited in their ability to measure non-weight-bearing activities, such as cycling and upper limb movements. In studies of preschool children, the co-operation of preschool staff and parents is required to ensure that accelerometers are worn correctly and finally, accelerometers can inadvertently fail, leading to loss of data (Trost et al., 2008). One limitation of accelerometry is that variation exists surrounding cut-points or thresholds which are used to reduce the raw activity counts into sedentary behaviour, light physical activity (LPA) and moderate-to-vigorous physical activity (MVPA) (Cliff et al., 2009b), and the use of different thresholds can have significant effects on estimates used to define the behaviour and activity level (Reilly et al., 2008).

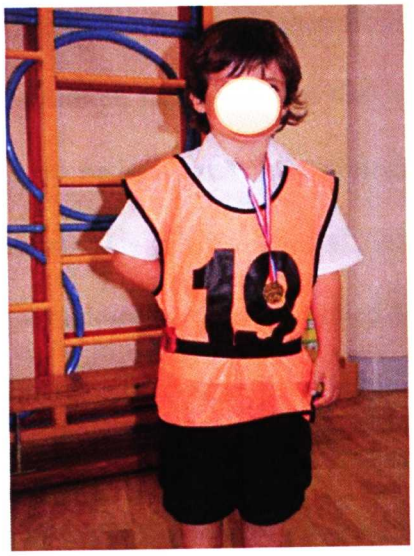

Figure 2.1 An Actigraph GT1M accelerometer and its positioning on the right hip

2.5 Levels and patterns of habitual physical activity in early childhood

Findings from studies using accelerometers continue to offer important insights into young children's PA patterns. Studies conducted by (Hinkley et al., 2010, Pfeiffer et al., 2009) indicate that preschool age children spend approximately 60 minutes partaking in MVPA (range: 20 - 90 minutes), equating to approximately 8% (3% - 12%) of their daily waking hours (Iglowstein et al., 2003). These studies suggest that this age group accumulate a substantial amount of light intensity activity, approximately 80 – 150 minutes per day, estimating that preschool children spend a total of approximately 2 to 3.5 hours per day in PA. Given the increasing number and range of childcare providers in England and the fact that virtually all preschool children attend some sort of child care provision with the number steadily rising since 2004 (Department for Education, 2010), it is plausible to assume that the majority of this PA takes places during childcare or preschool attending hours. Many parents when asked perceive their children to be active (Adamo et al., 2010), and in particular, there is a common societal belief that preschool children are, by nature,

highly active. In contrast, the bulk of the evidence from studies that have directly measured PA in preschool children has illustrated that very few children meet PA recommendations set forth by national and international guidelines. For example, findings from a recent meta-analysis (Bornstein et al., 2011) demonstrated the wide variability that exists in reported accelerometer-derived MVPA levels of preschool-aged children, with estimates indicating preschool-aged children accumulate anywhere from 40 to 100 minutes of MVPA daily. It is precisely this variability that limits a true understanding of the prevalence of physical inactivity in this population and, therefore, restricts the ability to make decisions related to promoting, tracking, and reporting the PA of this population. This wide variation indicates that no clear conclusions can be drawn regarding the typical PA levels in the preschool population. In essence, this situation is disconcerting, especially with respect to the numerous studies conducted to date that have employed one of the most sophisticated means of measuring PA – accelerometry. Consequently, no definitive statements related to the estimates of preschooler's daily MVPA levels can be made at this time. Hence, caution needs to be exercised when interpreting the pooled estimates of preschool children's MVPA. However, regardless of how PA in this age group is measured or reported, minutes/ hours (Pate et al., 2004, Trost et al., 2008), minutes per/day (Cardon et al., 2008, Vale et al., 2009), percentage of time (Reilly, 2010, Hannon and Brown, 2008), levels of MVPA in preschool children, have in the majority of cases, been shown to be consistently low and levels of sedentary behaviour are high (Goldfield 2012). Studies have reported that 3-5 year olds spend a small proportion of their time (anywhere between 10 and 100 minutes/day depending on sampling frame [epoch length] and accelerometer cut-off points) engaged in MVPA accounting for only a small fraction of the day (Bornstein et al., 2011,

Benham-Deal, 2005, Montgomery et al., 2004). A review of preschoolers attending childcare also found remarkably low levels of MVPA (Reilly, 2010) , this study reviewed 12 studies including 96 different childcare centres (including day care centres and preschool settings), and >1900 individual children using objective measures of PA and concluded that young children's typical levels of PA within child care centres were low and led to an accumulation of less than 60 minutes of MVPA per day. The majority of evidence suggests that young children are insufficiently active to accrue the health benefits of PA and may therefore be at risk for adverse health consequences related to physical inactivity. However, caution is advised when interpreting preschool children's activity levels in respect of the heterogeneity of methods used when assessing this behaviour.

2.6 Physical activity and sedentary behaviour recommendations for early childhood

As noted previously, PA is central to optimal growth and development in preschool aged children. Accurate and reliable measurement of PA is also important for determining whether children are sufficiently active to benefit health. The obesity epidemic which has affected young children (Department of Health, 2010) was a major driving force for the development of age specific PA and sedentary behaviour recommendations in the United Kingdom (Department of Health, 2011). In the United Kingdom, levels of PA and sedentary behaviour among young children are obesogenic (Reilly et al., 2004, Reilly et al., 2006) and excess weight gain which has taken place by the time of adolescence may often have occurred largely by the time children enter primary school (Gardner et al., 2009). The recently released PA guidelines in the United Kingdom (Department of Health, 2011) alongside the Australian PA guidelines are the only government endorsed guidance that have provided quantitative recommendations in age-appropriate categories.

Recommendations from other countries (Canada, New Zealand and the United States of America) are *policy orientated statements* providing guidance for parents, health and educational professionals. Although this type of descriptive guidance is potentially useful per se, they have several limitations, for example, the absence of a specified amount of recommended daily PA. Quantitative prescriptive recommendations offer a number of advantages over descriptive, qualitative guidelines most importantly the facilitation of ongoing monitoring and surveillance of PA in children (Department of Health, 2011).

Within the literature concern has been expressed that PA recommendations for older children have a limited scientific basis (Anderson et al., 2008). The new PA guidelines for the United Kingdom are supported by empirical research exploring associations between activity and health outcomes (as detailed above in section 2.2.1 and 2.2.2) in this age group, data on the patterns of activity during the early years and changes in activity patterns as children age. The recommendation specifically states: *children of pre-school age who are capable of walking unaided should be physically active daily for at least 180 minutes (3 hours), spread throughout the day* (Department of Health, 2011, p. 20). The recommendation of three hours of activity stems from both expert opinion and existing healthy outcome literature and highlights a significant period of time during a child's waking day which should be set aside daily for PA. Further, this allows for the decline in PA levels when young children start primary school. It is also important to note that the recommendation does not include PA *intensity* guidelines, which reflect children's natural, intermittent and sporadic PA patterns. These recommendations are one of the first mechanisms which attempt to change the activity levels and patterns of young children by informing those in contact with this population about the importance of

PA engagement from a young age. Future guidelines are likely to consider being developmental-specific or gender-specific, target specific social or population groups, or are likely to be more detailed and precise on the intensity and duration of PA (Reilly, 2010).

As described previously, there is a wealth of evidence which illustrates the detrimental effects that excessive time spent being sedentary can have on children's health. The evidence appears strongest for excess body fat and poor cognitive functioning. The findings surrounding body fatness are important given that data from the National Child Measurement Programme which reports that 23.1% of preschool children in the UK are overweight or obese (Department of Health, 2010), locally these figures were similar with 23.6% of Liverpool preschool children being classified as overweight or obese. However, on a national level preschool children were less obese (9.8%) than their Liverpool counterparts (12.0%) (Merseyside Intelligence Team, 2012). As the amount of time spent being sedentary (specifically screen time) increases as young children move into formal schooling (Certain and Kahn, 2002) and throughout childhood and adolescence (Hardy et al., 2006) it is important to minimise time spent in these behaviours. Based on the research surrounding ST and consensus from international expert groups, sedentary behaviour recommendations have been established in recent years. Seven countries have issued guidelines for ST and/or screen time, of which three set specified and quantified limits. Many of the recommendations are in fact open to interpretation due to the lack of detail, for example the United Kingdom guidelines state '*All under 5s should minimise the amount of time spent being sedentary (being restrained or sitting) for extended periods (except time spent sleeping)*' (Department of Health, 2011, p.20). Similarly, Ireland recommend that children should '*Increase physical activity by*

replacing sedentary time – watching TV, playing computer games, talking on the phone – with active time' (Department of Health and Children, 2009, p.10). On the other hand, Australia has specific quantified guidelines for screen time and for time spent being sedentary. Recommendations state: *'For children 2 to 5 years of age, sitting and watching television and the use of other electronic media should be limited to less than one hour per day*' and '*Infants, toddlers and preschoolers should not be sedentary, restrained or kept inactive for more than an hour at a time, with the exception of sleeping*' (Department of Health and Ageing, 2010, p.1). It is suggested that the paucity of quantified guidelines is due to gaps in the research about the amount of time spent being sedentary and how this impacts on body weight, or the specific correlates of sedentary behaviour and screen viewing (Biddle, 2010).

2.7 Correlates of physical activity in early childhood

The promotion of physical activity during early childhood is a public health priority (Department of Health, 2011, Department of Health, 2003). Examining key correlates and determinants of PA in preschool children can inform interventions seeking to prevent the age related decline as children approach older childhood and adolescence (van Sluijs et al., 2008). Research exploring the correlates of preschool children's PA commenced in the early 1980's (Buss, 1981), however the majority of the literature has evolved in the last 10 years given the low levels of PA among preschool children (Reilly, 2010). Correlates of PA in young children have been identified across a number of settings and contexts. For example, characteristics of the child's demographic and biological characteristics (e.g. gender, family risk for disease, ethnicity and age), social and cultural variables (play rules at home, parents encouragement and teacher education), behavioural variables (requests from child)

and physical environments (time outdoors, type of preschool attended) have all been shown to be associated with young children's PA (Hinkley et al., 2008). Identification of such correlates is necessary so that interventions aimed at increasing PA can specifically target such factors. Nowadays, preschool children spend their time across a variety of different settings including their home, preschool, attending organised activities in their community or at a relative's home (Hinkley et al., 2012). Within each of these environments children are exposed to different types of stimuli and attitudes towards PA e.g. extra children to play with, more TVs and media apparatus, extra space to play and support for PA from their parents. Identifying correlates across settings is compounded by a child's inability/ inaccuracy associated with self reports or a parent's lack of understanding to know what their child was exposed to in their absence. The identification of PA correlates in the preschool population is challenging due to the diversity of PA tools used to measure activity (Pate et al., 2010). Many of the instruments measure different aspects of the behaviour and therefore differences in identified correlates may not be consistent (Dolinsky et al., 2011). A review of 39 correlates of PA was conducted by Hinkley et al., 2008 who reported that gender, parents levels of PA and time spent outdoor are the main predictors of PA. The limited amount of published literature at this time suggests many of the correlates have been investigated infrequently and thus conclusive findings cannot be drawn. Other research has investigated the childcare setting as an environment for promoting PA (Ward et al., 2010). For example, studies investigating the ground surface, play structures and open spaces in educational settings have identified positive correlations with PA levels (Cosco et al., 2010). Fewer children per m^2 of outdoor space, recess duration (Cardon et al., 2008), active opportunities, play equipment, and staff training in physical education (Bower

et al., 2008) have also been found to have positive effects on PA levels. A review of PA correlates in older children (Sallis et al. 2000) also implies that PA is a complex behaviour with multiple determinants. Such findings supports the use of ecological models of PA behaviour which considers determinants from multiple environments, including intra-personal (e.g. psychological), inter-personal (e.g. social) and physical environments (Sallis, 1999).

2.8 Interventions to promote physical activity in young children

Increasing opportunities for PA is acknowledged as an essential option for dealing with the rising incidence of obesity and to support more young children to meet PA guidelines (National Institute of Health and Clinical Excellence, 2006). There are several evidence-based reasons for targeted interventions designed to increase PA and decrease sedentary behaviour during preschool years, making it a potentially critical window to intervene. The most notable advantage of targeting improvements in healthy active living behaviours in the early years is that altering health behaviours in young children is considerably easier than in older children, adolescents, or adults (Goldfield et al., 2001). This is likely due to the fact that young children's health behaviour is more malleable as they have either not yet adopted an unhealthy lifestyle or have not yet had one for a long period of time. Perhaps more importantly, it is easier to promote PA in young children because they are completely responsive to environmental (childcare/ parent) control and stimulation of the activity environment. Moreover, care providers, including parents are the most powerful role models and can therefore represent key agents of change and targets for intervention to foster healthy habits in their young children.

As previously described, the majority of preschool children in England attend some form of child care provision. Intervening with those working within childcare settings, to equip them with knowledge and skills to promote healthy active living in children under their care may therefore provide substantial health benefits for children. This is also true for parents. Given that parents are the primary social force influencing preschool child development, it has been suggested that attempts to increase children's PA should target the whole family (Timperio et al., 2004, Norton et al., 2003). Parents can influence children's PA behaviours through role modelling and direct involvement and these influences may last beyond adolescence (Norton et al., 2003). Parental support, direct help from parents and opportunities to exercise have consistently been associated with child PA (Oliver et al., 2010, Moore et al., 1991, Gustafson and Rhodes, 2006). Table 2.1 identifies interventions which have targeted both childcare settings and the home environment. The studies listed in table 2.1 and described below identifies that (a) PA has been quantified using a range of measurement techniques, (b) interventions have predominantly been conducted in North America, and (c) a variety of intervention strategies have been employed. No studies have been conducted using a longitudinal design therefore the long term effects and sustainability of the intervention strategies across time have not been investigated. The variation in methodologies used complicates comparisons between studies in the identification of effective intervention approaches in this age group.

2.8.1 Interventions within the childcare setting

Utilising the childcare environment as a setting for intervention delivery is recommended as children spend a large proportion of their day in this environment. In addition, rich, stimulating settings such as preschools with in-house knowledgeable caregivers can facilitate preschoolers development (Ward et al.,

2010). Interventions targeting the childcare setting have become more popular in recent years, however very few still exist. The majority of interventions have implemented a PA intervention into the pre-existing preschool curriculum (Binkley and Specker, 2004, Eliakim et al., 2007, Fitzgibbon et al., 2005, Fitzgibbon et al., 2006, Reilly et al., 2006), whereas others have used environmental or policy strategies to increase PA (Cardon et al., 2009, Alhassan et al., 2007, Hannon and Brown, 2008, Trost et al., 2008). Studies manipulating the preschool curriculum have implemented average-to-strong research designs, with one within-centre randomisation (Binkley and Specker, 2004), one between centre randomisation (Eliakim et al., 2007) and three cluster randomised controlled designs (Fitzgibbon et al., 2005, Fitzgibbon et al., 2006, Reilly et al., 2006). However, only two of the studies demonstrated positive changes to children's PA (Binkley and Specker, 2004, Eliakim et al., 2007). Binkley and colleagues implemented a 12 month intervention (30 minutes per day/ 5 $d \cdot wk^{-1}$) which included gross motor activity (jumping, hopping, and skipping) and fine motor activity activities designed to keep them sitting quietly. In the other study, Eliakim and colleagues implemented a 14 week intervention (45 minutes per day/ 6 $d \cdot wk^{-1}$) using a circuit training approach with a focus on endurance activities whilst incorporating co-ordination and flexibility activities. Support to limit sedentary activities and to engage children in more PA after school was also offered. A unique element of this study was the mode of delivery; two sessions per week were delivered by professional coaches, whereas on other days, they were led by a member of staff within the school. From studies reviewed which generated a null response, two were conducted in African American (Fitzgibbon et al., 2005) and Latino populations (Fitzgibbon et al., 2006). Both of these interventions were delivered by the preschool teacher and lasted for 14 weeks

(45 minutes per day/ 3 $d \cdot wk^{-1}$), with equal time devoted to nutrition and PA. Although a positive reduction in children's weight was observed in the African American sample, no changes in PA (as measured by self-report) were observed in either of the trials. One of the most notable preschool interventions to date, conducted in Scotland, was the Movement and Activity Glasgow Intervention in Children (MAGIC) study (Reilly et al., 2006). Despite generating positive results in a pilot study (Reilly and McDowell, 2003), the main trial lasting 24 weeks (30 minutes per day/ 3 d·wk-1), delivered by childcare setting staff did not increase children's PA levels but improved fundamental movement skills. The investigators noted that insufficient staff training was a possible cause, although process data showed good implementation of the PA programme during the full trial, investigators perceived that quality of delivery in the pilot study was greater. Other interventions which have manipulated preschool policies or the environment have measured PA during the intervention delivery (Alhassan et al., 2007, Hannon and Brown, 2008, Trost et al., 2008) rather than after the intervention. The type of interventions delivered have varied from additional outdoor free play time (Alhassan et al., 2007), provision of special portable equipment on the playground (Cardon et al., 2009, Hannon and Brown, 2008) and the provision of specialised training to classroom teachers on topics such as integrating PA into their usual classroom lessons (Trost et al., 2008). None of these studies had robust research designs per se and could, in most cases, be described as pilot or feasibility studies.

2.8.2 Family focused interventions

As opposed to childcare based interventions, an alternative approach for increasing PA among children may be to encourage parent involvement (Salmon, 2010, Timperio et al., 2004, Gortmaker et al., 1999). Parental support for PA, direct help

from parents, and opportunities to exercise have consistently been associated with adolescent PA (Sallis et al., 2000) and more recently with preschool children's PA (Oliver et al., 2010). However, identifying family-focused intervention strategies for reducing preschool children's ST and increasing PA levels is problematic as such work remains in its infancy. Intervention studies to date have involved parents in a variety of ways, through including direct role linked parent training, family counselling, or preventive messages during family visits (Sääkslahti et al., 2004, Harvey-Berino and Rourke, 2003, McGarvey et al., 2004). McGarvey and colleagues implemented a 12 month intervention where parents received 6 key messages regarding PA and healthy eating every other month, an invalid questionnaire reported mixed effects on the children's PA levels; the intervention group engaged in more active play however there was no effect on family PA engagement. Similarly, results from a 16 week parent education programme reported no effect on children's PA measured using accelerometry, the authors concluded that it was likely that the study was not sufficiently powered to detect PA differences (Harvey-Berino and Rourke, 2003). More favourable results were reported in a Finnish intervention (Sääkslahti et al., 2004), who implemented a three year intervention with parents and children aged 4-7. The intervention programme included an annual, intensive session with intervention-group parents receiving information on how and where to be active in their local area, important aspects of PA and consequences of physical inactivity. Parents were also made aware of the results of previous PA intervention studies. The discussion of previous intervention outcomes were intended to motivate parents to encourage and train their children to be physically active. During the annual session, parents were also provided with PA demonstrations by a trained physical educator. After 3 years, children in the intervention group were recorded as spending more

time playing outdoors, and playing in the high-activity category which increased with age, whereas no change occurred in the control group. Conversely, a randomised controlled trial (Fitzgibbon et al., 2005) which attempted contact with parents via organised activities such as family workshops or fun evenings resulted in no effect on PA, however the authors reported that the measurement tool was that of poor quality and a more objective way of capturing PA may have generated more positive results. Distance based intervention strategies such as sending educational material to the child's home in the form of letters or homework has resulted in mixed or null effects on child PA. A 4-week randomised controlled trial was implemented to evaluate the effectiveness of intervention approaches aimed at incorporating parental participation and increasing parents' knowledge and practice when delivering more opportunities for PA to their children (Cottrell et al., 2005). The intervention focused on accumulating more steps per day. Step counts were recorded for the 4 weeks, with no differences between groups for weeks 1, 2 and 3, however during week 4 children in the intervention group accumulated significantly more steps than the comparison group. Caution must be taken when interpreting the results of this study due to high attrition rates (>50% by week 4). Null findings in PA measured by accelerometry were observed in two clustered randomised controlled trials (Fitzgibbon et al., 2006, Reilly et al., 2006) , the details of which have been outlined in Section 2.7.1. Both of these trials incorporated a home based element as well as a childcare element. Intervention group families in both of these trials received educational materials with guidance on how to link physical play at childcare and at home. Additionally, parents in the MAGIC Study (Reilly et al., 2006) were encouraged to seek opportunities to reduce the amount of time they spent watching television.

To date, there is no obvious factor to identify which type of family focused intervention strategy is most effective at decreasing ST or increasing PA. Given the variability in study design and outcome variable reported; the measures used to assess the outcome variables; and the lack of reporting intervention fidelity, dose and exposure, it is not possible to draw any conclusions as to best involve parents to yield the most promising outcomes for increasing PA in this age group at this time. Systematic reviews have predominantly focused on older children (Kriemler et al., 2011, Thomas, 2006, van Sluijs et al., 2007) and have also expressed concern over the great heterogeneity of study design, study quality, and assessment tools used to measure intervention effect. Although the majority of studies reviewed here have notable methodological limitations, the collective information obtained provides an overview of intervention strategies involving parents. Sending material home to families in the form of newsletters or homework does not appear to be an effective method of promoting PA engagement among children. However, there was stronger evidence that making direct contact with parents (McGarvey et al., 2004, Sääkslahti et al., 2004) via organised meetings and activities was a more effective way to involve families in increasing PA among children.

Table 2.1 Summary of preschool intervention studies. Table ordered by publication date.

Authors	Sample	Country	Intervention	Parent Involvement?	PA Assessment	Comparison Group?	Main findings
Harvey Berino et al. (2003)	43 children Varied settings (n=N/R).	USA	16 weeks Educational workshops	Yes	Accelerometry	Yes	There were no time or group differences in any of the determinants of maternal exercise behaviours.
Specker et al, (2003)	239 children Children's centres (n=11)	USA	12 months Gross motor activity Fine motor activity	No	Accelerometry	No	Higher activity levels were observed in gross motor group.
McGarvey et al. (2004)	185 children Varied settings (n=N/R).	USA	1 year Educational workshops	Yes	Self-report	Yes	Frequency of engaging in active play with child increased.
Saakslahti et al. (2004)	228 children Setting: N/R	Finland	3 years Educational workshops	Yes	Self-report	Yes	Intervention group spent more time playing outdoors and play in the high-activity category increased with age
Cottrell et al. (2005)	437 children Preschools (n=N/R)	USA	4-wceks Provision of information	Yes	Pedometer	Yes	No group differences during weeks 1,2,3. During week 4 treatment group accumulated significantly more steps
Fitzgibbon et al. (2005)	409 children HeadStart centres (n=12)	USA	14-weeks PA sessions Provision of information Homework	Yes	Self-report	Yes	Exercise frequency and intensity and hours of TV viewing per day similar among treatment and control children post-intervention and at 1 and 2 year follow-up
Fitzgibbon et al. (2006)	401 children HeadStart centres (n=12)	USA	14-weeks PA sessions Provision of information Homework	Yes	Self-report	Yes	No significant differences between groups in reported frequency and intensity of exercise or in TV viewing at any assessment point.
Reilly	454 children	Scotland	24 weeks	Yes	Accelerometry	Yes	Group allocation had no significant effect on

et al. (2006)	Preschools (n=36)		PA sessions Homework				the on PA and sedentary behaviour at 6 or 12 months.
Eliakim et al. (2007)	101 children Preschools (n=4)	Israel	4 months Classroom-based activity After school support	Yes	Pedometer	Yes	Daily step count was significantly greater in the intervention group.
Alhassan et al. (2007)	33 children HeadStart centre (n=1)	USA	2 days Additional outdoor play	No	Accelerometry	Yes	No statistically significant differences between groups for average total daily CPM or % MVPA for total daily and during the school day.
Trost et al. (2008)	42 children Preschool (n=1)	USA	8 weeks Classroom based activity	No	Accelerometry and direct observation	No	Increase in MVPA for all weeks. Increase in VPA for final 2 weeks.
Hannon et al. (2008)	76 children Preschool (n=1)	USA	4 weeks Play equipment	No	Accelerometry	No	Children decreased ST and increased MVPA over 5 observations.
Cardon et al. (2009)	583 children Playground (n=40)	Belgium	8 weeks Play equipment Play markings Play equipment and markings	No	Accelerometry	Yes	The interventions were not effective in increasing the average activity levels, the % of engagement in MVPA, or in decreasing sedentary time.

N/R = not reported; PA = physical activity; MVPA = moderate-to-vigorous physical activity; VPA = vigorous physical activity; WIC = women, infants and children

2.9 Ethical implications when working with families of young children

Ethical issues arise in all aspects of research, and are particularly salient when studying vulnerable members of society, such as in the studies reported within this thesis which looked at the physical activity of young children attending preschool and whilst they were in their own homes. During the research process I emphasised to the children that they could choose whether to take part or not, and that if they decided to participate they were always free to change their minds – for a few minutes, for a whole session or forever. Although this flexibility might appear unnecessary to many experienced researchers, it enabled the children, parents and staff to become increasingly familiar with the technical equipment, and this in turn helped to demystify the research process, empowering the participants rather than making them the objects of research. In addition, I asked parents to talk about the research with their child without the researcher or staff present, and to inform staff and researcher of the child's responses. This second process of consultation revealed some clear child parameters. For example, one boy asked if the research would interfere with his outside playtime, and one girl expressed concern that the study might restrict her playing with her best friend. With regard to child consent, Article 12 of the United Nations Convention on the Rights of the Child (UNCRC, 1989) clearly states children's rights to express their views on all matters that affect them. Some researchers prefer to use the term 'assent' rather than 'consent', arguing that minors are unable to give legal consent. However, as Alderson and Morrow point out (2004:98-99), in English law, 'competent minors' under 16 can give valid consent, with 'competence' defined as having sufficient understanding and intelligence to understand what is proposed. Working with young children involves several ethical considerations which include:

- Have all parents and children who attend the preschool setting been made aware of the planned research project?

- Have the researchers and/or gatekeepers made it clear to participants of all ages that they are under no obligation to participate in the research?

- Have all participants been reassured that there will be no negative outcomes if they choose not to participate?

- Have participants been given both informal and formal opportunities, over a period o time, to accept or decline to participate in the research, e.g. through informal discussions and opt-out/opt-in written agreements?

- Have participants been given the opportunity to ask the researcher/ research team questions about the research?

- Have the participants had occasion to view/handle the equipment before the onset of data collection?

- Have parents talked privately with their child/ren about the research and reported back any child concerns?

- Have all participants been given researcher contact details, e.g. phone number and address?

- Have all of the above negotiations been conducted in the participants' first language/via an interpreter if necessary?

2.10 Summary

This literature review has highlighted the health benefits of increased PA and reduced ST in preschool children. Due to heterogeneity among studies related to differences in methodological differences and variations in intervention protocol, the precise prevalence of children meeting the current guidelines for health enhancing PA is currently unknown. PA is, however, known to decline from childhood to adolescence and many preschool children exceed screen time recommendations. The high number of children classified as overweight or obese indicates that preventive action against low levels of PA and excessive weight gain is necessary from an early age. The counter intuitive results arising from the few interventions which have been conducted in this population suggest that more intervention research is warranted in this area. One such approach for promoting PA and reducing ST is through developmentally appropriate active play within the childcare setting using teachers and parents as agents of change. This type of activity is thought to appeal to preschool children given their innate desire to be playful and move about.

Active play is difficult to define but typically encompasses playful activity that is significantly above resting metabolic rate. Little evidence exists surrounding the contribution of active play to the daily PA levels of preschool children; however in older children active play is associated with mean daily activity levels, and more interestingly MVPA in girls. Much more needs to be known about this relationship in preschool children. Childcare provision and its access have changed dramatically over the last two decades, with the vast majority young children attending some form of childcare provision during their preschool years. This setting provides an ideal opportunity to emphasise the adoption of a physically active lifestyle by facilitating and enhancing the PA behaviours and movement skills of preschool children. In turn,

such behaviours may mitigate the decline in activity often observed during the transition from childhood to adolescence. A collection of evidence exists suggesting that preschool and childcare settings, policies and practices strongly influence children's PA behaviours. Although interventions to modify PA in the childcare setting are still in its infancy, research has identified the potential for structured PA programmes to increase the amount and the intensity of PA and improve motor skills. It has been recommended that both educators and researchers should be involved in the implementation of an intervention and that parental involvement is critical to ensuring transfer of knowledge from the intervention setting to the home environment (Riethmuller et al., 2009). As for high quality randomised controlled trials testing lifestyle interventions in preschool-aged children, these remain scarce with previous interventions in this age group limited by failing to assess intervention effects relative to a comparison group over a long-term follow up period, and failing to objectively assess changes in habitual PA or ST. High quality randomised controlled trials are warranted to determine *if* intervening during the early years of life is effective in changing the behaviours of preschool children and if so, *what* techniques for behaviour change are most effective.

2.11 Major aims of the thesis

A review of the discussed literature has led to the formation of the major aims of this thesis. Aim 1 is to assess within-day variability of objectively measured moderate-to-vigorous PA during weekdays and weekend days among preschool children. This will provide original data on the patterns of PA in this age group and how sex and time spent at school impacts on these patterns; this will allow findings to be contextualised in relation to the development of interventions aimed at increasing PA in this age group. Aim 2 is to investigate through a cluster randomised controlled trial, the short-term effects (6 weeks) and the long-term effects (6 months) of a curricular Active Play intervention on preschool children's sedentary and PA behaviours and investigate the influence of specific confounding variables on ST and PA. This investigation will provide an insight into the effectiveness an intervention which is co-delivered by experienced Active Play workers and preschool teachers, and whether this will result in a decrease in ST and an increase in PA. This investigation will also investigate the differences in the intensity of the Active Play sessions between the intervention and comparison group. Aim 3 is to investigate, through a cluster randomised controlled trial, the short-term effects (10 weeks) of a family focused Active Play intervention on children's weekday and weekend day ST and total PA, whilst examining the influence of mediating and moderating variables on ST and total PA. This will be one of the first investigations to provide an insight into whether involving parents as a key agent of change can positively change the PA behaviours of preschool children.

Aim 1: To assess within-day variability of objectively measured MVPA during weekdays and weekend days among preschool children. A secondary aim was to examine differences in these patterns by sex and enrolment at school – Chapter 3.

Aim 2: To investigate the effect of a curricular Active Play intervention on children's sedentary and PA behaviours, and investigate the influence of specific confounding variables on ST and PA – Chapter 4.

Aim 3: To investigate the effect of a family focused Active Play intervention on children's weekday and weekend day ST and total PA, and second to investigate the influence of mediating and moderating variables on ST and total PA – Chapter 5.

Thesis study map

A thesis study map appears at the beginning of each study chapter to demonstrate the objectives and key findings of the studies, and demonstrate where each study fits in to the overall thesis.

Study	Objectives
Study 1: Patterns of objectively measured moderate-to-vigorous physical activity in preschool children	**Objectives:** • **To assess within-day variability of objectively measured MVPA during weekdays and weekend days among preschool children.** • **To examine differences in these patterns by sex and enrolment at school.**
Study 2: Effect of a school-based Active Play intervention on sedentary time and physical activity in preschool children	
Study 3: Effect of a family focused Active Play intervention on sedentary time and physical activity in preschool children	

It is also important to note the dates of data collection; briefly data was collected between September 2009 and December 2011. Two different samples were recruited during the duration of the programme of research. The sample of children used in study 1 (September 2009 and March 2010) and study 2 (September 2009 – June 2010) were the same. The data presented in the cross-sectional study (study 1) was also used as the baseline data for the school based intervention (study 2). A separate sample was recruited for study 3 (September 2011 – December 2011).

Chapter 3

STUDY 1

Patterns of objectively measured moderate-to-vigorous physical activity in preschool children

The main outcomes of this study are currently under review in the *Journal of Physical activity and Health*: O'Dwyer, M.V., Fairclough, S.J., Knowles, Z., Foweather, L., Ridgers, N.D. and Stratton, G. Patterns of objectively measured moderate-to-vigorous physical activity in preschool children.

3.1 Introduction

Sufficient PA during the early years offers protection against excess weight gain (Jimenez-Pavon et al., 2010), improves bone (Janz et al., 2010) and cardiovascular health (Burgi et al., 2012), and assists with the development of fundamental movement skills (Fisher et al., 2005). Unfortunately, empirical research suggests that preschool children are not active enough to benefit their health (Reilly, 2011, Tucker, 2008). Despite the urgency to increase preschoolers' PA, evidence regarding successful approaches remains equivocal (van Sluijs et al., 2008). Prior to conducting intervention-based research, a comprehensive understanding of the target behaviour is warranted as it maximises the potential for improvements. Identifying periods of the day which are susceptible to high and low levels of PA will help to identify key times to intervene and potentially change PA behaviours. Limited information regarding preschool children's patterns of daily PA is reported, with most studies investigating daily PA rather than focusing on specific intensities (Verbestel et al., 2011), elements of the school day (e.g. recess or physical education classes) (McKenzie et al., 1992) or specific discrete segments of the day (O'Connor et al., 2009). The majority of research has focused on the preschool population as a whole or using gender specific analyses (Verbestel et al., 2011). Given the variety of childcare alternatives available (Trost et al., 2010, Ward et al., 2010), little is known about how different preschool environments, such as attending preschool for a half day or a full day, effect children's PA levels.

The primary aim of this study was to assess within-day variability of objectively measured MVPA during weekdays and weekend days among preschool children. A secondary aim was to examine differences in these patterns by sex and enrolment at school.

This study hypothesises that:

- Children's weekday MVPA is more variable during weekdays than weekend days
- Boys accumulate more MVPA than girls during weekdays and weekend days
- Children who attend school for 3 hours per day are more active than children who attend school for 6 hours per day.

3.2 Method

3.2.1 Participants and settings

Children were recruited from twelve randomly selected preschools in a large urban city in the northwest of England. Preschools were located in the same geographical area of high social and economic deprivation (Department of Communities and Local Government 2010). All children between 3 and 4.9 years attending the preschool were invited to participate (n = 673). Informed parental consent (please see appendix 1) was obtained from 240 children (36% response rate). In England all three and four year olds are entitled to 15 hours free preschool education for 38 weeks of the year. This applies until children reach compulsory school age (the term following their fifth birthday). Although not compulsory, virtually all preschool children attend some form of childcare provision. Classes run from Monday to Friday and start at 9:00 and finish at 15:00. Parents can opt to send their children to preschool for a half day (3 hours) or a full day (6 hours) but must pay an additional

fee for attendance exceeding 15 hours per week. The research protocol received ethical approval from the University Ethics Committee (Reference 09/SPS/027).

3.2.2 Instrumentation

ActiGraph accelerometers (GT1M ActiGraph, Pensacola, FL.) measured PA every 5 seconds to capture the intermittent nature of children's MVPA.

Raw accelerometer counts are a unit-less, dimensionless outcome, and thus require calibration in order to be translated and reported in ways that are biologically meaningful, such as time spent at differing activity intensities (e.g. MVPA). Definitions of activity intensity are subsequently derived from calibration with energy expenditure or direct observation, providing a cut-point threshold that is identified by a specific count value. In this study minutes of MVPA were determined using age specific cut-points of 205-410, 272-412 and 298-418 counts per 5 s epoch for children aged 3, 4 and 5 years, respectively (Sirard, 2005). These cut-points were chosen over others given that they are the only preschool age specific cut-points available and because plausible physiological and developmental reasons have been outlined as to why the relationship between accelerometer activity counts and activity intensity might differ with age. Although these cut-points have been criticised for underestimating MVPA, the decision was made to utilise them and underestimate rather than overestimate children's MVPA. Time spent in MVPA (min) was the main outcome. MVPA levels per hour (mins/hour) were calculated to assess within-day variability. Patterns of weekday and weekend MVPA were observed between 07:00 and 20:00 for the following time segments during weekdays: preschool (07:00-9:00), during school (09:00-15:00) and after school

(15.00-20.00) and during the weekend: morning (07:00-12.00), daytime (12:00-17:00) and evening (17:00-20:00).

3.2.3 Procedure

PA was monitored on seven consecutive days (Wednesday through Tuesday) during October 2009 and March 2010. Daylight hours and temperatures during both months were very similar ~ 11.5 hours and ~10.5°c, respectively (UK Met Office, 2012). A previous study conducted in a similiar geographical area did not find any variation in children's PA levels across seasons during recess (Ridgers et al., 2006a). Participants were instructed to wear the accelerometers on an elastic belt on the right hip (anterior to the iliac crest) during all waking hours except during water-based activities. Body mass was measured to the nearest 0.1kg using digital Tanita scales (Model WB100-MA, Tanita Europe, The Netherlands). Stature was measured to the nearest 0.1 cm using a portable Leicester Height Measure (SECA, Birmingham, UK). BMI (mass (kg)/stature^2 (m)) was calculated and children were classified as underweight, normal weight, overweight or obese using sex and age-specific cut-points (Cole et al., 2000). To examine potential school-related differences, participants were categorized in two groups: those who attended school for three hours and those who attended school for six hours.

3.2.4 Statistical analyses

Data were initially checked for compliance to the monitoring protocol using MAHUffe (Analyser v 1.9.0.3). Firstly, the minimum number of hours per day that the ActiGraphs were worn was determined. Twenty minutes of consecutive zeros were considered periods of non-wear time (Catellier et al., 2005). To be included as a

valid measurement day, children were required to wear the accelerometer for 619 and 624 minutes during weekdays and weekend days, respectively. These wear times were calculated by defining 80% of the total length of time during which 70% of the sample wore the accelerometer (Catellier et al., 2005). Children were finally included in the analyses if they wore the monitor for a minimum of 3 days including one weekend day. The final sample consisted of 188 children (100 boys and 88 girls). Reasons for missing data included non-compliance when wearing the accelerometer (n=43), technical problems (n=6), and loss of accelerometers (n=3). Independent samples t-tests revealed no significant differences between children with complete and incomplete PA data ($p > 0.05$).

Descriptive statistics (mean (SD)) were used to describe the study population. Independent samples t-tests examined differences between boys and girls for age, stature, body mass, body mass index (BMI), enrolment and MVPA. Three-way repeated measures ANOVAs were used to test variability in PA across sex and enrolment (three or six hour). A 13 (hour of the day) x 2 (sex: boys or girls) x 2 (enrolment: half or full day) repeated measures ANOVA was used to assess within-day variability during weekdays and weekend days. A 2 (type of day: weekday or weekend day) x 2 (sex: boys or girls) x 2 (enrollment: half or full day) repeated measures ANOVA was used to assess between-day variability. Post hoc analyses were conducted for significant main effects using Tukey's HSD. Data were analysed using PASW Statistics v.18, and the significance level was set at $p \leq 0.05$.

3.3 Results

Participant characteristics and descriptive PA data (mean [SD]) are shown in Table 3.1. Overall, boys engaged in significantly more MVPA than girls during both week and weekend days. The largest sex differences were observed during the school day (09:00-15:00) and during the weekend day (12:00-17:00). No gender differences existed for other segments of week days or weekend days.

A significant hour-by-enrolment interaction effect (F = 3.17, $p < .001$) revealed that the overall weekday pattern of activity differed by enrolment classification (Figure 3.1). During weekdays children who attended school for a half day engaged in 6.4 minutes more MVPA during the school day (09:00-15:00) ($F = 14.34$, $p < .001$) and 4.7 minutes more MVPA after school (15:00-20:00) ($F = 6.34$, $p < .001$) when compared to children who attended school for a full day. This equates to a total weekly gain of 41.3 minutes more MVPA per school week. There were no differences between groups in the before school time period (07:00-09:00). Patterns of MVPA in the full day children were characterised by a significant increase in MVPA between 12:00 and 13:00 followed by a significant decrease from 13:00 and 14:00. During this period, the MVPA levels of children enrolled for a half day remained stable.

Figure 3.2 shows the daily activity patterns of boys and girls attending school for a half day and a full day. There was a significant hour by gender interaction ($F = 3.681$, $p <.001$), however there was no hour by gender by enrolment interaction ($F = 1.08$, $p = .371$). Marked differences in activity patterns were observed between boys and girls who attended school for a half day. The activity patterns of children enrolled for a full day demonstrate consistent peaks and troughs, representing the typical school day, with children sitting in classrooms interspersed with periods of free play and recreation. The activity patterns of boys and girls from each enrolment

category were very similar, however boys consistently engaged in more MVPA than girls. The period between the end of school and bed-time appeared to be the period of the day where the largest variation occurred, particularly for half-day boys who were significantly more active than the other groups.

Figure 3.3 shows weekend PA patterns for boys and girls during the weekend. No hour main effects were observed ($F = 1.12$, $p = .305$). As before the PA patterns of boys and girls were remarkably similar, differing only in the amount of intensity achieved. Boys engaged in significantly more MVPA during daytime hours (12:00-17:00) ($F = 6.05$, $p = .04$) accumulating on average 6.58 minutes more MVPA during daytime hours than girls. Peaks during weekend days are less pronounced than the peaks in MVPA during school attending days. After 11:00 a steady state of activity was observed until 17:00 when both boys' and girls' levels of MVPA decrease.

Table 3.1 Mean (SD) demographic and physical activity data for preschool children

		Boys (n = 100)	**Girls (n = 88)**
Age (year)		4.6 (0.6)	4.5 (0.5)
Stature (cm)		106.4 (6.1)	107.2 (5.5)
Body mass (kg)		18.9 (3.2)	19.4 (3.1)
BMI ($kg \cdot m^{-2}$)		16.6 (1.6)	16.7 (1.6)
% OW/ OB		22.2	24.5
Half day enrolment (n)		27	29
Full day enrolment (n)		68	64
MVPA (min)			
Weekday			
Before school	(07:00-09:00)	2.8 (2.5)	2.3 (1.9)
During school	(09:00-15:00)	**26.5 (12.4)**	**22.2 (9.2) ***
After school	(15:00-20:00)	13.9 (7.6)	12.5 (6.3)
Weekend			
Morning	(07:00-12:00)	13.1 (14.8)	9.7 (5.9)
Daytime	(12:00-17:00)	**23.9 (15.8)**	**19.3 (9.9) ****
Evening	(17:00-20:00)	7.5 (6.1)	6.8 (5.2)

Significant gender differences are highlighted in bold; OW/OB = overweight/ obese * $P < 0.001$ **$P < 0.05$

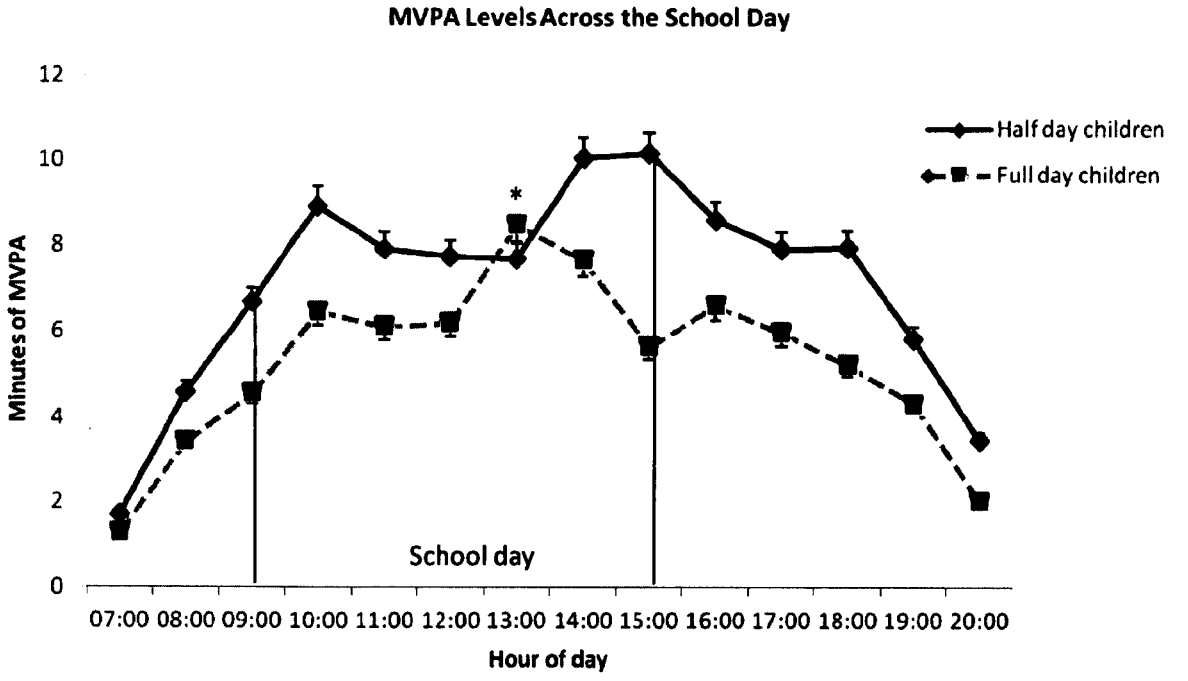

Figure 3.1 Enrolment specific physical activity pattern (mins/hour) for weekdays (*p< .05)

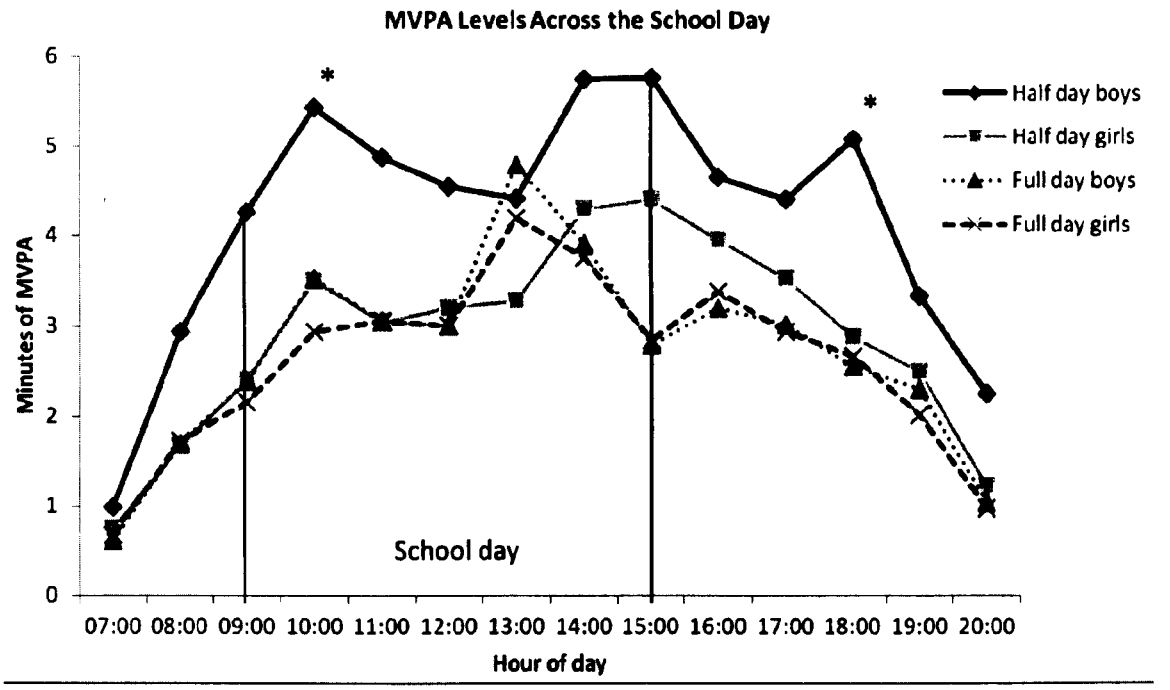

Figure 3.2 Enrolment and gender specific physical activity pattern (mins/hour) for weekdays (*$p < .05$)

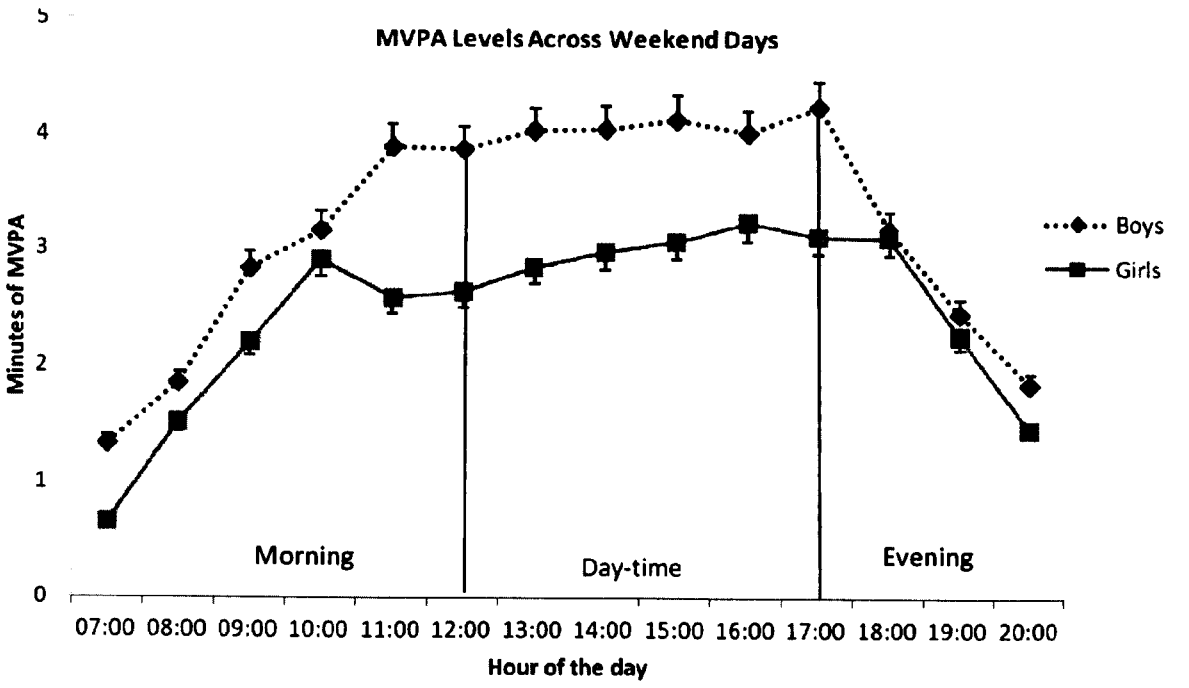

Figure 3.3 Physical activity patterns (mins/hour) on weekend days

3.4 Discussion

The purpose of this study was to assess within-day variability of objectively measured MVPA during weekdays and weekend days among preschool children. A secondary aim was to examine differences in these patterns by sex and enrolment at school, which has not been reported in the literature to date.

Children who were enrolled at school for half a day accumulated more MVPA than children who attended school for the full day and engaged in a structured routine encompassing a fixed classroom timetable and scheduled recess. In England, children attending preschool for a half day have access to continual outdoor provision, allowing them to move freely between indoors and outdoors throughout the preschool day. This may afford them an increased opportunity to be active whilst at school. Children attending preschool for a half day may also spend more time in their parents company, and it is feasible that increased parent support and rules inhibiting sedentary behaviours could be associated with increased PA in these children (Oliver et al., 2010). Children attending school for a full day demonstrated a consistent pattern of activity during weekdays, with morning travel to school, lunchtime (12:00-13:00) and the immediate after-school period being the key times when children were most active.

Most studies show that recess and lunchtime are key times for MVPA during the school day, though levels could be higher than they are (Cardon et al., 2009, Hannon and Brown, 2008, Ridgers et al., 2006b), similarly this study indicates that girls and particularly boys, maximised their opportunity to increase their MVPA during free play time. Increased MVPA during this time period emphasises the importance of recess in a preschooler's day. During weekdays boys and girls from each enrolment

category demonstrated very similar patterns of activity, however consistent with previous research in older children boys were significantly more active during the lunch time hour (Riddoch et al., 2007). This may be due to their domination of the playground space (Ridgers et al., 2006a). The before and after school segments of the day appeared to be the most stable, possibly due to the routines that children are accustomed to from the point of waking to going to school and from finishing school to going to bed. Similar patterns have been demonstrated with older children (Ridgers et al., 2010a, Fairclough et al., 2007, Riddoch et al., 2007).

The preschool curriculum is likely to provide more opportunities for active play than the primary school curriculum. However, patterns of activity for children attending school for a full day were highly variable throughout the day, which is comparable to other research in most young children (Verbestel et al., 2011) and to older UK children (Riddoch et al., 2007) . Sigmund and colleagues reported that as preschool children make the transition into primary education their patterns of activity remain the same but their activity levels decline (Sigmund et al., 2009). This is demonstrated in the current study where preschoolers accumulated more MVPA across the school day than older children in the UK (Riddoch et al., 2007). Moreover, there is a remarkable similarity between preschool children's activity levels and their older counterparts suggesting that blocks of inactivity are already apparent in the preschool environment. Previous curricular based PA interventions have been effective (Hannon and Brown, 2008, Trost et al., 2008) although more intervention research is warranted in this age group.

Consistent with findings from previous studies in this population (Verbestel et al., 2011, Benham-Deal, 2005), MVPA declined in the afterschool period except for in the case of boys who spent a half day at school. Children in this group were younger

than children enrolled for the full day and research suggests that daytime naps decrease with age (Acebo et al., 2005). Half-day boys experienced significant increases in MVPA from 17:00 to 18:00 which may be explained by increased energy after a period of rest. The drop in activity in half day girls and full day boys and girls may be linked with elements of the home environment preventing children from participating in active play (e.g. increased screen time) (Burdette and Whitaker, 2005) or parents perceptions that preschool children are engaging in enough PA at school (Irwin et al., 2005).

This study found that weekend patterns of PA demonstrated less variation than school days, which is consistent with previous research (Burdette and Whitaker, 2005, Verbestel et al., 2011). Morning hours were characterised by a steady increase in MVPA, possibly due to children waking up later. During the weekend, children were most active during daytime hours (12:00-17:00), with boys engaging in significantly more MVPA than girls. Despite children engaging in more activity during this time period, intervening during the weekend may increase children's MVPA. For example, parental support for PA has been identified as a significant correlate in this age group (Gustafson and Rhodes, 2006), thus given the increased time children spend with their parents during the weekend, this may hold significant importance for the design of future interventions.

First, this study is limited by the absence of an activity diary for use after-school and during the weekend which would provide more information about the context in which children were physically active. Second, though current recommendations for this age group focus on the accumulation of all intensities of activity, this study investigated MVPA as this has the best evidence in relation to health in this age group. Nevertheless, the present study adds to the dearth of literature on patterns of

PA in this population. Strengths of this study include high compliance rates of participants to the measurement protocol (78.3%) and the sex specific investigation of both week and weekend day objectively monitored PA in a large sample size.

3.5 Conclusion and future research

Within-day variability in preschool children's PA was highlighted and discrete periods of the day were identified which could be targeted to increase pre-schoolers' PA levels. Boys displayed higher levels of MVPA than girls however; all children did not accumulate enough PA for health benefits. Children who attended school for a half day accumulated more MVPA than children who were present at school for a full day, suggesting that the school environment is conducive to ST. Teachers should incorporate more PA into their daily classroom activities. After-school hours and weekends were also susceptible to low levels of PA. Future interventions in this age group should target parents given the relationship between parental support for PA and increased activity in this age group.

Thesis Study Map

Study	Objectives
Study 1: Patterns of objectively measured moderate-to-vigorous physical activity in preschool children	Objectives: • To assess within-day variability of objectively measured MVPA during weekdays and weekend days among preschool children. • To examine differences in these patterns by sex and enrolment at school. Key findings: • Children who were enrolled at preschool for a full day were less active than children enrolled for a half day. • Boys were significantly more active than girls. • After school hours were significantly less active. • Patterns of MVPA during the weekend were less variable.
Study 2: Effect of a school-based Active Play intervention on sedentary time and physical activity in preschool children	**Objectives:** • **To investigate the effect of a curricular "Active Play" intervention on children's sedentary and physical activity behaviours.** • **To investigate the influence of specific confounding variables on sedentary time and physical activity.**
Study 3: Effect of a family focused Active Play intervention on sedentary time and physical activity in preschool children	

Chapter 4

STUDY 2

Effect of a school-based Active Play intervention on sedentary time and physical activity in preschool children

The main outcomes of this study are currently under review in the *International Journal of Behaviour, Nutrition and Physical Activity*: O'Dwyer, M.V., Fairclough, S.J., Knowles, Z., Foweather, L., Ridgers, N.D. and Stratton, G. Effect of a school-based Active Play intervention on sedentary time and physical activity in preschool children.

4.1 Introduction

The preschool years have been identified as an important time for the development of healthy behaviours, such as PA. (Ward et al., 2010). Moreover, play and the mastery of fundamental movement skills are the substrate of PA during the early years (Cliff et al., 2009a) which provides the foundation for lifelong engagement in PA (Reilly et al., 2006, Telama et al., 2005, Malina, 1996). During early childhood PA significantly contributes to the prevention of obesity (Jimenez-Pavon et al., 2010, Moore et al., 2003) and cardiovascular disease (Burgi et al., 2012, Sääkslahti et al., 2004) and it influences bone health, motor development (Janz et al., 2010, Hardy et al., 2010) and promotes positive cognitive functioning and social development (Burdette and Whitaker, 2005). Recent PA guidelines in the United Kingdom recommend that children under the age of five years who are capable of walking should participate in at least one hundred and eighty minutes of PA (light intensity and above) and reduce the amount of time spent being sedentary (Department of Health, 2011). Despite preschool children being the most active segment of the population, a large proportion of young children are insufficiently active and spend a substantial amount of time sedentary (Hinkley et al., 2010, Reilly, 2010, Tucker, 2008).

The childcare environment provides one setting where interventions may be delivered to increase PA (Waring et al., 2007). Several reviews have identified

interventions that have been conducted to increase PA in children and youth (Kriemler et al., 2011, van Sluijs et al., 2007), but few have targeted preschool settings (Campbell and Hesketh, 2007, Chau, 2007). The stable preschool infrastructure (Story et al., 2006) and willingness of staff to participate in PA programmes (Cashmore and Jones, 2008) have prompted researchers to explore the potential of this environment for increasing PA. Despite this not all staff working in childcare settings feel confident to deliver PA programmes (Breslin et al., 2008). In light of this, the need for preschool curriculum based interventions to implement structured PA involving staff development are needed (Bundy et al., 2011, Niederer et al., 2009).

Despite the importance of play on preschool children's physical, cognitive, emotional and social development (Ginsburg, 2007), promoting active play has been under researched (Brockman et al., 2010). During the early years of life, children engage in 'active play' that is significantly above resting metabolic rate (Simons-Morton et al., 1990b). Recent research has found that active play is positively associated with MVPA levels (Brockman et al., 2010). Activity during play can be increased, for example, by painting markings on playgrounds to promote active games, with significant increases observed in the shorter and longer terms (Stratton and Mullan, 2005, Stratton, 2000), respectively. Further, play equipment and activity cards (Verstraete et al., 2006) and the use of portable equipment at day care facilities (Bower et al., 2008) have also increased children's PA. Despite the encouraging findings from active play interventions in school-age children, there is a paucity of evidence on interventions that promote active play in preschool children. Therefore, the aims of this study were to investigate the effect of a curricular "Active Play"

intervention on children's sedentary and PA behaviours, and investigate the influence of specific confounding variables on ST and PA.

4.2 Method

4.2.1 Participants and settings

Twelve schools from a large city in the North West of England were randomly selected and invited to take part in the study. Randomisation, stratified by local ward (5 in Liverpool), was accomplished by drawing folded sheets of paper, each marked with a school's code, from a hat. Allocation alternated between groups, i.e. 1st, 3rd, 5th participant into intervention group. While web or computer-based randomisation techniques exist, this randomisation procedure remains acceptable for samples of $n \leq 60$ ($n \leq 30$ per group) (Portney and Watkins, 2000). Participants and researchers were not blinded to the experimental group. Schools were attached to a SureStart children's centre, which provided a variety of advice and support for parents and carers of children aged 5 years or under who resided in the most disadvantaged parts of England (House of Commons Children Schools and Families Committee, 2010). Schools were located in neighbourhoods in the highest 10% for national deprivation (Department of Communities and Local Government, 2010). All 12 schools agreed to take part in the research study.

Initially, all parents were invited to a meeting at their respective school where the aims of the project were outlined. Parents who were unable to attend the meeting were given an information pack via the school which detailed the same information. All children from nursery and reception classes (aged 3-4.9 years) were invited to participate in the project ($n = 673$) and asked to return informed written parental consent, child assent, and medical forms. Please see appendix 1. Two hundred and

forty children (mean age 4.5 years, SD = 0.6 years; 51.7% male) agreed to participate (36% response rate). Subsequently, schools were randomly allocated to either the intervention (109 children) or comparison groups (139 children). The flow of participants through the study is illustrated in Figure 4.3 (Schulz et al., 2010). The study was approved by the University ethics committee. (Reference Number: 09/SPS/027).

4.2.2 Intervention design

This randomised controlled trial was conducted across two academic years (from October 2009- November 2010). Of the 12 schools recruited, 6 were allocated into time-phase 1 (academic year 1) and 6 were allocated into time-phase 2 (academic year 2). This design aimed to maximise recruitment and control for the influence of seasonal variation (Kolle et al., 2009). Each Active Play intervention was conducted for 6 weeks to fit with the local authority school calendar. Assessments were conducted at baseline, immediately following the 6-week intervention and again at 6-months follow-up. The project time line is outlined in Table 4.1. Additionally, after completion of all post-test data collection, children in both the intervention and comparison group received a certificate and an Active Play goody bag including some equipment to promote physically active play (Figure 4.1).

Table 4.1 Active Play Research Project Time Line

	Data collection and intervention delivery				
	Design, planning & recruitment	*Baseline*	*6 week intervention*	*Post-test*	*Follow-up*
Phase 1	May – Sept 2009	Oct 2009	Oct – Nov 2009	Dec 2009	July 2010
Phase 2	Jan – Feb 2010	Mar 2010	Apr – May 2010	Jun 2010	Nov 2010

Figure 4.1 Incentives for children in the intervention and comparison group

4.2.2.1 Active Play Intervention

PA provision in preschools in the UK is usually designed and led by classroom teachers or assistants. Few preschools have specialist physical education teachers (British Heart Foundation National Centre, 2011). For this reason, the use of external play practitioners for a period of time during a school term is becoming increasingly popular with approximately 50% of SureStart centres in the UK using external agencies (British Heart Foundation National Centre, 2011). Schools randomised to the intervention (INT) group received the Active Play programme, which was designed and implemented by highly qualified Active Play staff from the sport and leisure directorate of the local authority. The Active Play programme is a 6-week educational programme for staff and children in preschool settings. The programme was delivered using a *2-2-2* delivery approach. Specifically, weeks 1 and 2 were led by the Active Play delivery team and observed by the school staff, weeks 3 and 4 were co-delivered by the delivery team and the school staff, and in weeks 5 and 6,

the school staff led the delivery whilst the Active Play staff supported. When the Active Play team vacated the setting, the teacher continued to deliver the programme. The Active Play programme aimed to increase PA, develop fundamental movement skills, strength, agility, co-ordination and balance, and enhance children's self-confidence to play actively and freely. The programme also aimed to empower staff and increase their levels of self-efficacy in delivering an active play curriculum. The content of the intervention was contained within a comprehensive resource pack that included twenty activity cards (the description of example cards can be found in Table 4.2), a user manual focusing on topics such as "Getting activity at the right level", "Maximising moderate and vigorous activity levels" and "Including all children", exemplar lesson plans, signposting information; recommending useful resources and points of information, and a poster promoting Active Play (see Figure 4.2). The activity cards linked directly to the UK preschool curriculum (Department of Education, 2012). Additionally, intervention schools received an on-demand help service for additional support whilst the programme was on going. Examples of support included ideas for extra games or assistance with active fun days.

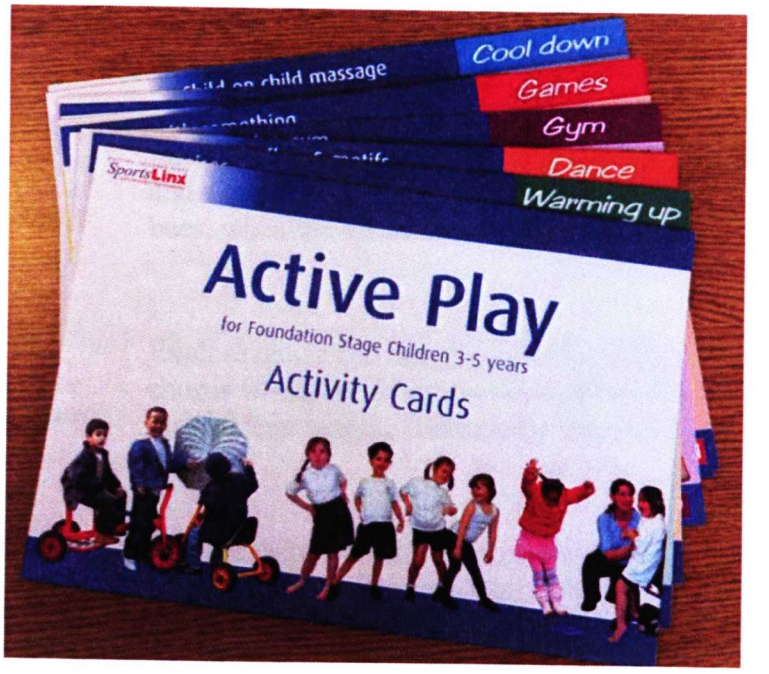

Figure 4.2 The Active Play resource pack

4.2.2.2 Comparison Schools

Comparison schools were asked to continue to deliver their usual PA provision. They received an Active Play resource pack (Figure 4.2) and were informed to refer to this for ideas.

Table 4.2 Description of example Active Play cards

Card	Content
Warming up: *Exploring bodies*	Introduce children to warming their bodies up for activity and explore body parts. Children move around like buzzing bees, when the sound cue is given they touch a body part.
Dance: *Free flow and motifs*	Explore dance and movement using stories, combining a chorus where the group moves together and verses where the children explore and express themselves.
Gym: *Jumping gym*	Explore different ways of jumping. Children participate in bunny hops and standing jumps. Introduce a rope on the floor to make the activity more difficult.
Games: *Sending with accuracy (targets)*	Explore precision and co-ordination. Practise target games individually, in pairs, or as a group. e.g. draw targets on walls and aim for your favourite e.g. different fruits
Cool down: *Child on child massage*	Introduce children to positive touch through massage, whilst cooling their bodies down after exercise

4.2.3 Instrumentation and procedure

4.2.3.1 Physical activity

PA was measured using an accelerometer set to record at 5-second epochs over 7 consecutive days (GT1M ActiGraph, Pensacola, FL.). Participants were instructed to wear the accelerometers on an elastic belt on the right hip (anterior to the iliac crest) during all waking hours except for water-based activities. Accelerometry has been validated against direct observation in preschool aged children (Pfeiffer et al., 2009, Sirard, 2005).

4.2.3.2 Physical activity data management

MAHUffe (Analyser v 1.9.0.3) was used to analyse the collected data. Age specific cut-points were used to determine time spent sedentary or participating in light, moderate or vigorous PA (Sirard, 2005). Please see Table 4.3 for a description of PA cut points used. Periods of 20 minutes of consecutive zeros were removed from the data as these were considered periods of non-wear time (Esliger, 2005). To be included as a valid measurement day, the accelerometer was required to be worn for a 623 minutes at baseline, 565 minutes at post-test, and 563 minutes at follow-up per day. These wear times were calculated by defining 80% of the total length of time during which 70% of the sample wore the accelerometer (Catellier et al., 2005). Children were finally included if they wore the monitor for a minimum of 3 days including one weekend day (de Meij et al. 2011).

Table 4.3 Age specific accelerometer cut points (60 second count per epoch)

	Sedentary	Light	Moderate	Vigorous
3 years old	<1207	1208-2459	2460- 4923	>4924
4 years old	<1455	1456- 3247	3248- 4939	>4940
5 years old	<1595	1596- 3563	3564- 5019	>5020

4.2.3.3 Active Play session physical activity

PA during the Active Play sessions was measured during week 3 of the intervention when the same session content was taking place in each school. Researchers visited 3 intervention and 3 comparison schools during an Active Play session. For convenience, 60 children (30 intervention and 30 comparison) were randomly selected from 6 schools and asked to wear an ActiGraph uniaxial accelerometer for

the duration of the Active Play session. Data were reduced using the same protocol as described for daily PA.

4.2.3.4 Anthropometrics

Body mass was measured (to the nearest 0.01 kg) using digital scales (Tanita WB100-MA, Tanita Europe, The Netherlands). Stature was measured (to the nearest 0.1 cm) using a portable stadiometer (Leicester Height Measure, SECA, Birmingham, UK). BMI (mass (kg)/stature^2 (m)) was calculated and children were classified as underweight, normal weight, overweight or obese using sex and age-specific cut-points (Cole et al., 2000).

4.2.3.5 Parental Characteristics Questionnaire

Parental and community characteristics were assessed using the Parental Characteristics Questionnaire (please see appendix 1). This questionnaire was devised using a combination of ALSPAC questionnaires (Blair et al., 2004, Taylor and Baker, 1997, Wildschut and Golding, 1997), which included question categories such as 'Having a Baby', 'Your Environment', 'About Yourself', and 'Adult Learning'. The questionnaire comprised of 8 items. Items 1-3 focused on general information about the child and parent including sex, birth dates, adult's relationship to the child and how many hours the child attended school each day (3 hours= half day and 6 hours = full day). Items 4-6 focussed on the parents' backgrounds including home postcode, ethnicity, and current marital status. Items 7-8 focussed on the parent's level of education and current employment status. All answers required a 'tick the box' response with the exception of postcode where the full postcode was supplied and used to obtain an index of multiple deprivation (IMD). For each participant, socio-economic status (total deprivation rank) was derived from home

postcodes entered into the Office for National Statistics online application (Department of Communities and Local Government, 2010). Two hundred and thirty eight children's homes (99.2%) were located in the highest 10% for deprivation nationally. The remaining two children's homes were in neighbourhoods in the top 30% for national deprivation.

4.2.4 Statistical analysis

Full data were obtained for 86 boys [35 intervention, 51 comparison] and 70 girls [35 intervention, 35 comparison) for use in the analyses. Reasons for missing data included non-compliance when wearing the accelerometer (n=65), technical problems (n=12), sickness (n=3), loss of accelerometers (n=3) and participants moving schools (n=1). Descriptive statistics were calculated to describe the final sample (Table 4.4). Independent t-tests were conducted to examine any differences in sex, socio economic status (SES), ethnicity, weight status, group allocation and enrolment at school, between children who were excluded and included in the PA analyses. In addition, independent-samples t-tests were performed to determine whether there were any significant differences in the percentage of time spent participating in MVPA between the intervention and comparison groups during the Active Play session. These data were analysed using PASW Statistics v.18, and the significance level was set at $p \leq 0.05$.

The main analysis used to estimate the effect of the intervention on children's PA levels and ST was multilevel modelling, which is considered to be the most appropriate data analysis technique for nested data (Goldstein, 1995). Data were analysed using MLwiN v.2.23 software. A three-level multilevel data structure was used to determine the effects of the Active Play intervention. The three levels of

analysis were time point (6-weeks, 6 months; level 1), child (level 2) and school (level 3). An association model was used to determine the effects of the intervention after being corrected for confounding variables (Twisk, 2006). Time spent in ST, LPA and MVPA were defined as the outcome variables. Baseline values for ST, LPA, MVPA, BMI and accelerometer wear time (continuous variables) and time-point, sex, time spent at school, parents levels of education and ethnicity (categorical variables) were used as covariates. Dummy variables were created for time point enabling analyses of a 6 week and 6 month intervention effect. Two analyses were conducted on all three outcome variables (ST, LPA and MVPA) to examine the intervention effect over time points. The first analysis (crude analysis) determined the effect of the intervention over time whilst controlling for baseline PA, whilst the second analysis (adjusted analysis) determined the intervention effect when the covariates were added to the model (Twisk, 2006). In addition, potential effect modification was assessed by constructing interaction terms between the intervention group and all covariates. Constructing interaction terms allowed me to investigate whether the intervention effect was different for different sub-groups (e.g. boys and girls or different ethnicities). Separate analyses were conducted for ST, LPA and MVPA. Regression coefficients in the model were assessed for significance using the Wald statistic (Twisk, 2006). Statistical significance was set at $p< 0.05$, with the exception of $p < 0.1$ which was used for interaction terms (Twisk, 2006).

4.3 Results

4.3.1 Exploratory analysis

Independent samples t-tests revealed no statistically significant differences in PA variables (ST, LPA, and MVPA) between boys and girls, between those who remained in the study and those who dropped out or between children with complete and incomplete PA data ($p > 0.05$). The descriptive (mean, SD) anthropometric characteristics at baseline and ethnic background of the children are displayed in Table 4.4. Independent-samples t-tests revealed that there were no significant differences between boys and girls in the intervention and comparison groups for age and anthropometric data ($p > 0.05$). Eighty-four per cent and 75% of the intervention and comparison group were White British, respectively.

Table 4.5 summarises the raw, unadjusted scores for the children's PA levels. Percentages of time spent in different intensities of PA during the Active Play sessions are reported in Table 4.6. Children in intervention sessions were significantly more active than those in comparison sessions ($p < 0.001$). There were no differences by sex within sessions ($p>0.05$).

4.3.2 Main analyses

Table 4.7 shows the effect of the intervention on ST, LPA and MVPA at 6 weeks and 6 months post intervention. No intervention effect was found for ST, LPA or MVPA at 6 weeks or 6 months. When the correction for potential confounders was performed (adjusted analysis), sex and the amount of hours children spend at school were significant predictors of ST, LPA and MVPA. The results indicated that girls engaged in 11.3 minutes more ST (CI: 4.6 to 17.9) and 3.2 minutes less LPA (CI: -5.2 to 1.2) than boys. Additionally, children who attended school for six hours (whole school day) engaged in 11.4 minutes more ST (CI: 3.8 to 19.0) and 6.2 minutes less (CI: -9.3 to -3.1) MVPA than children who attended school for three

hours (half day). Analysis also revealed that accelerometer wear time was a significant predictor of ST with children who wore the accelerometer for longer accumulating more ST.

Table 4.8 shows the intervention interaction terms with covariates investigating potential effect modification. Positive interaction terms were found between the intervention and baseline ST and LPA (both $p<0.001$). There were no other significant interactions.

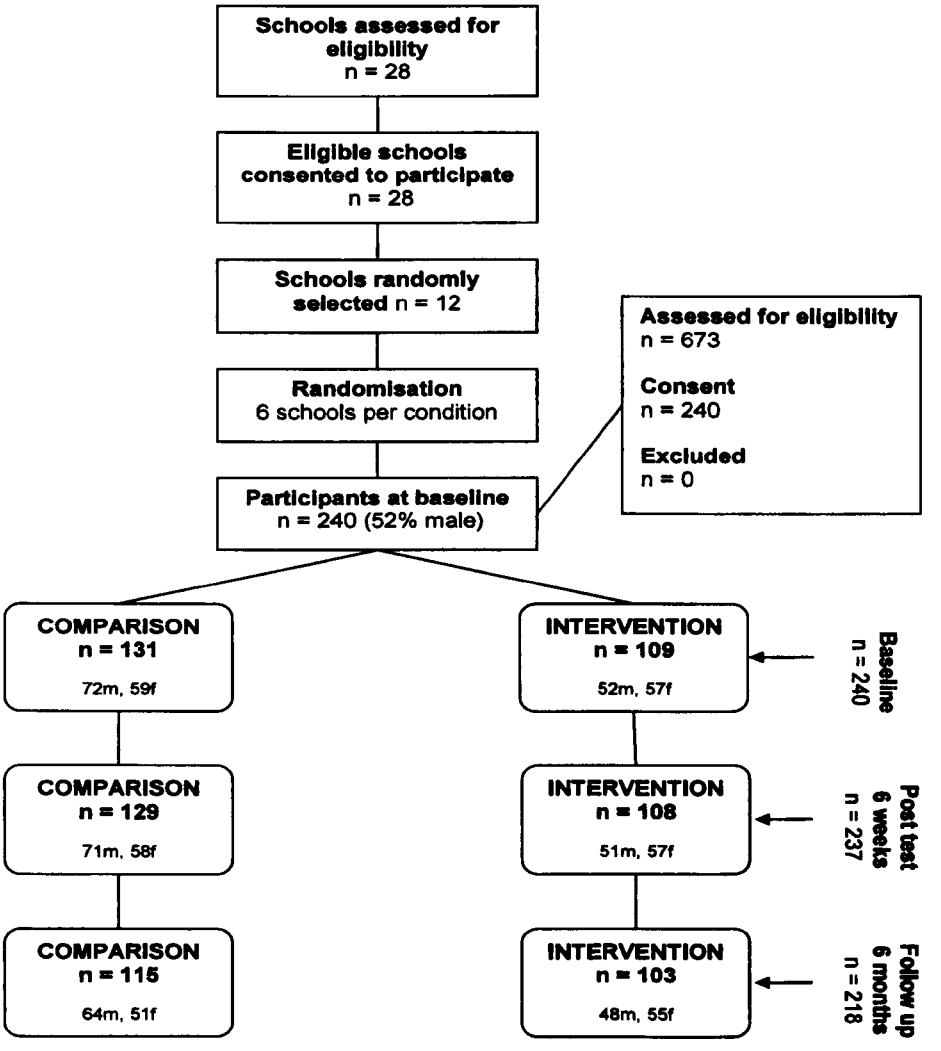

Figure 4.3 School and participant flow through the project (study 2)

Table 4.4 Baseline unadjusted descriptive data for the sample (mean (SD))

	Intervention						Comparison					
	Boy Mean	SD	Girl Mean	SD	Total Mean	SD	Boy Mean	SD	Girl Mean	SD	Total Mean	SD
Age (y)	4.6	0.6	4.7	0.5	4.7	0.5	4.7	0.6	4.4	0.6	4.5	0.6
Stature(cm)	105.4	6.4	108.6	5.1	107.0	6.3	107.0	5.9	106.4	5.0	106.8	5.5
Mass (kg)	18.5	3.2	19.8	3.2	19.1	3.3	19.2	3.2	19.0	3.1	19.1	3.2
BMI(kgm^2)	16.7	1.8	16.6	1.7	16.7	1.7	16.7	1.8	16.8	1.9	16.7	1.9
%OW/OB	22.6		25.2		23.9		21.7		25.7		23.7	
Ethnicity §	85.0		82.9		84.3		70.6		80		75.3	

Notes: BMI standardised by age and sex (Cole, 2000), OW = overweight; OB = obese, § = reference: %white British, Values are mean (SD)

Table 4.5 Uncorrected mean minutes (SD) for time spent sedentary and being physically active

		Baseline				6 weeks				6 months			
		INT (n=109)		COM (n=131)		INT (n=108)		COM (n=129)		INT (n=103)		COM (n=115)	
		Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
ST	Boy	649.5	54.3	636.3	55.7	581.7	88.0	605.5	68.4	536.8	52.8	560.5	58.0
	Girl	645.5	56.1	625.2	60.8	608.1	77.6	585.9	76.1	525.7	56.5	557.5	55.5
LPA	Boy	69.1	13.9	70.8	11.0	68.5	16.5	70.3	13.0	59.9	15.1	58.7	15.1
	Girl	75.4	14.5	73.6	15.1	70.9	14.5	69.4	15.8	67.9	15.6	64.4	12.6
MVPA	Boy	45.2	17.7	40.3	15.2	46.5	19.2	37.5	15.1	35.8	16.6	32.4	12.6
	Girl	40.5	17.1	42.4	17.1	39.2	17.7	40.6	13.6	35.4	14.4	35.9	14.8

Data collected in North West England between September 2009 and December 2010. All values reported are in minutes.
Key: Int = intervention group; Com = comparison group; ST = sedentary time; LPA = light physical activity; MVPA = moderate-to-vigorous physical activity

Table 4.6 Percentages (SD) of time spent participating in MVPA and Total PA during the Active Play session

	Intervention Sessions (n=30)		Comparison Sessions (n=30)	
	Mean	**SD**	**Mean**	**SD**
% MVPA	**31.3 (8.5)**	**8.5**	15.9 (6.3)	6.3
% Total PA	**45.2 (8.4)**	**8.4**	27.8 (8.8)	8.8

Data collected during week 3 of Active Play intervention. All values reported are in percentages.
Key: Int = intervention group; Com = comparison group; MVPA = moderate-to-vigorous physical activity; PA = physical activity. Bold faced text = P≤ .001

Table 4.7 Multilevel models: estimated effect of covariates and Active Play intervention on time spent being sedentary, in light physical activity and in moderate-to-vigorous physical activity from fully adjusted models

	ST (mins)		LPA (mins)		MVPA (mins)	
Parameter	**β**	**95% CI**	**β**	**95% CI**	**β**	**95% CI**
Difference from baseline – post-test	7.9	-1.5 to 17.3	-0.1	-2.6 to 2.4	1.4	-2.1 to 4.9
Difference from post test – 6 month	-2.5	-12.5 to 7.5	-2.8	-5.5 to -0.1	-4.0	-7.7 to -0.3
Difference from baseline – 6 month	10.4	-0.4 to 21.2	2.8	-0.1 to 5.7	-5.4	-9.3 to -1.5
Intervention	3.6	-4.3 to 11.4	0.1	-2.1 to 2.3	-0.1	-3.0 to 2.84
Sex	**11.3**	**4.6 – 17.9****	**-3.2**	**-5.2 to -1.2****	-2.6	-5.3 to 0.1
Hours spent at school	**11.4**	**3.8 to 19.0****	-2.3	-4.7 to 0.1	**-6.2**	**-9.3 to -3.1*****
BMI – GM	-0.7	-2.26 to 1.26	0.7	0.1 to 1.3	0.4	-5.0 to 5.8
Wear time – GM	**0.8**	**0.60 to 0.99*****	0.1	-0.1 to 0.3	0.1	-0.1 to 0.3
Parents education						
Trade	6.4	-15.6 to 28.4	0.3	-6.4 to 7.0	-1.4	-10.2 to 7.4
University	1.0	-6.6 to 8.6	0.9	-1.5 to 3.3	1.3	-1.8 to 4.4
Ethnicity						
W/other	4.2	-11.0 to 19.1	-3.7	-8.2 to 0.8	-0.5	-6.6 to 5.6
Mixed race	-13.6	-27.9 to 0.7	-2.4	-6.7 to 1.9	1.9	-2.7 to 6.5
Asian	9.6	-10.0 to 29.2	-5.4	-11.3 to 0.5	-3.8	-11.4 to 4.2
B/ African	0.5 (11.2)	-21.5 to 22.5	1.9	-4.8 to 8.6	-2.4	-11.2 to 6.4
Other	16.0 (10.8)	-5.2 to 37.2	-4.5	-10.8 to 1.8	-2.1	-10.3 to 6.1
Random	**Mean**	**SE**	**Mean**	**SE**	**Mean**	**SE**
School Level	29.1	28.9	0.8	2.1	2.0	3.9
Child Level	931.8	73.3	85.1	6.7	153.4	12.0
Time point Level	0.0	0.0	0.0	0.0	0.0	0.0
Deviance						
Crude Model	5660.45		3969.18		4088.69	
Adjusted Model	3424.52		2573.68		2782.56	

Note: Significant effects are indicated in bold: * P ≤ .05, ** P ≤ .01, *** P≤ .001. Reference categories for intervention is comparison; for sex is boys; for hours spent at school is 3 hours; for parents education is did not complete high school; for ethnicity is white British. BMI and accelerometer wear time are reported as continuous variables where the average is centred around the grand mean (GM). The intervention β value represents the estimated difference in PA levels for the intervention schools against the comparison schools when all other parameters are included in the final model. The values presented for sex, hours at school, BMI, wear time, parents education and ethnicity are generated from the baseline – follow up analysis. A positive β value indicates a positive intervention effect on the PA levels of the intervention children compared with the comparison school children during the whole week over time.
Abbreviations: β = Regression coefficient; SE = Standard Error; CI = Confidence Interval.

Table 4.8 Intervention interaction terms with covariates investigating potential effect modification

Interaction term	β	SE	*P*- value
Sedentary time			
Intervention x ST baseline	0.81	0.05	0.00 *
Light physical activity			
Intervention x LPA baseline	0.76	0.04	0.00 *

* $p < 0.001$

4.4 Discussion

The aim of this study was to investigate the effects of an Active Play intervention on children's whole week ST and PA levels. A secondary aim of the study was to investigate the influence of specific confounding variables on the outcome measures.

The inclusion of 6 structured Active Play sessions, co-delivered by experienced Active Play professionals and school teachers, was not effective in decreasing children's ST or increasing PA over time. However there were positive interactions found between the intervention and baseline ST and LPA indicating that the intervention effect was stronger for children who engaged in more ST and LPA at baseline. Moreover, children did not meet PA recommendations. Pre-schoolers in this study were sedentary for 10.8 hours of their total waking day similar to other studies (Cardon et al., 2009, Dowda et al., 2009, Alhassan et al., 2007). On one hand the high levels of ST that children engaged in was worrying, on the other hand these provide a strong rationale for interventions that aim to decrease ST time. Converse to our findings increasing provision of outdoor play equipment (Hannon and Brown, 2008) or creating a more active curriculum (Trost et al., 2008) significantly increased MVPA. However, in both of these studies the interventions were limited to one setting with small numbers of participants. When our 6-week intervention (one session per week) was implemented with a larger sample size and within more settings, the results were not as favourable as those reported in other studies (Hannon and Brown, 2008, Trost et al., 2008). It is most likely that the lack of change in PA was a result of the low frequency of sessions (once a week) and the short length of the intervention (6 weeks). Although this investigation examined the effects of simply adding a structured active play session during preschool time, other forms of preschool interventions have been investigated. Reilly and colleagues used

accelerometers to measure the effects of adding 3 x 30 minutes sessions per week for 24 weeks into the preschool day (Reilly et al., 2006). Similar to our results, this intervention did not significantly increase children's activity levels and the investigators concluded that they did not deliver an adequate dose of PA, despite rigorous implementation of the intervention and promising results in a pilot study (Reilly and McDowell, 2003). Another PA intervention implemented in 40 preschools in Belgium, found that using playground markings and equipment did not significantly increase PA levels of children (Cardon et al., 2009). In contrast to our findings, interventions have been conducted which have resulted in increases in PA (Specker and Binkley, 2003, Eliakim et al., 2007). These studies were not "play oriented", but were controlled in design with well structured, repetitive exercise regimes delivered frequently (5-6 times per week for 4-12 months). It is questionable whether these approaches were as developmentally appropriate as other studies that focus on active play (Ginsburg, 2007). One of the aims of the Active Play programme was to increase levels of MVPA during Active Play lessons. Children in the intervention group sessions were significantly more active than those in the comparison group, suggesting that the activities delivered were appropriately intense, but were not of sufficient duration or frequency to affect overall PA. It is estimated that during a 39-week school year, children in the Active Play specialist led sessions spent approximately 8 more hours in MVPA than children in the comparison sessions. Without the use of direct observation during the session it was not possible to determine the precise activities that best promoted PA. It is recommended that future studies include an observational measure to contextualise the activity within the session (Ridgers et al., 2010a). Failure to increase PA out of school is generally consistent with previous studies (Sallis et al., 1992) although some interventions

have been successful (Kriemler et al., 2011). Programs that increased children's PA relied mainly on external control such as parental reinforcement (Chen et al., 2009, Sääkslahti et al., 2004) or PA at home (Loprinzi and Trost, 2010). Although limited by parent recall, using an activity diary in the future may capture this information. Another possibility for the lack of increase in MVPA may be attributed to the displacement of PA or the 'activitystat' hypothesis (Baggett et al., 2010, Reilly, 2011, Metcalf et al., 2010). For example, on days when the children accumulated extra MVPA, they may have increased the amount of time spent being sedentary; whereas on a day where the children did not partake in moderate-to-vigorous activities, they might increase the amount of LPA they accumulated and decrease the amount of time in sedentary activities. Future studies should investigate total PA rather than specific intensities, particularly given the PA recommendations for this age group.

Despite observing no intervention effect, this study contributes to the limited intervention literature in this population. Firstly, levels of PA were very low and levels of ST were very high, which was consistent with findings reported by Reilly and colleagues (Reilly, 2010). High levels of ST have been associated with excessive use of screen based entertainment in this population (Hinkley et al., 2012). However, we did not record information in relation to electronic media use and it was therefore difficult to state with confidence the reason for the high recordings of ST. Although the prevalence of screen-based entertainment and media that are accessible by the current generation of children may be related to this (Council on Communications and Media, 2011). It is also worth noting that accelerometer wear time decreased across time points. From discussions with parents and teachers, many children did not want to wear their activity monitor for the seven days period. Future research

should acknowledge this challenge and try to establish a solution which maximises monitor wear time and improves compliance in such studies.

Secondly, preschool boys were more active than their female counterparts which is consistent across the literature (Hinkley et al., 2008, Montgomery et al., 2004, Hands and Larkin, 2006). When potential pupil and school level confounding variables were investigated, girls spent significantly more time sedentary and less time in LPA. Over 6 months this accumulates to approximately 34 hours more ST for girls and 10 hours more LPA for boys. Girls also accumulated less MVPA than boys, though this was not significant. These sex differences have been consistently demonstrated in the literature with boys often being observed playing in larger groups, partaking in play which involves increased risk, and engaging in more 'rough and tumble' play often involving expansive body movements, thus expending more energy (Pate et al., 2004, Yan et al., 2002, DiPietro, 1981). Another explanation for these sex differences may be that girls receive less encouragement from teachers and peers to engage in energetic play. However, a previous study examining PA behaviour among preschool children found no significant sex differences in prompts to be active (Jackson et al., 2003). Whatever the underlying reason for the observed sex difference, our observation that 3 to 5 year old girls engaged in significantly more ST and less LPA supports the recommendations that girls require additional support to achieve optimal levels of PA, even at preschool age. This in turn may drive the acquisition of fundamental movement skills which are key correlates of PA in this age group (Burgi et al., 2012, Orsega-Smith et al., 2007).

Thirdly, children who attended school for fewer hours each day (i.e. the younger children in the sample) were more active than their older counterparts (Hinkley et al.,

2010). One explanation for this may be the greater opportunity that younger children have to be more active outside of the classroom setting. This differs to their older counterparts who at the age of 4- to 5- years were part of formal education and spend more time each day in a classroom based learning environment, typically involving extended periods of time sitting down. This finding may also be attributed to the age-specific cut-points used to interpret the PA data, which increase with age, (Sirard, 2005), though other studies have shown that age is not associated with activity levels in the preschool population and that differences may be related to the environmental factors (Montgomery et al., 2004, Jackson et al., 2003).

Interestingly, our results show that BMI, maternal education and child's ethnicity had no effect on ST and PA levels corresponding with other research investigating BMI (Finn et al., 2002) and SES (Sallis et al., 1988) but not with ethnicity (Pate et al., 2004). In summary, these findings are important as they highlight the influence of school, home and child level confounding variables on children's activity levels and the complexity of the process associated with changing behaviours, even during this early stage of life. The limitations of the current study include: (i) the inclusion of the primary care giver (directly or indirectly) during the intervention may have benefitted the results (ii) the non-completion of an activity log book during the time the children wore the accelerometer may have helped explain the types of activity the children engaged in outside of the sessions, (iii) a very low response rate during recruitment, with only 36% of the children targeted signing up for the research, (iv) the choice of accelerometer cut-points used have been criticised as being too high, specifically the MVPA thresholds (Reilly et al., 2008) and (v) the sample used is not representative of all preschool children.

The strengths of this intervention lie in the delivery of the Active Play programme by experienced professionals and school personnel, and its flexible design which respected the autonomy of teachers to use the material outside of the weekly structured sessions. These features coincide with the need for sustainable programmes of PA. Important strengths of the current research are: (i) the research design; the inclusion of a randomised controlled trial with a large sample size and the inclusion of a 6 month follow up, (ii) both groups were matched for SES (iii) the use of an objective measure of ST and PA (iv) the use of multilevel analyses taking into accounting of children within preschools.

4.5 Conclusion and future research

Although the intervention was sufficiently intense, a 6 week Active Play programme was too short to accrue any changes in ST and PA engagement in the short and longer-term. Teachers and practitioners should be cautious when adopting structured PA programmes for use with preschool children. However, programmes such as Active Play are not likely to impart negative effects on young children's activity levels, when delivered in a developmentally-appropriate way. To achieve public health goals, physical education programs should promote PA during school time as well as outside of school.

Thesis Study Map

Study	Objectives
Study 1: Patterns of objectively measured moderate-to-vigorous physical activity in preschool children	Objectives: • To assess within-day variability of objectively measured MVPA during weekdays and weekend days among preschool children. • To examine differences in these patterns by sex and enrolment at school. Key findings: • Children who were enrolled at preschool for a full day were less active than children enrolled for a half day. • Boys were significantly more active than girls. • After school hours were significantly less active. • Patterns of MVPA during the weekend were less variable.
Study 2: Effect of a school-based Active Play intervention on sedentary time and physical activity in preschool children	Objectives: • To investigate the effect of a curricular "Active Play" intervention on children's sedentary and physical activity behaviours. • To investigate the influence of specific confounding variables on sedentary time and physical activity. Key findings: • The intervention had no effect on ST or PA at 6-weeks or 6-months. • Children in the intervention sessions engaged in significantly more MVPA than children in the comparison sessions. • Boys engaged in more ST and LPA than girls. • Children who were enrolled at preschool for half a day were significantly more active than children who were enrolled for a full day.
Study 3: Effect of a family focused Active Play intervention on sedentary time and physical activity in preschool children	**Objectives:** • **To investigate the effect of a family focused "Active Play" intervention on children's weekday and weekend day sedentary time and total physical activity.** • **To investigate the influence of mediating and moderating variables on sedentary time and total physical activity.**

Chapter 5

STUDY 3

Effect of a family focused Active Play intervention on sedentary time and physical activity in preschool children

The main outcomes of this study are currently under review in the *International Journal of Behaviour, Nutrition and Physical Activity*: O'Dwyer, M.V., Fairclough, S.J., Knowles, Z., and Stratton, G. Effect of a family focused Active Play intervention on sedentary time and total physical activity in preschool children.

5.1 Introduction

PA and sedentary behaviour in early childhood have significant effects on health parameters. Sufficiently active preschool children have increased protection against obesity (Jimenez-Pavon et al., 2010) and cardiovascular disease (Sääkslahti et al., 2004, Wilkinson, 2008). PA during the preschool day and limited outdoor playtime are related to BMI in young children (Trost et al., 2003, Takahashi et al., 1999). Also insufficient PA can have a negative impact on psychosocial factors such as self-esteem (Ekeland et al., 2004) and are associated with poor fundamental movement skill acquisition during childhood (Williams et al., 2008). The early years are an ideal window to promote PA, as motor development at this life stage is more malleable than in later childhood and adolescence (Matusik and Malecka-Tendera, 2011, Skouteris et al., 2010), and risk factors for overweight can be more easily modified (Parsons et al., 1999). Furthermore PA levels during the early years of childhood are predictive of activity levels later in adulthood (Telama et al., 2005).

Studies investigating the correlates of PA in children have found parent attitudes, behaviours, parenting styles and practices to have a profound influence on children's health behaviours (Hinkley et al., 2008, Sääkslahti et al., 2004, Sallis et al., 2000). For example, one study (Sääkslahti et al., 2004) found that children whose parents received information on how, when, and where to encourage their child's PA, spent more time playing outdoors in comparison to children whose parents received no

information. Additionally, studies investigating the correlates of sedentary behaviour in this age group have reported indeterminate associations between variables such as television viewing, age, gender and BMI, however a significant negative association between parental rules and sedentary behaviours was reported (Hinkley et al., 2010).

There is a need to explore both feasibility and efficacy of parent targeted lifestyle interventions that aim to influence the health behaviours of children. For such interventions to be effective, the active involvement of parents is particularly important (Golan, 2006). Interventions have previously been conducted where parents contribute in a low to medium capacity e.g. consenting to participation, through home tasks, or receiving letters (Manios, 2006, Fitzgibbon et al., 2005, Sääkslahti et al., 2004). According to De Bock and colleauges, (De Bock et al., 2010) the effects of directly exposing parents to an intervention have been understudied yet parents' participation in interventions is essential given the evidence to suggest significant correlations that exist between parental support and child PA level (Gustafson and Rhodes, 2006). Parent's play a vital role in the facilitation of their child's PA. They are knowledgeable about the barriers to PA and have a sense for opportunities that are consistent with their child's preferences (Dwyer et al., 2009). Furthermore, parental behaviour is noted as one of the strongest determinants of both child PA (Oliver et al., 2010) and BMI (Watson et al., 2011, Kleiser et al., 2009). They can provide an environment which affords their children playful opportunities, allowing them to practice different motor activities and improve their skills (Pellegrini and Smith, 1998). The role of parents within a PA intervention may therefore foster more active lifestyles during the preschool years and beyond. However, few interventions targeting preschool children have investigated the effectiveness of directly involving parents within PA interventions

and little is known about how to successfully engage and motivate parents and other caregivers to promote and support children's PA at home. Moreover, the evidence related to PA interventions in child care settings is not definitive and given that parents play a significant role in shaping and supporting their children's PA behaviour further research is warranted regarding their involvement (Loprinzi and Trost, 2010, Hinkley et al., 2008). Due to the limited intervention based research targeting child care settings, parents must be willing to take responsibility for encouraging and supporting their children's PA behaviour. Consequently, the development of programs to educate and support parents in this endeavour should be a priority.

Therefore, the aims of this study were first to investigate the effect of a family focused "Active Play" intervention on children's weekday and weekend day ST and total PA, and second to investigate the influence of mediating and moderating variables on ST and total PA.

This study hypothesises that:

- A 10-week family focused Active Play intervention will positively impact on young children's total PA and ST
- A 10-week family focused Active Play intervention will identify specific mediating and moderating variables which affect preschool children's total PA and ST
- Parent's participation in sport and their physical activity levels will have an effect on preschool children total PA and ST.

5.2 Method

5.2.1 Participants and settings

Twenty-four SureStart children's centres from a large city in the North West of England were invited to take part in this study. SureStart children's centres are a free service for families with children aged 5 years or under and are situated in the most disadvantaged parts of England. They provide a variety of advice and support for parents/carers and services are targeted from pregnancy through to entry into compulsory education (House of Commons Children Schools and Families Committee, 2010). All children's centres were located in neighbourhoods in the highest 10% for national deprivation (Department of Communities and Local Government, 2010). Of the 24 children's centres invited, 15 agreed and 8 were randomly selected to take part in the study.

Initially, the research team organised a meeting with a member of staff from the children's centre, typically a health promotion worker or alternate professional. The aim of this meeting was to describe the project and outline the aims of the research. The children's centre staff received information packs and distributed them to eligible families. Information packs contained a participant information letter, consent form, assent form, medical questionnaire and preschool-age PA questionnaire (Pre-PAQ) (Dwyer et al., 2011). Please see appendix 1. To be eligible to take part children had to be registered at the participating children's centre, be aged between three and 4.9 years, and not have any significant physical or intellectual disability which restricted them from participating in the intervention or impair the accuracy of PA measurement. Families meeting the inclusion criteria in each participating children's centre were invited to take part in the project (n=182). The final recruited sample consisted of seventy-seven families and seventy-nine

children (mean age 3.7years, SD = 0.6; 51.9% male), equating to a 42% response rate. Subsequently, children's centres were randomly allocated to either the intervention (n=4) or comparison group (n=4). Once the children's centres were randomly allocated to their group, schedules for data collection and intervention delivery were devised. At post-test, the intervention and comparison group lost 1 and 2 families, respectively. Reasons for losses included moving house (n=1) and time constraints (n=2). The flow of children's centres and families through the study is illustrated in Figure 5.1 (Schulz et al., 2010). The study was approved by the University ethics committee (Reference: 09/SPS/027).

5.2.2 Intervention design

This cluster randomised controlled trial was conducted for 10 weeks during the school autumn term (September to December 2011). The research design was implemented to avoid contamination across settings (Bland, 2004). The 10 week duration was selected to fit the local authority school calendar and represented a significant period for observing short-term experimental effects. Assessments were conducted at baseline and immediately following the intervention.

5.2.2.1 A family focused Active Play intervention

5.2.2.1.1 Theoretical model

The intervention was designed using a socio-ecological model (Bronfenbrenner, 1979) and aimed to influence children's total PA and time spent in sedentary behaviour. This was achieved by manipulating known mediators and moderators in the social environment (Golley et al., 2011, Oliver et al., 2010). Specifically, the intervention targeted parents as a key agent for PA promotion. The Foresight report

(Butland et al., 2007) and the World Health Organisation (Branca et al., 2007) have indicated that a whole system approach to tackling behaviour change is critical, and have stressed the importance of considering behaviour change alongside environmental, policy and community approaches.

5.2.2.1.2 Physical activity and parent's educational workshops

The intervention followed the model recommended for developing and evaluating complex interventions (Medical Research Council, 2008). Firstly, a user group was consulted on both the content and duration of the intervention. The use of such a group has been endorsed as it likely to result in better, more relevant science and a higher chance of producing implementable data (Medical Research Council, 2008). The user group (n=12) consisted of a convenience sample of parents, play workers, teachers and health promotion workers from within the children's centre setting. Informal discussions were held with each user group member separately and notes were taken by the lead researcher. Once meetings with user group members were completed notes were shared with participants to check for accuracy. A draft intervention programme was then written using evidence from the literature combined with user group views. Specifically user group members suggested that intervention sessions lasting no longer than 1 hour would be most suitable and that parents should be consulted on a delivery time that works best for them. Additionally, user group members unanimously voted that text messages were the most appropriate way to engage parents and maintain contact with them during non-contact weeks. Finally, the members of the user group felt that parents would benefit from the provision of information regarding free activities in their local area. These views were then supplemented by resources from programmes that targeted preschool children such as; Munch and Move (Hardy et al., 2010), Unplug and Play

(Australian Heart Foundation) Change for Life (National Health Service, UK), Free Range Kids (Sustrans, UK), and Lets Get Kids on the Go! (British Heart Foundation). The first draft of the intervention was then shared with an expert group (n=5) including PA experts, paediatric exercise science researchers, a chartered sports psychologist and researchers working with parents on a local childhood obesity treatment programme. An overview of intervention content and associated components can be found in the Table 5.1.

The intervention occurred every other week and comprised of 5 contact sessions over a 10 week period. Each session lasted approximately 70 minutes which consisted of 10 minutes registration and checking home activity completion and 60 minutes delivery time. Parents and children were separated for the first 20 of the 60 minutes. During this time the children participated in active play and the parents attended an educational workshop. The remaining 40 minutes of delivery was spent as one group participating in active play. The active play element of the intervention was delivered by team of professional play workers. The educational component of the parent's workshops was delivered by the lead researcher and a research assistant who had previously worked on interventions targeting family behaviour change.

Table 5.1 Overview of intervention content

	Session theme & rationale	Active play delivery	Parent(s) workshop element	Programme home linked activity
Session 1	***Importance of involving parents & the new PA guidelines*** Start Active, Stay Active physical activity guidelines. Parents unsure of physical activity guidelines. Family-based interventions targeting preschoolers should include strategies to increase parental support for physical activity.	Introduction to active play: movement with confidence, spacial awareness and responding to activity based instructions.	Importance of parent(s) in physical activity promotion and behaviour change Introduction to new physical activity guidelines.	Allow child to choose one activity each day and play this with them for 10 minutes. Sign up for Change4Life
Session 2	***Stages of development & fundamental movement skills*** Proficient FMS during preschool years is correlated with increased PA levels. Age 2 – 7: window of opportunity for skill development.	Explore balancing, hopping and throwing through different games.	Developmental stages of early childhood What are FMS? Why are FMS important?	Parent(s) and child are asked to perform a locomotor, object control , balance or stability game each day for 10 minutes.
Session 3	***Overcoming the barriers that exist in outdoor and indoor play. Let's get risky!*** Parents do not want their children to play outdoors. Outdoors associated with dangerous and taking risks.	Using an obstacle course, encourage parent(s) to take risks with their children whilst being active.	Discussions about societal changes. Breaking down the barriers.	Parent(s) and child are asked to take part in one indoor or one outdoor activity they usually don't participate in each day for 10 minutes.

Session 4	***Energetic play – (using P.O.W. message: Pulse higher – Out of breath – Warm feeling)*** Preschool children are not accumulating enough MVPA for health benefits. MVPA is important for child development.	Using a variety of fun games, aim to get children 'out of breath' and red in the face.	Learn to identify different physical activity intensities Discuss why high intensity physical activity is important?	Parent(s) and child take part in 10 minutes per day of high intensity activity Self-monitor child's screen time using the chart provided.
Session 5	***Reducing screen time & Celebration Event*** TV associated with obesity in preschool children. Excessive TV in child care settings. TV and irregular sleep patterns.	Main activity involved Musical Mats to Liverpool Little Stars activity song resource.	Define screen time and the guidelines Discuss alternatives and ways to limit screen based activity.	Using the family rules template limit screen time each day.

5.2.2.1.3 Intervention implementation strategies

On the first day of the intervention each family received a log book called the Move It! Snap It! Log It! Diary. The log book was adapted from one developed with families involved in a local child weight management programme (Watson et al., 2011). The log book was one of a number of behaviour change techniques used within the intervention. Log books allowed families to self-monitor their home activity; permitted the research team to set graded tasks and provide instruction for these tasks; provide feedback on performance of the tasks; provide contingent rewards and allowed the families to agree to a behavioural contract (Golley et al., 2011). Previous research supports the inclusion of self-monitoring of behaviour to prompt intention formation specific goal setting, providing feedback on performance, and prompting review of behavioural goals in interventions designed to promote PA (Golley et al., 2011, Michie et al., 2009). Families were asked to bring their log book to each intervention session where they were reviewed by a member of the delivery team. Completed log books were linked to a progressive reward system. Rewards were linked to PA promotion such as activity bags, an Active Play key fob and an active dance DVD. Log books also contained contact details for additional support. Additionally, after completion of all post-test data collection, families in both the intervention and comparison group received a certificate, Active Play key fob, a Liverpool's Little Stars activity song book and a £10 shopping voucher. The voucher was only rewarded if the families complied with all measurements.

5.2.2.1.4 Provision of resources and instructional materials

Providing parents with instructional and educational material has been associated with positive changes in PA within this age group (Manios et al., 2002). All families

received resources and instructional materials throughout the intervention to allow them to implement the intervention at home and complete their home activities. The resources included current UK PA guidelines for the early years, Munch and Move fundamental movement skills teaching manual and accompanying games which encourage the development of such skills, Play4Life indoor and outdoor games ideas, Liverpool Active Parks map, British Heart Foundations 'Let's Get Kids on the Go' activity booklet, local swimming pool schedules, 100 ways to Unplug n' Play, Unplug n' Play electronic media tally template, and Unplug n' Play tips for setting family rules around screen time At the first session, all families were instructed to sign up for the Change4Life campaign.

5.2.2.1.5 Follow up support

Follow up support can contribute to the effectiveness of an intervention (Michie et al., 2009, Abraham and Michie, 2008). During discussions with user group members it was evident that text messages were the most popular way (in comparison to phone calls, social media websites or email) to communicate key messages and contact families taking part in the intervention. Families received five text messages between each intervention session. Families received five text messages during the non-contact weeks. The first message thanked families for attending the session or queried why they did not attend the session, the second, third and fourth messages were key messages or prompts relating to the intervention content from the previous week and the fifth text message reminded families of the next session. Text messages were also used during the data collection weeks when families wore the accelerometers.

5.2.2.2 Comparison group

Children's centres allocated to the comparison group did not receive any intervention or associated materials during the study period. They were asked to continue with their usual PA provision and maintain their standard relationship with parents.

5.2.3 Instrumentation and procedure

At baseline (0 weeks) and post-intervention (10 weeks) child and parent habitual PA was measured. At baseline the primary caregiver also completed the Pre-PAQ (Dwyer et al., 2011), detailed below.

5.2.3.1 Children's habitual physical activity

PA was measured using 5 second epoch over 7 consecutive days (GT1M ActiGraph, Pensacola, FL.). Participants were instructed to wear the accelerometers on an elastic belt on the right hip (anterior to the iliac crest). Parents were provided with a chart to document when the child put the monitor on and when it was taken off. This method of quantifying ST and activity levels has been validated against direct observation in preschool aged children (Pfeiffer et al., 2009, Sirard, 2005).

5.2.3.2 Physical activity data management

MAHUffe (Analyser v 1.9.0.3) was used to analyse accelerometer data. As in Study 2, age specific cut-points were used to determine time spent sedentary or participating in light, moderate or vigorous PA (Sirard, 2005). Periods of 20 minutes of consecutive zeros were removed from the data as these were considered periods of non-wear time (Esliger, 2005). To be included as a valid measurement day, the accelerometer was required to be worn for a minimum amount of time during weekdays and weekend days. Wear times were calculated by defining 80% of the total length of time during which 70% of the sample wore the accelerometer

(Catellier et al., 2005). This cut-off at baseline was 521 and 483 minutes for weekdays and weekend days, respectively and 466 and 448 minutes at post-test for weekdays and weekend days, respectively. Children were finally included if they wore the monitor for a minimum of 3 days including one weekend day (Jackson et al., 2003) .

5.2.3.3 Adults habitual physical activity

Parent's PA data was measured using the same accelerometer procedures as children. ActiGraph count cut-points for ST (100cpm), light (≤1952cpm), moderate (≤5724cpm), and vigorous (>5725cpm) intensity PA (Freedson et al., 1998) were used to determine parental ST and PA levels. Periods of time greater than 60 minutes of consecutive zeros were considered periods of non-wear time and were not included in further analysis (Hawkins et al., 2009). Minimum accelerometer wear time was calculated separately for weekdays and weekend days at baseline and post-test. This minimum wear time at baseline was 541 and 563 minutes for weekdays and weekend days, respectively and 602 and 500 minutes at post-test for weekdays and weekend days, respectively. Days during which participants did not achieve the minimal wear time were considered as non-compliant days and were not used in the analyses. Parents were included if they had 4 valid days of data including one weekend day (Hawkins et al., 2009).

5.2.3.4 Questionnaire

A shorter version of the Pre-PAQ (please see appendix 1) was administered to all parents before the intervention commenced. This tool has acceptable validity and reliability in this population (Dwyer et al., 2011). Questions in reference to the child enrolled in the programme were completed by the parent. Parents were asked to proxy-report general information about their family unit, home and community

environment, specific information surrounding the PA habits of themselves and their child participating in the programme. In section 1 (items 1-9) parents reported their relationship to the child, their age (years and months), current marital status, education level, ethnicity and the number of children living in the household. In section 2 (items 10-17) parents reported their full home postcode which was used to establish socio-economic status (Department of Communities and Local Government, 2010), the size of the area within their home perimeter, the availability of specific equipment within their home and backyard, the availability of specific electronic media within their home, available internet connection and the presence of a television in their child's bedroom. Parents reported the presence of specific facilities in their neighbourhood, the amount of time their child spent in a car over the previous week (for weekday and weekend days) and the number of days their child actively travelled around their neighbourhood within the last week. In section 3 (items 19-25) parents reported the type of childcare and any organised activity their child attended in the last week. Finally, parents reported if their child usually consumed meals in front of the television. In section 4 (items 26 -27) parents reported whether they had ever played sport at a competitive level and the nature of this sport.

5.2.4 Statistical analysis

5.2.4.1 Exploratory analysis

Analyses were performed on an intention to treat basis. Full data (parent and child PA and questionnaire) were obtained for 58 families (32 comparison and 26 intervention) and used in subsequent analysis. Reasons for missing data included non-compliance with accelerometer procedure (n=14), withdrawal from the study (n=3) and loss of accelerometers (n=4). Descriptive statistics were calculated to

describe the final sample (Table 5.2). Independent t-tests were conducted to examine differences between participants who were either included or excluded in the PA analyses. The alpha level was set at $p \leq 0.05$.

5.2.4.2 Main analysis – identifying significant predictor variables

A Pearson product moment correlation matrix was generated to assess correlation coefficients between the outcome variables and other confounding variables. Additionally, a stepwise backward regression was performed for each of the outcome variables to determine which variables best predicted the outcome. These data were analysed using PASW Statistics v.18, and the significance level was set at $p \leq 0.05$.

To determine significant predictor variables multi-level modelling was conducted, which was considered the most appropriate technique for nested data (Twisk, 2006). A two-level data structure was used, where children were defined as the first level and school as the second level (Twisk, 2006). Data were analysed using MLwiN v.2.23 software (Centre for Multilevel Modelling, University of Bristol, UK). An association model was used to assess the effects of the predictor variables on the main outcome measures. Variables were added to the model in three stages (Van Sluijs et al., 2005) (1) significant variables identified in the backwards stepwise regression, (2) significant variables identified from the Pearson product moment correlation matrix, and (3) using empirical research to identify potentially confounding variables (Dolinsky et al., 2011, Hinkley et al., 2008, Hinkley et al., 2010). The sequence in which the predictor variables were added to the model can be found in the Table 5.3 and Table 5.4. The effect of the predictor variables on the outcome variable was assessed for significance by comparing the -2 log likelihood

(2*LL) for each model using the Chi-square distribution with 2 degrees of freedom and the Wald statistic. Alpha was set at $p < .05$ for all analyses (Twisk, 2006).

5.2.4.3 Main analysis – testing the intervention effect

Once all significant predictor variables for each of the four outcome variables were identified, the effect of the intervention was analysed using a three-level data structure. The three levels of analysis were time point (level one), child (level 2) and school (level 3). An association model was used to identify the effect of the intervention after being corrected for significant confounding variables. Two analyses were conducted on all four outcome variables (weekday ST and total PA and weekend ST and total PA) to examine the intervention effect over two time points. The first analysis (crude analysis) determined the effect of the intervention over time whilst controlling for baseline ST or total PA, whilst the second analysis (adjusted analysis) determined the intervention effect when the covariates previously identified as significant predictor variables in the association model were added to the model (Twisk, 2006). In addition, potential effect modification was assessed by constructing interaction terms between the intervention group and all covariates. Separate analyses were conducted for weekday and weekend ST and total PA. Regression coefficients in the model were assessed for significance using the Wald statistic (Twisk, 2006). Statistical significance was set at $p < 0.05$, with the exception of $p < 0.1$ which was used for interaction terms.

5.3 Results

5.3.1 Exploratory analysis

Independent samples t-tests revealed no statistically significant differences in ST and total PA between boys and girls, between those who remained in the study and those

who dropped out or between children with complete and incomplete PA data ($p > 0.05$). The accelerometer data showed that boys and girls engaged in 542.1 (64.7) and 545.3 (74.5) minutes of ST during the weekday, respectively and 504.5 (99.1) and 510.4 (45.9) minutes of ST during the weekend, respectively. Boys and girls engaged in 115.9 (21.4) and 110.1 (28.1) minutes of total PA during the weekday, respectively and 107.5 (29.7) and 97.0 (30.6) minutes of total PA during the weekend, respectively. The descriptive data for parents and children at baseline are displayed in Table 5.2. Independent-samples t-tests revealed that there were no significant differences between boys and girls or mothers and fathers in the intervention and comparison groups for age ($p > 0.05$). Ninety-one per cent of the sample was White British.

5.3.2 Main analyses

Table 5.5 shows the effect of the intervention on ST during weekdays and weekend days immediately after the intervention was delivered (10 weeks). A significant intervention effect was found for weekday and weekend day ST. Children in the intervention group participated in 8.76 minutes (CI: -12.32 to -5.2) and 23.11 (CI: -29.17 to -17.06) less ST during weekday and weekend days, respectively. When the correction for potential confounders was performed (adjusted analysis), the analysis revealed that parents participation in sport and child's sex were significant predictors of weekday ST. Further data indicated that children whose parents previously participated in sport engaged in 7.12 minutes less ST (CI: -9.57 to -4.67) than children whose parents were not regular sports participants and girls engaged in 9.48 minutes more ST (CI: 6.37 to 12.59) than boys. The number of television sets in the home, parents achieving the PA recommendations and child's participation in organised sport were significant predictors of weekend ST. Children who had less

than the average number of televisions (3.06) at home accumulated 9.65 minutes less ST (-14.84 to -4.46), while children whose parents achieved the PA recommendations accumulated 11.49 minutes less ST (-13.99 to -8.99) and children who attended organised sport participated in 11.08 minutes less ST (-19.01 to -3.15). All other covariates were not significant predictors of ST; however they did improve the fit of the model and were therefore retained.

Table 5.6 shows the effect of the intervention on total PA during weekdays and weekend days immediately after the intervention was delivered (10 weeks). A significant intervention effect was found for weekday and weekend day total PA. Children in the intervention group participated in 4.70 (CI: 2.96 to 9.44) and 10.24 (CI: 10.24 to 18.08) minutes more PA than children in the comparison group during the weekday and weekend day, respectively. The results indicated that children of parents who participate in sport accumulated 4.54 (CI: 1.32 to 7.13) minutes more total PA than children whose parents do not. Parents who were sufficiently active were significant predictors of weekend total PA; children of parents who were more active participated in 9.08 (CI: 0.05 to 18.11) minutes more total activity than their non-active counterparts. All other covariates were not significant predictors of total PA; however they did improve the fit of the model and were therefore retained.

Potential effect modification resulted in a positive interaction term between the intervention and parents participation in sport ($p<0.10$). There were no other significant interactions (Table 5.7).

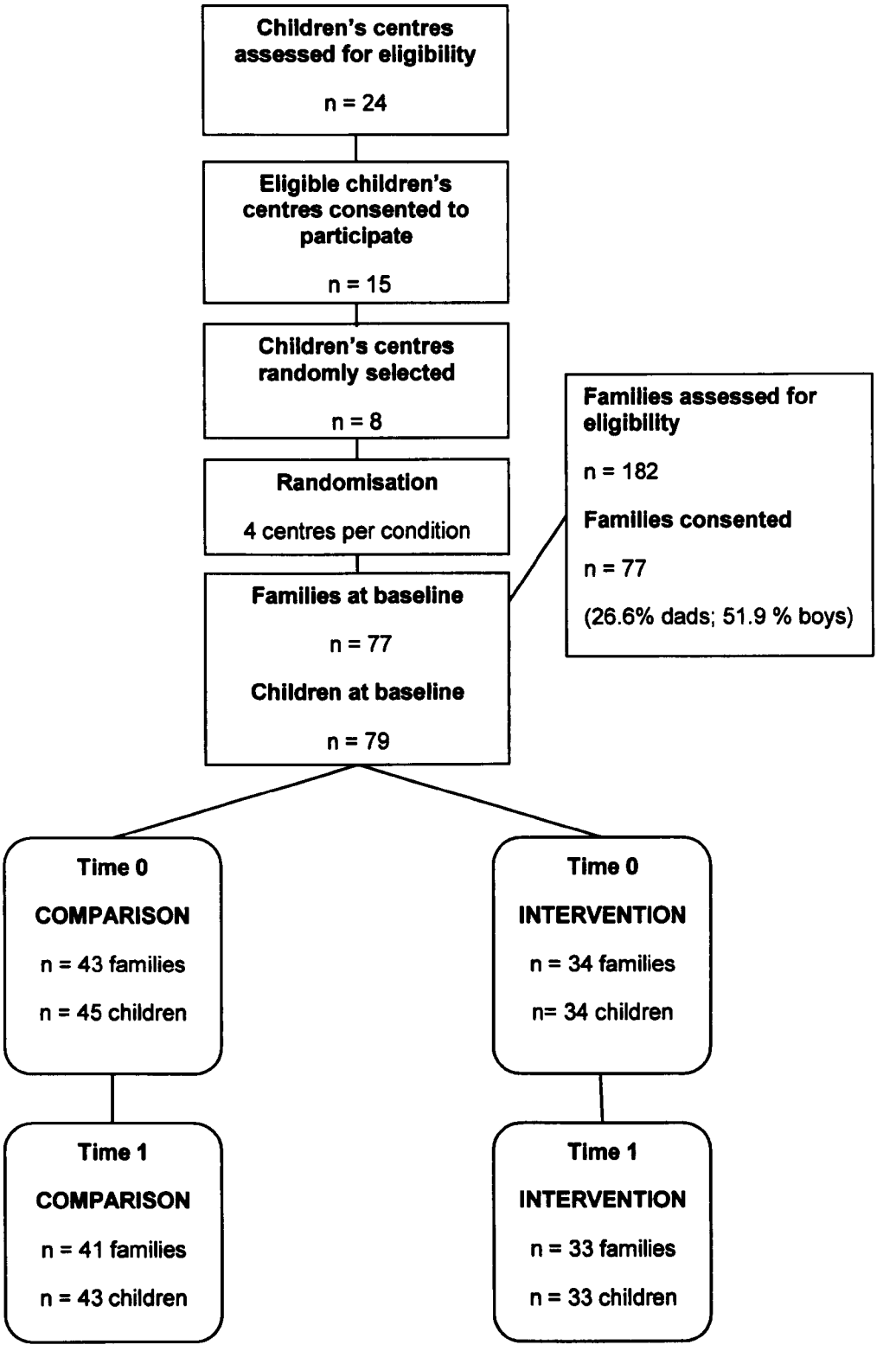

Figure 5.1 Children centre and flow of families through the project (study 3)

Table 5.2 Baseline descriptive data (mean (SD))

Parents	
Age (years)	33.7 (5.3)
% Male	26.6
% white British	91.2
Education	
% High school or less	63.4
% Technical or trade school	3.3
% University	33.3
% Married	70.7%
% achieving PA recommendations*	31.6%
Children	
Age (years)	3.8 (0.6)
% Male	51.9%
% achieving PA recommendations*	23.2 %

* based on whole week physical activity

Table 5.3 Order of predictor variables entered into the sedentary time models

Weekday sedentary time	Weekend sedentary time
Time spent in car during weekend	**Time spent in car during weekend**
Attend organised activities	**Number of TVs at home**
Parent's physical activity	**Parent's physical activity**
Parent's play sport	**Parent's play sport**
Space to ride bike at home	Child's sex
Number of PC's at home	**Number of sibling's**
Neighbourhood natural space	**Child's age**
Child's sex	**Attend organised activities**
Childs age	TV in bedroom
Number of sibling's	Time spent in car during weekday
TV in bedroom	Number of day's active travel per week
Time spent in car during week day	**Type of childcare attended**
Number of day's active travel per week	Eat meals at TV
Type of childcare attended	Parent's sex
Eat meals at TV	Parent's age
Parent's sex	Ethnicity
Parent's age	Parent's highest level of education
Ethnicity	Neighbourhood playground
Parent's highest level of education	Neighbourhood green space
Neighbourhood playground	Neighbourhood park
Neighbourhood green space	Neighbourhood pool
Neighbourhood park	Neighbourhood gym
Neighbourhood pool	Neighbourhood natural space
Neighbourhood gym	Access to play equipment at home
Access to play equipment at home	Space to ride bike at home
Number of TV's at home	Number of PC's at home
Internet access at home	Internet access at home

Significant predictor variables are indicated in bold and were retained for the final association model

Table 5.4 Order of predictor variables entered into the total physical activity time models

Weekday total physical activity	Weekend total physical activity
Child's age	Internet access at home
Ethnicity	Childs age
Parent's physical activity	Ethnicity
Parent's play sport	**Parent's physical activity**
Child's sex	**Parent's play sport**
Type of childcare attended	Child's sex
Space to ride bike at home	Type of childcare attended
Access to play equipment at home	**Space to ride bike at home**
Neighbourhood playground	Access to play equipment at home
Neighbourhood park	Neighbourhood playground
Neighbourhood green space	Neighbourhood park
Neighbourhood pool	Neighbourhood green space
Neighbourhood natural space	Neighbourhood pool
Neighbourhood gym	Neighbourhood natural space
Number of sibling's	Neighbourhood gym
TV in bedroom	Attend organised activities
Number of TVs at home	TV in bedroom
Eat meals at TV	Number of TV's at home
Time spent in car during weekday	**Eat meals at TV**
Time spent in car during weekend	**Time spent in car during weekday**
Number of day's active travel	Time spent in car during weekend
Attend organised activities	Number of day's active travel
Parent's age	Parent's age
Parent's sex	Parent's sex
Parent's level of highest education	Parent's level of highest education
Number of PC's at home	Number of PC's at home
Internet access at home	Number of sibling's

Significant predictor variables are indicated in bold and were retained for the final association model

Table 5.5 Estimated effects of covariate and intervention on sedentary time during the week and weekend days

	Weekday Sedentary Time				Weekend Sedentary Time		
	Model 1	Model 2			Model 1	Model 2	
Correlate	**β (SE)**	**β (SE)**	**95% CI**	**Correlate**	**β (SE)**	**β (SE)**	**95% CI**
Constant	553.32 (6.04)	**569.39 (23.66)**	**529.02 to 615.76**	Constant	517.85 (7.43)	**530.98 (20.45)**	**490.85 to 571.01**
Intervention	-12.86 (8.55)	**-8.76 (1.82)**	**-12.32 to -5.2**	Intervention	-1.82 (1.01)	**-23.11 (3.09)**	**-29.17 to -17.06**
Attend organised activities		-5.67 (10.18)	-25.62 to 14.28	Minutes in car (weekend)		-0.15 (0.18)	-0.5 to 0.53
Parent's play sport		**-7.12 (1.32)**	**-9.57 to -4.67**	Number of TV's at home		**-9.65 (2.65)**	**-14.84 to -4.46**
Space to ride bike at home		-13.72 (16.72)	-46.49 to 19.05	Parent's physical activity		**-11.49 (1.28)**	**-13.99 to -8.99**
Number PC's in home		1.13 (7.39)	-13.25 to 15.61	Parent's play sport		-2.19 (3.14)	-8.34 to 3.96
Child's sex		**9.48 (1.59)**	**6.37 to 12.59**	Child's age		-4.44 (10.74)	-24.49 to 16.61
Child's age		9.01 (11.12)	-12.78 to 30.08	Number of sibling's		-3.31 (10.28)	-23.45 to 16.83
TV in bedroom		12.81 (14.11)	-14.84 to 40.46	Attend organised activities		**-11.08 (4.05)**	**-19.01 to -3.15**
Type of childcare attended		0.80 (2.99)	-4.88 to 6.48	Type of childcare attended		-1.57 (3.60)	-8.62 to 5.48
Neighbourhood playground		34.39 (23.61)	-11.88 to 58.00				
Neighbourhood pool		12.90 (13.47)	-7.5 to 33.3				
Neighbourhood gym		48.85 (51.59)	-52.26 to 149.96				
Play equipment at home		19.10 (17.31)	-14.82 to 53.02				
Number of TV's at home		14.64 (8.05)	-1.13 to 30.41				
Internet at home		25.96 (32.53)	-43.97 to 102.16				
Random				**Random**			
School Level	0.00 (0.00)	32.60 (79.49)		School Level	0.00 (0.00)	28.97 (9.32)	

Child Level	1596.71 (239.36)	639.39 (144.01)	Child Level	1759.70 (287.65)	508.71 (93.23)
Time point level	0.00 (0.00)	0.00 (0.00)	Time point level	0.00 (0.00)	0.00 (0.00)
Deviance	909.009	467.193	Deviance	732.065	303.865

Note: Significant effects are indicated in bold: * P ≤ .05, **P ≤ .01, ***P≤ .001. Reference categories for intervention is comparison; for attend organised activities is no attendance; for parents participate in sport is no participation; for space to ride bike at home is ample space; for sex is boys; for neighbourhood playground is no playground; for neighbourhood pool is no pool; for neighbourhood gym is no gym; for play equipment at home is ample equipment; for internet at home is yes connection in place; for parents achieve physical activity recommendations is not achieved. Number PCs in home
Child's age, number of TV's and PC's at home, type of childcare attended, minutes in car (weekend) and number of siblings are reported as continuous variables where the average is centred around the grand mean (GM). The intervention β value represents the estimated difference in levels of sedentary time for the intervention centres against the comparison centres when all other parameters are included in the final model.
Abbreviations: β = Regression coefficient; SE = Standard Error; CI = Confidence Interval.

Table 5.6 Estimated effects of covariate and intervention on total physical activity during the week and weekend days

	Weekday Total Physical Activity				Weekend Total Physical Activity		
	Model 1	Model 2			Model 1	Model 2	
Correlate	β (SE)	β (SE)	95% CI	Correlate	β (SE)	β (SE)	95% CI
Constant	107.99 (2.98)	**103.45 (8.54)**	**86.71 to 120.18**	Constant	95.57 (3.35)	**78.27 (9.39)**	**59.87 to 96.67**
Intervention	-0.97 (3.95)	**4.70 (0.89)**	**2.96 to 9.44**	Intervention	2.48 (1.52)	**10.24 (4.00)**	**2.4 to 18.08**
Parent's play sport		**4.54 (1.32)**	**1.95 to 7.13**	Parent's physical activity		**9.08 (4.61)**	**0.05 to 18.11**
Type of childcare attended		1.16 (1.21)	-1.21 to 3.53	Parent's play sport		0.81 (4.86)	-8.72 to 10.34
Neighbourhood pool		5.27 (5.64)	-5.78 to 16.32	Space to ride bike at home		-6.81 (5.63)	-12.44 to 4.22
Parent's sex		0.92 (5.54)	-9.93 to 11.77	Eat meals at TV		11.28 (7.51)	-3.43 to 25.99
				Minutes in car (weekday)		-0.06 (0.04)	-0.13 to 0.01
Random				**Random**			
School Level	40.49 (29.79)	36.53 (31.27)		School Level	0.00 (0.00)	371.95 (167.44)	
Child Level	218.44 (35.74)	200.12 (38.16)		Child Level	359.89 (60.40)	125.21 (38.68)	
Time point level	0.00 (0.00)	0.00 (0.00)		Time point level	0.00 (0.00)	0.00 (0.00)	
Deviance	742.666	570.172		Deviance	619.382	295.867	

Note: Significant effects are indicated in bold: * P ≤ .05, **P ≤ .01, ***P≤ .001. Reference categories for intervention is comparison; for parents participate in sport is no participation; for neighbourhood pool is no pool; for parents gender is male; for parents achieve physical activity recommendations is not achieved; for space to ride bike at home is ample space; for eat meals at TV is does not eat at TV. Type of childcare attended and minutes in car (weekday) are reported as continuous variables where the average is centred on the grand mean (GM). The intervention β value represents the estimated difference in levels of sedentary time for the intervention centres against the comparison centres when all other parameters are included in the final model.
Abbreviations: β = Regression coefficient; SE = Standard Error; CI = Confidence Interval.

Table 5.7 Intervention interaction terms with covariates investigating potential effect modification

Interaction term	β	SE	*P*- value
Weekday sedentary time	N/A	N/A	N/A
No significant interactions identified			
Weekend sedentary time	N/A	N/A	N/A
No significant interactions identified			
Weekday total physical activity			
Intervention x parent's play sport	14.23	5.32	0.07 *
Weekend total physical activity	N/A	N/A	N/A
No significant interactions identified			

* $p < 0.10$

5.4 Discussion

The aim of this study was to investigate the effect of a 10-week family focused 'Active Play' intervention on children's weekday and weekend day ST and total PA. Secondary objectives were to investigate the influence of specific confounding variables on children's weekday and weekend day ST and total PA.

Compared with an age-matched comparison group, a family focused intervention delivered in children's centres located in areas of high deprivation resulted in a positive significant intervention effect on children's ST and total PA assessed using accelerometry for weekday and weekend day. The presence of a significant intervention effect on children's ST and PA are similar to the findings from other empirical family focused studies, which have demonstrated significant increases in PA levels (Kriemler et al., 2010, Klohe-Lehman et al., 2007, Manios et al., 1999). Furthermore these results suggest that children in the intervention group engaged in 1.5% and 4.3% less ST during weekdays and weekend days respectively, and 4.5% and 13.1% more total PA during weekdays and weekend days respectively than

children in the comparison group. Of interest is the change in ST and PA from weekdays to weekend days. The results indicate that children in the intervention group participated in 23.1 minutes less ST and 10.2 minutes more total PA than children in the comparison group. If maintained, this equates to approximately 64 hours less ST and 16 hours more total PA over 6 months, which in turn may have positive effects on children's BMI (Mo-suwan et al., 1998), cardio metabolic disease (Sääkslahti et al., 2004) and fundamental movement skills (Reilly et al., 2006). A possible reason for this may be that children were more exposed to support from their parents at the weekend which is positively associated with children's PA at home but not when attending childcare (Loprinzi and Trost, 2010). The positive changes in children's ST and PA suggest that the intervention successfully convinced parents about the importance of PA for their children. Further, our findings confirmed that parents were motivated to encourage their children to spend more time engaging in PA and less time in sedentary behaviours. The intervention influenced factual and direct messages that matched the preferences of parents with young children. The varied conveyance of key messages to parents during the intervention allowed for differences between parents' knowledge base and their ability to process information e.g. through practical tasks, group discussion, supplementary information and text alerts (De Bock et al., 2010).

Compared with other interventions varying in duration from six months to three years (Kriemler et al., 2010, Puder et al., 2011, Sääkslahti et al., 2004, McGarvey et al., 2004, Anand et al., 2007), this intervention was relatively short in duration, with contact sessions occurring every other week. The significant reduction in ST and increase in total PA may be attributed to the intense delivery style, continual reinforcement of key messages and active involvement of parents over the 10 weeks

(Manios et al., 2002, Kriemler et al., 2010, Sääkslahti et al., 2004). Parents and children received high exposure (Nixon et al., 2012) to the intervention, for example both participating in the Active Play sessions together, which has been found to positively affect changes in behaviour over time (Adams et al., 2009, Fitzgibbon et al., 2006).

To maximise the chances of a long term intervention effect we employed a number of behaviour change processes and techniques. Similar to other studies (Kriemler et al., 2010), these included building self-efficacy by setting home activities and providing performance feedback, identifying and motivating readiness to change by consistently providing general information on the importance of PA for young children. Follow up prompts were also used in the prevention and management of relapse, this included sending text alerts with key messages relating to home-based activity. Parents were asked to log their home activity progress in the "Move It, Snap It, Log It" diary. Anecdotal evidence at post-intervention implied that parents had increased their awareness of the importance of PA and made behavioural changes. While this is a promising indicator of the intervention effect, this information told us little about the short or long-term changes made by the families and whether these behaviours had become habitual (Wood et al., 2002). Our intervention also placed a strong emphasis on parental role-modelling, with parents encouraged to join in the active play sessions; complete the home activity diary with their child and attend the end of intervention celebration event together.

A review of the correlates of ST (Hinkley et al., 2010) and PA (Hinkley et al., 2008) in preschool children highlight how these behaviours are influenced by individual and environmental factors. In this study, a number of confounders for weekday and weekend day ST and total PA were identified. These included parent's participation

in sport and their PA levels, child's sex, availability of media in the home and attendance at organised activities. Potential effect modification was assessed for all covariates in order to investigate whether the intervention effect was different for different subgroups (Twisk, 2006). The results revealed a significant interaction for parent's participation in sport, but not for any other variables. The intervention effect was stronger for weekday PA for children whose parents participated in sport. This finding may be related to the positive relationship which exists between increased child activity and parents own activity levels as well as their support for their child's PA (Loprinzi and Trost, 2010).

Gustafson and colleagues (Gustafson and Rhodes, 2006) conducted a review on the parental correlates of children's PA and despite a lack of existing studies to draw firm conclusions from; unanimous results supported the importance of parents' PA on their children's activity levels. In the current study parent's participation in sport and PA were positively associated with children's PA levels and ST. Few studies have investigated the relationship between parent and child activity levels among children in this age group using an objective measure of PA; research using self-report as a measure of PA for parents report conflicting results ranging from no relationship with accelerometer-derived PA (Trost et al., 2003) to positive results with directly observed PA (Spurrier et al., 2008, Sallis et al., 1988). Other studies which have objectively monitored parent's PA have also reported a significant positive association between parent and child levels of activity (Oliver et al., 2010, Moore et al., 1991). This study adds objective evidence for a relationship between parent's activity and child's ST, highlighting the importance of parental involvement in preschool PA intervention design and promotion. It is difficult to state the precise

nature of parental involvement required. Our results suggest that parents should be encouraged to be physically active themselves to stimulate increased child PA.

Previous family focused studies have evaluated the effects that enable children to be active, including providing a family orientated health education programme, as well as the provision of extra PA (Hesketh and Campbell, 2010). While some empirical research has compared intervention effects between boys and girls activity, to the best of the authors knowledge, no family focused intervention studies have considered the effect of the intervention effect or the differences in the intervention effect when individual and environmental factors have been controlled for.

Consistent with most other studies boys accumulated less ST than girls during weekdays (Dolinsky et al., 2011). In contrast to our findings, a review of ST correlates concluded that there was an indeterminate association between child's sex and sedentary behaviour as measured by accelerometry (Hinkley et al., 2010). The contrasting findings are perhaps due to the multi-dimensional nature of children's sedentary behaviours and the lack of consistent evidence surrounding ST and other potential correlates (Hinkley et al., 2010). Other studies investigating the relationship between child's sex and ST have found inconsistent results (Hinkley et al., 2008, Hannon and Brown, 2008, Montgomery et al., 2004). We found no gender differences for PA; however we did not investigate intensity specific PA such as moderate and vigorous levels. The number of television sets in the child's home significantly contributed to children's ST, no other studies report the number of televisions in the home, however television viewing and the presence of a television set in the home have been the most commonly examined sedentary behaviour, but a lack of consistency within studies make it difficult to draw robust conclusions about associations (Hinkley et al., 2010). Lastly, children who attended organised activities

accumulated less ST at the weekend, this maybe also related to parents support for PA and their likelihood to facilitate engagement by participation in active play at home, by playing with their child, providing transportation to parks and other activity-related facilities, and providing reinforcement for PA participation (Loprinzi and Trost, 2010).

Our study has several unique elements. First, our intervention moves beyond an educational focus by fostering a "learning by doing" approach evident within the child and parent Active Play sessions. Second, we have designed and implemented a multi-component intervention that incorporates an existing Active Play programme to promote PA in this age group. Third, this intervention was inexpensive and relatively straight forward to implement costing approximately £4.12 per family per week to deliver. As a fourth element we use a multi-pronged strategy to change behaviours. We chose to broaden our focus by including lifestyle-related activities (e.g. encouraging active travel) that could be practiced daily. We also included 'non-sport related' forms of PA (e.g. providing an interactive dance resource and a city map of green spaces and playgrounds), which may appeal to the broader preschool population and their families. Finally, the use of an objective measure of ST and PA as well as the use of multilevel analyses adds to the rigour of our methodology.

Despite its strengths, we acknowledge the limitations of our study design. Our intervention does not target all levels of the socio-ecological system, in which preschoolers' behaviours develop. For example, the intervention has not been developed with teachers and childcare staff in mind and is not anchored within the early year's foundation stage national curriculum. Previous research suggests that this might hinder the readiness of teachers to take ownership in the intervention change process (Cargo and Mercer, 2008). Second, while a user group was formed

and its members consulted individually on the intervention content initially, they were not consulted on the planning of the intervention. Therefore, our study cannot purely be characterised as community-based research. However, a systematic review of community-based research found only 4 of 60 studies demonstrating community participation across all research phases (Viswanathan et al., 2004). A further limitation of our intervention is that due to time restraints the initial set of ideas was not refined and discussed with input from parents of children enrolled at the intervention preschools, but rather from parents involved in the user group. Our intervention required a degree of parental time commitment at a level that might exceed parental resources. This may, in turn, threaten sustainability through fluctuations in parental time availability and as children progress from voluntary childcare to mandatory formal preschool over the next 1-2 years. Future interventions should consider including preschool teachers in elements of interventions to assist with the adoption of key messages thus limiting potential effects on the changing school process. Additionally, there was a low number of fathers involved in the intervention, future studies should make an effort to involve more fathers given how influential their parenting styles can be on preschool children's makers of health (Wake et al., 2007). The inclusion of a large number of predictor variables in analyses increases the risk of a significant finding occurring simply due to chance, therefore any significant results from these analyses should be treated with caution. Lastly, the absence of a long term follow-up does not allow us to make concrete assumptions on the sustainability of the intervention.

5.5 Conclusion and future research

This investigation contributed to the dearth of empirical literature investigating the short-term effects of a family focused intervention on preschool children's ST and

total PA. Our findings suggest that the effect of the intervention was significant in decreasing children's ST and increasing their PA. These findings are important from a health promotion perspective as they reiterate the importance of a family approach, by directly involving parents in the intervention programme. In this study, a significant interaction term indicated that the effects of the intervention were stronger for children whose parents participated in sport. This study also identified a number of confounding variables which have a significant effect on children's ST and total PA, with the most frequent confounding variable being parents own PA levels and their participation in sport. From an ecological perspective, the results suggest that children whose parents are sufficiently active and participate in sport, those with fewer televisions at home and attend organised activities are the children who are most likely to habitually participate in health enhancing PA. There is need to evaluate the longer-term effects of family focused PA interventions in this age group.

Thesis Study Map

Study	Objectives
Study 1: Patterns of objectively measured moderate-to-vigorous physical activity in preschool children	Objectives: • To assess within-day variability of objectively measured MVPA during weekdays and weekend days among preschool children. • To examine differences in these patterns by sex and enrolment at school. Key findings: • Children who were enrolled at preschool for a full day were less active than children enrolled for a half day. • Boys were significantly more active than girls. • After school hours were significantly less active. • Patterns of MVPA during the weekend were less variable.
Study 2: Effect of a school-based Active Play intervention on sedentary time and physical activity in preschool children	Objectives: • To investigate the effect of a curricular "Active Play" intervention on children's sedentary and physical activity behaviours. • To investigate the influence of specific confounding variables on sedentary time and physical activity. Key findings: • A 6-week school-based Active Play intervention had no effect on ST or PA at 6-weeks or 6-months. • Children in the intervention sessions engaged in significantly more MVPA than children in the comparison sessions. • Boys engaged in more ST and LPA than girls. • Children who were enrolled at preschool for half a day were significantly more active than children who were enrolled for a full day.
Study 3: Effect of a family focused Active Play intervention on sedentary time and physical activity in preschool children	Objectives: • To investigate the effect of a family focused "Active Play" intervention on children's weekday and weekend day ST and total PA. • To investigate the influence of mediating and moderating variables on ST and total PA. Key findings: • A 10-week family-focused Active Play intervention had positive effects on ST and total PA. • Intervention children engaged in 1.5% and 4.3% less sedentary time during weekdays and weekend days, respectively, than children in the comparison group. • Intervention children engaged in 4.5% and 13.1% more total PA during weekdays and weekend days, respectively, than children in the comparison group. • Parent's participation in sport and their PA levels, child's sex, availability of media in the home and attendance at organised activities were significant predictors of ST and total PA in this age group.

Chapter 6

Synthesis

6.1 Introduction

There is mounting evidence that PA levels across the life course are insufficient. Insufficient levels of PA lead to earlier mortality and increased morbidity. The focus of PA research is to reduce morbidity and increase age at mortality and to intervene as soon as is practically possible. Children of preschool age are insufficiently active and therefore the biggest impact is to develop effective PA interventions at an early age. Whilst a number of reviews have demonstrated an improved understanding of PA promotion in young children significant gaps still exist in the extant literature. These gaps include robust data regarding the patterns of PA in UK preschool children. Furthermore, there is little evidence documenting the effectiveness of PA interventions in preschool children. The aim of this PhD thesis was to assess the patterns of physical activity in preschool children and evaluate the effectiveness of two different types of Active Play interventions on preschool children's ST and PA. This was achieved through a series of empirical studies, each informed by the findings of the previous study. Study 1 aimed to assess within-day variability of objectively measured MVPA during weekdays and weekend days among preschool children. A secondary aim of this study was to examine differences in these patterns by sex and enrolment at school. Key findings from this study concluded that children enrolled at preschool for a half day engaged in more MVPA than children enrolled at preschool for a full day. Furthermore, boys who attended school for a half day engaged in significantly more MVPA than any other group. From this study it is recommedned that future interventions should target the afterschool period and weekends as these were the segments of the week which were prone to low levels of PA. Study 2 aimed to investigate the effect of a curricular Active Play intervention on children's ST and PA, and investigate the influence of specific confounding

variables on ST and PA. The findings from this study revealed that a 6-week school-based Active Play intervention was not sufficient enough to decrease ST and increase PA at post intervention and 6-month follow up. However, a promising result from this study was the intensity level of the Active Play intervention group sessions in which the children engaged in significantly more MVPA than the children in the comparison group. The findings from this study also revealed that sex and school enrolment were significant predictors of PA in this age group, whereby boys engaged in less ST and more LPA than girls. Additionally, children who were enrolled at preschool for a half day were significantly more active than their full day counterparts. Following this study it was recommended that future interventions should directly engage parents as agents of change. The final study (study 3) aimed to investigate the effect of a family focused Active Play intervention on children's weekday and weekend day ST and total PA, and investigate the influence of mediating and moderating variables on ST and total PA. This study revealed that a 10-week family focused Active Play intervention prompted a significant decrease in ST and increase in total PA at post intervention, suggesting that this type of intervention promoted short term changes in children's PA behaviours. Overall, the results suggest that including parents in intervention programmes is an effective way to improve PA in this age group. The findings from this study recommended that preschool activity interventions should engage parents; however a medium to long-term follow up should be implemented to assess the effects of such interventions over time.

The synthesis that follows will discuss the overarching findings and their implications for practice, whilst outlining the limitations of the research and

considering some of the recommendations for future research. The synthesis will finish by discussing the challenges of measuring PA in the preschool populations.

6.2 Key findings and implications for practice and research

A major theme within the thesis was the assessment of patterns of MVPA in preschool children. Identifying patterns of PA allowed for informed, targeted interventions to be designed and delivered. Additionally, investigating the patterns of PA in 3-5 year old UK children provided an insight into a day in the life of these children, an area of PA research which has not been investigated prior to this study. Interestingly, study 1 revealed that children who attended preschool for a half day accumulated more MVPA than their counterparts who attended preschool for the full day. This finding suggests that the structured school environment has already impacted on preschool children's PA levels, a finding which informed the development of the school based intervention (study 2). Interestingly, the most and least active children had almost identical daily activity patterns, albeit at different levels. Of particular note is the apparent importance during weekdays of the period from the end of preschool to bedtime (15:00h onwards). It is during this period that the active children seem to be substantially more active, particularly the boys. At the weekends, inactive children exhibit extremely flat activity profiles min throughout the day. Conversely, the more active children show peaks of activity during late morning and mid-afternoon.

When investigating the patterns of PA (study 1), MVPA was used as the main outcome measure. At the time of analysis no specific PA guidelines existed for preschool children and the majority of literature assessing the prevalence of PA and the health related benefits of PA in this age group used the guideline of 60 mins.d^{-1} of MVPA as a comparison. This study in the thesis is therefore limited by the

investigation of specific intensities (MVPA) rather than total PA (LPA, MPA and VPA). Future studies should acknowledge the recent preschool PA guidelines (Department of Health, 2011) and investigate total PA rather than intensity specific PA. This would advance the field of PA research in this age group, particularly if all countries adhered to the same PA guidelines and if all research groups agreed on investigating the same outcome measure, thus making comparisons across countries and studies more straight-forward.

After investigating the PA patterns of preschool children, this thesis investigated whether two different types of Active Play interventions reduced ST and increased PA. Active play was used as a vehicle for PA promotion as this type of play generally peaks during the preschool years (Pellegrini and Smith, 1998). Additionally, if delivered at a moderate-vigorous intensity, active play has the potential to positively impact on children's health (Simons-Morton et al., 1990b).

Before discussing the intervention studies it is important to note that the studies were based on a socio-ecological model (Bronfenbrenner, 1979). The model provided a framework which comprised of complex *systems* of relationships affected by multiple levels of the surrounding environment. In the curricular based intervention (study 2), the child's microsystem was influenced, in that the individual child was provided with an opportunity to participate in structured Active Play sessions and their class teacher undertook Active Play training through observing, participating and co-delivering the sessions. In the family focused intervention (study 3), the child's microsystem, mesosystem and exosystem were influenced. This included involving the child's immediate family, the children centre or school they attended and elements of the community in which they lived. In both interventions the

intervention effect on habitual ST and PA were objectively measured using uniaxial accelerometers.

In all of the studies, characteristics about the child, their parents, their family structure and their home and community environment were measured. Study 1 and 2 used a combination of ALSPAC questionnaires, while study 3 used a shorter, version of the Pre-PAQ. These measures provided an indication of the mediators and moderators of ST and PA in this age group, and provided a rationale for targeting them in the intervention studies. This linked to the socio-ecological model as they helped identify the layers of influence which interventions should target.

The overarching theme in the thesis was the effect of two different types of Active Play interventions on ST and PA in preschool children. The cross-sectional study (study 1) revealed that boys were more active than girls and children who spent less time at preschool were more active than children who attended preschool for the whole day, although specific groups of children were identified as being more active than others, all groups were insufficiently active to benefit their health. The study investigating patterns of PA also revealed segments of the week prone to lower levels of PA, specifically class time, the afterschool period and weekends. Consequently, this study recommended that interventions should target the school and home environment.

In response to the recommendations from study 1, the first intervention (study 2) targeted the school environment. The impact of providing teachers with Active Play training led by Active Play specialists did not significantly change children's habitual ST and PA. However, when compared to the comparison teacher-led sessions, children within the intervention specialist-led Active Play sessions engaged

in a significantly higher percentage of MVPA during the same amount of time. This finding enforces the value of utilising trained Active Play specialists and supports the need for improved teacher training in terms of PA and active play promotion within preschool settings. Based on what is known about the impact of training for preschool setting staff on children's PA and the need for more training opportunities expressed by childcare providers, a recommendation on training for health and education professionals on ways to increase children's PA is appropriate (British Heart Foundation National Centre, 2011). Furthermore, this study was limited by an insufficient amount of qualitative evidence. Future research should incorporate a detailed assessment of the process of the intervention in an attempt to aid researchers understanding of what worked well and what did not, and in what contexts. Combining different qualitative and quantitative research methods to assess the PA levels within the Active Play session would have helped the researchers understand why the children in the intervention sessions engaged in more MVPA than the children in the comparison sessions. This is important for policy development at a school and children's centre level as well as at a local authority level. Moreover, in terms of translational research, it is essential that the context of change is understood to aid the translation of key message to practitioners working in the area of early years PA promotion.

Similar to the findings in study 1, children in study 2 who were enrolled at school for a half day engaged in more MVPA than their full day counterparts. This consistent finding is worrying seeing as a growing number of young children spend substantial amounts of time in childcare and early education programmes and infers that the 6 hour school day at this age can have a negative impact on children's PA. Returning to the socio-ecological model used in this thesis, which proposes that preschool

children's immediate family are the most influential layer in their life during these developmental years raises a question regarding how many hours preschool children should be spending in a childcare environment, away from their parents influence. This finding from study 1 and 2 raises a concern about whether sending a child to preschool for a full day may have a negative impact on their health. Future research should investigate this finding in more depth.

For practical reasons and to fit with the school term the intervention in study 2 was delivered each week for 6 weeks. This was a short intervention period and likely responsible for the lack of change in habitual ST and PA, however it was practical from a schools perspective and a research perspective. If the intervention programme was any longer, monitoring of PA would have commenced after the Christmas break and any potential effect on ST and PA were likely to be lost. Regarding logistics of delivering the intervention, one teacher commented that '*6-weeks was good, if it was any longer we would have had trouble with the hall and even still it was difficult sorting out times and space availability, so if it [the sessions] ran across two terms, I don't think we could have took part in the programme*'. In relation to lesson planning, one teacher stated '*this length of time was perfect, as a teacher I work in 6 week blocks, all of my planning concentrates on the 6-week cycle, I think teachers are programmed that way – so for that reason, Active Play was a great length*'. Although this design was practical, it was not effective and did not achieve its primary aim. Moving forward, future research should investigate the feasibility of other intervention designs e.g. an intense intervention over a week or an intervention which is longer in duration, but is delivered every other week, scheduling the non-contact week around half-term holidays.

The recommendations from Study 2 informed the design of Study 3. In Study 2 a 6-week school-based Active Play intervention was not sufficient to decrease ST and increase PA; however PA data from the Active Play sessions revealed that the intervention was intense enough. Based on Bronfenbrenners socio-ecological model (Bronfenbrenner, 1979), the new UK PA guidelines for preschool children, and informed by findings from previous research (Sääkslahti et al., 2004, Oliver et al., 2010, Loprinzi and Trost, 2010), a 10-week parent focused Active Play intervention was designed and implemented which aimed to increase total PA and decrease ST. As role models and providers of opportunities to be active, parents can shape children's PA behaviours in powerful ways (Ventura and Birch, 2008). A period of ten weeks was chosen for the intervention as it coincided with the Autumn-Winter school term and feedback from the user-group agreed that 10-weeks, with contact sessions every other week, was deemed appropriate to run a programme. At post-intervention, one parent stated: "*The 10 week programme really suited us, if the sessions were every week it would have been too much, having the extra information; the multi skills manual and the games ideas were enough to allow us to practice at home*". The intervention aimed to influence children's total PA and time spent in sedentary behaviour. This was achieved by manipulating known mediators and moderators in the child's social environment. The study found that the intervention, consisting of Active Play sessions for children and their parents and parent educational workshops, was effective in increasing children's total PA and decreasing ST at post-test. This study also identified a number of confounders for weekday and weekend day ST and total PA, with the most commonly reported confounding variable associated with parents PA levels or their participation in sport. This is an important finding, consistent with Oliver et al. 2010 and supports the

inclusion of parents in future interventions aimed at changing preschool children's PA behaviours. This study is limited by a number of factors. Firstly, this intervention did not target all levels of the socio-ecological system. The intervention was not developed with teachers and children centre staff in mind, which may threaten the sustainability of the intervention. By involving staff and adopting a family-partnership model, it allows those practitioners to work more effectively and confidently with parents and young families. Within this model staff are encouraged to reflect on their practice and, following from the extra knowledge, ideas and skills gained during the intervention training, to identify any changes that they recognise as being necessary within their setting. Additionally, due to time restraints, a long term follow-up was not included in the study design. Moving forward, a medium (6-month) to long-term (1 year) follow up is recommended to assess the effects of the intervention over time.

Alongside rigorous implementation of the intervention, the inclusion of parents in this study was a key element of short-term success. Adults control where and how children under the age of 5 spend their time. The decisions adults make influence the variety, frequency, and intensity of children's movement experiences and thus their motor development, energy expenditure, and body weight. For example, whether a preschooler at home spends time watching television or playing outdoors may have implications for that child's gross motor development, movement, and energy expenditure. Thus it is the cumulative impact of decisions made by adults that can shape the development of the bodies and minds of young children. During the early years of a child's life there are many adults who make decisions surrounding the activities that preschool children participate in e.g. parents, teachers, play practitioners, children centre staff, etc. However, it is the parents (or guardians) who

have the greatest influence primarily because children of this age spend the majority of their time in their parents care, hence the inclusion of them in study 3 as a key agent of change. Therefore, how children spend time with their parents and the nature of the physical environment in the home are two key leverage points for encouraging a healthy, active lifestyle from birth to the age of 5. Parents establish household rules and establish social boundaries in these two areas. Therefore, for recommendations and guidelines to affect these areas, they must reach parents. Parents will inevitably seek advice on raising their children from who they trust. Outside the confines of friends and family, the professionals they often trust include health care providers, childcare providers and early childhood educators. These professionals function within institutions, programs and professional organisations that can develop effective practice and policy that influence the content and frequency of professional's communication with parents on a number of issues affecting children's PA. With this in mind, combining intervention elements from study 2 and study 3 will have the optimal chance of success at changing children's ST and PA. For example, developing an intervention combining all of the following elements ensures that all levels of the child's socio-ecological system are influenced thus providing the best opportunity for change; educating staff within childcare and educational settings about how to effectively deliver PA to preschool children, educating parents about the benefits of PA through the conveyance of key messages and how to facilitate PA in the home, providing active play for children, parents and childcare staff and at the end of the intervention providing outlets to PA opportunities within the community. Future studies should also incorporate a detailed process evaluation into their study design, in order to identify which factors contribute to the intervention succeeding or failing.

It is recommended that parents should be aided in their efforts to decrease ST and increase total PA of their children by the professionals from whom they already seek advice about parenting and through current, popular mediums of communication e.g. social media. For parents to be receptive to this advice, they must feel encouraged by these professionals, and the advice must be practical and compatible with individual parent beliefs, which coincides with the theory of the socio-ecological framework. Messages about PA and sedentary behaviour must be consistent across settings – from the GP practice, to the government guidelines, to the children's centre and education provider, this prevents parents from feeling confused about what they should be doing with their children. For example, one method of conveying key messages which worked well within study 3 was the use of text messages. Text messages were used throughout the intervention to reinforce key messages, remind parents to complete their home activity, fill out their log books, and to remind them about the time and place of their next Active Play session. Families also received text messages on a daily basis during the activity monitoring phase reminding them to wear their monitor on that day. These text messages were well received by parents and should be used in future studies to aid compliance to the intervention and measurement protocol.

In the field of children's PA research, it is hypothesised that social-level factors, such as those from family, peers, schools, and neighborhoods, interact with individual-level factors to determine PA behaviour. For this reason, the intervention studies within this thesis were underpinned by a socio-ecological model, which specifies that personal and environmental factors interact to influence health behaviour on many different levels. Despite increased recognition in recent years of the potentially important role of social environmental factors on PA, as well as the

potential interactive effects of these factors with other psychosocial variables (Duncan et al., 2002, Giles-Corti et al., 2003) few studies have systematically examined the effects of social environmental influences on youth PA. To address this gap in the literature, both intervention studies within this thesis examined the intervention effect on the primary outcome variable using multilevel modeling. This was an appropriate technique to use as children in both studies were nested within preschools or children's centres, and therefore a multilevel structure existed. Multilevel modeling allowed for the data to be simultaneously analysed from different levels of the social hierarchy, in essence this was a repeated measures within the children, children within classes or families and classes or families within preschools or children's centres. This technique allowed for the data to be analysed in a more technically appropriate manner compared to traditional single level methods e.g. general linear models, and to increase the complexity and contextual richness of research questions from both intervention studies. Moreover, this analysis technique is noted as being robust against missing data points (Quené and van den Bergh, 2004). Studies should continue to apply this method of data analyses as this approach is likely to shed light on the influences of ST and PA at different levels or within different contexts, which can inform the development of practical and effective interventions within different contexts and at multiple levels of the social hierarchy.

6.3 Measuring and analysing PA and ST in preschool children

The decision to assess PA and ST using hip-mounted Actigraph accelerometers in each of the 3 studies was supported by their previous validation for measuring free-living PA in preschool children (Fairweather et al., 1999, Sirard, 2005). Additionally, accelerometers allow for an objective measurement of movement and

lend themselves to the sporadic and intermittent nature of young children's PA. In all studies, accelerometers were programmed to monitor PA using a short epoch length (5 seconds), as shorter monitoring time periods may provide a more precise record of the transient nature of preschool children's PA and more accurately detect short bouts of children's PA (Baquet et al., 2007, Cliff et al., 2009a). The use of accelerometers was met with resistance from some parents and teachers during the initial information sessions. Some parents expressed concern that their child would not wear the accelerometer for the whole day or that the elastic belt would be uncomfortable and restrict the child from playing freely. Teachers expressed concerns about loss or potential mix-up of accelerometers among children. Whilst these are all valid concerns, every effort was made by the research team to ensure the parent and child were given enough time to familiarise themselves with the accelerometer and measurement protocol. In terms of loss or potential mix-up, parents and teachers were made aware of how important the devices were to the success of the research project, but were never made feel uncomfortable about what would happen if an accelerometer was misplaced. The apprehension surrounding the accelerometers is likely one of the reasons for the low response rate in both of the intervention studies (<40%). Going forward, future studies should develop recruitment strategies which attempt to maximise the number of families participating in the research programme. Effective recruitment strategies should be shared within the literature to aid other researchers when working with similar populations. Albeit noted as a valid and reliable way monitor PA in this age group. The studies within this thesis are limited by the use of a uniaxial, non-waterproof accelerometer, as levels of PA are likely to be underreported given the types of PA that preschool children participate in, which uniaxial monitors are unable to detect

(e.g. swimming, riding a bike, digging in a sand pit or pushing a doll's pram). If possible, future studies should use omni-directional, waterproof accelerometers which are likely to capture more PA in this population (e.g. Actigraph GT3X+).

The same PA intensity cut-points (Sirard, 2005) were utilised across all studies to ensure consistency and aid comparisons. These cut-points were chosen as they were the only age specific thresholds available and as recruitment was across the preschool age range (3-5), these were deemed the most appropriate. However, there are a number of contentious issues relating to how best to analyse accelerometer data, which make comparisons across studies difficult (Masse et al., 2005). In particular the identification of appropriate cut-off points for PA classifications is yet to be determined for young children (Cliff et al., 2009b, Penpraze et al., 2006). Further, the range of thresholds has influenced the understanding of the dose-response relationship between PA and health outcomes as well as the effectiveness of interventions (Corder et al., 2008).

An important issue relating to the measurement of PA data was encountered within this thesis. For a day to be considered as a valid measurement day, researchers typically set a minimum wear time for which the accelerometer must be worn. In the literature, this ranges from 3 to 10 hours.day^{-1} (Penpraze et al., 2006). If above the minimum wear time the day is included in the analysis. Within this thesis however, a alternative different approach was used. The minimum wear time was calculated by defining 80% of the total length of time during which 70% of the sample wore the accelerometer (Catellier et al., 2005). This was calculated separately for weekdays and weekend days, and each of the days were assessed individually for acceptable wear time. By using this approach, the number of children included in the analyses was maximised. Within this thesis the minimum wear time varied from 541 to 623

mins.day^{-1} with the baseline data collection phase always resulting in higher wear times, possibly due to the novelty effect of wearing the accelerometer for the first time. This was likely the case in study 2, where the participants wore the accelerometer at 3 time points. Feedback from parents suggested that 7 days monitoring at 3 time points within a 6 month period was a big commitment, which may explain the decrease in wear time across time points. Although we adjusted for wear time within the analysis to control for the influence of longer wear times on ST and PA, future studies should investigate the influence of varying accepted wear times (e.g. 9,10,11 hours) on children's ST and PA levels. Further, decision rules used in data reduction should be explicitly described by researchers, and attempts should be made to standardise criteria, based on the available evidence, in order to allow comparison across studies. By agreeing on a minimum wear time, researchers will be able to advise parents on how long their child should aim to wear the accelerometer for each day, which in turn may aid compliance during data collection and remove some reservations parents may have with regard to their child taking part in a research project.

6.4 Recommendations for practice and research

Based on the findings from this thesis, the practical implications are as follows:

- Centre staff provide opportunities for light, moderate, and vigorous physical activity for at least 15 minutes per hour while children are in care;
- Centre staff provide daily outdoor time for physical activity when possible;
- Provide a combination of developmentally appropriate structured and unstructured physical activity experiences

- Centre staff should act as positive role models by participating in physical activity with children;
- Centre staff should integrate physical activity into activities designed to promote children's cognitive and social development;
- Centre staff should provide an outdoor environment with a variety of portable play equipment, a secure perimeter, some shade, natural elements, an open grassy area, varying surfaces and terrain, and adequate space per child;
- Centre staff should provide an indoor environment with a variety of portable play equipment and adequate space per child;
- Centre staff should provide opportunities for children with disabilities to be physically active, including equipment that meets the current standards for accessible design under the Special Educational Needs and Disabilities Act 2001;
- Centre staff should avoid punishing children for being physically active;
- Centre staff should avoid withholding physical activity as punishment;
- Centre staff should implement activities for preschoolers that limit sitting to no more than 30 minutes at a time; and
- Parents should limit the use of push-chairs for preschoolers and use only when necessary.
- Childcare regulatory agencies should encourage childcare and early childhood educators to seek consultation on an annual basis from an expert in childhood physical activity;
- Childcare regulatory agencies requiring childcare providers and early childhood educators should be trained in ways to encourage physical activity

and decrease sedentary behaviour in young children through certification and continuing education; and

- National organisations that provide certification and continuing education should include content on how to counsel parents about children's physical activity and sedentary behaviours.

Based on the findings from this thesis, the research implications are as follows:

- Incorporate a long-term follow-up to assess the sustainability of interventions;
- Identify key behavioural settings for promoting physical activity in young children;
- Investigate the effectiveness, feasibility and sustainability of structured physical activity programmes led by physical education specialists or community-based physical activity providers;
- Investigate ways in which childcare and education providers can engage and motivate parents and other caregivers to promote and support physical activity at home;
- Work with families to identify the most appropriate strategies to recruit, engage and improve family lifestyle behaviors
- Identify and address reasons for low father participation in physical activity interventions;
- Identify modifiable factors (e.g. parenting habits; environmental factors such as the design of childcare facilities) to help inform intervention design; and
- Investigate non-modifiable factors (e.g. age and gender) to help inform how to 'target' interventions.

6.5 Conclusion

A major theme within the thesis was the assessment of patterns of MVPA in preschool children. Identifying patterns of PA allowed for informed, targeted interventions to be designed and delivered. Additionally, investigating the patterns of PA in 3-5 year old UK children provided an insight into a day in the life of these children, an area of PA research which has not been investigated prior to this study. Interestingly, study 1 revealed that children who attended preschool for a half day accumulated more MVPA than their counterparts who attended preschool for the full day. This finding suggests that the structured school environment has already impacted on preschool children's PA levels, a finding which informed the development of the school based intervention (study 2). Children spend a large proportion of their day at school with their class teachers; therefore a school-based intervention was subsequently implemented. Interestingly, consistent with the findings from study 1, this study also identified children who attended school for a half day were more active than children who attended for a full day.

When investigating the patterns of PA (study 1), MVPA was used as the main outcome measure. At the time of analysis no specific PA guidelines existed for preschool children and the majority of literature assessing the prevalence of PA and the health related benefits of PA in this age group used the guideline of 60 mins.d^{-1} of MVPA as a comparison. The study in this thesis is therefore limited by the investigation of specific intensities (MVPA) rather than total PA (LPA, MPA and VPA). Future studies should acknowledge the recent preschool PA guidelines (Department of Health, 2011) and investigate total PA rather than intensity specific PA. This would advance the field of PA research in this age group, particularly if all countries adhered to the same PA guidelines and if all research groups agreed on

investigating the same outcome measure, thus making comparisons across countries and studies more straight-forward.

Chapter 7

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Appendix 1

Study Related Documents

Participant information sheet and parental consent form (Study 1 and Study 2)

LIVERPOOL SportsLinx
Putting Children First!

liverpool JMU

School of Sport and Exercise Sciences
Henry Cotton Building
15-21 Webster St
Liverpool, L3 2ET

Dear parent/carer/guardian,

At Liverpool John Moores University (LJMU) we are doing some research into physically active play in children aged 3-5 years. We are focusing on the SportsLinx 6 week Active Play programme, which has been delivered in many children centres, nurseries and early years foundation stage settings around Liverpool for approximately 3 years. The research project will begin this Spring/ Summer and we are writing to ask whether you and your child may be interested in taking part.

The project is looking to see how physically active play affects the physical activity levels, skill ability, behaviour preferences and psychological well being of children. The project will require children to take part in a 6 week Active Play programme inside of school time; the Active Play sessions will take the place of your child's usual physical activity sessions. During this time, we will ask them to take part in some activities that are listed overleaf.

If you would like your child to take part in this project please return the completed forms in the *Invitation Pack* to your child's teacher at school by Monday 22nd February 2010.

We hope you consider taking part in our project and look forward to hearing from you.

Yours sincerely,

Dr. Nicola Ridgers
Project Leader
RISES

Mareesa O'Dwyer
REACH Group Research Officer
RISES

LIVERPOOL JOHN MOORES UNIVERSITY

PARENTAL CONSENT FORM

Title of project: Effect of a 6 week Active Play programme in Early Years settings in Liverpool

Mareesa O'Dwyer and Dr Nicola Ridgers

Research Institute for Sport and Exercise Sciences

Please tick/cross the relevant boxes below:

1. I confirm that I have read and understand the information provided for the above study. I have had the opportunity to consider the information, ask questions and have had these answered satisfactorily. 1

2. I understand that my child's participation in the research is voluntary and that I am free to withdraw him/her at any time, without giving a reason and that this will not affect my legal rights. 2

3. I understand that any personal information collected during the study will be anonymised and remain confidential. 3

4. I give permission for photographs to be taken of my child during the project, which may be used for subsequent academic/promotional purposes associated with Active Play and SportsLinx. 4

5. I am aware that some children will be filmed during the sessions for academic purposes, and I give permission for my child to be filmed during these sessions. 5

6. I agree for my child to take part in the above study. 6

Name of Child _____

Childs School _____

Name of Parent/Guardian: _____

Signature:_____

Date: _____

Name of Researcher: Date: Signature:

Name of Person taking consent: Date: Signature:

(If different from researcher)

LIVERPOOL JOHN MOORES UNIVERSITY

ASSENT FORM FOR CHILDREN / OTHER DEPENDENTS

Title of project: Effect of a 6 week Active Play programme in Early Years settings in Liverpool

Mareesa O'Dwyer and Dr Nicola Ridgers

Research Institute for Sport and Exercise Sciences

Child (or if unable, parent/guardian on their behalf) to circle all they agree with:

1. Has your child read (or have read to) the information about this project? Yes/No
2. Has somebody else explained this project to your child? Yes/No
3. Does your child understand what this project is about? Yes/No
4. Has your child asked all the questions they want to ask? Yes/No
5. Has your child had their questions answered in a way they understand? Yes/No
6. Does your child understand that it's OK to stop taking part at any time? Yes/No
7. Is your child happy to take part? Yes/No

If any answers are 'no' or your child **doesn't** want to take part, don't sign your name!

If your child **does** want to take part, you can write your name below

Your child's name _____

Date _____

Your parent or guardian must write their name here if they are happy for you to do the project.

Print Name_____

Sign _____

Date _____

Child's Medical Form

This form should be completed as accurately as possible by the carer/parent/guardian. All information will remain confidential. The form is designed to ensure that your child has no medical condition/illness that might compromise their safety to take part in the project. It will also be available in case of emergency

Name of child:_____

Ethnicity: _____ **Date of Birth:** _____

Full Address:_____

_____**Post Code:** _____

Home Tel No.: _____ **Parent/Guardian Mobile No.:** _____

Emergency Tel No.:_____

	YES	NO
Has your child ever had any surgery?		
Has your child ever suffered from any injuries?		
Has your child recently suffered from any illness? (in the last 3 month		
Has your child been involved in any major accidents?		
Is your child currently being treated by your doctor?		
Is your child on any long term medication?		
Was your child born pre-term?		
Does your child have problems with:		
• hearing		

• vision		
• bones/joints		
• co-ordination		
• diabetes		
• epilepsy		
• respiratory problems		
• heart problems		
Is your child allergic to any medication?		
Does your child carry any medication in case of emergency?		
Is there any history of heart disease in the Childs family?		
Is there any history of high cholesterol in the Childs family?		
Is there any history of high blood pressure the Childs family?		
Is there any family history of unexplained sudden death?		
If you have <u>answered YES</u> to ANY questions please <u>provide relevant detail</u> OR ***<u>anything else</u> that may be relevant i.e. any other medical conditions/issues;***		

LIVERPOOL JOHN MOORES UNIVERSITY

PARTICIPANT INFORMATION SHEET

(Parents Questionnaire)

Title of Project Effect of a 6 week Active Play programme in Early Years settings in Liverpool

Mareesa O'Dwyer and Dr Nicola Ridgers

Research Institute of Sports and Exercise Sciences

1. What is the purpose of the study?

The main **purpose** of the research project is to investigate the delivery of the Active Play programme and also see what effect it has on activity levels, behaviour change, well being and as well as other components of physical fitness including fundamental movement skills in children aged 3-5 years. These outcome measures will be assessed before, after and during the Active Play programme using a variety of different measurement tools one of which is a parental characteristics questionnaire which we are asking you if you would like to complete.

2. Do I have to take part?

No. It is up to you to decide whether or not to take part. If you do you will be given this information sheet and asked to complete the questionnaire. You are still free to withdraw at any time and without giving a reason. A decision to withdraw will not affect your rights/any future treatment/service you receive.

3. What will happen to me if I take part?

- You will be asked to fill out a questionnaire which asks you your date of birth, where you live, your ethnicity, about your role in your family, your marital status and your qualifications.
- It will take approximately 15 minutes to fill out the questionnaire.
- You will return the questionnaire to your child's teacher in a sealed envelope. It will then be passed on to the Active Play research team.

4. Are there any risks / benefits involved?

There are no risks or discomforts involved in this research. You will be asked to give up approximately 15 minutes of your time to complete the questionnaire.

5. Will my taking part in the study be kept confidential?

In order to protect subject anonymity all participants who consent to be involved in the focus groups will be given a unique identifying code, which will be used in all data spreadsheets that will be shared or discussed through different media. One spreadsheet that contains information concerning names and codes will be held by the main applicant (MOD), but will be separate to the data spreadsheets. All personal data will be treated with

confidentiality, with paper archives being kept in a locked facility within LJMU, digital archives and spreadsheets being password protected, and audio tapes being kept in a secure locked office

Parents Active Play Questionnaire (Study 2)

Parents Active Play Questionnaire (#1)

IMPORTANT INFORMATION

BY COMPLETING THIS QUESTIONNAIRE YOU CONSENT TO:

1. Having read and understood the information provided for the above study, had the opportunity to consider the information, ask questions and have had these answered satisfactorily.
2. Understanding that your participation is voluntary and that you are free to withdraw at any time, without giving a reason and that this will not affect your legal rights.
3. Understanding that any personal information collected during the study will be anonymised and remain confidential.
4. To take part in the above study.

PLEASE ANSWER THE FOLLOWING QUESTIONS BY CIRCLING THE APPROPRIATE WORD/NUMBER, TICKING THE APPROPRIATE BOX(ES) OR FILLING IN THE BLANK SPACES

AT THE BACK OF THIS PACK YOU WILL FIND A BLANK PAGE FOR ADDITIONAL COMMENTS.

Question 1:

Your child's class: Nursery ☐ Reception (☐ ease tick)

If nursery, is it Morning ☐ Afternoon (☐ lease tick)

Your child's gender: Male ☐ Female (☐ ease tick)

Question 2:

Your child's birth weight: _____

Your child's birth height: _____

Question 3:

What is the relationship between you and the child involved in the Active Play programme? Please tick one box.

I am the child's biological parent ☐

I am the child's legal guardian ☐

I am the child's carer ☐

Other ☐ Please specify

_____

What is your gender? Please tick one box.

Male ☐ Female ☐

Question 4:

Your Full Postcode: _____ *e.g. L17 9QW*

Question 5:

What is your ethnicity? Please tick one box.

White English (in England) ☐

White Welsh (in Wales) ☐

Other White British ☐

White Irish ☐

Other White background ☐

Mixed: White and Black Caribbean ☐

Mixed: White and Black African ☐

Mixed: White and Asian ☐

Mixed: Other Mixed background ☐

Indian ☐

Pakistani ☐

Bangladeshi ☐

Chinese ☐

Other Asian background ☐

Black Caribbean ☐

Black African ☐

Other Black background ☐

Arab ☐

Gypsy/Romany/Irish Traveller ☐

Other Ethnic Group ☐lease specify: _____

Question 6:

What is your current marital status? Please tick appropriate box.

Single ☐

Married ☐

Civil partnership ☐

Divorced ☐

Separated ☐

Widowed ☐

Co- habiting ☐

About Your Qualifications:

Question 7 (a)

Do you have any GCSE's or O-Levels?

Yes ☐ How many? _____

No ☐

Do you have any CSE's?

Yes ☐ How many? _____

No ☐

Do you have any Scottish Standard Grades?

Yes ☐ How many? _____

No ☐

Do you have any AS-Levels?

Yes ☐ How many? _____

No ☐

Do you have any A-Levels?

Yes ☐ How many? _____

No ☐

Question 7 (b)

Have you achieved any qualifications listed below? Please tick all that apply to you.

Trade Apprenticeship ☐

BTEC (Edexcel) First or general diploma with credit ☐

City and Guilds Higher Operative/ Craft Part 2 ☐

GNVQ Intermediate level ☐

LCCI certificate (second level) ☐

Full NVQ level 2 ☐

PEI stage 2 ☐

RSA (OCR) Diploma 1 ☐

Pitmans intermediate level 2 ☐

ONC ☐

OND ☐

City and Guilds Advanced Craft/ Part 3 ☐

Full NVQ3 1 ☐

GNVQ Advanced; or LCCI diploma (third level) ☐

Pitmans Level 3 Advanced Higher Certificate ☐

RSA (OCR) Stage 3 Advanced ☐

Certificate/ Diploma ☐

BTEC (Edexcel) SCOTVEC National Certificate/ Diploma ☐

ESOL and Foreign Languages advanced awards ☐

Access to Higher Education courses ☐

Question 7 (c)

Do you have any of the following: a first (bachelors) degree (e.g. BA, BSc), or HNC; HND; BTEC (Edexel) Higher National Certificate/Diploma; Higher education certificate; Higher education diploma; LCCI advanced; full NVQ level 4; Nursing SRN; Teaching qualification; RSA Higher diploma)?

No, none of these ☐

Yes, one or more, all completed more than 3 years ago ☐

Yes, one or more, including at least one completed in the last 3 years ☐

Question 7 (d)

Do you have a higher degree (e.g. PhD, DPhil, MPhil, MSc, MBA) or any other Post-graduate qualification (e.g. full NVQ5; other high level professional qualification such as chartered accountancy)?

No, none of these ☐

Yes, one or more, all completed more than 3 years ago ☐

Yes, one or more, including at least one completed in the last 3 years ☐

Do you have any other academic or technical qualification that we haven't mentioned? If Yes, please give full name as well as abbreviations

Yes ☐ What is the name of this qualification(s)? _____

No ☐

Question 8 (a)

Which best describes your current situation? Please tick one box.

Paid a salary or wage by an employer ☐

Paid a salary or wage by an agency ☐

Sole director of own limited business ☐

Running or a partner in a business or professional practice ☐

Working for yourself ☐

A sub-contractor ☐

Doing freelance work ☐

Not working at the moment ☐

Don't Know ☐

Question 8 (b)

What is your current occupation? If you are unemployed at this present time, please state *'unemployed'* in the space provided.

Nearly done....

Your signature: _____

Tel no. where we can contact you if necessary: _____

What time of day would best suit you? _____

Your name: (capitals) _____

Your child's name: (capitals) _____

Please give the date on which you completed this questionnaire: DD/MM/**20**YY

Please give your date of birth: DD/MM/**19**YY

Thank you for taking the time to complete our questionnaire.

Participant information sheet and parental consent form

School of Sport and Exercise Sciences

Liverpool John Moores University

Byrom Street

L32AF

Dear parent/carer/guardian,

At Liverpool John Moores University we are doing some research into physically active play in children aged 3-5 years. We are focusing on the SportsLinx Active Play programme, which has been delivered in many early years settings around Liverpool. The research project will begin this September and we are writing to ask whether you and your child maybe interested in taking part.

The project is looking to see how physically active play affects the physical activity levels of children. The project will require children to take part in 5 Active Play sessions over a 10 week period, inside of children centre time. During this time, we will ask the children to take part in some activities that are listed overleaf. We will also run 5 workshops over 10 weeks for parents/carers/guardians of children taking part in the Active Play programme. These workshops are designed to help parents make positive changes to their children's physical activity levels by giving them ideas and advice about playing with younger children. These workshops will also be run at the children's centre.

If you are interested, the accompanying *Information Pack* has all the information you need to help you decide whether you and your child would like to be part of this new project. This project will provide an interesting, enjoyable and rewarding experience for everyone involved, and help promote physical activity, positive behaviour and learning.

If you would like your child to take part in this project please return the completed forms in the Invitation Pack to a member of staff at your children's centre by Wednesday 7th of September.

We hope you consider taking part in our project and look forward to hearing from you.

Yours sincerely,

Mareesa O'Dwyer

PhD Research Student
Research Institute of Sports and Exercise Science

LIVERPOOL JOHN MOORES UNIVERSITY

Title of Project Investigating the effects of a 10 week Active Play programme in Early Years settings in Liverpool

Researcher: Mareesa O'Dwyer

Department: Research Institute of Sports and Exercise Sciences

What is the aim of this project?

The aim of the project is to find out if the Active Play Programme:

- Changes how much physical activity your child participates in
- Investigate whether involving parents/carers/ guardians in the Active Play programme makes a difference to your child's physical activity levels

Why are we doing this project?

Our previous research with Liverpool preschool children tells us that children are not taking part in enough physical activity and playtime to benefit health. We have designed an Active Play programme for children and some workshops for parents, which we believe will increase physical activity levels and encourage parents to provide more active play opportunities for their children. Given the young age of the children, we believe that involving parents/carers/ guardians is important if we want to see a difference. For this reason we are also inviting the parents to be part of this research project.

Does your child have to take part?

No. It is up to you to decide for your child to take part. If your child does take part you will be given this information sheet and asked to sign a consent form. You and your child are free to withdraw at any time and without giving a reason. A decision to withdraw will not affect your childs rights/any future treatment/service you receive.

Can your child take part?

Are they aged between 3-5 years old and attend children's centre? If the answer to these questions is YES then your child can take part.

What does your child do in the project?

All of the children's centres that take part in the study will be split into two groups. This decision will be at random (in a lottery draw). Each of the groups is described on the next page.

Group 1 (Intervention)

Children attending centres in this group will take part in a 10 week Active Play programme beginning in September (5 sessions over 10 weeks). These sessions will be delivered by one of our Active Play workers. Our Active Play workers are employed by SportsLinx. They are qualified sports coaches with experience in delivering Active Play sessions to children aged 3-5. The Active Play sessions being delivered will take place within the childrens centre day. This time will be agreed with each of the children's centres and parents will be informed about this. Each child in this group will get to wear an activity monitor before and after the programme. Parents/carers/guardians of children attending children's centre in this group are asked to attend all of the workshops. These workshops will include topics such as; getting your children active at home, ideas about what to do in your local community to stay active and games ideas aimed at improving movement skills.

Group 2 (Comparison)

Children attending centres in this group will not take part in the Active Play programme. They will just do what they usually do in terms of attending children's centre. Each participant in this group will also get to wear an activity monitor at two different time points. Parents/carers/guardians of children's attending children's centre in this group will receive some physical activity information.

Other things that we'll be doing

As part of this project we will be collecting some information about each of you as parents/ carers/ guardians and also about your child. You will be provided with a separate information sheet and consent form for this questionnaire.

The research team will visit your child's children's centre over the duration of the programme and do some data collection with your child and take some measurements –all are explained below. We have broken it up into what your child will be doing at the children's centre and what they will be doing at home.

What we will do when we visit the children's centre:

Height and weight measurements

We will measure your child's height and weight.

Physical activity monitoring

Children: We will ask your child to wear a little gadget called an activity monitor (also known as an accelerometer) around their waist every day for 7 days to see how active they are. They can wear it all the time except when taking a bath or shower, when going swimming or when in bed. They will be given it at the children's centre and asked to wear it at home too. It doesn't get in the way and children soon forget they have them on. You will not have to press any buttons or set this gadget just simply put it around your child's waist. Children will be asked to wear this before and after the ten weeks Active Play programme. It is really important that you encourage your child to wear this all the time. After the 7 days you or your child can return the activity monitor to your child's teacher and a member of the research team will collect it at the children's centre. If you agree, we can also send you a reminder text message to put the monitor on your child each morning.

Parents: We will also be asking some parents to wear activity monitors for the same 7 days as their children. This will help the children wear the monitor when they see their parents wearing them.

Discussions with parents/carers/guardians

Before and after the 10 week Active Play programme, we will conduct some discussions with some parents/carers/guardians. These discussions will investigate how you felt about the programme, what you learnt from the programme and how you plan to integrate what you learnt into your family's life.

What you and your child will do at home:

A parents/ carers/ guardians questionnaire

We will ask you fill out a questionnaire at the beginning of the programme, which will tell us a bit about you and your families' background.

A home task

During the workshop each week, we will set a task for you and your child to do at home. A sample task might be to practice the fundamental movement skills we discussed at the workshop. If you agree, we can also send you a text message to remind you to complete the home task.

What are the benefits of your child taking part in the project?

- If they are in the intervention group, they will get to take part in a 1 hour session of fun and games in the children's centre for a period of 10 weeks with one of our Active Play workers.
- If your child takes part in this study he/she will adding to a new research area and therefore informing the design of more programmes like Active Play in the future for children all over Liverpool and the UK.
- The findings of the project will be made available to the children's centre, which will allow them to improve their physical activity service for parents and children
- You will receive a **£10 shopping voucher** if you complete the programme, fill out your log books and return your activity monitors.

What is expected of the parent/carer/guardian?

- We ask you to show enthusiasm and support the project. You are a really important part of this project and we cannot complete it without you.
- We ask you to attend each of the workshops and complete the home tasks.
- Please encourage your child to wear the accelerometer to the children's centre, at home and at the weekends when they have it.
- If you are in the intervention group, please complete the home task with your child and fill out the log book.

I'm interested in my child taking part in the project, what do I do now?

If you are interested in your child taking part, this is what to do next:

1) You as the parent/carer/guardian should fill in the **Consent Form** within this pack.
2) You and your child should fill in the **Assent Form** within this pack. You can verbally read this out to your child and tick the boxes on their behalf.
3) You, as the parent/carer/guardian should fill in the **Medical Form.**
4) When you have filled in these **3 forms** you should return them to a member of staff at the children's centre **no later than 9th of September.** Forms received after this date may not be considered for the project.

What will happen next?

Our Active Play team will contact the children's centre to arrange some dates for data collection and the Active Play programme and workshops. In September 2011, our research team will visit the children's centre your child attends. We will take some of the measures outlined above. During October, November and December you and your child will begin the Active Play programme (that is if you are in the intervention group). This will take up approximately one hour per week. Once this programme finishes (in early December 2011) our research team will re-visit the children's centre and take some more measurements. We realise that this is the Christmas period and it will be very busy in children's centres; we therefore appreciate your co-operation around this time.

Important Information

CRIMINAL RECORD BUREAU (CRB) CHECKS

All members of the Active Play delivery and research team are fully qualified and CRB checked.

CONFIDENTIALITY

All collected information will be stored securely at Liverpool John Moores University, and only people working on this project will have access to the information generated. Any information that is subsequently used in reports or future publications will not contain names of participants. Unique identifying codes, known only to the research team, will be used when discussing collected information.

PARTICIPATION

Please note that you can choose whether or not you would like to take part. It is voluntary. If you begin to take part and change your mind, you can stop taking part at any time. You do not have to tell us why.

LIVERPOOL JOHN MOORES UNIVERSITY

PARENTAL CONSENT FORM

Title of project: Investigating the effects of a 10 week Active Play programme in Early Years settings in Liverpool

Researcher: Mareesa O'Dwyer

Department: Research Institute of Sports and Exercise Sciences

Please tick/cross the relevant boxes below:

7. I confirm that I have read and understand the information provided for the above study. I have had the opportunity to consider the information, ask questions and have had these answered satisfactorily. 1

8. I understand that my child's participation in the research is voluntary and that I am free to withdraw him/her at any time, without giving a reason and that this will not affect my legal rights. 2

9. I understand that any personal information collected during the study will be anonymised and remain confidential. 3

10. I give permission for photographs to be taken of my child during the project, which may be used for subsequent academic/promotional purposes associated with Active Play and SportsLinx. 4

11. I am happy for you to send me reminder text messages 5

12. I agree for my child to take part in the above study. 6

Name of Child _____

Name of Parent/Guardian: _____

Signature: _____ Date: _____

LIVERPOOL JOHN MOORES UNIVERSITY

ASSENT FORM FOR CHILDREN / OTHER DEPENDENTS

This form should be completed as accurately as possible by the carer/parent/guardian. All information will remain confidential. The form is designed to ensure that your child has no medical condition/illness that might compromise their safety to take part in the project. It will also be available in case of emergency

Name of child:_____

Ethnicity: _____ **Date of Birth:** _____

Full Address:_____

_____**Post Code:** _____

Home Tel No.: _____ **Parent/Guardian Mobile No.:** _____

Emergency Tel No.:_____

	YES	NO
Has your child ever had any surgery?		
Has your child ever suffered from any injuries?		
Has your child recently suffered from any illness? (in the last 3 month		
Has your child been involved in any major accidents?		
Is your child currently being treated by your doctor?		
Is your child on any long term medication?		
Was your child born pre-term?		
Does your child have problems with:		
• hearing		

• vision		
• bones/joints		
• co-ordination		
• diabetes		
• epilepsy		
• respiratory problems		
• heart problems		
Is your child allergic to any medication?		
Does your child carry any medication in case of emergency?		
Is there any history of heart disease in the Childs family?		
Is there any history of high cholesterol in the Childs family?		
Is there any history of high blood pressure the Childs family?		
Is there any family history of unexplained sudden death?		
If you have <u>answered YES</u> to ANY questions please <u>provide relevant detail</u> OR ***<u>anything else</u> that may be relevant i.e. any other medical conditions/issues;***		

Parents and carers active play questionnaire (Study 3)

Active Play Parents and Carers Characteristics Questionnaire

Section 1. General Information

3. What is your relationship to the child in the programme? Please circle your answer.

1. Mother
2. Grandparent
3. Other (please state) _____
4. Father
5. Guardian

4. How old are you? Please circle your answer.

1. Less than 20 years old
2. 20- 29 years
3. 30- 39 years
4. 40- 49 years
5. 50- 59 years
6. 60- 69 years
7. More than 7 (Day/month/year)

5. What is your current marital status? Please circle your answer.

1. Single
2. Married
3. Living with partner
4. Separated
5. Divorced
6. Widowed
7. Never married

6. What is your primary ethnic background? Please circle your answer.

1. White
2. Black Caribbean
3. Black African
4. Black other (please give details) _____
5. Indian
6. Pakistani
7. Bangladeshi
8. Chinese
9. Other (please give details) _____

7. What is your current level of education? Please circle your answer.

1. Completed GCSE's or equivalent
2. Completed A-Levels, BTEC or equivalent
3. Technical or trade certificate e.g. carpenter, electrician
4. University or tertiary qualification e.g. BA, BSc, MSc, PhD
5. None of the above

8. What is your home postcode?

9. Excluding the child in this programme, how many other children (brother, sisters, step-brothers, step-sisters, foster children, etc.) under the age of 18 currently live in the same house as the study participant? Please enter number below?

_____

What are their ages and gender?

	Years	Months	Gender (please circle)
Child 1			Boy Girl
Child 2			Boy Girl
Child 3			Boy Girl
Child 4			Boy Girl
Child 5			Boy Girl
Child 6			Boy Gir
Child 7			Boy Girl

Section 2. Home and neighbourhood

10. What best describes the outdoor area within your home perimeter? Please circle the answer.

1. No space at all
2. A small space
3. A medium space (e.g. a standard block of land)
4. A large space(e.g. ¼ acre/ 1000m^2 or more)

11. Do you have access to any of the following facilities within your backyard or home environment? Please circle all answers which apply	**Yes**	**No**
1. Large play equipment (e.g. swing set, climbing frame, slide)	☐	☐
2. Area suitable to ride a tricycle, bike, scooter, etc.	☐	☐

12. How many of the following items are in your home?	**How many?**
1. Television sets	☐
2. DVD or video players	☐
3. Electronic game consoles (PlayStation, Nintendo, X-Box, Wii, DS)	☐
4. Computers (laptop, desktop, iPad)	☐

13. Do you have the following connection in your home?	**Yes**	**No**
1. Internet	☐	☐
2. Pay television	☐	☐

14. Is there a television in your child's bedroom?

15. Does your neighbourhood have the following	**Yes**	**No**	**Not**

places or facilities where your child can be active? **sure**

Please circle all answers which apply

1. Playground ☐ ☐ ☐
2. Communal 'green' or field ☐ ☐ ☐
3. Public park ☐ ☐ ☐
4. Public swimming pool ☐ ☐ ☐
5. Fitness gym with preschool activities ☐ ☐ ☐
6. Club that offers activities/ sports for young children ☐ ☐ ☐
7. Open and accessible natural spaces areas (e.g. beaches, rivers, woods) ☐ ☐ ☐

16. Do you own a pet? If so, please list the number and types of all the pets in your home.

_____

_____

_____

17. How long did your child spend in a car, <u>in total</u>, <u>LAST WEEK</u>?

Weekdays (Monday – Friday) ☐ Hours ☐ Minutes

Saturday ☐ Hours ☐ Minutes

Sunday ☐ Hours ☐ Minutes

18. How often did your child walk (e.g. to a friend's house, to the shop, to the park, to childcare, etc.) to get around your neighbourhood <u>LAST WEEK?</u> (Please tick only one box)

Not at all ☐ 1-2 days ☐ 3-4 days ☐ 5-7 days ☐

Section 3. About your child

19. Please state your child's birth weight _____

20. Which child care facilities did your child attend LAST WEEK? Please circle all answers which apply

1. None ⟶ **please go to Q.21**
2. Informal child care (grandparents, friends, older brother/ sister)
3. SureStart children's centre
4. Private day care/ nursery
5. Preschool (reception class at school)

21. Does your child have any diagnosed physical or medical condition that affects his/her ability to play and be physically active? Please circle the answer

1. No

Yes (please state nature of condition) _____

22. How well do these statements describe your child? Please tick one box for each statement.

	Never	Rarely	Occasionally	Frequently	All the time
My child is very active	☐	☐	☐	☐	☐
My child needs me to motivate him/ her to play	☐	☐	☐	☐	☐
My child needs company to be motivated to play	☐	☐	☐	☐	☐

23. How active would you rate your child compared to other children? Please circle the answer

1. A lot less active
2. Less active
3. The same
4. More active
5. A lot more active

24. Does your child eat his/her meals in front of the television? Please circle the answer

1. Not at all or rarely
2. 1 meal a day
3. 2 meals a day
4. 3 meals a day

25. Does your child attend any organised physical activity or sports (e.g. swimming, Jumping Jacks. Dads n'Lads) during the week? Please circle the answer

1. No
2. Yes

If you answered yes to the last question, can you tell us how much time your child spends at this activity typically EACH WEEK?

Name of organised activity	**Total time usually spent in that activity each week**	
Swimming	Hours	Minutes
Active programme (e.g. Jumping Jacks, Gym Tots)	Hours	Minutes
Dance	Hours	Minutes

Sport: Name the sport _____

Other: Name of activity _____

Section 4. About you

26. Have you ever played sport at a competitive level? (e.g. for a school team, youth club team, local club) Please tick one box

☐ I have participated in sport at a competitive level

☐ I have never participated in sport at a competitive level

If you answered YES, have you ever participated in a sport at a.....?
(please tick all boxes that apply)

1. Amateur/Club level	Youth (0-18years)		Adult (18+ years)	
2. County level	Youth (0-18years)		Adult (18+ years)	
3. National level	Youth (0-18years)		Adult (18+ years)	
4. European/World Championship level	Youth (0-18years)		Adult (18+ years)	

Thank you for completing this questionnaire ☺

Please return to the children's centre with your activity monitor.

Appendix 2

Asociated Publications and Communications

Journal Articles

O'Dwyer, M.V., Foweather, L., Fairclough, S., Knowles, Z., Ridgers, N., Stratton, G. (under review) Objective measure of moderate-to-vigorous physical activity patterns in preschool children, *Journal of Physical Activity and Health.*

O'Dwyer, M.V., Foweather, L., Fairclough, S., Knowles, Z., Ridgers, N., Stratton, G. (under review) Effect of a school-based active play intervention on sedentary time and physical activity in preschool children, *International Journal of Behaviour, Nutrition and Physical Activity.*

O'Dwyer, M.V., Foweather, L., Fairclough, S., Knowles, Z., Stratton, G. (under review) Effect of a family focused active play intervention on sedentary time and physical activity in preschool children, *International Journal of Behaviour, Nutrition and Physical Activity.*

O'Dwyer, M.V., Graham, E., Knowles, Z. (under review) Preschool children's physical activity: Perceptions, practice and movements towards policy, *Early Years International Journal.*

O'Dwyer, M.V., Foweather, L. Stratton, G. & Ridgers, N.D. (2011) Physical activity in non-overweight and overweight UK pre-school children: Preliminary findings and methods of the Active Play Project, *Science and Sports*, 26, 6, 345-349.

Book Chapter

O'Dwyer, M.V., Knowles, Z.R., Ridgers, N.D. & Stratton, G. (2011) Physical activity, play and the pre-school years. *Paediatric Exercise Science*, Nova Science Publishers, NY.

Short Communications

O'Dwyer, M.V., Knowles, Z., Fairclough, S.J., Ridgers, N.D., Foweather, L., Stratton., G. (2011) Can a 6 week school based Active Play intervention increase moderate-to-vigorous physical activity and decrease sedentary behaviour? European Group of Paediatric Work Physiology XXVII Biennial Conference.

O'Dwyer, M.V., Foweather, L., Stratton, G. and Ridgers, N. (2010) Differences in physical activity between non-overweight and overweight preschool children, *Science and Sports*, **25**, 15.

Ridgers, N. O'Dwyer, M.V. and Stratton, G. (2010) The physical activity and play behaviours of pre-school children during lunch recess, *Science and Sports*, **25**, 12.

Conference Proceedings (Oral)

O'Dwyer, M.V., Knowles, Z., Fairclough, S.J., Ridgers, N.D., Foweather, L., Stratton., G. (2011) Can a 6 week school based Active Play intervention increase moderate-to-vigorous physical activity and decrease sedentary behaviour? European Group of Paediatric Work Physiology XXVII Biennial Conference.

O'Dwyer, M.V., Knowles, Z., Fairclough, S.J., Ridgers, N.D., Foweather, L. and Stratton. G. Within day variability of objectively measured physical activity during

weekdays and weekend days in preschool children (2011) 16th Annual Congress of the ECSS, LJMU, UK.

O'Dwyer, M.V., Knowles, Z., Fairclough, S.J., Ridgers, N.D., Foweather, L. and Stratton. G. Can a 6-week school based Active Play intervention increase moderate-to-vigorous physical activity or are we missing something? (2011) ECSS Pre-conference Symposium, LJMU, UK.

O'Dwyer, M.V. and Knowles, Z., (2011) Active Play: what we did and what made a difference. LJMU Child Health Seminar: *We are all in this together.* The REACH Group, LJMU, UK.

O'Dwyer, M.V., Foweather, L., Stratton, G. and Ridgers, N.D. Differences in habitual physical activity between non-overweight and overweight pre-school children (2010) The 1st European Congress on Physical Activity and Health among Young Children (0-6 years), France.

O'Dwyer, M.V., Ridgers, N.D. and Stratton, G. The Active Play Project (2009) Liverpool Active City Breakfast Seminar, LJMU, UK.

Conference Proceedings (Poster)

O'Dwyer, M.V., Knowles, Z., Fairclough, S.J., Ridgers, N.D., Foweather, L. and Stratton. G. Can a 6-week school based Active Play intervention increase moderate-to-vigorous physical activity and decrease sedentary behaviour? (2011) 16th Annual Congress of the ECSS, LJMU, UK.

O'Dwyer, M.V., Knowles, Z., Fairclough, S.J., Ridgers, N.D., Foweather, L. and Stratton. G. Can a 6-week school based Active Play intervention increase moderate-to-vigorous physical activity and decrease sedentary behaviour? (2011) Physical activity and sedentary behaviour interventions for children and young people: From Robust Research to Reality in Practice, ECSS Pre-Conference Symposium, LJMU, UK.

O'Dwyer, M.V., Knowles, Z., Fairclough, S.J., Ridgers, N.D., Foweather, L. and Stratton. G. Can a 6-week school based Active Play intervention increase moderate-to-vigorous physical activity and decrease sedentary behaviour? (2011) Institute of Health Research, LJMU, UK.

O'Dwyer, M.V., Knowles, Z., Fairclough, S.J., Ridgers, N.D., Foweather, L. and Stratton. G. Can a 6-week school based Active Play intervention increase moderate-to-vigorous physical activity and decrease sedentary behaviour? (2011) Faculty of Science Post Graduate Research Day, LJMU, UK. **[Prize Winner: joint second place]**

O'Dwyer, M.V., Stratton, G. and Ridgers, N.D. Assessing physical activity in preschool children using accelerometry (2010) The 3rd International Congress on Physical Activity and Public Health, Canada.